A Smartphone-based Real-time Medication Adherence Monitoring App to Support Full Medication Self-Management among Elderly Faculty Members with Chronic Illness

W. K. ElSaid[1,*], Mona Esmat[1], Nahed Amasha[1]
[1]Computer Department, Mansoura University, Egypt
Emails: prof_wessam@mans.edu.eg; monaesmat1980@gmail.com; nahed_amasha@mans.edu.eg

Abstract

There has been a widespread misconception that the role of physicians in healthcare systems is limited to accurate diagnosis and prescription writing. This poor vision is based on the assumption that the patient will fully adhere to the written medical prescription, which rarely happens in reality, because most patients disregard their physicians' instructions for purposeful reasons like financial hardship or inadvertent causes like forgetfulness. In the contemporary university community, which blends in-person instruction with distance learning, the duties of University faculty members go beyond simple research and teaching to include other responsibilities that would place more burdens and stress on them, which could have a detrimental effect on their lives and cause their medical treatment regimens to fall flat totally. With the development of artificial intelligence techniques and the increasing use of mobile devices, it's easier to develop intelligent apps that cover every part of our everyday routine, including the medical sector, as it's now possible to remotely diagnose, treat and monitor patients' adherence to prescribed medication plans without the need for direct human involvement. This paper combines artificial intelligence techniques and mobile technology to build a healthier university community by providing an effective smart medication reminder mobile app that supports the principle of medication self-management to improve adherence of medication in-take among patient faculty members at Mansoura University who are undergoing long-term therapy. The evaluation plan of the proposed smart medication reminder mobile app was implemented at two primary levels. The proposal's acceptability was tested at the initial level by a team comprising both mobile app developers and medical professionals. The proposal's feasibility was tested on a random sample of patient faculty members from Mansoura University in the second level. The outcomes of the first evaluation level showed that, the services provided by the proposal were highly gained satisfaction of the evaluation team, which means it is suitable for wider use in University environments. While, the outcomes of the second evaluation level revealed that the percentage of taking meds improved among the sample of patient faculty members after using the proposal more than before, which means that it is a useful tool to enhance medication adherence of patient faculty members, especially the elderly with chronic medical disorders.

Keywords: Medication Self-Management; Medication Adherence; Medication Reminder Apps; Acceptability Analysis; Feasibility Analysis; SUS Score

1. Introduction

Worldwide, many physicians agreed that, the success of outpatient therapy depends on at least four factors: recognition of ill health, diagnosis of illness, planning of treatment and the patient adherence to therapeutic plan [1]. One of the common bad behaviors of some patients is non-adherence to the prescribed medications, which

DOI: https://doi.org/10.54216/FPA.180209
Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

is a serious concern as it reduces the benefits of Medicare and imposes a significant financial burden on modern health care systems [2].

According to the World Health Organization, the concept of medication adherence refers to the degree to which a person's behavior is consistent with the agreed-upon recommendations from the healthcare provider. Furthermore, it differs from the term compliance, as the latter means the patient's obedience to the doctor's authority, whereas the adherence implies the cooperation between patient and doctor to enhance patient's health by incorporating the medical viewpoint of physician and the patient's lifestyle, values and preferences [3].

Scientifically, physicians attribute patients' non-adherence to medical instructions and recommendations for many psychological, social and economic reasons, including: financial difficulties, inadequate education, poor communication between doctor and patient, unpleasant side effects of medications, bad tasting medications, and family turmoil, mistrust of doctors, and mental illnesses and disabilities [4]. In fact, patients' non-adherence to prescribed medications can be addressed through several practical measures, such as: developing patient education, changing the frequency, dose, or method of taking medications, prescribing medications at affordable prices, communicating with patients about medication costs, providing patients with financial or psychosocial support, monitoring treatment levels in the patient's bloodstream and reducing the side effects of medications during the therapeutic period [5].

Based on the diagnosis acceptance and initiation of treatment, patients' non-adherence falls into four broad categories as follows [6]:

1- **Non-Compliers:** People who reject the diagnosis and need treatment.

2- **Partial Compliers:** People who are satisfied with the diagnosis and treatment, but do not adhere to the medical instructions necessary to improve their health.

3- **Adequate Compliers:** People who follow health advice sufficiently to generally improve their health or control any health deficiencies.

4- **Over Compliers:** People who strictly adhere to the necessary medical instructions to improve their health.

Recently, Artificial Intelligence (AI) has become one of the emerging technologies affecting all areas of life. Historically, the history of AI can be divided into the following stages [7]:

1- AI roots date back to the 1950s, when the programming language Lisp was invented and used to implement and develop self-modifying applications.

2- In the 1970s, AI was described as one of the frontier technologies when Expert Systems (ES) were developed.

3- In the 1980s, AI was described as the leading technology when the Japanese government began its research and development efforts to develop an AI-based computer architecture called the Fifth Generation Computer System (FGCS).

4- In the 2000s, AI has come to the prominence again in the form of self-learning systems that appear in applications of robotics, smart hubs, intelligent data analytics, etc.

Not long ago, Information and Communications Technology (ICT) has provided a large number of important tools that can serve all areas of daily life [8]. One of the most important of these tools is mobile devices [9] that have a huge number of wonderful advantages, which can be exploited to make our lives better and maintain healthy [10] and ourselves fit.

In our contemporary reality, the modern health systems are increasingly employed mobile health (mHealth) platforms to support healthcare delivery to patients, including medication adherence [11].Today, the huge amount of mobile applications available in the App Store provide many promising tools to solve simple and complex problems in various fields, including healthy environmental, where there are a wide range of medical smartphone apps that support patients' healthcare and play an important role in reducing the shortcomings of patients' non-

DOI: https://doi.org/10.54216/FPA.180209
Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

adherence to prescribed medications, especially those with long-term therapies [12].

Initially, Android medication reminder apps were used in hospitals and homes of elderly people who suffer from multiple diseases and intake different types of medications for long periods according to a certain medical schedule [13]. On the other hand, with the recent developments, these apps are widely used to remotely monitor patients' intake of their treatments specified to their health condition by medical professionals [14]. Now, although young people have more independence and responsibility for their health and well-being, they depend on their parents for help in choosing, obtaining, and managing prescription and non-prescription medications [15].

This research paper provides a high-quality healthcare tool for the university sector, where it involves a smart mobile App that helps academic staff members to remind prescribed medications and includes regular follow-up of required treatments to improve their rate of medication adherence.

The subsequent parts of the paper are organized as follows: Section 2 describes the research problem. Section 3 presents the research significance. Section 4 presents the research objectives.Section 5 presents the research approach. Section 6 presents the research questions and hypotheses. Section 7 provides the theoretical background of the research. Section 8 discusses the details of a newly developed medication self-management mobile app. Section 9 reports the findings of the research upon the core information derived from experimenting the proposal. The last section concludes the research and gives the main paths for future work.

2. Research Problem

The problem of the current research can be described as follows:

Medically, it has been proven that despite effective methods of treatment, the proportion of patients adhering to treatment is very low, where the majority of patients fail to achieve regularity in taking medications as prescribed by the specialist doctors, which leads to lower clinical results, higher direct and indirect healthcare costs and affects overall quality of life.Therefore, the promotion of therapeutic adherence is considered as an integral component of healthcare activities for patients, especially those with chronic diseases.

With the orientation of various Egyptian universities towards obtaining academic accreditation from the National Authority for Quality Assurance and Accreditation, the role of the faculty member in many colleges is no longer limited only to teaching process, but also includes other major aspects, such as annual plan, annual report, educational quiz, course specification, course report, course file, … etc., which would add more stress and burdens on various organs of the faculty member's body, such as the brain, memory, nerve cells, hand, muscles, ... etc.

Unfortunately, these heavy workloads along with other factors, such as high economic costs of living, high costs of health care activities and low awareness of medication adherence contribute to the inability of faculty members with chronic illnesses to take medications as prescribed by medical professionals. Therefore, it is necessary for the educational system, especially the University, to provide innovative approaches for improving patient faculty members' adherence to self-medication as determined by their treating physicians, in a manner that benefits their well-being and health.

Now, cell phones have become an integral part of most people's daily routine. Therefore, the present study has designed a novel smartphone-based medical app that meets the healthcare needs of chronically patient faculty members and reminds them of the exact medication dosage at the correct time in light of their exhaustion in various tasks, whether teaching, research, administrative...etc., which certainly helps them live a healthier life, enlarges their energy levels, enhances their work productivity, and increases their institutional loyalty.

3. Research Significance

The significance of the current research can be described as follows:

3.1 Keeping pace with new trends that seek to employ modern technological means to serve all aspects and

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members of the education system;

3.2 Highlighting the most important diseases that affect capabilities of elderly faculty members, whether research, teaching, administrative, etc.

3.3 Helping patient faculty members to self-medicate with the assist of the proposed smartphone-based medication reminder app.

4. Research Objectives

The objectives of the current research can be described as follows:

4.1 Verifying the validity of the proposed smartphone-based medication reminder app for use in real work environments.

4.2 Determining the feasibility of the proposed smartphone-based medication reminder app in improving the adherence rate of the patient faculty members in Mansoura University to the prescribed treatments.

5. Research Approach

The current research followed the following approaches:

5.1. Descriptive Approach

The survey method was used to review previous studies related to the variables of the current study and prepare the study's theoretical framework.

5.2. Experimental Approach

The pilot approach was used to test the effectiveness of the proposed smartphone-based medication reminder app in providing accurate prompts and reminders to the participating patients to take all medications as directed by caregivers.

6. Research Questions and Hypotheses

The questions and hypotheses of the current research can be described as follows:

6.1. Research Questions

With the country's modern trends towards providing high-quality education and lifelong learning opportunities, the responsibilities of faculty members in various universities are increasing. In addition, with the enormous burden currently placed on the backs of faculty members, there are significant concerns about the ability of patient faculty members to remember the medications prescribed by medical professionals. For this reason, there was a need to utilize modern systems to follow up the medication adherence of patient faculty members, especially with chronic diseases.

The problem of the current research can be formulated in the following two questions:

A- What is the applicability of the proposed medication reminder mobile app in the real environments?

B- What is the rate of improvement in patient adherence that can be achieved through the proposed medication reminder mobile app among patient faculty members in the Egyptian university sector?

6.2. Research Hypotheses

A hypothesis (H) is a proposed explanation for an observed phenomenon or set of phenomena. In a scientific context, it is a precise guess about the relationship between two or more variables, and its validity is tested through a set of organized steps using the scientific approach.

The current study is based on the following two major hypotheses:

H1: The proposed medication reminder mobile app is widely usable in real settings.

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H2: The proposed medication reminder mobile app is able to improve the adherence rate of patient faculty members in Egyptian university sector to the prescribed treatments.

7. Research Background

The theoretical background of the current research can be described as follows:

7.1. Literature Review

To gain an in-depth knowledge on the topic of the current study, we reviewed a large number of scientific papers related to the scope of our research, then we revised the content of these papers and the core findings derived from these studies will be presented in descending order from the most recent to the oldest in the following discussion:

7.1.1 A study entitled "Application of smartphone technologies in disease monitoring: a systematic review", which was conducted by "Jeban Chandir Moses, et al. (2021), and aimed to reveal the extent to which chronic patients accept the use of modern technologies to remotely monitor and manage their diseases during the Covid19 pandemic. The study systematically examined the use of smartphone applications in monitoring and managing chronic diseases by relying on the data acquired from scientific studies published in famous databases such as Medline, Web of Science, Embase, and Proquest during the period from 2010 to 2020. The obtained results showed that, the weight management app improved a wide range of healthy eating, physical and psychological activities such as eating behaviors, dietary intake pattern, mean body weight, mean body mass index, mean waist, and stress levels. The study concluded that, the technological applications can be widely used for disease monitoring, while taking into consideration many regulatory guidelines when designing, developing, and deploying smartphone solutions intended for chronic patients [16].

7.1.2 A study entitled "Oral medication adherence among adolescents and young adults with cancer before and following use of a smartphone-based medication reminder app", which was conducted by "Lauri A. Linder, et al.(2019)", and aimed to evaluate the expected benefits of the proposed medication reminder mobile application called AYAs in helping adolescents and young adults suffering from cancer to take oral medications regularly according to the instructions of their treating doctors. The results of the study showed that, the AYAs classified the level of commitment into four phenotypes :(1) high adherence during the preintervention and intervention periods, (2) low pre-intervention adherence, and improved adherence during the intervention period, (3) low adherence during both periods, and (4) high pre-intervention adherence, and low adherence during the intervention period. The study concluded that the AYAs did not achieve the expected results, where the overall adherence did not improve after its use [17].

7.1.3 A study entitled "Effectiveness of smartphone-based medication reminder application on medication adherence of patients with essential hypertension: a clinical trial study", which was conducted by "Sajede Mohammadi Torkabad, et al.(2020)", and aimed to determine the efficacy of a smartphone-based medication reminder application called DaroYab in medication adherence of hypertensive patients. The results of the study showed that, the proposed application improved the adherence of the patient sample. The study concluded that, the health care providers recommended using DaroYab because of its several pros, including effectiveness, simplicity, and inexpensiveness [18].

7.1.4 A study entitled "Smartphone-based application to improve medication adherence in patients after surgical coronary revascularization", which was conducted by "Chunyu Yu, et al.(2020)", and aimed to evaluate the feasibility of the proposed smartphone-based application in improving the medication adherence of heart patients after Coronary Artery Bypass Grafting (CABG).The results of the study showed that, the patients initially adhered to taking the prescribed treatments through the proposed smartphone application with high adherence percentage as measured by the translated Chinese version of the 8-item Morisky Medication Adherence Scale (MMAS-8), but unfortunately, with the passage of time, this percentage sharply decreased until it was completely absent, where the participating patients withdrew from the study. The study concluded that, the proposed smartphone-based application supports preventive measures for patients after CABG surgery, but it did not achieve the desired results, as they were not superior to their conventional counterparts [19].

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Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

7.1.5 A study entitled "A smartphone-based app to improve adjuvant treatment adherence to multidisciplinary decisions in patients with early-stage breast cancer: observational study", which was conducted by "Jing Yu, et al.(2021)", and aimed to determine the main factors influencing non-adherence to breast cancer treatment and to identify the effectiveness of the proposed smartphone-based application in improving the adherence rate with Multidisciplinary Treatment (MDT).The results of the study showed that, the proposed smartphone-based application did not improve patients commitment to anti-HER2 therapy or endocrine therapy, but it only reduced the non-adherence rate to adjuvant chemotherapy and radiotherapy.The study concluded that, further scientific studies are needed to confirm the feasibility of using smartphone-based applications in the routine MDT clinical practice for breast cancer [20].

- **General Comment on Previous Studies**

It is clear from the previous studies that, the use of smartphone-based applications to enhance patients' self-adherence to prescribed medications are a focal point in several scientific research papers. After analyzing the previous studies, it appears that some studies have confirmed the extreme importance of smartphone-based applications in reminding patients to take medications and thus improving the rate of medication adherence. While others have feared to use this type of software in the health sector, as over time patients participating in some studies they have lost their passion for using these applications to help adhere to taking medications, and they attributed the reason for this to the forgetfulness factor.

The main contribution of this research is the employment of smartphone-based health applications in university institutions to help faculty members, especially the elderly who are undergoing long-term treatment, to take their medications as prescribed by specialist doctors in order to improve their health condition, which of course has positive effects on their capabilities, whether research, teaching, administrative, etc.

7.2. Mobile Health (mHealth)

With the advent of the Affordable Care Act, telehealth received a great deal of attention, which was reflected in the development of healthcare services in many areas, including gap service coverage (eg, night-time radiology coverage), urgent services (eg, telestroke services and teleburn services), mandated services (eg, the delivery of health care services to prison inmates), and the proliferation of video-enabled multisite group chart rounds (eg., extension for community healthcare outcomes programs) [21].

Recently, the rapid growth in smartphone devices has made a significant impact on the field of mobile Health (mHealth), as it collects or presents healthcare information and data and provides dynamic engagement for patients, healthcare providers, and new means to improve health outcomes [22]. According to the Global Observatory for eHealth (GOe) of the World Health Organization (WHO), mHealth is a medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, Personal Digital Assistants (PDAs), and other wireless devices [23].

Now many medical software applications can assist with tasks ranging from information and time management to medical education and training [24]. Moreover, the use of mobile health applications can support patients' self-efficacy, improve access to healthcare services, and improve relationships between patients and providers in ambulatory settings [25].

Ultimately, although mobile platforms act as one of the best client services, they face many challenges in presenting and delivering accurate health information through medical mobile apps due to limitations in power supply, computational capabilities, and operational abilities, as they run on small batteries that are unable to play heavy multimedia files and security algorithms for a long time [26].

8. Proposed Application

The proposed smart medication reminder mobile app was designed and developed based on the mobile platform to help the patient academic faculty member to take each prescribed medication dose properly. The elements of

DOI: https://doi.org/10.54216/FPA.180209
Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

the proposed medication reminder app have been organized into three parts: Overview, Algorithm and Implementation. The detail of each of these parts will be presented in the following discussions:

8.1. Overview

Medication non-adherence has always been one of the most prominent health-related problems, where many scientific studies have revealed that patients 'non-adherence to the prescribed medications back to many reasons, the most prominent of which are forgetfulness and poverty.

In the university sector, the academic faculty members perform multiple tasks and responsibilities, such as research, teaching, meetings and attending conferences, symposiums, workshops, seminars. As a result, there are significant health concerns for this group of patients, especially those over retirement age.

The current paper employed artificial intelligence technology to build a smart medication reminder mobile app to improve faculty members' self-management of medications without needing assistance from others.

The proposed smart medication reminder mobile app provides a number of key operations, the core of which is to remind patients 'faculty members at university institutions to take the right dosage, at the right time, and using the right method. A block diagram for the major steps involved in the medication reminder process can be outlined below in Figure.1.

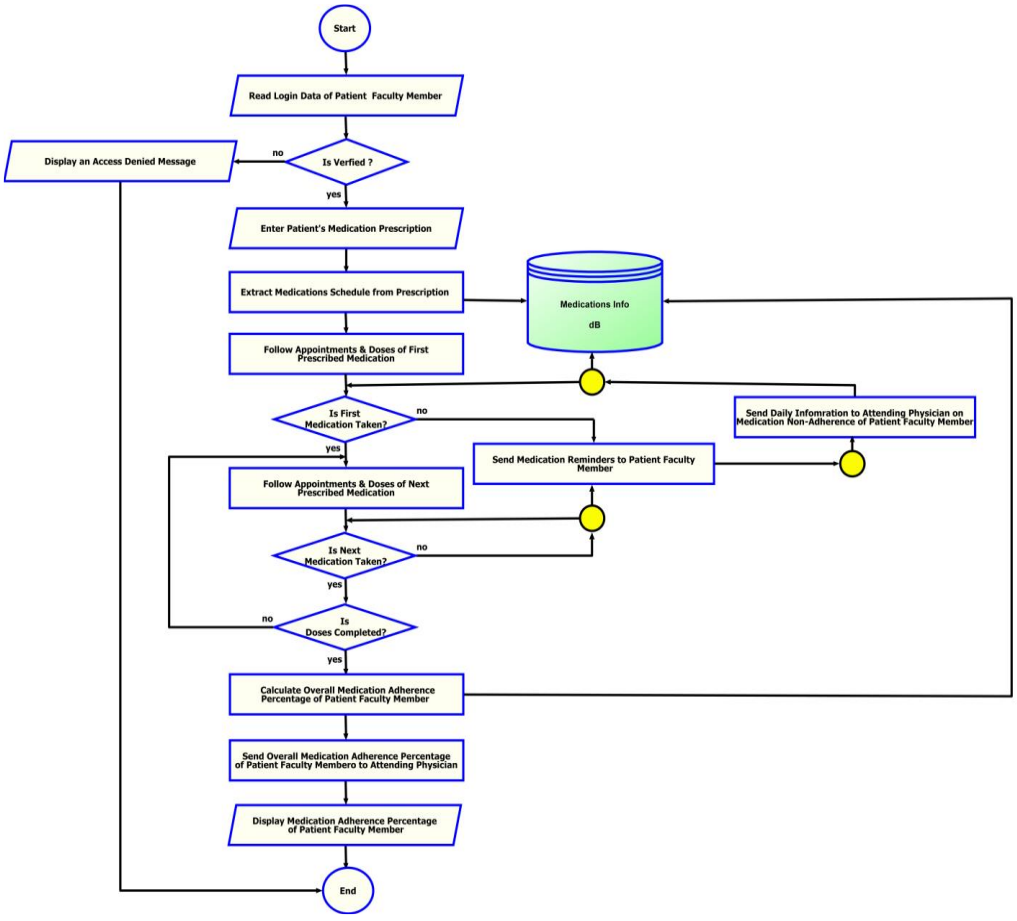

Figure 1. Major Steps Occurred in Medications Reminder Process

From the above Figure, the proposed smart medication reminder mobile app verifies the member's identity; if it is wrong, it exits; otherwise, it proceeds to read important data. For each medicine prescribed in the prescription,

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Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

including the patient's name, medicine's name, medicine's dosage, medicine's duration, and medicine's instructions. Then, it monitors prescribed medications, reminds patient faculty members when doses are due, and reports the specialized physician of the medication errors.

8.2. Algorithm

To achieve the desired outcomes of the proposed medication reminder mobile app, it applied a new methodology that included the following algorithm:

Input: Image of medical prescription of patient faculty member.

Output: Medication adherence percentage of patient faculty member.

Procedures: The core operations of the proposed medication reminder mobile app can be summarized as follows:

1- The proposed app acquires the prescription image of the patient faculty member through wired or wireless image acquisition methods.

2- The proposed app extracts the medicine key information, such as code number, common name, chemical name, price, production date, expiry date, manufacturer, clinical notes, and possible side effects for all medicines specified in the acquired prescription image.

3- The proposed app extracts the medicine usage information, such as treatment regimen, including dosing, frequency, and time for all medicines specified in the acquired prescription image.

4- The proposed app stores both key and usage information in the database.

5- The proposed app periodically follows up in real time the appointment and dose of each prescribed medication.

6- The proposed app sends real-time notifications to the patient faculty member to take the required medicine regularly on time as prescribed to get the most benefits from it.

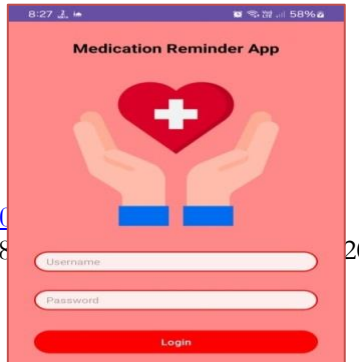
7- The proposed app sends a brief daily report to the attending physician to determine the extent to which the patient's behavior matches the prescriber's advice.

8- The proposed app displays a final report accompanied by the percentage of the patient faculty member's adherence to the prescribed medication dosages during the specified periods.

8.3. Implementation

To execute tasks and enjoy services offered by the proposed medication reminder mobile app, a pictorial user interface was designed. When the proposed medication reminder mobile app is installed on the patient faculty member's smartphone, s/he can utilize its services conveniently and easily. The functionality of the major screens of the proposed mobile app will be described in a quick and simple way in the following sub-section:

Once the patient faculty member launches the proposed mobile app, the "Login" screen shown in Figure.2 will appear to verify the identity of the patient faculty member.



DOI: https://doi.org/10.54216/FPA.1802
Received: July 27, 2024 Revised: October 28 2025

Figu Screen

From the above screen, the patient facu er the necessary login data (username and password), which if it is entered correct Acquisition" screen shown in Figure.3 will appear to display methods of supplying the proposed mobile app with a copy of the electronic medical prescription issued for his/her health condition by the specialist doctor with the help of an software application installed on his/her computer; otherwise the entry request will be denied.

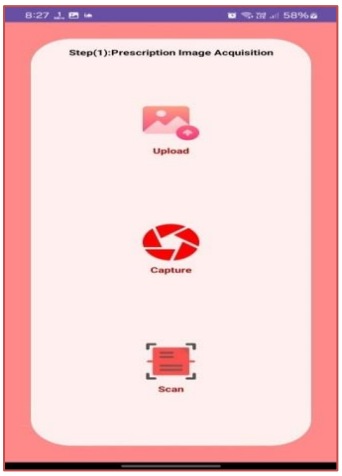


Figure 3. Screenshot of Prescription Image Acquisition

From the above screen, the patient faculty member is allowed to enter the computer-generated prescription - not a handwritten version - in three different methods. In the "Upload" method, the stored image of the electronic prescription is uploaded from the smartphone of the patient faculty member. In the "Capture" method, the electronic prescription is captured in real-time by high-resolution smartphone camera of the patient faculty member. In the "Scan" method, the electronic prescription is scanned through an image-scanning device of the patient faculty member.

Upon completion of the process of acquiring electronic prescription, the "Medications Schedule" screen shown in Figure.4 will appear to display the therapeutic schedule appropriated for the health condition of the patient faculty member.

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Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

Figure 4. Screenshot of Medications Schedule

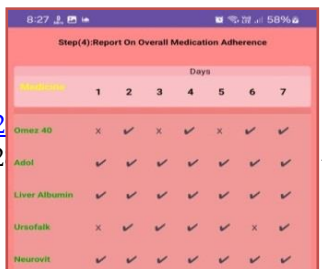
From the above screen, the proposed mobile app furnishes the prescribed medications to the patient faculty member, and it specifies under each medicine the number of doses due throughout the day.

Upon completion the process of presenting the medications schedule, the "Automated Monitoring" screen shown in Figure.5 will appear to monitor the medications extracted from the medical prescription and required to be taken by the patient faculty member

Figure 5. Screenshot of Medications Adherence Tracking

From the above screen, the proposed mobile app asks the patient faculty member to capture an image of the target medication strip via the front-facing camera facing the mouth of his/her smartphone. Then, it automatically performs many internal operations to determine which medications have been taken at the time scope specified in the medical prescription or not. After that, it displays and provides the treating physician with summarized information regarding the patient's commitment to take the required medications throughout the day.

Upon completion of the process of tracking the medications adherence, the button "Overall Report" is pressed to display the "Medications Statistics" screen shown in Figure.6, which displays detailed, up-to-date information on therapeutic adherence of the patient faculty member.



DOI: https://doi.org/10.54216/FPA.1802
Received: July 27, 2024 Revised: October 2 4, 2025

Figure 6. Screenshot of Medications Adherence Statistics

From the above screen, the proposed mobile app furnishes a comprehensive report on the medication adherence of patient faculty member according to the treatment period specified in the medical prescription by a specialist doctor, followed by the total percentage of adherence.

9. Experimental Results

It is known in the areas of software engineering that the testing phase is carried out to support or refute the study hypotheses. In the current work, the pre-defined hypotheses (H1, H2) were validated in two testing stages. The first hypothesis (H1) was validated in the first testing phase to analyze the acceptability of the proposed smart medication reminder mobile app, while the second hypothesis (H2) was validated in the second testing phase to analyze the feasibility of the proposed smart medication reminder mobile app.

Both testing stages are presented in detail below:

9.1. Acceptability Analysis

To check the validity of the H1, a mixed group of experts from multidisciplinary at Mansoura University, Egypt was selected, who collaborate to comprehensively and easily test the acceptability of the proposed smart medication reminder mobile app. The first type of the selected evaluation group included an elite number of software app developers at Mansoura University whose role focused on measuring the compatibility of the proposal with the major objective criteria known for evaluating software solutions.While the second type of the selected evaluation group included an elite number of gastroenterologists at Mansoura University, whose role focused on measuring the ability of the proposal in achieving the targeted medical services.

In practice, the procedures of this test were based on the System Usability Scale (SUS) questionnaire, whose native ten statements were changed a little to suit our research paper. The modified SUS consisted of ten statements that are scored on a five point Likert scale of agreement strength and covers a broad spectrum of targeted dimensions of mobile app assessment. To answer the SUS questionnaire questions, the evaluation members were asked to assign a score for each question from 1 to 5, where point (1) means strongly disagree, point (2) means disagree, point (3) means neutral, point (4) means agree and point (5) means strongly agree.

Following completion of the applied SUS, all the questionnaire instruments distributed to the evaluation team were collected, and investigated where the uncompleted ones were treated as defective survey and eventually excluded from statistical calculations. For each completed questionnaire, the total SUS score acquired from the evaluators' responses was calculated according to the steps in [27], as follows:

DOI: https://doi.org/10.54216/FPA.180209
Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

1- **Step-1:** The value (1) was subtracted from the user's response to odd-numbered items.

2- **Step-2:** The value (5) was subtracted from the user's response to even-numbered items.

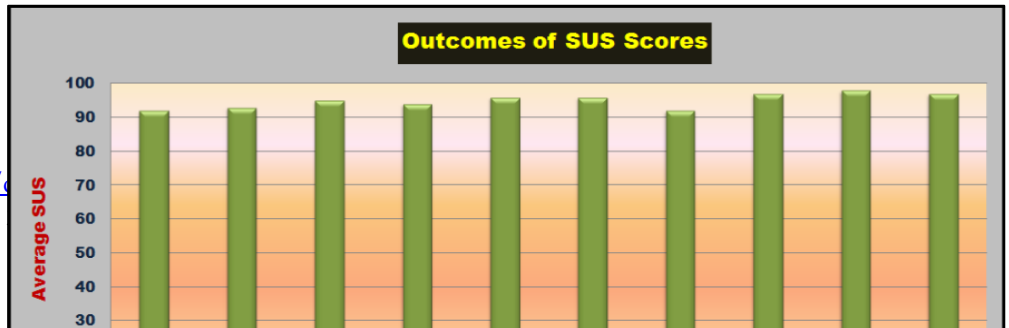
3- **Step-3:** All converted values were added together to produce their sum in the range 0 to 40.

4- **Step-4:** The sum value was multiplied by the value (2.5) to obtain SUS score in the range from 0 to 100 instead of from 0 to 40.

Finally, when the calculations of SUS scores for all accepted questionnaires were completed, the SUS outcomes were recorded in Table.1 and graphed in Figure.7. Furthermore, the results obtained were statistically analyzed to determine acceptability trends, and described in Table.2 and graphed in Figure.8.

Table 1: SUS Outcomes for Proposed Smart Medication Reminder Mobile App

EVALUATOR NO	EVALUATOR TYPE		AVERAGE SUS SCORE
	SOFTWARE APP DEVELOPER	GASTROENTEROLOGIST	
1	93	91	92
2	92	94	93
3	94	96	95
4	93	95	94
5	98	94	96
6	96	96	96
7	90	94	92
8	95	99	97
9	97	99	98
…	…	…	…
Last	96	98	97
Mean			95



DOI: https://
Received: July

Figure 7. Findings of SUS Measurement

Table 2: Statistical Analysis of Acceptability Outcomes

ACCEPTANCE SCOPE	EVALUATOR ACCEPTANCE	
	FREQUENCY [F]	PERCENTAGE [%]
95 : 100	8	40
90 : 94	6	30
85 : 89	4	20
80 : 84	2	10

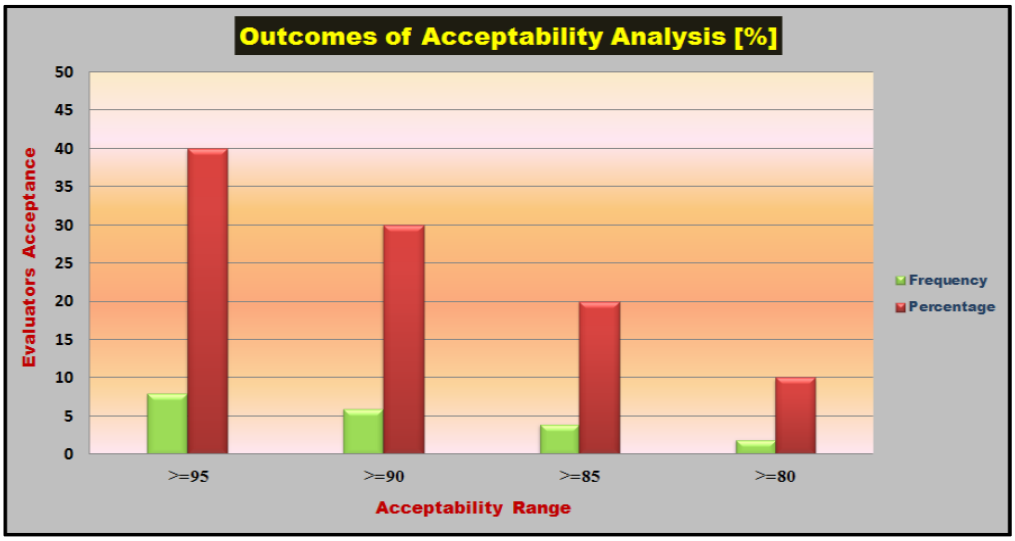


Figure 8. Statistical Analysis of Acceptability Findings

The results above show that, more than 40% of the evaluators (F=8) rated the proposed smart medication reminder mobile app with an overall SUS score greater than or equal to 95, more than 30% of the evaluators (F=6) rated the proposed smart medication reminder mobile app with an overall SUS score greater than or equal to 90, more than 20% of the evaluators (F=4) rated the proposed smart medication reminder mobile app with overall SUS score greater than or equal to 85 and more than 10% of the evaluators (F=2) rated the proposed smart medication

DOI: https://doi.org/10.54216/FPA.180209
Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

reminder mobile app with an overall SUS score greater than or equal to 80.

To classify the quality of the obtained SUS score, we relied on the adjective rating of SUS score reported in the published research paper No.[28] and shown in Table 3, in which the author(s) classified the acceptability of the software application based on the SUS score into several levels, which is if the SUS score is above 85, it means that the acceptability of the application is high, if the SUS score is between 70 and 84, it means that the acceptability of the application is ranging from good to excellent, if the SUS score is between 50 and 69, it means that the acceptability of the application is acceptable, and if the SUS score less than 50, it means that the application is unusable and not accepted.

Table 3: Statistical Analysis of Acceptability Outcomes

SUS SCORE	ADJECTIVE RATING
>=85	High
70-84	Good
50-69	Acceptable
<50	Not Accepted

From the previous results, the obtained SUS score is classified as high level, which means the proposed smart medication reminder mobile app received a high acceptance from the evaluators, whether mobile app developers or medical professionals.

Ultimately, with these affirmative results, we can conclude that the first hypothesis (H1) is correct, which means the proposed smart medication reminder mobile app can be generalized in various Egyptian universities.

9.2. Feasibility Analysis

After completing the activities of testing the first hypothesis, we proceeded to experiment with the validity of H2. The experiment was conducted on a random sample of sixteen patient faculty members at Mansoura University suffering having a number of long-term digestive diseases.

To ensure maximum reliability of feasibility outcomes, we followed a developed strategy while testing the proposed smart medication reminder mobile app on the selected sample of patient faculty members. The developed strategy included three important steps, namely: (1) Pre-Intervention Phase, (2) Intervention Phase, and (3) Post-Intervention Phase.

These three phases will be discussed in detail the following:

A. Pre-Intervention Phase

The purpose of this phase is to determine the initial activities performed to test the feasibility of the proposed smart medication reminder mobile app.

Before a short time of the experiment, the researcher help seeking from other specialists to design a new medication adherence study questionnaire. Then, he communicated with enrolled physicians to treat patient faculty members either by going to their offices at Mansoura University or to their private clinics, and asked them to carefully answer all questions of the prepared opinion poll as an initial step to determine the medication adherence level of their patients. After that, he collected all the questionnaires, carefully analyzed their items, computed the medication adherence percentage for all patient members of the experiment sample before applying the proposed smart medication reminder mobile app to them, and recorded the results obtained in the first column of Table.4.

DOI: https://doi.org/10.54216/FPA.180209
Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

B. Intervention Phase

The purpose of this phase is to experiment the proposed smart medication reminder mobile app on the previously identified sample of the patient faculty members to verify the validity or falsehood of the second hypothesis (H2).

To adhere to the basics and ethics of sound scientific research, the researcher pre-emptively obtained an informed consent from all enrolled patient faculty members before participating in the experiment.

By the time of the experiment, the researcher firstly installed the proposed smart medication reminder mobile app on mobile devices of the selected sample of patient faculty members. Secondly, he fed the proposed smart medication reminder mobile app with images of patients' prescriptions one by one using methods of acquiring medical prescription images previously outlined in Figure.3 during the implementation section. Thirdly, the proposed smart medication reminder mobile app extracts, from the prescription image, the medication data required for the electronic monitoring regimen of patient medication adherence. Fourthly, the proposed smart medication reminder mobile app continuously provides the treating physician with an accurate information about the patient's daily commitment rate to prescribed medications. Fifthly, with the completion of the treatment period, the proposed smart medication reminder mobile app calculates the patient's overall medication adherence percentage and forwards it to the attending physician.

C. Post- Intervention Phase

Once the experiment had finished, the researcher thanked the treating physicians and the sample of patients for their continued support and cooperation in completing the experiment. Then, he obtained the results of implementing the proposed smart medication reminder mobile app and presented them in a meaningful way in the second column of Table.4.After that, he analyzed the experiment outcomes using common analytical measurements to verify whether they support the second hypothesis or not.

Table 4: Outcomes of Measuring Effectiveness of Proposed Smart Medication Reminder Mobile App

PATIENT NO	MEDICATIONS ADHERENCE PERCENTAGE [%]	
	PRE-TEST	POST-TEST
1	88	94
2	89	98
3	95	100
4	92	99
5	93	98
6	87	92
7	94	100
8	96	100
9	90	99

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10	95	100
…	…	…
…	…	…
…	…	…
60	91	99
Overall Average	87	95

It is clear from the previous results that, there is a high correlation between the proposed smart medication reminder mobile app and the level of adherence to long-term medication regimens.

The aforementioned findings demonstrate that, prior to the intervention, the overall average medication adherence for the patient faculty members who took part in the experiment was 87%, but it increased to 95% following the use of the proposed smart medication reminder mobile app.

Finally, with these powerful results, we can conclude that the second hypothesis (H2) is true, which means the proposed smart medication reminder mobile app is a healing tool and can be used in various Egyptian universities to help ailing academic faculty members take the prescribed medication doses at the right time.

10. Conclusion and Future Work

To support the health of patient faculty members, the current scientific research paper presented a smart medication reminder mobile app that provides an on time medication reminder service for those who have difficulty adhering to the recommended medication regimen.

The proposed smart medication reminder mobile app performs many tasks, such as reading prescribed meds from the electronic medical prescription, reminding the patient of the timing and dosage of each medication, tracking medication usage in real time, and providing the treating physician with a daily and comprehensive report on the patient's compliance with prescribed medication regimens.

Once its usefulness was confirmed, it was tested on a group of patient faculty members at Mansoura University to determine its feasibility. The outcomes of feasibility analysis were outstanding, as the overall average medication adherence of examined sample of patients was significantly improved after using the proposed smart medication reminder mobile app than before.

The current research will be expanded in the future by including patient university staff of all ages, not just adults with chronic illnesses.

Ethics and Dissemination

Ethical approval has been obtained from the Scientific Research Ethics Committee at the Faculty of Specific Education, Mansoura University. Study findings will be available to the wider public through open access publications.

Conflict of Interests

The authors have no conflict of interests with respect to the research, authorship, and/or publication of this research.

Acknowledgment

DOI: https://doi.org/10.54216/FPA.180209
Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025

Sincerest thanks to God, who guided us to the correct paths, supported and enabled us to accomplish this valuable work.

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DOI: https://doi.org/10.54216/FPA.180209
Received: July 27, 2024 Revised: October 28, 2024 Accepted: January 14, 2025