

## Deployment of Mobile Application for Sustainable Healthcare Delivery

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### Abstract

*In many developing countries, mobile devices reach more people than the electricity grid, road network, water supply or fiber optic network. Mobile services enable the public and private sectors to reach these communities. One of the key areas of this interactive contact is health. This article presents a hybrid mobile healthcare system based on Android, iOS, and Windows platforms using the Ionic framework. The proposed mobile application allows optimal communication for multiple stakeholders in the medical field, especially patients, doctors, and pharmacists. The purpose of this application is to reduce the time and cost of transaction processing and to increase the flexibility of accessing available information whenever and wherever you need it. Unlike other similar types of applications, our application includes the ability to provide patient discharge summaries (PODS) to patients, send health tips to patients, and reduce customer service costs effectively. It has unique features such as providing a critical communication link between doctors and patients. . A prototype of the proposed mobile health application was implemented using the new Ionic framework and booklet to ensure its practicality on multiple platforms such as Android, iOS, and Windows. The Ionic framework should be adopted for hybrid mobile application development, providing simplicity and flexibility in the user interface (UI) and user experience (UX). It has the potential to break the country's dominant technology monopoly. Tests of the app have shown significant savings in time and mobility for doctors and patients.*

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**Keywords:** Mobile App, Healthcare, Native, Web, Hybrid and Ionic Framework

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### 1.0 Introduction

Health is a vital aspect in the existence of individuals. The preservation of health is essential for human existence. Various illnesses target the human immune system, hence demanding the importance of preventing and managing diseases. This is the primary explanation for why individuals seek a fast and appropriate physician to address their sickness, commonly referred to as a physical examination. The usual procedure for screening starts with selecting a doctor to consult with. This is accomplished by aligning the doctor's schedule with the preferred time for the medical examination (<http://www.cfah.org>). Once you have identified the correct doctor, the subsequent action is to pay a visit and obtain the order number. The individual in need of medical attention is waiting. The doctor will perform a medical examination on him. Once the examination is completed, he will be required to compose a medical report. Medical professionals need to observe and track the progression of the disease in patients as part of their duties. The amount of medical procedures a patient has to go through during a doctor's visit

can be excessive and burdensome. There could be an excessive amount of waiting queues or maybe the doctor is unavailable when the patient comes to the clinic.

This article suggests the development of a mobile app that aims to improve accessibility and convenience in the healthcare industry. A mobile app, also known as a mobile application, is a computer program or software specifically created to operate on a mobile device like a smartphone, tablet, or smartwatch. The initial purpose of the applications was to assist with productivity, specifically for tasks like email management, organizing schedules, and maintaining contact lists. However, the rapid growth into other applications was driven by the high demand from the public for these applications. Some additional industries include mobile gaming, the automation of industrial processes, GPS and location-based services, as well as order tracking and ticket buying. In other words currently, there is an abundant selection of countless applications accessible. Apps are usually acquired from a platform managed by the mobile operating system owner, like the App Store for iOS or the Google Play Store. There are both free and paid apps available, and the profits from these apps are divided between the creator and the platform through which they are distributed. Mobile applications are frequently compared to desktop applications, which are specifically created to operate on a desktop computer. Conversely, web applications function through a mobile web browser rather than directly on the device.

Mobile devices are portable electronic gadgets that are designed to be used on the go. They allow users to access various functions and services such as making calls, sending messages, browsing the internet, and running applications. These devices have become an essential part of modern life, revolutionizing the way people communicate and access information. Mobile devices come in various forms, including smartphones, tablets, and wearable devices. They have significantly increased convenience and connectivity, enabling people to stay connected and productive wherever they go. Furthermore, mobile devices have also transformed industries such as commerce, entertainment, and health by providing new opportunities and experiences for users. Overall, mobile devices have become an integral part of everyday life, making tasks easier, and enhancing communication and productivity (<https://en.wikipedia.org>).

There are mainly three kinds of apps — native, hybrid and web-based.

#### **Native apps**

Native apps refer to applications that are designed and developed specifically for specific mobile platforms. Hence, an application built for Apple devices will never function on Android devices. That is the reason why many businesses create applications for various platforms. During the process of creating native apps, experts integrate top-quality modules for the user interface. This results in improved performance, uniformity, and a positive user experience. Users also gain advantages from having greater access to Application Programming Interfaces (APIs) and can freely utilize all applications available on a specific device without any limitations. Additionally, they effortlessly transition between different applications. The primary goal of developing these applications is to guarantee optimal performance for a particular mobile operating system. (<https://en.wikipedia.org>).

### **Web-based apps**

These applications are developed using HTML5, CSS, or JavaScript programming languages. Having a strong internet connection is necessary for the correct functioning and positive user experience of these particular groups of applications. By default, these applications occupy a smaller amount of storage space on the user's devices in comparison to native and hybrid applications. As all personal databases are stored on Internet servers, individuals can access their desired data from any device via the internet. One limitation is that app developers do not have enough access to the API of the mobile operating system. (<https://en.wikipedia.org>).

### **Hybrid apps**

The idea behind hybrid apps involves combining features from both native and web-based apps. This category includes applications that are created using Xamarin, React Native, Sencha Touch, and other similar technologies. These are designed to provide assistance for both web and native technologies on various platforms, which is why they are called hybrid. In addition, these applications are simpler and quicker to create. It entails the utilization of a solitary code that can function across various mobile operating systems. (<https://en.wikipedia.org>).

### **1.1 Statement of Problem**

The traditional approach in healthcare involves using paper-based systems for various activities, including documenting patient information, assigning patients to doctors, facilitating patient-doctor interactions, and accessing medical imaging and analysis reports. This results in a slower and less effective process, often resulting in the loss of patients' records. However, the mobile app we develop is compatible with various operating systems like Android, iOS, and Windows. Once it is implemented, it allows healthcare practitioners to swiftly retrieve vital data, minimize waiting periods, and allocate more of their time to patient care regardless of location and time.

### **1.2 Motivation**

It is quite obvious that the major challenge emerging from the implementation healthcare services lies in enabling seamless management and sharing of patients' health data. And to fully integrate the patient in healthcare processes it is of crucial importance to empower them with adequate tools and methods to control their own health. The implementation of our mobile healthcare model would address the problem and increase the possibility of improving patient-centred care by the professionals through improved access to information from different platforms.

### **1.3 Aim and Objectives of Study**

The aim of this work is to develop a hybrid mobile healthcare application that works across multiple platforms, such as native iOS, Android, desktop and the web as a progressive Web App- all with one code base. This application provides optimal communication among patients, doctors and other stakeholders for efficient healthcare services and delivery. It will help patient and doctor to communicate each other for appointment, prescription management and patient data management at any time using mobile with different platforms. The objectives of the research are:

1. To develop mobile based healthcare application that can provide an improved quality of communication between the patients and the health care professionals, which is a critical and predictive factor of treatment outcomes for patients.

2. To design an interactive mobile healthcare application that can improve the patients' adherence to both medication and behavioural regimens designed to both treat and manage
3. To show that mobile technologies have the potential to connect doctors with patients without diminishing the quality of care the patients receive, and in some cases, even improving it.
4. To enhance the work flow and all the activity that happens in healthcare service and delivery.
5. To investigate the several flaws within patient healthcare management, with a view to propose architectural framework for mobile patient management that can yield significant cost savings for both health providers and seekers.
6. To create mobile online interaction platforms between doctors and patients for easy and quick treatment, with extended support from doctors to patients.

#### **1.4 Significance of study**

The major significance of this work is to provide a new design of hybrid mobile healthcare application that incorporates preventive care services for all stakeholders in the healthcare sector. By using the proposed mobile healthcare application, all the stakeholders will have wider opportunity to access accurate and up-to-date information with less time and effort as well as improved efficiency of the information flow. The users of this hybrid mobile application do not need to spend to acquire different mobile platform i.e. having android, iOS and Windows phones.

#### **2.0 Literature Review**

The early stages of mobile health, also known as m-health, were characterized as wireless telemedicine where mobile telecommunications and multimedia technologies were combined with mobile healthcare delivery systems (Istepanian and Lacal, 2003). Since that time, it has expanded to encompass any application of mobile technology to solve healthcare issues, including but not limited to improving access, quality, affordability, resource allocation, and behavior norms. Therefore, it has the potential to encompass a diverse range of individuals, items, and the activities that link them together. The essential aspect of these connections revolves around the sharing of information. Mobile technologies are unable to transport drugs, doctors, patients, and equipment physically from one place to another. However, they are capable of transferring and manipulating various types of information including coded data, text, images, audio, and video. The primary technologies used for transmitting mobile health (m-health) information include GSM, GPRS, 3G, and 4G-LTE mobile phone networks. Additionally, computer-based technologies such as Wifi and WiMAX are used, as well as Bluetooth for short-distance communication. These technologies function on hardware networks consisting of devices such as mobile phones, mobile computers (including notebooks, tablets, and personal digital assistants), pagers, digital cameras, and remote sensors. These software platforms vary greatly, ranging from open-source operating systems such as Linux, Google's Android, and Nokia's Symbian to proprietary ones like Apple's iOS and Microsoft's Windows 7 Mobile. In addition to these operating systems, there are methods for gathering and handling information, such as identifying images, recognizing text, and converting text into spoken words. And on top of all these bases, there are numerous applications that have been

created for mobile devices, with the majority of them being available for the public to download through online app stores. (Qiang, Yamamichi, Hausman and Altman, 2011).

Mobile healthcare is a crucial component of electronic medicine which entails the utilization of mobile devices like smartphones, tablets, and personal digital assistants to deliver medical services and offer health-related information to patients (Royston, Hagar, Long, McMahon, Pakenham-Walsh, and Wadhvani, 2015). The health care system encounters various challenges, such as expensive healthcare expenses and limited access to quality medical services (Gupta, Clements, Coady, & Wang, 2015). At present, individuals can conveniently and affordably receive medical assistance by using mobile applications or websites on their mobile phones. This advancement in mobile healthcare enables prompt access to doctors' services. As a result, mobile healthcare can aid in lowering healthcare expenses and reducing wait times, as well as enhancing the effectiveness of medical resource utilization (Sliva and Rodrigues, 2015). As a result, it has the potential to contribute to sustainable progress in the area of medical health. Consequently, everyday consumers, particularly those who are at a higher risk, will experience advantages. In countries such as Nigeria, individuals residing in rural areas and urban migrant communities face challenges in obtaining good quality medical resources, and they also struggle to afford costly medical expenses. The distribution of medical resources is uneven, as evidenced by the surplus of medical facilities in certain large cities. Countries around the world are embracing the 4G era thanks to the advancement of mobile networks. This progress allows for enhanced mobile communication networks and constant improvements in software and hardware technology. (Yupeng, Yutao, Yue and Gwo-Hshung, 2019)

There are three distinct methods used for developing mobile platforms: the Native platform approach, the Web platform approach, and the Hybrid platform approach. Each method has its unique characteristics and pros and cons. Paraphrase: As a result, there is no single method that can be considered flawless when it comes to developing mobile applications (Huynh, Ghimire and Truong, 2017). The Native mobile approach is the most commonly used method in today's world. Nevertheless, Native platforms lack interactivity with other platforms because they operate independently and in parallel. A hybrid mobile app is considered a significant product that combines elements from different sources, including native and web applications. This is required to have a cohesive operating platform that can function on a mobile web browser and expand its capabilities, offer a wider range of styles, and enable access to important native features like motion sensors, accelerometer, GPS, camera, and file systems (Huynh, Ghimire and Truong, 2017; Spachos, Chifari, Chiazese, Merlo, Doherty and Bamidis, 2014). The hybrid mobile app is created to provide push notification, data-driven features, interactive elements, previewing in a browser, cost-effectiveness, and timely advantages (Tanque, 2017). Nowadays, not all mobile applications developed necessitate the inclusion of all the features typically found in a native application. Yusuf (2016) explained the importance of having a versatile application that can function on multiple platforms and seamlessly utilize the unique features of each platform to enable real-time communication on the internet and mobile devices.

This research project involved creating and testing a mobile app using a mix of different technologies. The goal was to showcase the capabilities of the Ionic framework, which provides a user-friendly platform for building hybrid mobile apps. The principles or frameworks for developing mobile applications are employed in hybrid mobile apps (Saleh, Ethan and Tom,

2016). The methodology employed in this study involves utilizing the Ionic framework as a contemporary and emerging strategy to address difficulties in developing cross-platform mobile applications (Griffith and Chris, 2016; Yusuf, 2016). The Ionic Framework is a fully open-source software development kit (SDK) that provides all the necessary tools and resources for creating hybrid mobile applications. Ionic is a platform that utilizes Angular.js and Apache Cordova to create hybrid mobile applications. It offers various tools and services that allow developers to use web technologies such as CSS, HTML5, and Sass to build these apps. Applications can be created using these Web technologies and subsequently made available through native app stores for installation on devices by utilizing Cordova. The Ionic Framework is a project that is completely free and open source, and it operates under the MIT license. The service will perpetually be available for usage without any cost, and it is driven by an extensive global collective. They possess a wide range of native device functionalities such as Bluetooth, HealthKit, Finger Print Authentication, among others, accompanied by Cordova/PhoneGap plugins and TypeScript extensions.

### **3.0 Methodology**

A methodology offers a systematic approach to development, reducing the likelihood of project components failing. It suggests a set of steps to be followed. Mobile application development refers to the tasks and steps involved in creating software specifically for small, portable computing devices that operate wirelessly. Just like web application development, the development of mobile applications also originates from conventional software development. However, a crucial distinction is that mobile applications are frequently developed with the intention of utilizing the distinct functionalities provided by a particular mobile device. Creating applications for mobile devices involves taking into account the limitations and characteristics of these devices. Mobile devices, such as smartphones and tablets, rely on battery power and are equipped with less advanced processors compared to personal computers. However, mobile devices offer additional functionalities like the ability to track location and capture images through built-in cameras. Mobile app development necessitates the utilization of specific integrated development environments. Initially, mobile applications undergo testing in a controlled development environment using emulators. Subsequently, they are tested in real-world scenarios. Emulators offer a cost-effective means for developers to evaluate applications on mobile devices they may not possess in person (Gao, Bai, Tsai and Uehara, 2014).

### **3.1 Approaches to developing Hybrid Mobile Applications**

There are three ways to create mobile applications: the Native approach, the Web approach, and the Hybrid approach. An important aspect is elaborated in the writings of Anibal (2017).

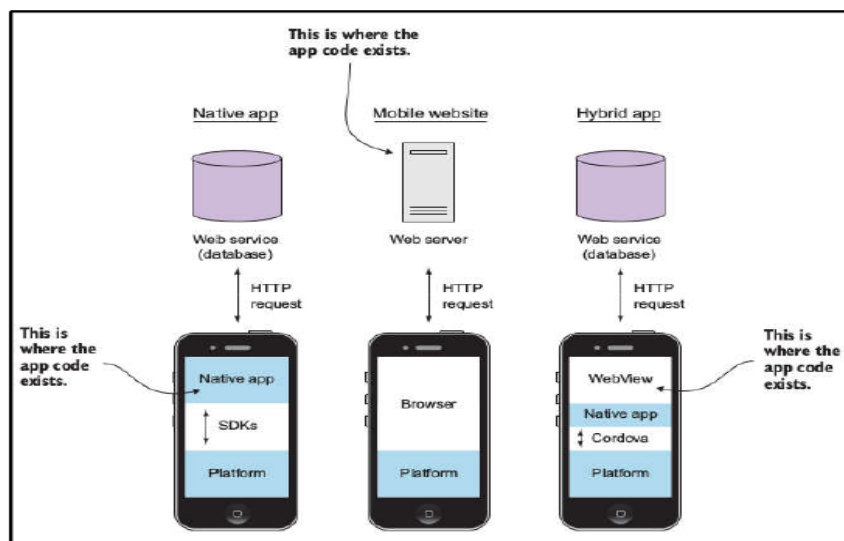


Fig. 1: Approach to development platform for building mobile apps.  
Adapted from Anibal (2017)

In the given figure, it can be observed that the Native approach relies on the specific platform being used. This implies that the development for specific platforms primarily relies on utilizing programming languages native to those platforms. Hence, they can solely function on the specific platforms they are designed for. Applications created using the programming languages specific to a particular operating system generally exhibit reliable performance. The large market shares of android, iOS, and Windows in the mobile market illustrate their dominance in the industry. After every development cycle, the applications are saved and made available to customers through their corresponding marketplaces, enabling them to easily acquire them. Mobile web applications are not directly installed onto the device. Instead, they are stored on servers located remotely and are transferred over the internet to be accessed on the device. They resemble websites that operate on a computer. As a result, they struggle to perform well in specific important tasks. Mobile web applications are dispersed through the internet. Hybrid mobile apps are created by merging web and native mobile technologies together. This implies that a webview built using JavaScript, HTML, and CSS is enclosed within a native container. Nevertheless, the hybrid application offers greater advantages in terms of cost savings for customers and provides significant relief for developers through code reusability. It also saves time and reduces the cost of production and maintenance. Developers no longer need to spend time learning and modifying multiple codes for various platforms, and there is the added benefit of having a web version of the mobile application available. The advantage benefits the individuals who use it. Users of the hybrid mobile app do not have to pay in order to obtain various mobile platforms owning smartphones that run on Android, iOS, and Windows operating systems.

Our suggested app utilizes a hybrid development strategy on the ionic platform, incorporating common web technologies and tools such as HTML5, CSS, and JavaScript. To create a hybrid mobile application, programmers first develop the fundamental structure of the app using HTML5 for mobile devices and then encompass it with a native device interface. The native wrapper acts as a middleman and converts instructions into a format that is understandable by the mobile device. The main component of the hybrid mobile app is the HTML5 core, which

operates within the native container. It utilizes the browser engine of the mobile device, rather than the actual browser, to display the HTML5 content and execute the JavaScript code locally. The core of the HTML5 app can be used again for different mobile platforms. Only the specific covering for each mobile device and operating system needs to be created. Software vendors can generate wrappers to help developers decrease the amount of time spent on development (Rouse, 2015).



Fig. 2: Hybrid mobile app development using ionic framework  
Source: Prismatic (2016)

In simpler terms, Ionic is a framework for developing mobile apps using HTML5. Its purpose is to connect Angular JS with mobile apps, creating a bridge between the two. Ionic app development includes a comprehensive collection of mobile optimized HTML, JS, and CSS components, which are enhanced with Angular JS and integrated with Software as a Service (SaaS). The use of Angular JS, SaaS, and PhoneGap allows the creation of a hybrid app. This app is created with a single code that can work smoothly on various mobile platforms such as Android, iOS, and Windows. (Prismatic, 2016).

### 3.2 Top advantages of choosing Ionic framework for app development

The following are the outstanding advantages mobile application developers will gain for using ionic framework:

#### 1. It is an open-source Framework

Ionic is a mobile framework that is free and open-source, designed to create applications for a variety of platforms. The framework uses its inherent capabilities to integrate with the CSS of the specific platform, resulting in a genuine appearance and experience on various mobile platforms. Ionic extensively decreased the necessity for rewriting code by presenting JS, CSS, and HTML components that are optimized for mobile usage. The combination of Angular JS and the duo creates a solid foundation for a strong structure and easily manageable code.

#### 2. Cross mobile app development made easy

Certainly, the Ionic framework has simplified, accelerated, and rendered cross-platform application development more feasible. The mobile application created with Ionic will work on all mobile platforms. Ionic allows skilled app developers to build a consistent and visually



impressive user interface effectively and efficiently, requiring only minimal resources and time. The mobile framework enables the quick deployment of all regular tools.

### **3. A great UI becomes more feasible**

Ionic provides a collection of useful mobile components (CSS and JS components) that can be utilized to create fundamental features commonly found in mobile apps. These features include sliding boxes, form inputs, sliding menu, tabs, prompts, buttons, and more.

The mobile framework also provides a wide variety of customizable themes and contemporary typography that can readily adjust to any mobile platform available. If desired, the default components can be modified by including pre-established CSS classes.

## **4.0 System Requirements**

The system requirements for building mobile healthcare apps vary depending on the digital platforms for which you are developing. In this research work, we will discuss the hardware and software requirements for developing a hybrid application that will run on various mobile devices and platforms.

### **Platform**

The platform organizations needed to develop, deploy and manage mobile apps are made from many components and tools which allow a developer to write, test and deploy applications into the target platform environment.

### **Front-end development tools**

Front-end development tools are focused on the user interface and user experience (UI-UX) and provide the following abilities:

- UI design tools
- SDKs to access device features
- Cross-platform accommodations/support

The standard front –end tools are:

- HTML5, CSS3, JavaScript

### **Back-end server-side**

Back-end tools pick up where the front-end tools leave off, and provide a set of reusable services that are centrally managed and controlled and provide the following abilities:

- Integration with back-end systems
- User authentication-authorization
- Data services
- Reusable business logic

The standard back –end tools are:

- PHP and MySQL

### **Hardware requirement**

A minimum of 4GB RAM and 20GB Hard-Disk space, Intel core i7 laptop processor clocked at nearly 2 GHz

## **4.1 Application Implementation Details and Testing**

Our proposed healthcare system is mainly composed of four (4) modules and every module contains several routines. The modules are:

- ❖ Doctor module
- ❖ Patient module
- ❖ Pharmacist module

❖ Admin module

Doctor module:

- The doctor shall register before login. He/She shall fill the registration form that consists of the following (First Name, Last Name, SIN, Specialization, Nationality, Gender, DOB, Address, Phone Number, Email, Position, User Name, Password) fields and receives an approval or denial.
- The doctor shall be able to login with his/her user name and password; also he/she shall be able to logout.
- The doctor shall be able to search for a patient by entering patient's first name, last name and file number.
- The doctor shall be able to view scheduled appointments
- The doctor shall be able to cancel appointments
- The doctor shall be able to view the patient complain
- The doctor shall be able to write report of his finding about the patient
- The doctor shall be able to view patient's reports (medical report or laboratory report or radiology report).
- The doctor shall be able to add prescription and add it to the patient's file.

Patient module:

- The patient shall register before login. He/she shall fill the registration form that consist of the following (First Name, Last Name, Nationality, SIN, Gender, DOB, Address, Phone Number, email, User Name, Password) fields and receive an approval or denial via an email.
- The patient shall be able to login with his/her user name and password, also he/she shall be able to logout.
- Write and post his complain
- The patient shall be able to schedule appointment
- The patient shall be able to view his/her medical reports or laboratory reports or radiology reports.
- The patient shall be able to view his/her pharmacy information.
- The patient shall be able to ask for his/her prescription to get ready.

Pharmacist module:

- The pharmacist shall register before login. He/she shall fill the registration form that consists of the following (First Name, Last Name, SIN, Gender, DOB, Address, Phone Number, email, User Name, Password) fields and receive an approval or denial via an email.
- The pharmacist shall be able to login with his/her user name and password; also he/she shall be able to logout.
- The pharmacist shall be able to search for a patient by entering the patient's first name, last name and file number.
- The pharmacist shall be able to send an email to the patient after getting the prescription ready.
- The pharmacist shall be able to view and update the information of the patient's insurance/ payment status.

Administrator module:

- The admin shall be able to login with his user name and password; and he shall be able to logout.
- The admin shall be able to search for a user (patient, doctor, nurse, and pharmacist) by user name, SIN and DOB to view the user's information.
- The admin shall be able to edit the user account.
- The admin shall be able to check the retrieved update.
- The admin shall have overall management of the system

#### 4.2 Testing

The application was tested by the stakeholders concerned using both Android and Windows smartphones and other devices to ascertain the communicability or operability of the application across platforms and the results turned positive.

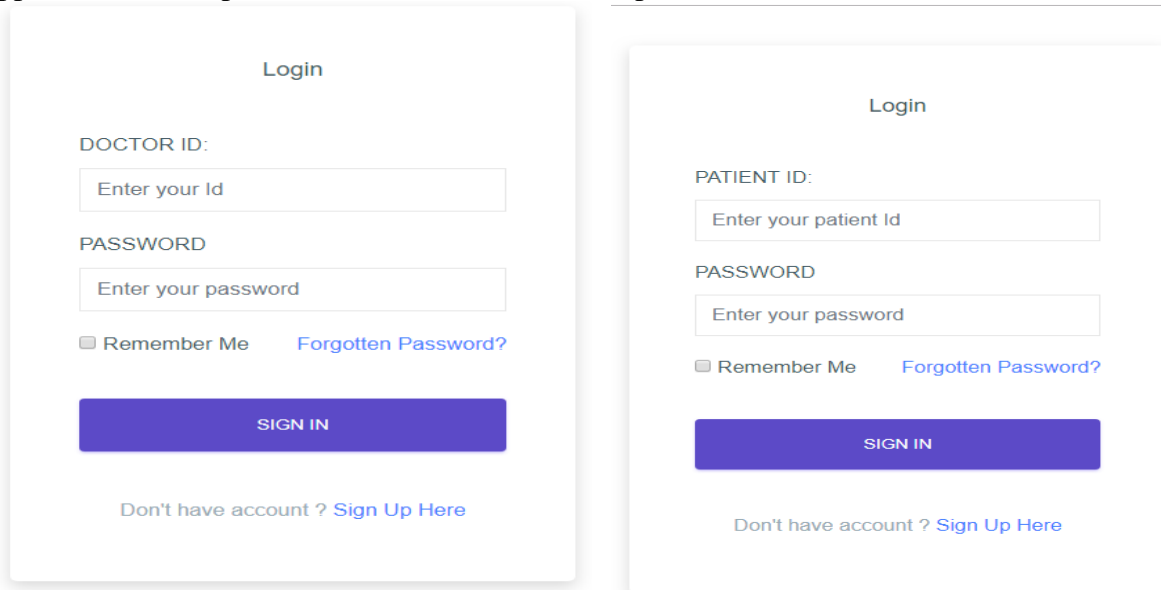


Fig. 3: different Login in Windows platform

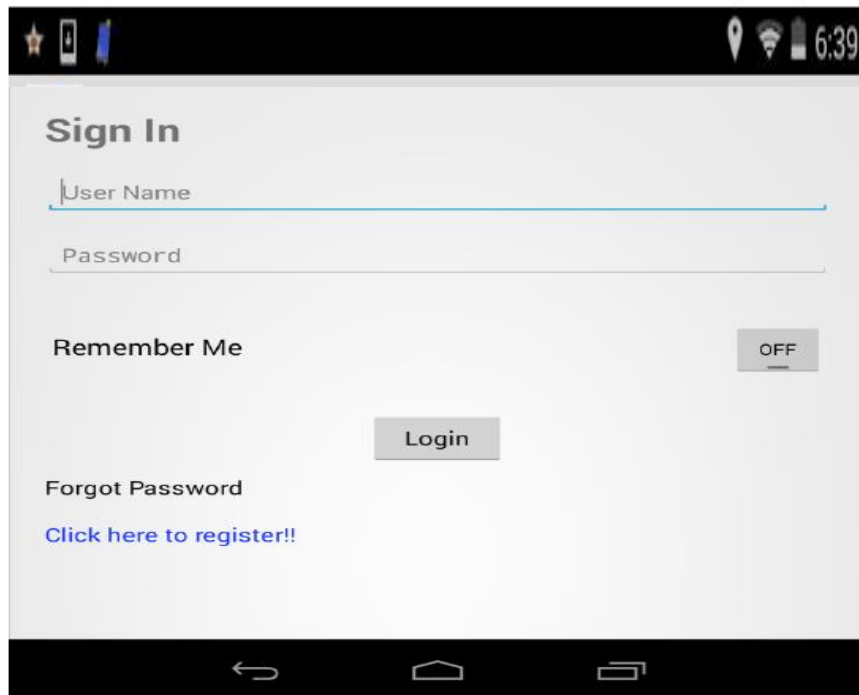


Fig. 4: Users Login in Android platform

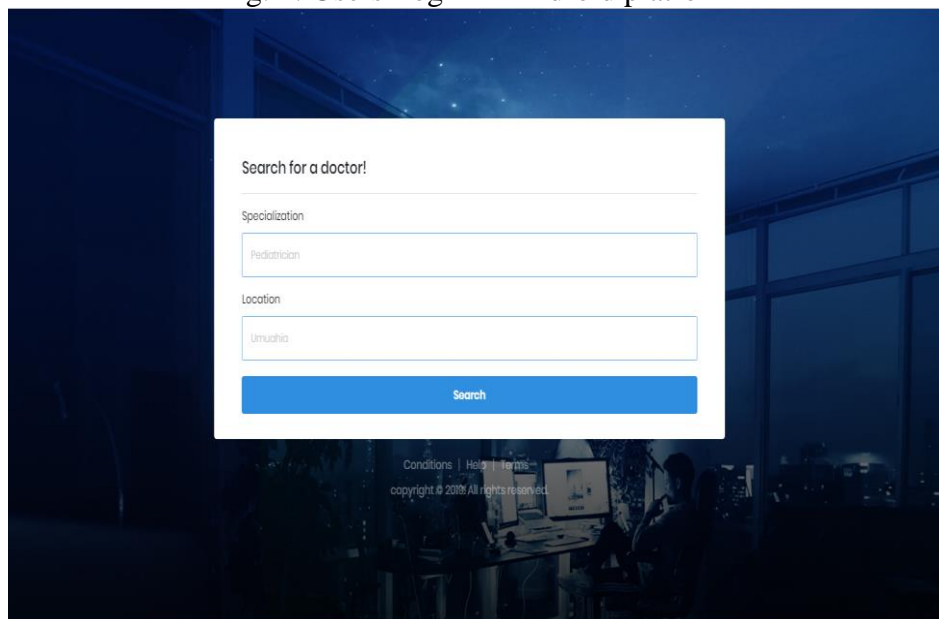


Fig. 5: Doctor Appointment booking in Windows platform

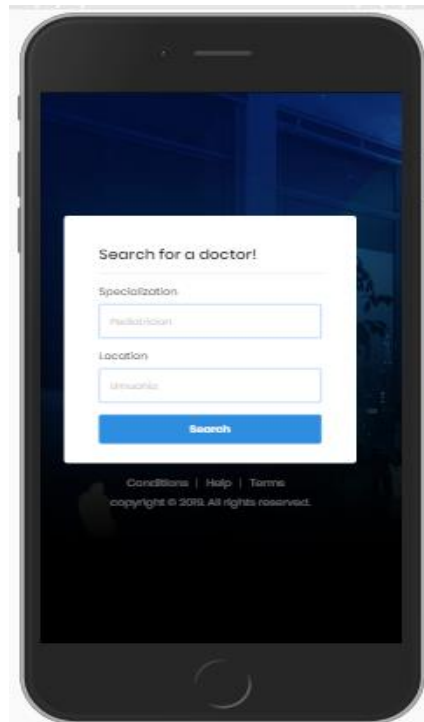


Fig. 6: Doctor Appointment booking in Android platform

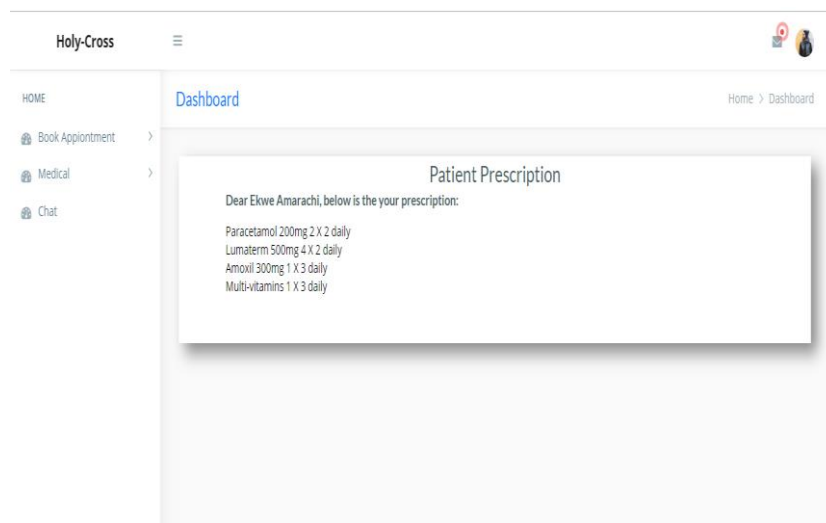


Fig. 7: Patient's list of prescription in Windows platform



Fig. 8: Patient's list of prescription in Android platform

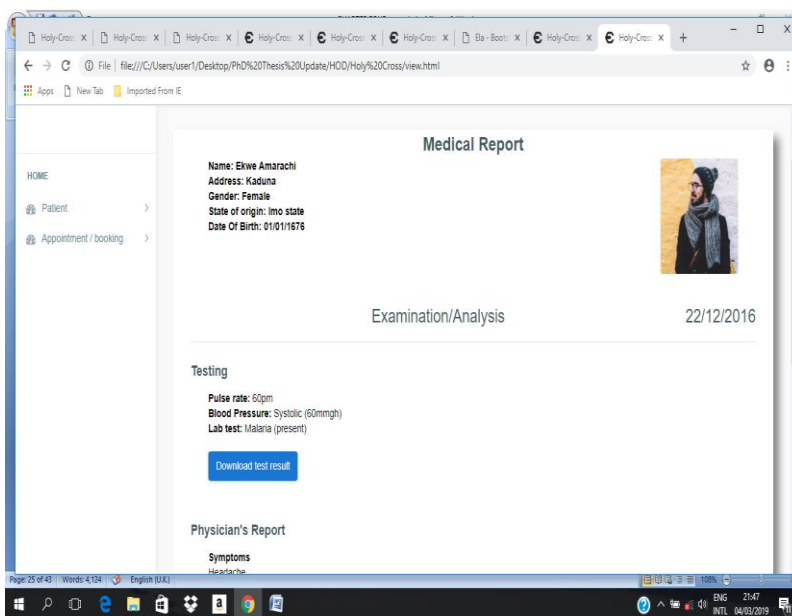


Fig. 9: Patient Medical report in Windows platform



Fig. 10: Patient Medical report in Android platform

## 5.0 Conclusion

Currently, with the advancements in science and technology, individuals are finding more convenient and efficient solutions to their daily issues. Similarly, the healthcare industry is receiving considerable attention from scientists and researchers who are working towards creating beneficial systems to provide care and save lives. In this article, we suggested a way to enhance the communication between healthcare providers and patients by creating a comprehensive structure and design for a future mobile healthcare application. The mobile healthcare application that is being suggested has significant possibilities for enhancing the quality of healthcare and making it more efficient. It also offers the convenience for patients to manage their health outside of the hospital and easily access information about their medications outside of the pharmacy. Additionally, it can reduce healthcare expenses by decreasing the frequency of doctor visits and enable healthcare providers to monitor the health of their patients.

The technologies listed in this report hold the power to revolutionize the provision of healthcare in various ways and tackle upcoming health obstacles. The integration of these technologies into healthcare delivery platforms is crucial and plays a significant role in providing improved patient care. The use of the ionic framework made the development of the hybrid application less demanding. This method enables a single code base to function for various platforms, including Windows, iOS, and Android. We are of the opinion that the design will provide equal support to all platforms, whether it is on phones or tablets.

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