Remote Patient Monitoring System

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Abstract—

Following heart surgery, several problems linked to the lungs, such as atelectasis, pneumothorax, and mediastinitis, will arise. In addition, numerous various disorders emerge in people following post-cardiac surgery. Patients should be handled with extreme caution following post-cardiac surgery. He or she should have daily examinations with a doctor to monitor vitals such as blood pressure, pulse, temperature, and so on. Patients will find it difficult to visit hospitals daily for checks. During pandemics, it will become more challenging for them. To tackle this issue, this study offers a Patient Monitoring System, which is a remote care application created for patients who are unable to attend hospitals owing to a variety of circumstances. Many elderly persons who require regular medical examinations owing to a range of health conditions are unable to visit hospitals daily. Many technologies and applications have emerged to address such difficulties, allowing individuals to consult doctors remotely without having to visit hospitals, yet the majority of features have been lacking. Patient Monitoring Solutions have been introduced, in which the patient and doctor interact, the patient may consult with his or her doctor remotely and get instructions, and the doctor can even check electronic medical records via a remote app. Furthermore, the system may give patients with other features such as nearby hospital locations, the availability of doctors near them, and a symptom checker. The suggested remote care application is effective in providing various features like communication remotely with doctors and appointment booking with doctor's availability.

Keywords: Atelectasis, Pneumothorax, Mediastinitis, Post – cardiac, Symptom checker, Patient Monitoring, vitals.

1. Introduction

Vital indicators such as heart rate and rhythm, respiration rate, blood pressure, and blood-oxygen saturation are frequently monitored in intensive care patients. Electronic monitors are often used to gather and display physiological data to give the best possible medical care. The use of non-invasive sensors in medical facilities (such as labour and delivery rooms or nursing homes) is on the increase to detect life-threatening infections or capture important data. Regular health monitoring is vital to avoiding illness and saving money in the long term. If the illness is detected and addressed early, the patient's options for medical care are substantially expanded. Patients with diabetes and cardiovascular disease may be monitored by sensors, which provide vital signs to doctors, who can then choose the best course of action to keep them healthy.

It has been shown that remote patient monitoring has a significant impact on reducing unnecessary ED visits and unneeded hospital admissions and reading missions. Shorter hospitalizations and lower healthcare expenses may be achieved because of ED diversion and early acute discharge. For patients with acute and chronic care monitoring needs, RPM may help save hospital costs by allowing patients to get appropriate monitoring levels in their homes. Using remote patient monitoring, healthcare practitioners may better assess the health of their patients and make informed decisions about the administration of treatment. Patients' symptoms may be tracked over time using RPM, which enables doctors to see patterns in the patient's condition and change their treatment strategy accordingly. When it comes to managing chronic disorders like COVID-19 infection, post-surgical recovery, maternal and child requirements, malignant neoplasm, and other diseases that are difficult to treat in person, remote patient monitoring may be a lifesaver for patients.

Patients benefit from remote patient monitoring because it provides them with the resources, they need to better understand their health. Patients must be knowledgeable about their health to make positive changes, the treatment options available to them, as well as their involvement in the process of becoming healthier. Easy access to health education materials increases their involvement even more. Patients may avoid the costs of an in-person visit when they get treatment through RPM. Patients save the difficulties and expenses of travel, parking, childcare, and/or taking time off work, which saves both time and money for the patient. Because it provides near-real-time information on the health state of each patient, remote patient monitoring helps clinicians prioritize their patient care. To reduce the amount of redundant paperwork, several RPM technologies may be linked to an EMR. With RPM, doctors may give certain treatments through remote access to ease patients' anxieties about overscheduling and staffing shortages. It relies on a team-based approach to care that gives physicians greater leeway.

Most people are unaware of the medical equipment and doctors available in hospitals at this time. Patients are frequently admitted to the wrong hospital, resulting in unnecessary time and expense as well as health risks. In the past, many of these incidents have been reported, and they continue to be reported today. From the outside, many hospitals appear to be in good shape, but in reality, they lack necessities like air conditioning, comfortable beds, and doctors. Today's healthcare industry operates more like a corporation than it ever has before.

In the healthcare industry, face-to-face consultations have been a part of the landscape for decades. Patients are compelled to seek treatment at the closest healthcare institution because of this issue. Lockdowns and the COVID epidemic have only exacerbated the situation. When it comes to the healthcare business, there's a need for an all-in-one platform where they can communicate what they've learned and learn from one another. Things might be better if the healthcare business had its platform. Physicians, healthcare plans, insurance providers, doctors, and patients should all be able to securely exchange information to deliver a comprehensive healthcare experience that is acceptable to everyone involved. All of the services that are accessible in remote care are included in the app for patients of this Patient Monitoring System.

2. Literature Survey

For a primary care service that is clinically and organizationally integrated, researchers have suggested an ideal design of remote patient monitoring systems [1] by T. Bratan et al. Additional healthcare services, such as social care, are included in the design. The emergency department, after-hours treatment, general practitioner services, and the involvement of patients and their caretakers allow for a collaborative approach. Cross-sector information exchange ensures the best degree of care for the patient.

[11] Personal digital assistants (PDAs) might be used by healthcare practitioners to make therapeutic judgments. Pip Divall and associates, et. al. Fitness gurus are increasingly using personal digital assistants (PDAs) and smartphones. The care component is critical for scientific researchers who are time constrained. However, PDAs may be used as a reference tool to collect evidence and advice on scientific conditions, medication calculations, and other information, as well as today to store scientific decision guide systems. Medical practitioners routinely use PDAs to keep their electronic diaries (CDSS). As clinicians become more aware of their usage of these devices, they may influence clinical policy. Hospitals without Wi-Fi networks will have to catch up quickly if they want to keep up with their patients' need for mobile devices like PDAs and cell phones. It is important to take in mind infrastructure and device safety while implementing devices in the workplace.

Concerning a patient's electronic health record and patient-driven architecture, A. Raman and co-workers (2007) [4] proposed a nonexclusive framework engineering for a remote patient monitoring framework. As of today, the most common method for a patient to be acknowledged for remote checking is to be referred to their medical service provider, or specialist. Patients' socioeconomic data is stored in a patient data framework, and a remote screen is linked to a focal information base in the above engineering. The flow of data between the patient data sets and the focal information base ensures that the right patient is linked to the right arrangement of vital data. Upon completion of this step, the patient file is complete. The HL-7 connection points and norms are used to direct information flow between the patient data sets and the focal information base. Though internet-based monitoring can be extremely beneficial for patients, clinicians, and guardians alike, the privacy of data is most easily compromised over the web. Tricks and extortion, such as illegal advertising, data fraud, and so on, are among the examples. Data fraud may happen as to the privacy of patients' personal information as they are being monitored from a distance. Patients of this type of rush to grant access to their private information to a variety of family members and other groups.

Song Foh Chew et al. (2011) [8] developed an article on Outpatient Appointment Scheduling with variable Inter appointment Times it initially looks at the unit charges linked with the expert and staff additional time, leaving the other 2 expenditures unspoiled. If having extra time at the end of the day is going to be expensive, we'll need to keep the extra time to a minimum. Additional time is the time remaining after the last quiet through seeing the specialist at the end of the workday. As a result, the first seven squares would not be affected, but the last square would be fundamentally longer if the unit cost of additional time is increased. Keeping the other two costs in mind, we only look at the unit cost for the specialist and staff inactive time. To put it another way, if the inactive time unit cost is increased, this implies that the amount of inactive time per square is being highlighted to a greater extent. If this unit cost is increased, then there should be no inactive time, at the very least, to maintain the normal absolute expense. This would lead the squares to be more constrained. In conclusion, is the unit cost of the patient holding up time? This originates from the manner that the second understanding in a square is continuous and must watch out for the main sufferer. What we are concerned about is the likelihood of a patient having lengthy help time. Assuming this happens and there is a flood into the next square, then, at that time, the chief patient of the following square now creates some holding up recollections. Assuming additional time and idle time are not concerns, we might perhaps prohibit the above-indicated circumstance from occurring. In this case, every one of the squares will be exceptionally long except for the last remaining one, which will be average.

Yuanyuan Du et al. (2011) [9] offered a Medical Alert and Tracking App for Android Devices which may help the customer with remembering when to take medicine and some other items which we commonly term as specialized solutions. It is useful for continuing patients. Moreover, by connecting to the Hospital Information System (HIS), PCPs may push straightforwardly the answer to the updated framework for every individual patient using explicit interfaces. Presently mobile phones offer Internet connection, so when the client isn't feeling fantastic, he may sign into the framework, and their state will be sent off the server. The server obtains the client's data and reminds the online professional that the online customer requires therapy.

The bioelectrical activity of the heart was recorded by A. K. Whitchurch et al. (2007) [3] to create a point-of-care monitoring system. The same module described in the preceding section is used to report EEG signals, but with a lower advantage setting, to expand ECG signals. It is possible to use an ECG to detect a variety of cardiac abnormalities, including arrhythmias and heart disease.

Data analysis, as described by H. Ketmaneechairat et al. (2017) [16], is the process of evaluating, cleansing, altering, and modeling data. The "Ministry of Public Health" website has a total of 500 pieces of medicinal information, which is used in research and gathered for the study. There are four types of drugs in the pharmacy, each with a different level of control: dangerous, special restricted, domestic, and ordinary. In the eyes of the Minister of Health, a "hazardous drug" is a kind of medicine that requires pharmacist monitoring. Prescriptions for particular medications must be given to the pharmacist, who must thereafter advise and distribute them. Minor illnesses may be treated with over-the-counter medications, which can be kept in a medicine cabinet in the house. The meds are not of the kind indicated above; rather, they are conventional medicines.

Singh et al. (2018) [19] presented the Online Health Care (OHC) web application as a way to provide digital healthcare services to Bangladeshi individuals from anywhere in the nation. It's not only about offering people basic health information when they register as patients since they may keep their medical details in the database for later use. Patients may create their personal profiles and add information about their medical history, look back at old records, book online appointments with registered physicians, and obtain online prescriptions from those doctors, using the service. They may access their patient's records and listen to their health issues through a messaging system, depending on the principal drug they give. Both patients and physicians may communicate with one another through the internet in this two-way approach.

3. Proposed Methodology

A complete implementation of the Patient Monitoring System is provided by the proposed system, along with the necessary modules. Part of these modules is patient registration and locating nearby doctors using the patient's location. Newly registered patients can use this patient monitoring system to find doctors and hospitals in their area by providing their location information, such as the patient's latitude and longitude.

In the suggested technique there are multiple flows of modules incorporated. The Patient Monitoring system comprises three key kinds of modules. Doctor’s list and availability modules. This module utilizes a Distance Matrix Service in which the service comes up with a distance matrix graph technique to determine the distance between the two items. Google's Distance Matrix service computes trip distance and journey time between various origins and destinations using a particular mode of travel. Another module includes slot booking to the doctor by the patient. The patient was able to schedule an appointment with the doctor by the availability of physicians which includes the slot timings of the doctors. Electronic medical data of the patients will be saved in our Patient Monitoring system. Previous and current health records of the individual patient may be kept and saved in the form of Health Records.

Flow of Execution of Modules

1. Dataset of doctor's list
2. Checking availability of doctors with distance matrix algorithm
3. Appointment booking with available doctors
4. Maintaining the health records of patients
5. Enabling communication services between patient and doctor.

Dataset of doctors' list

We utilized Cloud fire store, a database service offered by Firebase, to store physicians' datasets. Web, Android, and iOS apps may all be powered by Firebase, a backend service. Real-time databases, APIs, numerous authentication methods, and a hosting platform are all included in this service. Firebase with Google Cloud's Cloud Fire store is a versatile and scalable database for mobile, web, and server applications. You can design responsive applications that don't rely on network latency or Internet access by using Firebase Real-time Database's real-time listeners and offline support for mobile and web. Firebase and Google Cloud products, including Cloud Functions, may be seamlessly integrated into the Cloud Fire

store. We save data in collections and documents in the Cloud Fire storage and display data via the application's UI.

Availability of Doctors

Using the patient's geographic location and latitude and longitude, we may discover nearby physicians by pulling data from our database and comparing it to the information recorded in our database. Both the Distance Matrix method and Sort locations with the closest distance of available physicians are used. Distance Matrix service from Google computes trip distance and journey time between many origins and destinations using a single mode of transportation.

Detailed route information is not provided by this service. The Instructions Service may be used to receive route information, including polylines and textual directions, by providing the desired origin and destination to the service. The Distance Matrix Algorithm is used in this Service.

Appointment Booking System

The appointment system is described using a single-server queuing mechanism. Patients at open-access clinics may come and go as they like, while physicians in traditional clinics must be present to see walk-ins all day, every day.

Each booking request will be assigned an appointment time within the range of [0, T] or refused based on T, the session duration. If a patient has available appointments at a certain time, he or she may be able to arrange further appointments. A date and a time window are chosen by the patients themselves. For now, we will use firebase appointments to obtain the availability of each doctor. Another patient can't choose the previously reserved time slot after it has been reserved. The patient will choose a time that works best for them, and they'll fill out a form with their symptoms or other relevant information. By clicking "Confirm Appointment," they will be sent to a screen where they can enter their information and book the appointment. First come, first served here, patients can book appointments with the doctor of their choice if the slot is not already taken by another patient. Patients with higher-priority needs, such as those who require regular checkups with their doctor, may find this inefficient. When it comes to scheduling an appointment, this is the best option for both patients and hospitals. Using this method, doctors can be found closer to the patient's location, making it more convenient for the patient.

The models used for storing patients' appointment details are as follows.

Appointment Storage Structure:

This model consists of parameters that are defined below:

1) Appointment Type: This talks about the type of appointment that the patient can book with the doctor i.e., audio call or video call, or in-office appointment.

2) Appointment Status: This shows whether the appointment is confirmed or rejected by the particular doctor whom we booked an appointment with.

3) Id: It is the identification number of the particular appointment booked by the patient.

4) Appointment Date: The date on which the particular appointment is booked by the patient.

5) Slot Time: It is about the slot which the patient booked on a particular date.

6) Created At: It is the date on which this appointment is created.

7) Doctor Id: It is the identification number of the doctor with whom the appointment is booked.

8) Patient Id: It's the identity number of the patient who is booking the appointment.

The model involves these basic methods which are used to complete the appointment booking for a particular doctor. These methods are as follows. We are provided with a list of doctors with whom we can book an appointment. Here we have given features such as search and filter options which will help find the required doctor.

The search feature method is used as follows:

Search Method:

Step 1: Accept the input as a string which is the name of the particular doctor.

Step 2: Now we will search all the doctors who have the same name or similarities between them.

Step 3: We will output the list of doctors which we filtered.

The filter method usage is depicted in the following method.

Step 1: Accept the input as the list of doctors and the specialty user is searching for.

Step 2: Now, we will sort out the doctors based on the search field which is provided as input.

Step 3: The doctors who will come under the category will be returned as output in the form of a list.

The patient is provided with a calendar to choose a particular date for the appointment. There they will have slots available for a particular date. The following method is used for accessing slots on a particular date.

Get an Appointment on a Particular Date:

The following steps provide details on how the method works.

Step 1: Accept the input parameters such as the doctor's identity and the date.

Step 2: Create an instance to access the firebase and use it to access the data i.e., the appointment list.

Step 3: Now, filter the data using the appointment date and doctor id.

When we click on a particular slot on a particular date, we will check whether the slot is empty or not by using the following method.

Check Is Slot Empty:

The following steps involve checking the slot availability.

Step 1: Accept the input in the form of an appointment model from which we can access the various parameters.

Step 2: Similar to the previous method we filter out the data using parameters like appointment date, doctor id, and slot time.

Step 3: This will provide the final result in binary form i.e., True or false.

Finally, the appointment can be booked using the following method.

Book Appointment:

This will show how the appointment is finally booked for the particular doctor.

Step 1: Accept the input in the form of an appointment model i.e., payload.

Step 2: We will check whether the slot is empty or not by using the above method.

Step 3: If it is available then, we will redirect the user to the confirmation page where he will revise the details he provided during the booking of the appointment.

Step 3.1: Then after accepting the details, we book the appointment for the particular patient.

Step 4: Else, we will give a response saying failed to book an appointment.

Health Record Management System

Patients' data is first saved in local files and then transferred to a cloud storage service such as Firebase at their request. For EHRs, we describe a revolutionary concept-reconstruction outsourcing approach to cloud storage that relies on the secret sharing of data. Doctors and patients alike have access to the patient's records, which are kept in a firebase. Patients who have an appointment with a certain doctor have access to this information as well.

Records in this database are divided into four distinct groups. They're listed as follows:

1. Forms
2. Laboratory reports
3. ERX
4. Doctor's Reports

Here, the patient may pick files from his or her mobile device to upload their past health records into the program. In addition to providing a file name and category, he may also provide some more information about the document. Patients may access this information at any moment by adding the reference to their name in the fire store, which is accessed via the patient's profile. All doctors with scheduled appointments with patients may use this policy.

Architecture Flow

When it comes to a Patient Checking System, the architecture includes everything from Authentication and Appointments to Communication between various administrations and components.

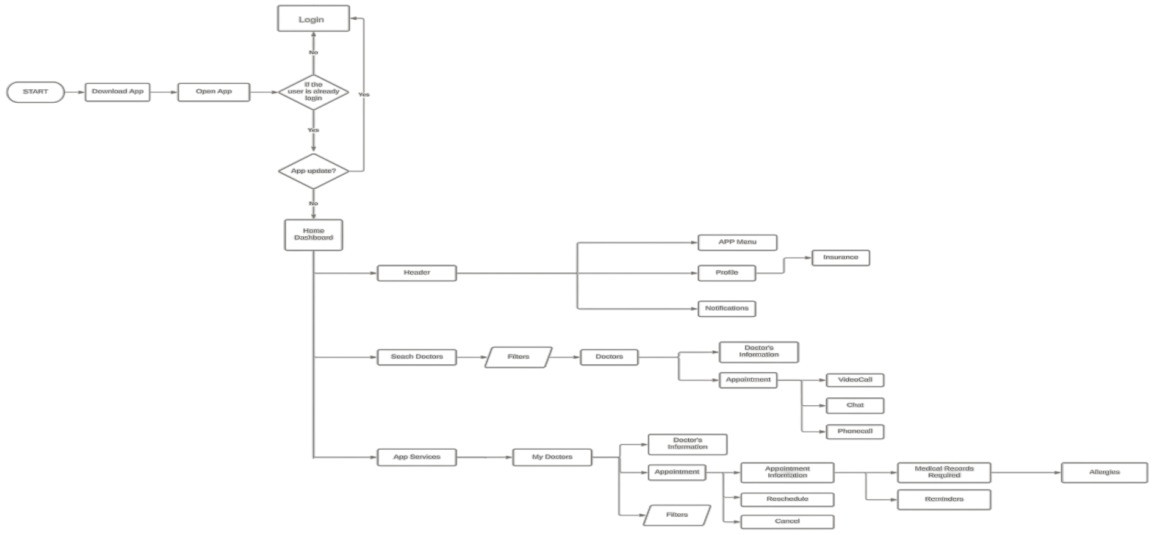

Fig. 3 Architecture Diagram of the Proposed System

Patients may now choose from a variety of Patient Monitoring systems; however, they all have drawbacks as compared to our preferred method. Just like Firebase's cloud-based fire store, the shudder system is used in this paper to help create multiple UI screens and store essential data, such as patient health records and order information. The major goal of this assignment is to provide a more user-friendly application for far-off silent checking. For the most part, it's better than the previous version.

Proposed Framework

Our Patient Monitoring app was built on the flutter Framework. Using the Flutter open-source framework, you can design multi-platform applications that look great and are natively produced using a single codebase. There are several advantages to this method, including speed, efficiency, and adaptability. As a result, it provides you with an SDK for creating mobile applications in Dart, Google's programming language. There are many aspects of the Flutter framework covered in this session, including how to set up Android Studio to build Flutter-based applications, the Flutter SDK installation, and the Flutter framework's architecture. Making a mobile app is a labour-intensive and time-consuming task. Several frameworks may be used to create a mobile application. Android uses a Java-based native framework, while iOS relies on an Objective-C/Swift-based framework unique to iOS.

4. Experimental Results

The end application will provide a facility to book an appointment with the doctor and the ability to share the required files via the application. This process starts as follows.

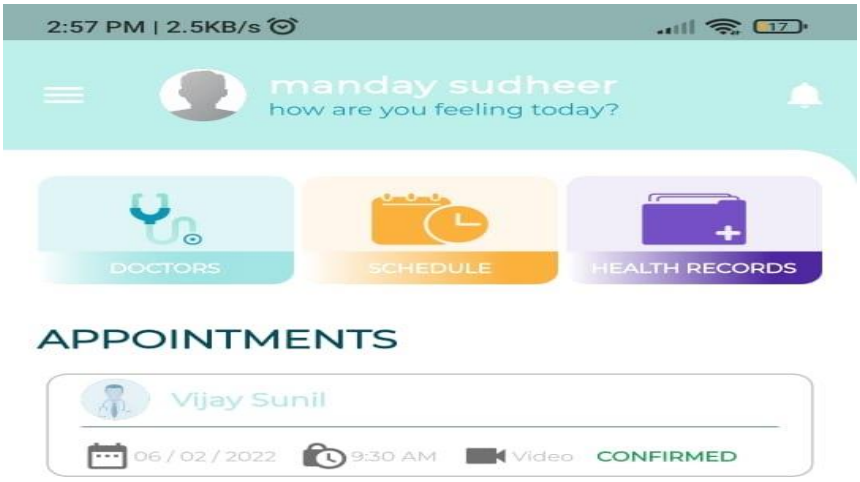

Fig. 4.1 Patients Dashboard Screen

Firstly, the patient login into the application where he can see the dashboard of the application which includes the following

- Recent appointments
- Doctors Module
- Schedule
- Health Records

Booking Appointment

To make an appointment, we first access the patient's geographical location and with the aid of the latitude and longitude of the patient's location, we identify accessible physicians close to their location by taking a dataset that was saved in our database. we have a list of physicians to select who are nearest to us, depending on the doctor's specialization and the criteria. There we have a filter option to classify the physicians and have a clear concept of whom we are making an appointment with

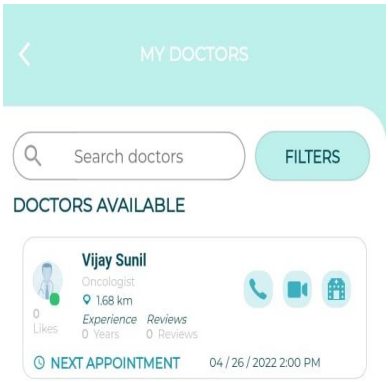

Fig. 4.2 Doctors List

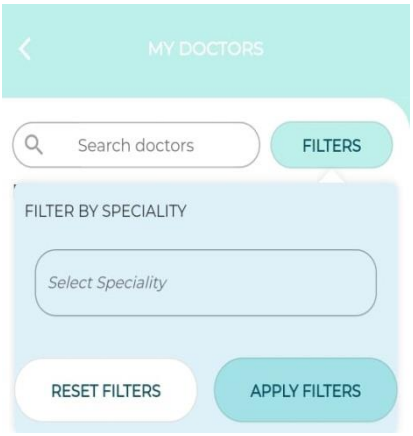

Fig. 4.3 Filter Doctors

Fig. 4.4 Booking appointment with slot

Health records

The user has the option to save his or her medical history here. There is a search feature and four file categories in the default display. We have the opportunity to upload files at the bottom of the page.

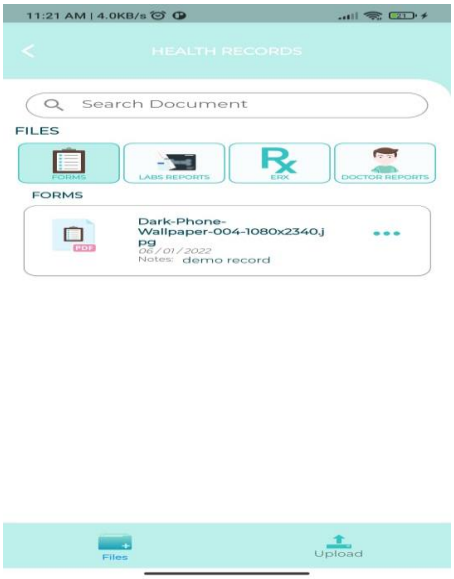

Fig. 4.5 Health Records

When we click on the upload option we will be directed to the upload page which has the required details to be filled and to choose a file from the device and upload it to the storage.

Fig. 4.6 Uploading File

For each file, we have the option to edit, open, share and delete option. Based on the option we choose the operation will be performed. These changes will be reflected in the firebase and changes are accessible to all the doctors who are linked to the patient. Sharing involves downloading the document and then asking the user to share the record with multiple sources. Opening the document can be done by downloading it from the fire store. Delete is designed not to completely delete the data from the firebase, but to make it not visible to the user allowing the user to feel that the document is deleted.

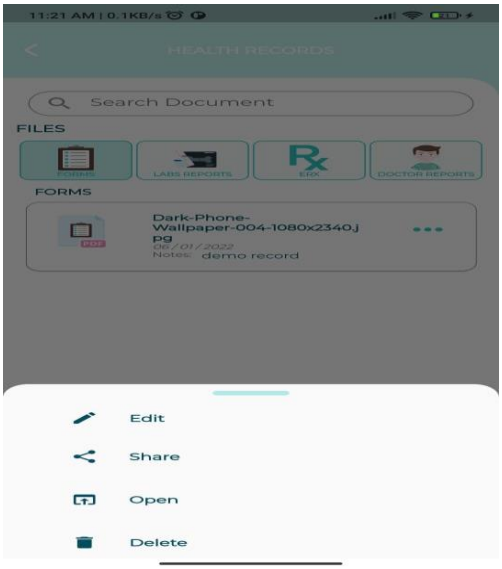

Fig. 4.7 File Options

5. Conclusion and Future Enhancements

Various modules needed by both the doctor's and the patient's applications were offered in this paper, which is a patient monitoring system. Patient records, appointments, and communication are all part of the doctor's flow section. Additionally, we integrated modules such as a list of physicians who are currently accepting new patients and an appointment scheduling system. Patients can schedule an appointment with a doctor using the Appointment

Module. We may view a list of nearby physicians in the patient flow application, and depending on their location, the distance between the patient and the doctor can be estimated. With this module, patients may simply interact with a physician through the Internet. Overall, the application is better for people who want to see their physicians from the comfort of their own homes.

In the future, this paper may be expanded by offering extra features and security for the application. The data may be in a Fast Healthcare Interoperability Resources where data can be transferred with many healthcare systems, live vitals may be acquired through applications leveraging third-party health devices integration as Fitbit smartwatches. The application may be further safeguarded by implementing role-based access and end-to-end encryption of data.

6. Discussions

Many Existing apps are concerned with delivering superior remote care features for patients. Although many of them failed to deliver essential vital elements in their application. Here below we may compare current apps with our remote care patient monitoring system

Aayu Mobile Application	mHealth Application	Remote Patient Monitoring System
Users will be shown a list of hospitals that can handle their particular ailment thanks to this technology. There's also information about a wide range of medications available via the system.	Health data may be synchronized with a web application for healthcare professionals (HCPs) by using the health data API. This system provides access to reports on patient data.	This device allows the doctor and patient to speak with each other remotely. When using a remote application, a patient may speak with their doctor and get instructions while the doctor can see their electronic medical records.
As a result of technological advances, customers now have access to a wide range of health insurance options. Additionally, this method fosters user interaction, which is beneficial for the spread of knowledge and the exchange of personal experiences.	Medical records may be accessed and exported by those who have been granted access to them. Alarms may also be set off automatically depending on the values collected, and alerts can be sent in many situations, such as when alarms are set off accidentally or intentionally.	Patients can get additional information, such as nearby hospitals and the names of nearby doctors, using the system. In terms of remote medical care, the suggested app is effective in supplying several features, such as remote communication with doctors and appointment scheduling depending on the availability of doctors.
This System Provides Information about health Insurance of Various Plans and cannot be used as a Remote care Application	This System Maintains Reports of the patient through APIs but does not provide any remote feature with the doctor in the application.	Our software enables patients to schedule appointments with their doctors and keeps patient records inside the application itself. Additionally, inside the program, it provides the distance between the closest accessible physicians. Communication between Patients and Doctors is the primary emphasis here.

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