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MeDASH: An Effective Way to Check the Availability of Pharmaceutical Drugs in Proximity Using QR-codes.

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ABSTRACT

Background: The rapid advancement of technology is reshaping industries, including healthcare. Doctors and pharmacists require efficient tools to manage inventory and meet patient needs effectively..
Contribution: This project introduces a mobile application that leverages QR code technology to provide real-time information on the availability of prescribed drugs in nearby pharmacies.
Method: The app has two interfaces. The doctor's interface records prescription details (drug name, dosage, frequency) and generates a QR code for the patient. The patient's interface scans the QR code to find nearby pharmacies with the prescribed drugs via a central database.
Results: The application generates QR codes within 0.19 seconds and displays them in 0.22 seconds on average. It integrates Google Maps to identify the patient's location and nearby pharmacies, offering precise directions to the selected pharmacy.
Conclusion: This solution enhances healthcare delivery by improving access to prescription drugs, offering convenience for both healthcare providers and patients, and addressing drug availability challenges.

1. Introduction

Typically, if a patient in Ghana goes to the hospital to go see a doctor, he or she is diagnosed and given a prescription. Obviously, they will have to send this prescription to the pharmacy to purchase the necessary medication. Access to essential medication is a critical

component of healthcare provision. However, in many developing countries like Ghana, there is inadequate access to essential medication due to factors including poor distribution systems and inefficient supply chain management. As a result, patients often face difficulties in obtaining the necessary medication, leading to poor health outcomes. To address this challenge, various interventions have been proposed, including the use of mobile health technologies to improve access to medicines. These technologies are becoming increasingly popular due to their potential to enhance healthcare delivery and improve patient outcomes [1], [2]. One of these technologies is the use of mobile applications that provide information on nearby pharmacies with specific medicines in stock by generating QR codes.

The healthcare industry plays a crucial role in society as it provides individuals with access to necessary medical services and supplies. One aspect of healthcare that has proven to be very problematic for many individuals is the accessibility of medications [3]. Patients often struggle to locate pharmacies that have the medications they require in stock. Patients may have to go from one pharmacy to the other until they find what they are looking for. This leads to frustration, delays in treatment and sometimes even worsening health conditions. This is particularly true in emergency situations when time is of the essence [4]. Additionally, pharmacies face immense pressure to maintain adequate stock of a wide range of medications as the demand for certain medications can increase or fluctuate rapidly. This can create significant challenges for pharmacies, particularly smaller ones, as they try to keep up with demand [5]. To address these issues, a mobile application that can quickly and accurately identify nearby pharmacies with the required medication in stock is highly needed. The application would allow patients to scan a QR code generated by their doctors, and it would display a list of pharmacies within a specified radius that have the medication in stock. This would significantly improve the patient's experience as it would eliminate the need for patients to call or physically visit multiple pharmacies in search of the required medication. It would also reduce pressure on individual pharmacies as the demand for a particular medication would be distributed across multiple locations, potentially reducing the frequency of stockouts.

Nevertheless, there are several challenges that need to be addressed to create a useful and effective mobile software application. This includes developing an accurate and up-to-date database of pharmacies and their inventory since this information can vary widely and rapidly [6]. Also, the mobile software application should have a user-friendly interface so both doctors and patients can enjoy using the application as well as ensuring the privacy and security of sensitive medical information. If the mobile software application is successfully built, it could really improve the accessibility of necessary medications and help improve the overall quality of life and health [7]. Accessibility to medication is a serious problem in Ghana. Pharmacies tend to run out of medications that are mostly in demand and since a lot of them don't keep track of their inventories they cause a lot of problems for patients who may urgently need such medication to feel better [8]. This study will yield significant results in the improvement of

patient outcomes and the quality of life. Currently, patients in search of their medication would have to move from one pharmacy to another to find the medicines they are looking for. Imagine being sick and after seeing the doctor, diagnosing your condition, and providing you with a prescription, you must go to a pharmacy to look for the prescribed medication with the hope that they will have the medication available to you. If they don't, you will have to repeat the process of moving to another pharmaceutical facility to find these medications. This will cause a lot of inconveniences and frustrations as the patient may need rest. With this in mind, we are developing an application that is relatively fast and accurate. This application will help reduce the time and effort it takes for patients to locate pharmacies with what they need in stock. The application will greatly benefit patients and people in general with limited mobility and transportation issues [9]. Also, by providing information on multiple pharmacies, the application can help distribute demand, thereby reducing pressure on individual pharmacies and ensuring that the medications are available for more patients. Better medication management provides patients with accurate information about the drug and helps them avoid missing doses and running out of medication [10]. Lastly, this application will help improve patient-provider relations and overall healthcare experiences. Patients would now easily be able to communicate with their pharmacists and doctors and build important and beneficial relationships with them [11].

Over the years, a significant number of deaths have been caused by health problems and the inaccessibility to require drugs or medications. For instance, diseases like malaria and cholera can be treated with the use of the right medication when it is taken in time. Malaria especially is both an endemic and perennial disease throughout Ghana, putting the entire population at risk [12]. According to [13], 'WHO' estimated in 2021 that there were roughly 5.3 million cases of malaria with 12,500 estimated deaths recorded in Ghana. We believe that with the use of an effective and accurate application like ours, patients will find it easy to get the medication needed to treat such diseases and thus lesser deaths will be recorded every year after that.

In [14], Truven Health Analytics developed Micromedex, a suite of mobile solutions that includes standalone apps such as Drug Information, Drug Interactions, IV Compatibility, Pediatrics Essentials, and Neofax Essentials. While the Drug Information app is free, the other apps require a subscription ranging from $9.99 to $29.99 per year. However, users who have access to the web-based Micromedex 2.0 through their institution can also access the IV Compatibility and Drug Interaction apps. Micromedex Drug Information offers over 4500 drug names and includes data from the DrugPoints database, providing information on doses, mechanism of action, drug strengths, pharmacokinetics, and clinical teaching points. The IV Compatibility app utilizes Trissel's 2 Clinical Pharmaceutics Database, allowing users to check for medication interactions related to Y-site tubing administration, solution compatibility, and admixture concerns. Micromedex is useful for pharmacists who require selective information

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access, but the limited information available on the free Drug Information app may not meet the needs of those seeking in-depth clinical information.

[15] is a mobile application that comes in various suites that can be accessed on mobile devices. The primary suite, Lexi-Drugs, provides a comprehensive drug database. Unlike Micromedex Drug Information, Lexicomp provides more comprehensive and detailed information on drugs. The mobile app provides the same information as the website accessed through a web browser. Other available suites offer features such as drug identification, intravenous drug compatibility, drug interactions, and medical calculators. The cost of the suites varies from $175 per year for Lexi-Drugs to $285 per year for access to all Lexicomp's features. [16] is an on-demand pharmacy delivery application that offers a range of products and services. It was founded by Prashant Tandon and Gaurav Agarwal. It provides accurate, authoritative, and trustworthy information on medicines and helps people use their medicines effectively and safely. Registration can be done with your mobile phone and an email address. You will receive an OTP (One Time Password) upon submission of a registration request. You can allow the application to auto-detect your current location or select your location from a list which helps the app whether you are within the premises of its operation. This helps the app notify you whether your present location is within the region of operation.

MedPlus [17] is a prominent chain of pharmacy retail stores in India, founded and owned by Gangadi Madhukar Reddy. Initially called "Aushadhi," MedPlus was established in 2006 and now has over 1,555 outlets, with the majority being owned by the company. To register, users need to provide their mobile number and email ID, and the app requires location access through network settings. MedPlus provides cross-channel services, enabling customers to access their products and services through both online transactions and physical outlets. Medscape is a complimentary mobile application that provides resources on various medical topics. The app's drug database includes over 7900 monographs on prescription, over the counter, and herbal medications, and provides data from the First Databank drug library. It contains an interaction checker that can evaluate up to 30 medications simultaneously [18]. Epocrates is a mobile application that offers drug reference resources. It was created by Jeff Tangney in 1998. Its free version, Epocrates Rx, includes drug information, interactions, pill identification, and other amazing features. However, it provides limited medication information, lacking detailed monographs. The app's data comes from the Multum database by Cerner. The full version, Epocrates Essentials, which includes more information on diseases, procedures, tests, and billing, costs approximately $159.99 per year [19].

NowRx was found in the year 2015 by Cary Breese and Sumeet Sheokand. Cary Breese found himself having to move from one pharmacy to another before having to wait in line for almost 20 to 30 minutes to drop off the prescription, pay for the medication and then see the pharmacists. After this incident, he then went ahead to develop one of the finest online pharmacies in the USA [20]. NowRx does not require an account to be accessed. It is an open platform where anyone can just send their prescriptions after going to the doctor via a fax or

filling a google form. Doctors can also directly send the prescription to NowRx. They immediately contact you to set up the delivery and collect a copy. An employee of theirs will deliver your medication within hours or up to a day [21]. Medications can be delivered within one hour if you pay extra. NowRx currently sells only medicines [22]. OptumRx [23] is part of the UnitedHealth Group operated in the USA. By revenue, it is the biggest healthcare company globally. Registration is required before access. To register, you must provide information such as mobile phone number and email. Customers are provided with unique HealthSafe IDs which consist of the username and their passwords. OptumRx is a mobile health application that provides customers with the convenience of purchasing medicines online and receiving them at their doorstep. The app also enables patients to easily request prescription renewals and refills from their doctors and can even help customers obtain medication without a prescription by coordinating with their doctor. Unlike other apps that merely offer discounted prices, OptumRx prioritizes helping customers manage and organize their medication intake. Customers can compare costs to determine the best option for them, and the app can help locate nearby pharmacies that are part of the OptumRx network. The My Medicine Cabinet feature is a key component of the app, providing essential information about the nature of medications and their intended goals. The delivery of medications is speedy, ensuring that customers receive their medication quickly and efficiently [16].

PillPack, founded in 2013, is a highly popular drug app for Android. In June 2018, Amazon acquired PillPack. The app primarily focuses on selling prescription drugs, but also offers assistance for medical issues with doctors or insurance companies, as well as the purchase of testing equipment and supplies. When customers order medicine online through PillPack, the company delivers the medication directly to their doorstep, while also sorting it based on dosage and time, relieving patients of the worry of remembering their doses. The medicines are delivered in small easy-to-tear packets that are labelled with time and dosages. Pillpack also requires an account to use in which patients can grant access to caregivers if there are any so pharmacists can get reach them to ask about anything relating to medicine. Unlike a lot of other health apps, Pillpack offers free shipping [24]. Saydl, established in 2016, is Saudi Arabia's premier on-demand internet pharmacy that offers medical and non-medical supplies to customers within an hour. The service is quick and hassle-free, and it links clients to other pharmacies. Saydl is recognized as one of the top medical reference applications available. Customers can register with Facebook and their email ids. An OTP will be received through SMS following a registration request submission. At present, Saydl enables customers to acquire various health-related products, including prescription and non-prescription medicines, vitamin supplements, diet, and fitness products, as well as beauty and skincare items. Saydl also provides delivery services for these products. Customers can simply take photos of their prescriptions for Saydl pharmacists to process their orders and deliver them to their homes. Saydl offers their customers free delivery on their first order. This app allows

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customers to check the products available in several places before placing their orders. Customers will only have to pay after the order has arrived [25].

In this project, we aim to develop a mobile software application codename MeDASH that enables patients to scan a QR code provided by their doctor and receive information on nearby pharmacies with the required medicine in stock. By doing so, we aim to address the challenge of inadequate access to essential medicines and improve healthcare outcomes for patients.

2. Method

MeDASH is our proposed mobile software application aimed at making it easier for users to find and purchase medications. The app features a user-friendly interface that allows users to search for medications and see which pharmacies in their vicinity have them in stock. If medication is not available, the app will suggest a similar alternative based on the information available in the database. Users can choose to create an account or use the app without signing up. Those who create an account will have access to additional features, such as the ability to consult with a doctor through the software application. Doctors will have a separate interface where they can prescribe medications and send prescription information to their patients via a QR code. The app will be particularly useful for individuals who need to find medications quickly and easily. It will eliminate the need for users to physically visit multiple pharmacies in search of a particular medication. The ability to consult with a doctor through the MeDASH software application will also be beneficial for individuals who may not have easy access to medical professionals.

This article presents an overview of a mobile software application designed to support decision-making in emergency healthcare. The app has multiple components, allowing customers to search for resources and information, with verified data stored in an administrator database. The app is registered with user authentication, and the backend database is a free SQLite database. Customers receive notifications via email and can access information on generic medicines and pharmacy locations from their current location. The app was developed using Eclipse IDE and Java programming language. It is secure and flexible and utilizes similarity-based retrieval and data objects. The article also discusses the algorithms used for approximate string-matching and Boyer-Moore string searching. The database requires approximately 250 Kbytes of memory. Health check-ups and online articles are also available. The application uses approximate string matching and Boyer-Moore string searching algorithms to find occurrences of query strings in large text [26]. The approximate string-matching algorithm uses unit cost edit, while the Boyer-Moore algorithm preprocesses the pattern and starts matching from the last character. The global positioning system (GPS) is a satellite-based radio navigation system that enables GPS receivers to determine their geo-location and time information in any weather condition, providing critical positioning capabilities to users worldwide [27]. This technology is available on Android smartphones and

internet-enabled devices and allows for autonomous use. The GPS is composed of three main components: the satellite that transmits position information, the ground station that controls and updates the satellite information, and the receiver that receives the location details. The GPS is commonly used to track the current location and directions to nearby pharmacies, hospitals, and commercial users [28].

2.1. MeDASH Software System Architecture

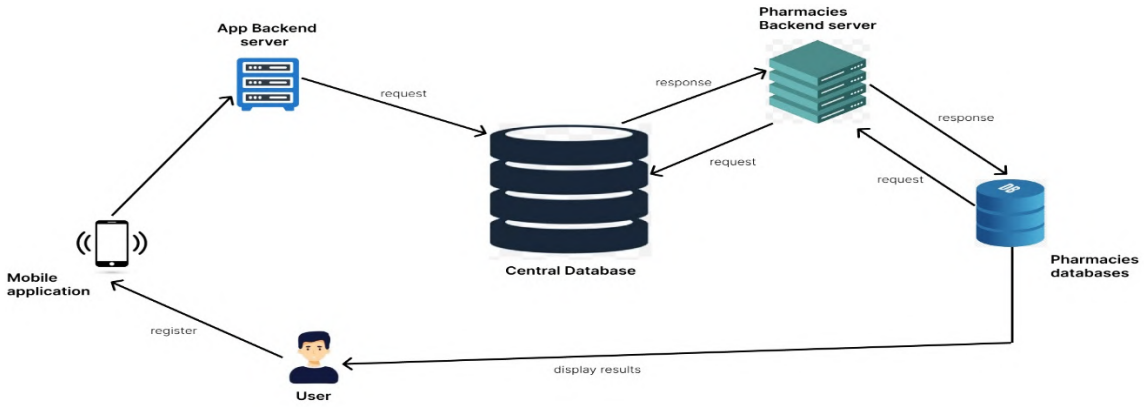

Figure 1. MeDASH software system architecture

Figure 1 shows how a user interacts with the MeDASH software application interface. The system follows a carefully orchestrated flow to provide accurate and timely information, and these are as listed in Table 1.

Table 1. MeDASH user actions and effects

Action	Effects
User Request	When a user searches for a specific drug or pharmacy location, the application initiates a request to the centralized database.
Central Database Processing	The centralized database processes the user's request and identifies the relevant pharmacy databases that hold the requested information.
Pharmacy Query	The centralized database sends queries to the identified pharmacy databases to fetch the relevant data.
Data Retrieval	The pharmacy databases respond with the requested drug information, availability, and location.
User Presentation	The application presents the user with the retrieved data, allowing them to view available drugs, dosages, and pharmacy locations on a user-friendly interface
Real-time Updates	As pharmacies update their databases with new drug information or availability, the centralized database ensures that the most current data is readily available to users

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2.2. MeDASH Software Application Flowchart

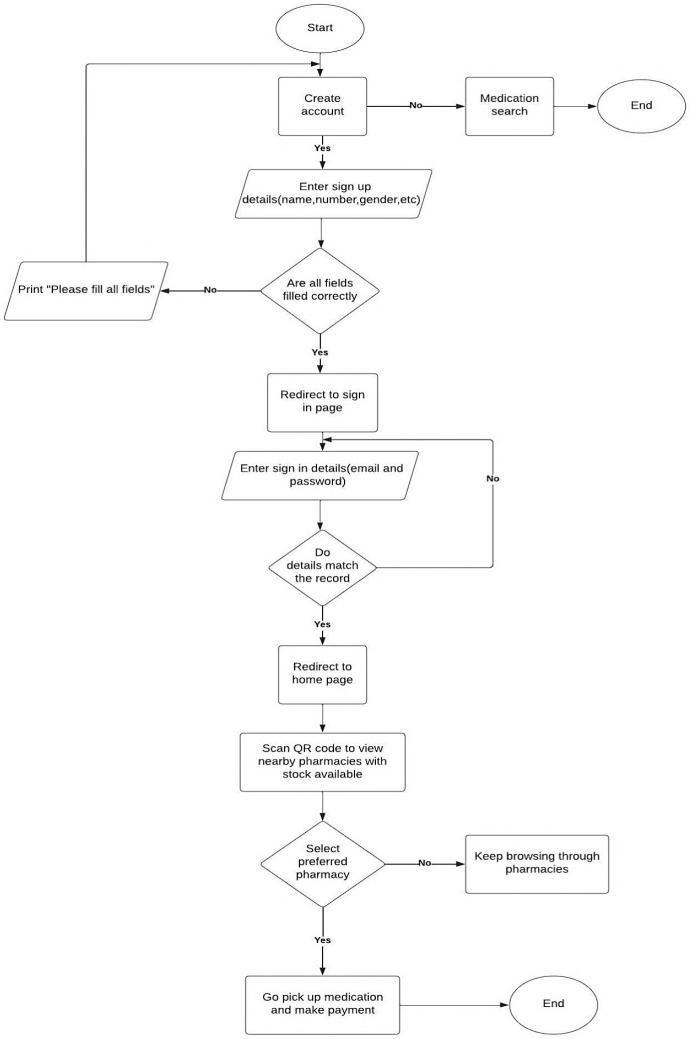

Figure 2. MeDASH software application flow chart

The MeDASH software application's flowchart outlines a comprehensive journey from account creation to drug searching and QR code scanning. This user-friendly design enhances user experience by providing real-time drug information and efficient navigation to preferred pharmacies. The flowchart shows how the app's features interconnect to create a seamless and practical experience for users. Table 2 contains details of the MeDASH software application features as illustrated with the flow chart in Figure 2.

Table 2. MeDASH software application features

Command	Events
Open the App	Launch the application on your device. The app's splash screen welcomes you with the application logo and name.
Account Creation	If you're a new user, tap on the "Create Account" button. Enter your email address and a secure password. Submit the information for account creation
Account Validation	The app verifies the entered email format and checks the password's strength. If the email is valid and the password meets the criteria, you're directed to the Home Page.
Home Page	On the Home Page, you're greeted with a user-friendly interface. Here, you can access various features of the app, such as searching for drugs, scanning QR codes, and more. Navigation buttons and intuitive icons guide you through the app's functionality.
Search for a Drug	Tap on the "Search" icon to enter the name of the drug you're looking for. The app searches the centralized database for the drug's availability and location. The search results display detailed information about the drug, dosage, and available pharmacies.
QR Code Scanning	If you have a prescription with a QR code, tap on the "Scan QR Code" option. The app opens the device's camera for QR code scanning. Once scanned, the app decodes the QR code to fetch drug-related information.
QR Code Information Display	The app presents the scanned drug's details, including name and availability status. An integrated map displays the locations of nearby pharmacies that have the required drug in stock.
Mapping and Routing	Upon selecting a preferred pharmacy, the app provides a mapped route to the selected pharmacy. Your current location is pinpointed on the map, along with the pharmacy's location. Turn-by-turn navigation instructions guide you to the pharmacy.
Pharmacy Arrival	As you approach the pharmacy, the app provides notifications to ensure you reach the destination. The map and directions remain accessible for your convenience.
User Profile	Access your user profile through the app's menu. View and manage your account information, including email and password
Logout and Exit	When done, log out of your account to ensure privacy.
Exit the app	Ends your session

2.3. MeDASH Software Technology Stack

As shown in Figure 3, the following technologies collectively formed the cornerstone of the MeDASH software application's development, catering to various aspects from design and functionality to communication and data management. Their strategic integration shows a well-rounded and sophisticated approach to crafting a user-centric and efficient pharmaceutical assistance software application.

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React Native:
This framework was used for the development of the frontend combined with HTML and CSS for the styling and layout of the interface of our application.

QR Codes:
Efficient Prescription Retrieval QR codes played a pivotal role in streamlining prescription retrieval. By integrating QR codes into the app, users can effortlessly scan prescriptions, enabling prompt and accurate access to vital drug-related information.

MySQL and Node.js:
Node.js facilitated server-side scripting, while MySQL ensured efficient database management.

Google Maps:
The integration of Google Maps added an invaluable dimension to your application. Users could pinpoint pharmacy locations, receive directions, and optimize their routes, all thanks to this feature.

JavaScript:
JavaScript was the driving force behind the frontend logic of our app. It enabled dynamic interactions, data handling, and user interface enhancements.

Git:
It enabled the team to work concurrently, manage changes, and track project evolution. This streamlined the development process and ensured codebase integrity.

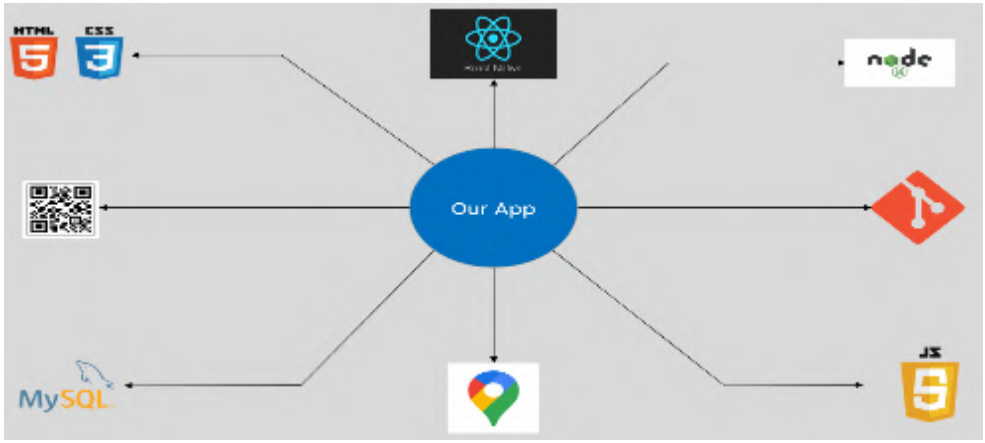

Figure 3. An illustration of the MeDASH software technology stack

2.4. MeDASH Software Application Interface

The MeDASH software application interface is described in the following subsections:

General Sign up and sign in page for the user:

After opening the application, the user selects the interface to **sign in/ up** for depending on the purpose of use, that is, either as a **patient** or a **medical professional (med pro)**. The user signs in if he or she has an account already after selecting the interface to use (enter email and password used for the sign up) else, the user taps on the "Register an account" to create one. If the user is without doctor's description (QR code) or the intention to generate QR code for a patient, he or she can use the application to search for medicine availability in the various pharmacies by tapping on "Go here to search.". Figure 4 displays screen shots for this event.

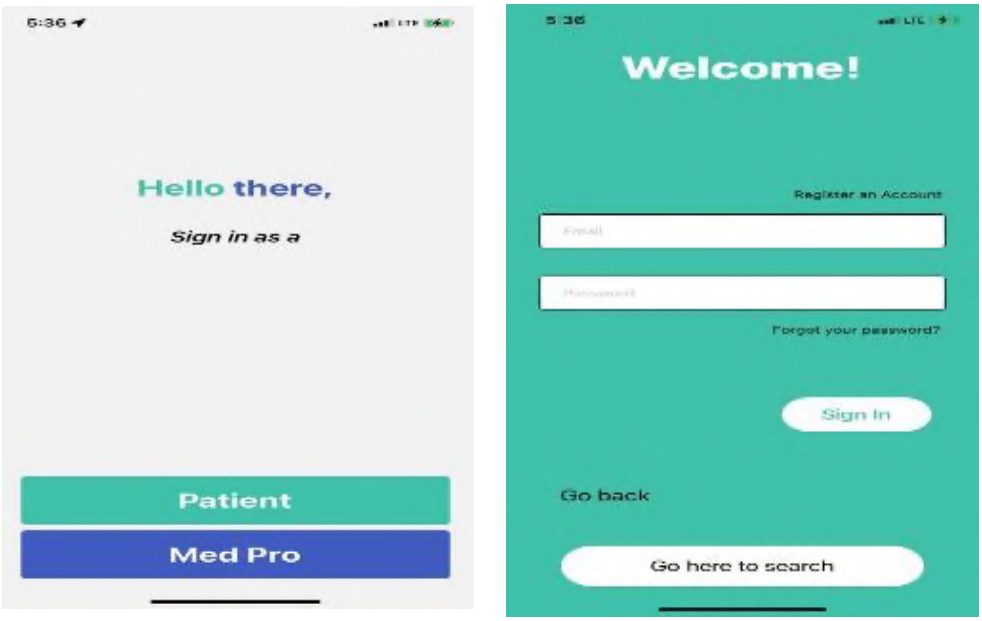

Figure 4. MeDASH application welcome and patient sign-in page

Patient's Interface (sign up):

The patient fills the rectangular boxes with his or her required details (first name, last name, email, contact, create and confirm password). In the **Next** page, the user checks the boxes if the information provided is applicable to them (allergies, any current medical conditions, current medications, previous adverse reactions). If any of the above in Figure 17.b is applicable, the user specifies them in the white box provided. For example, if the patient is allergic to oranges, having an ulcer, on Azithromycin or had rashes after using shea butter, it should be stated in the white box. The user then finishes up or taps "Sign in". Figure 5 displays screen shots for this event.

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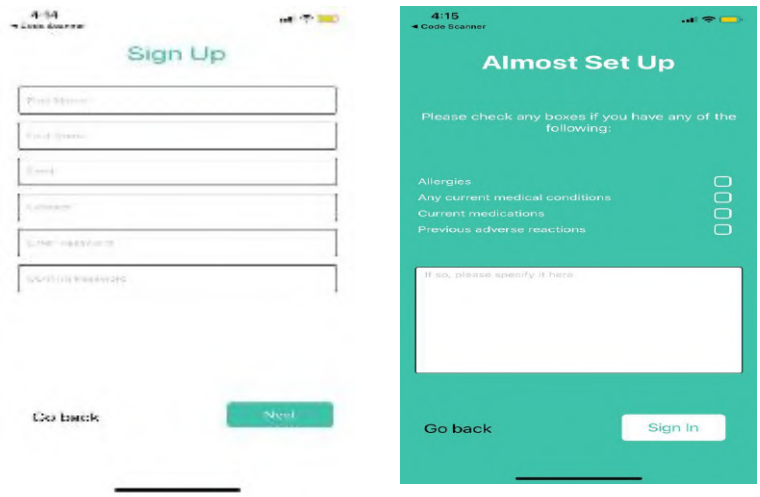

Figure 5. MeDASH application welcome and patient sign-up page

After sign-up and/ or log-in the home page as shown in Figure 6 is displayed. Description of the user can do in this case are represented in Table 3.

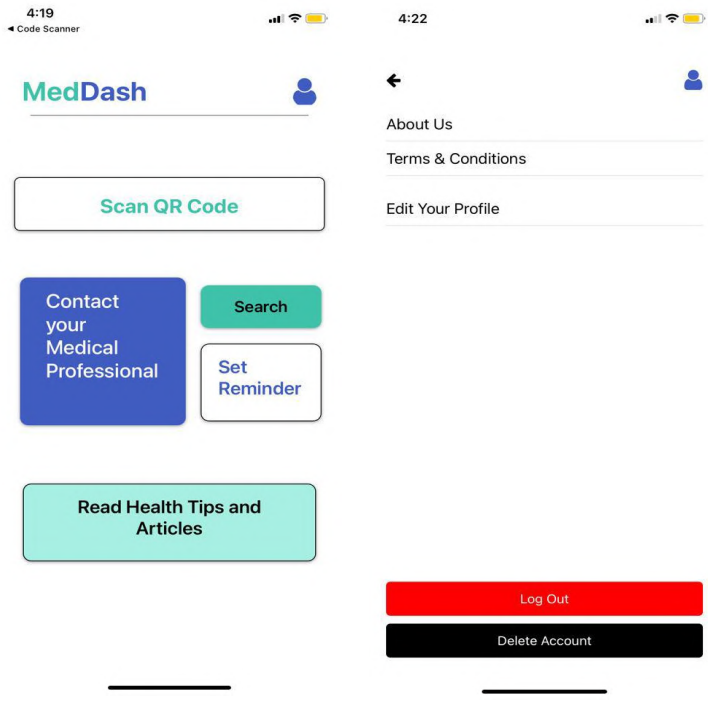

Figure 6. MeDASH application patient home and profile page

Table 3. MeDASH application patient home and profile

Action	Events
Profile icon	The user can (view terms and conditions, edit profile and log out)
Scan QR code	This opens the camera for the user to scan the QR code generated by the doctor. The information encrypted in the code is displayed to the patient/user, that is, the name of the

	medicines, pharmacies having the medicines with the number in stock and their locations. The information displayed can be saved as a pdf for references.
Contact your MED Pro	The details of the doctors who have signed up on the application will be saved in the patient's interface in case of emergency or medical advice.
Search	The patient can search for medicines and their availability in various pharmacies.
Set reminder	The patient can set a reminder for medical appointments or medicine intake.
Read Health Tips and Articles	Information on health is available on this feature. It is a link to a website on health tips and articles.

Doctor Interface (sign up):

The doctor fills the rectangular boxes in Figure 7 with his or her required details (first name, last name, email, contact, create and confirm password). In the Next page, the doctor fills the rectangular boxes consisting of (specialization (eg. surgery, midwifery, gynecology), educational background, hospital affiliation (eg. KNUST Hospital, Ayeduase Health Center), a required checkbox, "Ability to prescribe controlled substances" for the doctor to tick before finishing up.

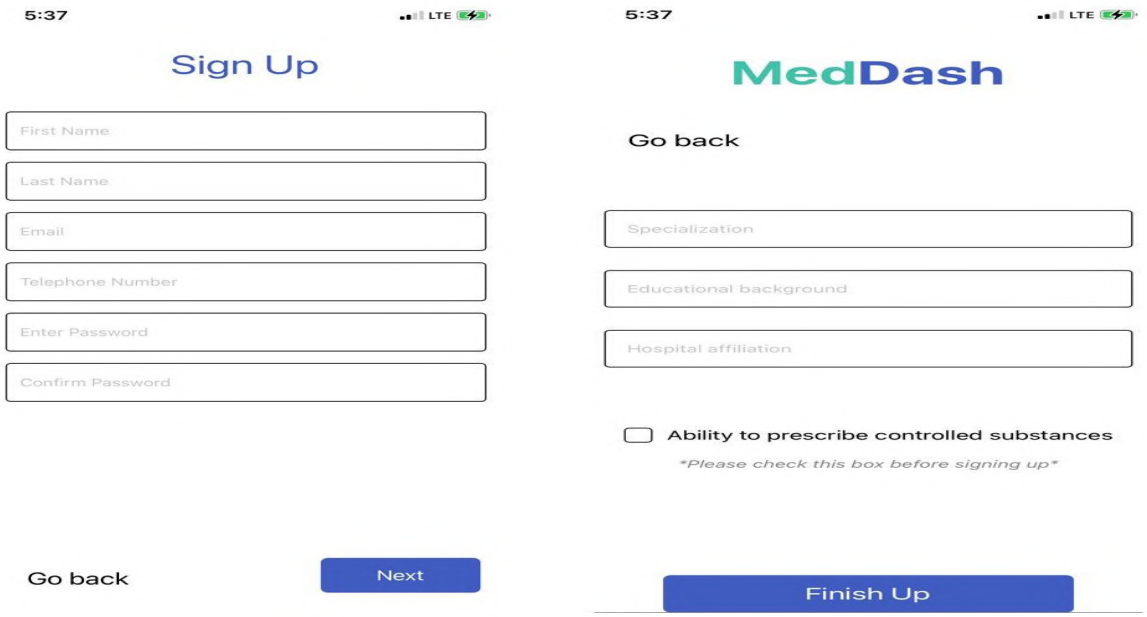

Figure 7. MeDASH software application: doctor sign up.

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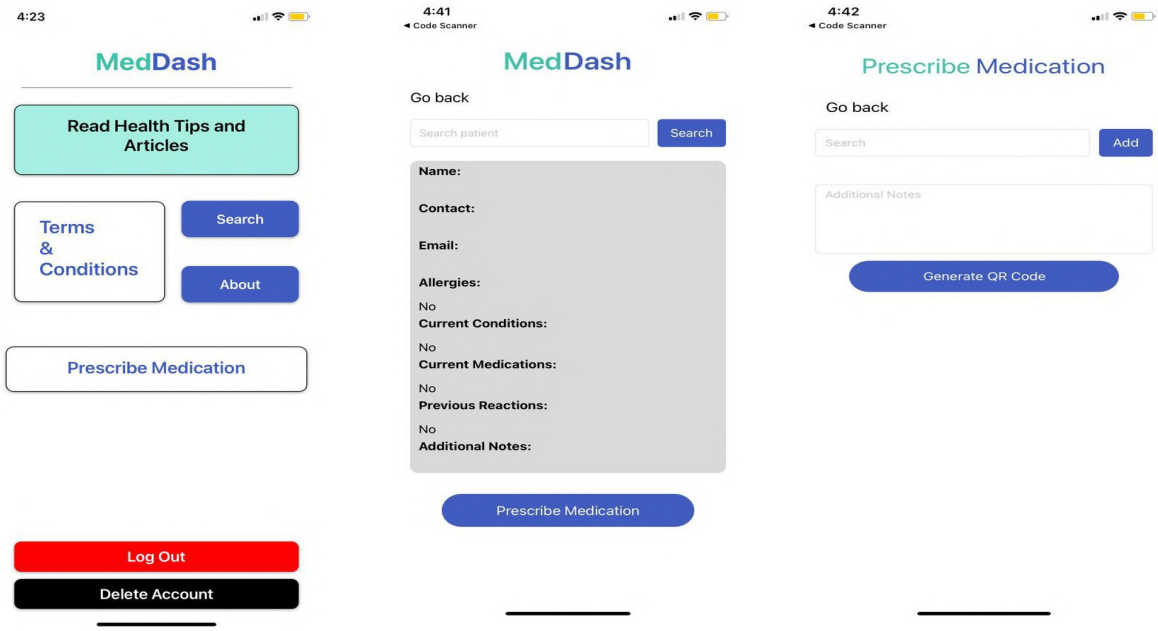

Figure 8. MeDASH software: application doctor home page or profile

The medical professional after signing up or logging in would have access to the following features in Figure 8:

Read Health Tips and Articles: Information on health is available on this feature. It is a link to a website on health tips and articles.

Search: The doctor can search for medicines and their availability in various pharmacies.

Terms and Conditions: The Terms and Conditions of the application usage are displayed in this feature.

About Us: The developers' information is available here.

Prescribe medication: This directs the doctor to where he or she prescribes medication for the patient. However, he or she must search for the patient to get the patient's details.

First page (After tapping on prescribed medication button from the home page)**:** Search for the patient's details using the patient's full name or contact. Patient's information display Prescribe the medication button.

Second page (After tapping on prescribed medication button from the first page): Search for medicines with their availability in various pharmacies. Add the medicine prescribed. Additional notes if necessary (that is indications and dosage)

Generate QR code: This is where the prescription is converted to a QR code.
Log Out: The doctor can log out from this button. It takes the user back to the sign-up page.
Delete Account: The doctor can also delete his account if he does not want to use it again.

2.5. MeDASH Backend Software Development

The MeDASH backend software application was developed using the MySQL database. Table 4 contains details about the database design process via creation of relational tables. Screen shots for the backend software are shown in Figures 9, Figure 10, and Figure 11.

Table 4. MeDASH database design

Relational table	Items
Medicines table	The columns include, id, name of medicine, med_description, quantity, pharmacy name, manufacturer
Pharmacies table	Data on the various pharmacies selected are put into the pharmacies table. Columns include id, pharmacies, and location
Med pro table	Generated from signing up. The doctor's information is saved in the database. Columns include id, first name, last name, email, contact, password, specialization, educational background, and hospital affiliation.
Patient table	The data of the patient is saved from signing up. Columns include id, first name, last name, email, contact, allergies checked, medical conditions checked, medications checked, password, reactions checked, additional message checked

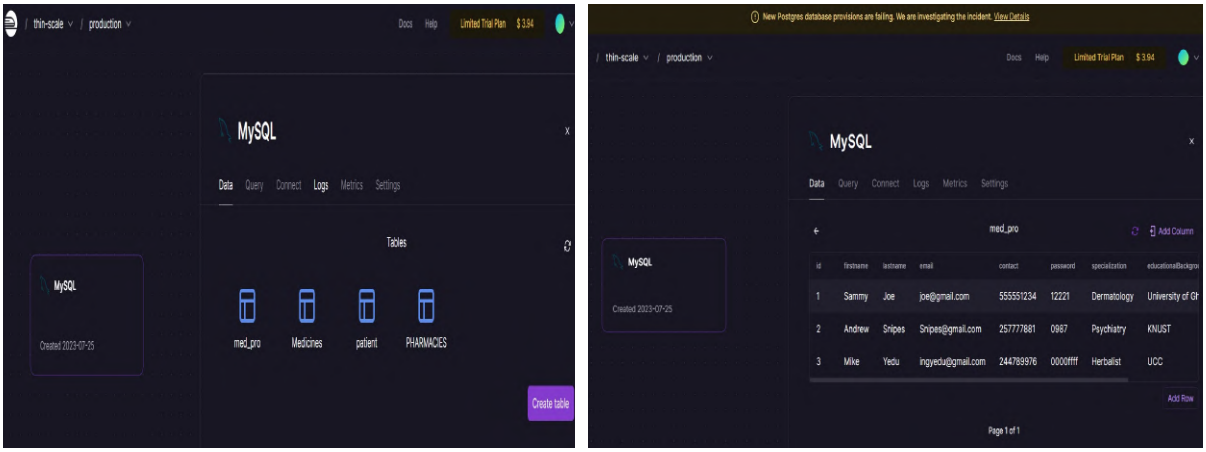

Figure 9. MeDASH backend software application

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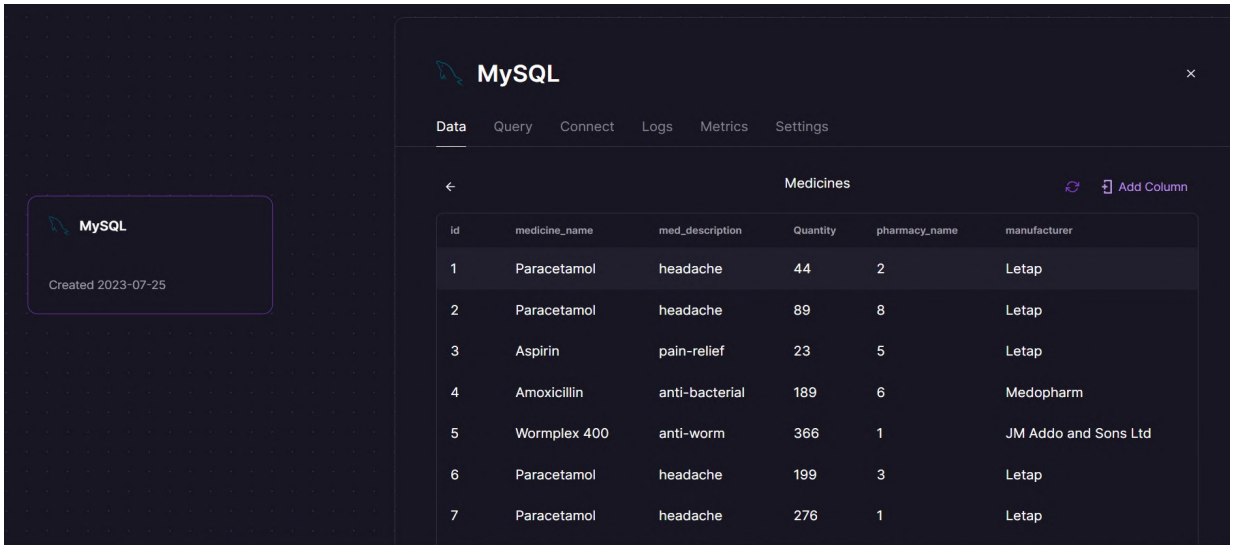

Figure 10. MeDASH application patient home and profile page

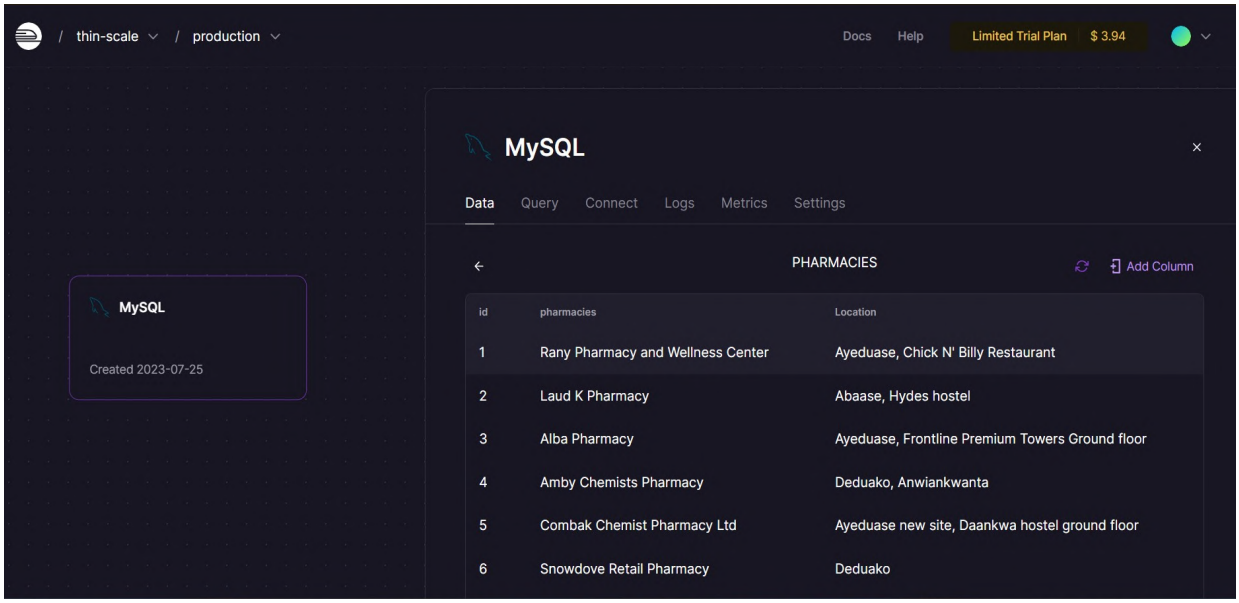

Figure 11. MeDASH application patient home and profile page

3. Results and Discussion

The MeDASH software was vigorously tested under different conditions and scenarios. The following describe some of the scenarios tested.

Scenario 1 – correct QR code -success info retrieval- pharmacy in proximity-

The MeDASH software application rapidly processes the information and fetches the corresponding prescription of medicine from the database. The retrieved data, including availability, is then promptly displayed to the user. Simultaneously, utilizing geolocation services, the app identifies the nearest pharmacy stocking the required medicine. A user-

friendly map interface pinpoints this pharmacy's location and offers navigation assistance for efficient and convenient retrieval. Figure 12 displays screen shots of the activities for scenario 1.

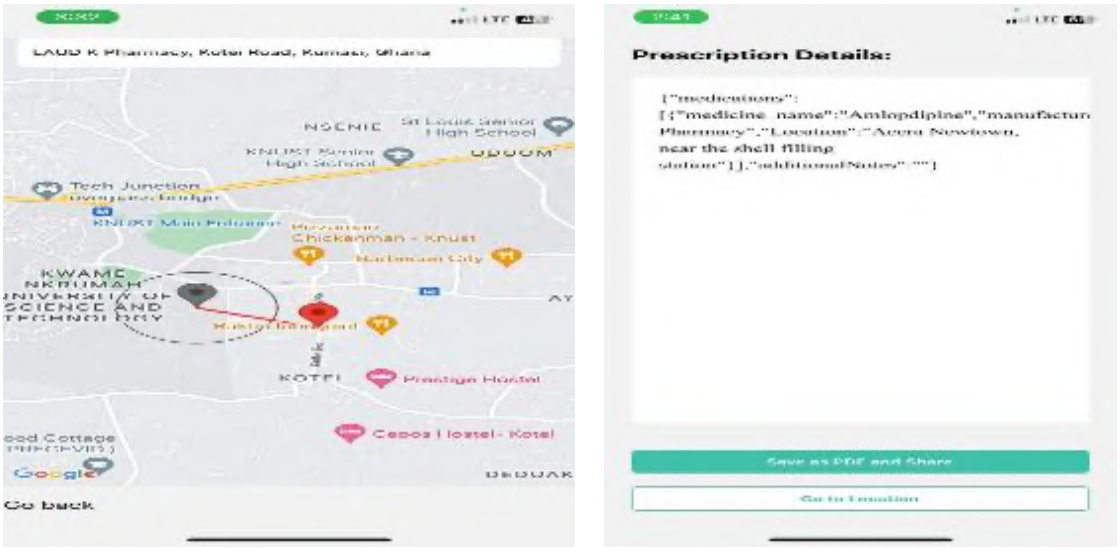

Figure 12. MeDASH software test scenario 1

Scenario 2 – correct QR code -success info retrieval- no pharmacy in proximity-

In this scenario, the QR code scan efficiently acquires prescription details from the database. Yet, the application discerns that the specific medicine is not presently stocked at nearby pharmacies. As a result, a message appears to inform the user that the item's availability is temporarily unavailable as indicated in Figure 13. However, doctors are supposed to check if the medication they are prescribing can be located easily by the users before prescribing them, but users can explore comparable options and swiftly locate an appropriate solution to their medical needs.

Figure 13. MeDASH software test scenario 2

Scenario 3 – wrong QR code -no info retrieval- no pharmacy in proximity-

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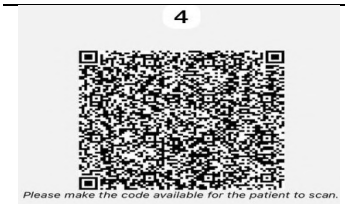
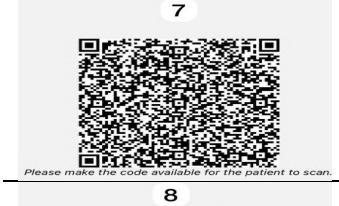
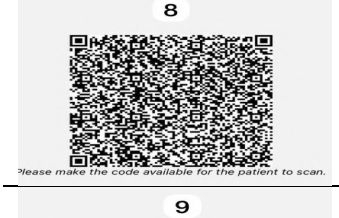
If the app's database fails to recognize the code, a proactive approach is taken. An alert message elegantly informs the user as seen in Figure 14 that the scanned QR code does not correspond to any registered medicine. The app, designed with precision, ensures users are kept informed and empowers them to make informed decisions based on the encountered situation.

Figure 14. MeDASH software test scenario 3

A dataset of 100 medical QR codes were generated from the database which has over 1000 drug prescriptions with their details stored. These QR codes were generated and scanned using the doctor and patient's interface respectively and the following information was recorded and tabulated in Table 5.

Table 5. MeDASH software scans and times

Medical QR codes	Generation Time	Display Time	Recognized
1	0.20 sec	0.22 sec	Yes
2	0. 13 sec	0.19 sec	Yes
3	0.29 sec	0.21 sec	Yes

4 	0.19 sec	0.26 sec	Yes
5 	0.18 sec	0.28 sec	Yes
6 	0.24 sec	0.23 sec	Yes
7 	0.15 sec	0.21 sec	Yes
8 	0.19 sec	0.20 sec	Yes
9 	0.18 sec	0.21 sec	Yes
10 	0.16 sec	0.18 sec	Yes

From Table 5, the time taken to generate each QR code, time taken to display results and whether the QR code was recognized were recorded. For simplicity only 10 QR codes from the 100 samples are included in the table. The time taken to generate the QR codes, and the time taken to display the results is relatively small (less than half a second). All the QR codes were recognized when scanned. Thus, it is very quick to generate and scan prescription QR codes (medical) using the application.

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From the results obtained from testing the QR codes, it indicates that the overall application functionality worked. The expected results were for the user to either successfully prescribe medication and generate a QR code for a patient, and or scan a QR code to display the information in it. These results were obtained. The times taken to scan and generate the QR codes were less than half a second which shows how quick the application works. All the sample QR codes were tested and recognized, the information encrypted in each code was displayed successfully and correctly.

Comparison of the results with current works

The overall performance of the MeDASH software application was compared to other state-of-the-art works as presented in Table 6. This was performed to provide a detailed assessment of the proposed solution.

Table 6. Comparing results with other related state-of-the-art works

Source	Purpose	Technique	Performance
[31]	Healthcare delivery for Covid-19 pandemic	QR code generation and scanning	3s scanning time readability range (100x100 pixel) ′= 1kb readability range (400x400 pixel) ′= 2kb
[32]	Personalized Drug Delivery Systems (PDDS)	QR code generation and scanning	N/A
[33]	Pharmacogenomics	QR code generation and scanning	Approximately 15s display time
[34]	Medication Prescription	QR code generation and scanning	N/A
[35]	Hospital Healthcare delivery	QR code generation and scanning	N/A
This work	Pharmaceutical drug delivery	QR code generation and scanning	0.19s mean generation time and 0.22s average display time

4. Conclusion

Overall, this project has achieved its objectives. The project has provided a user-friendly application for checking the availability of drugs using QR code generated by a doctor and was built using Visual Studio Code software as the platform, JavaScript, React Native with HTML and CSS as the language, framework, and page styling respectively. MySQL and Node.js were used to create the database to store information on drugs and pharmacies. The QR code was generated at a mean time of 0.19s and displayed in 0.22s. This result reflects fast responses which depict real-time operations thus providing higher performance or efficiency

of the application. Therefore, online healthcare delivery is significantly improved by a widescale implementation of this work. However, the application cannot be used offline (without internet connectivity) and shows the limitations of the work. Thus, future research will address the constraint to provide a holistic solution in this regard.

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