University of Khartoum

Faculty of Mathematical Sciences

Department of Statistics and Computer Science

Study on the Availability of Pharmacies and Medicine in Sudan

By:

AL Mohiad Hamid Abdalla Hamid

Alhag Bashir Abdalhalim Abdalrhman

Hassan Sorkatti Mohammed Ali Belail

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Under Supervision of

DR.Alargam Elsanhouri

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Verse

يَا أَيُّهَا الَّذِينَ آمَنُوا إِذَا قِيلَ لَكُمْ تَفَسَّحُوا فِي الْمَجَالِسِ فَافْسَحُوا يَفْسَحِ اللَّهُ لَكُمْ ۖ وَإِذَا قِيلَ انشُزُوا فَانشُزُوا يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ ۚ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ

Dedication

We dedicate this study to our country Sudan and its great people in the hope of building and developing the nation to be among the finest of countries in the world

Acknowledgement

First of all, full thanks to Allah for his blessing, kindness and aligning.

Great thanks to our parents and families.

A lot of thanks for supervisor DR.Alargam Elsanhouri.

Our sincerest gratitude to DR.Tareg Banga.

Thanks to all the people who helped us to make this research.

Abstract

Nowadays our country Sudan is cruising through a challenging transitional period full of turmoil. The transitional government faces considerable difficulties providing the most basic services for the population. Chief among which are the services related to the health and medication sector. With the availability of medicine at a critical low level, as we will show, also the distribution of pharmaceutical dispensaries (stores and warehouses) remains disproportional and uneven throughout the country with yet unclear strategy to even them out. This presents itself as a difficulty for the citizens to locate medicines or pharmacies in a timely manner and saving valuable time that reflects upon patients' health.

This study sheds some light on these disproportionalities and scarcities. By taking a model state (sample) and quantitatively calculating the ratios of pharmacies per capita, pharmacies per constituency, and on street level where possible. Along with other publicly available statistics indicating medicinal availability to reach a clear conclusion on the problem.

Then as a possible solution, we propose a model for an Android application and an online system connecting pharmacies all over the country to a single point through the internet, where information flood forms a Big Data center.

المستخلص

في هذه الآونة تمر بلادنا السودان بمرحلة انتقالية صعبة. حيث تواجه الحكومة الانتقالية صعوبات بالغة في توفير معظم الاحتياجات الأساسية للمواطنين. وبشكل رئيسي يعاني القطاع الصحي، حيث وصلت نسبة الوفرة الدوائية الى مستويات متدنية. ولكن كذلك توجد مشاكل قائمة من حيث عدالة توزيع مراكز صرف الدواء (صيدليات ومخازن) في أنحاء البلاد. كل ذلك يتمثل على شكل صعوبة للمواطنين في إيجاد الدواء المطلوب أو تحديد مكان الصيدلية في وقت وجيز منعاً لتأخر وصول الدواء الى المريض وحفاظاً على وقت مقدر من الضياع. ومازالت لا توجد أي استراتيجية واضحة تهدف الى المساواة في التوزيع.

هذه الدراسة تلقي بعض الضوء على هذه الاختلالات والندرات. بأخذ احدى الولايات كنموذج (عينة) وبطريقة كمية تتم دراسة نسبة توزيع الصيدليات الى عدد النسمات، نسبة الصيدليات الى المحليات، وعلى مستوى الشوارع. إضافة الى الاستشهاد بإحصائيات رسمية عامة لنصل الى خلاصة حول المشكلة.

بعد ذلك نقدم حل محتمل للمشكلة متمثلاً في تطبيق آندرويد ونموذج لـ سيستم أونلاين يعمل كنقطة توصيل لكل الصيدليات في البلاد عبر الإنترنت، حيث البيانات المجمعة ستشكل Big Data.

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Chapter 1

Introduction

1.1 Introduction

Medicines are an essential and critical part of health-care services in all cultures and societies and a component of many disease prevention programs and virtually all disease treatment plans. Given Sudan status as a developing country, one main concern is public health and medication, and to be exact, the availability and affordability of medicine.

Various diseases and illnesses can be prevented or treated with timely access to appropriate and affordable medicines, but it is a common case where one cannot locate or afford medicine.

Medicines are made available as authorized medicines, pharmacy preparations, or investigational medicinal products. For many diseases, active substances are available, and yet groups of ‘neglected’ patients or special patient groups will not receive the medicines they need. If a patient needs a medicine, which is not on the national market, it may be imported from abroad or prepared in a pharmacy. The complicated rules, which are nationally determined, for reimbursement (in some countries) and long procedures render importation a laborious way to make medicines available for the patient. To be reimbursed some countries require that medicines are to be shown to be efficacious, appropriate and economic.

Medicine shortages can occur for many reasons, such as manufacturing difficulties or problems affecting the quality of medicines that can impact on patient care or difficulties in importing them as is the case in Sudan.

Medicines are also increasingly expensive and their cost is compromising the affordability of health care. Managing the costs of medicines is critical to making the best use of limited resources to maximize health care for as many people as possible. Substandard, adulterated, unlicensed and spurious/falsely-labelled/falsified/counterfeit medicines are a growing problem that compromise health. There is a need for a system of assuring the integrity of the medicine supply chain to assure the value of medicines used for the prevention of disease and the treatment of patients[1].

Pharmacists are specifically educated and trained health professionals who are charged by their national or other appropriate (e.g. state or provincial) authorities with the management of the distribution of medicines to consumers and to engage in appropriate efforts to assure their safe and efficacious use. There is also increasing recognition that providing consumers with medicines alone is not sufficient to achieve the treatment goals. To address these medication-related needs, pharmacists are accepting greater responsibility for the outcomes of medicines use and are evolving their practices to provide patients with enhanced medicines-use services[2].

1.1.1 Policy Framework

In Sudan, a National Health Policy (NHP) exists. It was last updated in 2007. An official National Medicines Policy (NMP) document exists in Sudan. It was last updated in 2005.

The NMP covers:

- Selection of essential medicines
- Medicines pricing
- Procurement
- Distribution and regulation
- Pharmacovigilance
- Rational use of medicines
- Human resource development
- Research
- Monitoring and evaluation
- Traditional medicine.

There are official written guidelines on medicines donations. The Pharmaceutical policy implementation is being regularly monitored/assessed. The General Directorate of Pharmacy is responsible for this activity. There is a National Good Governance Policy in Sudan, both a multisector one and one specifically for the pharmaceutical sector and the Ministry of Labor and Human Resources Development is responsible for this policy.

A policy is in place to manage and sanction conflict of interest issues in pharmaceutical affairs. There is a formal code of conduct for public officials. The Sudan Medical Council is by law responsible for establishing ethics for all medical practices. There is a whistle-blowing mechanism allowing individuals to raise a concern about wrongdoing occurring in the pharmaceutical sector of Sudan. The Sudan Medical Council is responsible for receiving, handling and judging of all consumers complaints[3].

1.1.2 Intellectual Property Laws and Medicines

Sudan is not a member of the World Trade Organization; therefore, information on patenting laws is not applicable or available.

1.1.3 Manufacturing

There are 19 licensed pharmaceutical manufacturers in Sudan[3]. Sudan does not have the capacity for the Research & Development for discovering new active substances and the production of pharmaceutical starting materials. On the other hand, there is capacity for production of formulations from pharmaceutical starting materials and for repackaging of finished dosage forms.

In 2008 the percentage of market share by value of goods produced by domestic manufacturers was 20.6 %[3].

1.1.4 Regulation

This section covers a broad range of pharmaceutical regulatory policy, institutions and practices in Sudan.

The process of locating the right pharmacy or drug store housing the desired drug and the foreknowledge of its price, remains a troublesome effort and could have serious ramifications on the patient's well-being[3].

The regular way to find a nearby pharmacy is to have prior knowledge of the location of pharmacies or to ask about its location, but for medicines there is no practical way of locating the drug in any given nearby pharmacy, one would have to visit each one and ask. One of the problems with this traditional method is the loss of time in identifying pharmacies and drugs, and this reflects negatively on the health of the individual and may lead to serious problems if the drug is not found on time.

The process of locating the right pharmacy housing the desired drug and the foreknowledge of its price remains a troublesome effort. Moreover, it could have serious ramifications on the patient's well-being.

1.2 Statement of the Problems

The considerable difficulty of locating pharmacies and available prescribed medicines within a nearby pharmacy.

1.3 Objectives

1-Analysis of the current status of medicines and pharmacies in Khartoum state.

2- To propose a researched model for the rest of Sudan states.

3-Based on the data analysis, provide detailed information about the problem to decision makers.

4- Design a model for an app to connect users with medicines.

1.4 Research Aim

To improve the quality of life for the population by reducing average time of locating pharmacies and required medicines.

Chapter 2

Literature Review

2.1 Pharmacy

2.1.1 Introduction

Pharmacy is the science and technique of preparing, dispensing, and reviewing drugs and providing additional clinical services. A health profession that links health sciences with pharmaceutical sciences and aims to ensure the safe, effective, and affordable use of drugs. The professional practice is becoming more clinically oriented as most of the drugs are now manufactured by pharmaceutical industries. Based on the setting, the pharmacy is classified as a community pharmacy or institutional pharmacy. Providing direct patient care in the community of institutional pharmacies are considered clinical pharmacy[4]

2.1.2Impact of Pharmacy

The health of the public is fundamental to the happiness and welfare of all people. Barriers to good health include poor access to quality medical products, lack of access to trained health professionals and care, an inadequate health workforce, and unaffordable cost of care and poor standards of education of health-care professionals[5].

2.1.3 Historical Background

Humans have prescribed medications since Sumerian times, around 2,000 BC. After this, records of prescribing and dispensing medication have been found from ancient Greece, the Han Dynasty, and the Islamic Golden Age in Iraq. Since then, pharmaceuticals have exploded into a multi-billion dollar, international industry. There are about 291,000 pharmacists employed in the United States alone, and in 2014, pharmacies filled about 44.6 million prescriptions per capital.[6]

2.2 Medicine

2.2.1 Introduction

Medicine is the science and practice of establishing the diagnosis, prognosis, treatment, and prevention of disease. Medicine encompasses a variety of health care practices evolved to maintain and restore health by the prevention and treatment of illness. Contemporary medicine applies biomedical sciences, biomedical research, genetics, and medical technology to diagnose, treat, and prevent injury and disease, typically through pharmaceuticals or surgery, but also through therapies as diverse as psychotherapy, external splints and traction, medical devices, biologics, and ionizing radiation, amongst others.[7]

2.2.2 Impact of Medicine

Access to essential medicines and health products is critical for reaching universal health coverage. Medicines and health products are important for addressing health problems and improve quality of lives. They form an indispensable component of health systems in the prevention, diagnosis and treatment of disease and in alleviating disability and functional deficiency.[8]

2.2.3 Historical Background

Although there is little record to establish when plants were first used for medicinal purposes (herbalism), the use of plants as healing agents, as well as clays and soils is ancient.
Over time, through emulation of the behavior of fauna, a medicinal knowledge base developed and passed between generations. Even earlier, Neanderthals may have engaged in medical practices. As tribal culture specialized specific castes, shamans and apothecaries fulfilled the role of healer. The first known dentistry dates to c. 7000 BC in Baluchistan where Neolithic dentists used flint-tipped drills and bowstrings. The first known trepanning operation was carried out c. 5000 BC in Ensisheim, France. A possible amputation was carried out c. 4,900 BC in Buthiers-Bulancourt, France. Byzantine medicine encompasses the common medical practices of the Byzantine Empire from about 400 AD to 1453 AD. The Kahun Gynaecological Papyrus treats women's complaints, including problems with conception. Thirty-four cases detailing diagnosis and treatment survive, some of them fragmentarily. Dating to 1800 BCE, it is the oldest surviving medical text of any kind.[9] 2600 BC The Egyptian Imhotep describes the diagnosis and treatment of 200 diseases. 500 BC Alcmaeon of Croton distinguished veins from arteries. 130 AD Birth of Galen. Greek physician to gladiators and Roman emperors. 1489 Leonardo da Vinci dissects corpses.[10] 1928 Sir Alexander Fleming discovers penicillin. 2006 First vaccine to target a cause of cancer.[10]

2.3 Big data

2.3.1 Introduction

Big data is delineation of enormous of data that are either structured, semi structured or unstructured. When data is not able to be processed, stored by the traditional databases and software technologies then we categorize such data as big data. Created from the web companies, the organizations are producing and storing enormous of data. Data is becoming more valuable, presently the important step after creating database is analyzing the data in storage. The main reason we use data storage[11].

The term big data is relatively new. Big data is defined as a large volume of data, also determined by three characteristics: volume, variety, and velocity.

IDS also define big data as "a new generation of technologies and architectures, designed to economically extract value from very large volumes of a wide variety of data, by enabling the high velocity capture, discovery, and/or analysis.[11]

2.3.2 Impact of Big data

Big data analytics helps organizations harness their data and use it to identify new opportunities. That, in turn, leads to smarter business moves, more efficient operations, higher profits and happier customers.[12]

- Cost reduction: Big data technologies such as Hadoop and cloud-based analytics bring significant cost advantages when it comes to storing large amounts of data – plus they can identify more efficient ways of doing business[12]
- Faster, better decision making: With the speed of Hadoop and in-memory analytics, combined with the ability to analyze new sources of data, businesses are able to analyze information immediately – and make decisions based on what they've learned.[12]
- New products and services. With the ability to gauge customer needs and satisfaction through analytics comes the power to give customers what they want. Davenport points out that with big data analytics, more companies are creating new products to meet customers' needs.[12]
-

2.3.3 Historical background

The amount of data worldwide has been increasing since the emergence of the World Wide Web around 1994. The early search engines, specifically, AltaVista (which was acquired by Yahoo in 2003 and which later became the Yahoo! search engine) and Lycos (which was also a search engine and a Web portal—was created shortly after the emergence Web came along. They were later overshadowed by the likes of Google and Bing. Then came an array of social networks such as Facebook, launched in 2004, and Twitter, founded in 2006. LinkedIn, a professional network launched in 2003, boasts over 250 million users worldwide. Facebook has over 2 billion users worldwide today; of these, more than 800 million users are active on Facebook daily. Twitter had an estimated 980 million users in early 2014 and it was reported to have reached the rate of 1 billion tweets per day in October 2012.[13]

2.4 Location

2.4.1 Introduction

A location is the place where a particular point or object exists. Location is an important term in geography, and is usually considered more precise than "place." A *locality* is a human settlement: city, town, village, or even archaeological site. [14]

A place's absolute location is its exact place on Earth, often given in terms of latitude and longitude, Location can sometimes be expressed in relative terms. Relative location is a description of how a place is related to other places, Relative location can help analyze how two places are connected, Coordinates of longitude and latitude help pinpoint the absolute location of a person, place, or thing. Even absolute location is a form of relative location! Coordinates simply give a place's position relative to the Equator (latitude) and prime meridian (longitude).[14]

2.4.2Historical background

Eratosthenes in the 3rd century BC first proposed a system of latitude and longitude for a map of the world. By the 2nd century BC Hipparchus was the first to use such a system to uniquely specify places on Earth.[15]

2.5 Smartphone applications

2.5.1 Introduction

Smartphone have become very popular and widely use in recent year, smartphone can be used for business purpose and users are increasingly relying on them to store and handle personal information.

Smartphones includes devices with and without Touchscreens such as the iPhone, Blackberry, Samsung, Sony and HTC.

Impacts of Smartphone's

Smartphone has impacted almost all walk of human life. The prominent areas, where impacts of

Smartphone are obvious include business, education, health and social life. Mobile technology has drastically changed the cultural norms and behavior of individuals. The impacts are both at the positive side and also at the negative side. At one end Smartphone are enabling people to create their own micro-cultures and engage into activities considered dangerous of society and on the other end Smartphone enabling people to remain connected all the time[16].

2.5.2 History backgrounds

Today‘s Smartphone‘s has been around since Apple introduced the Smartphone in mass consumer market, but in reality the Smartphone has been in market since 1993. The different between today‘s Smartphone and early Smartphone‘s is that early Smartphone‘s were predominantly meant for corporate users and used as enterprise devices and also those phone were too expensive for the general consumers[17]. The Smartphone era is divided into three main phases. First phase was purely meant for enterprises. During this phase all the Smartphone‘s were targeting the corporations and the features and functions were as per corporate requirements. This era began with the advent of the very first Smartphone The Simon‘from IBM in 1993. Blackberry is considered as the revolutionary device of this era, it introduced many features including Email, Internet, Fax, Web browsing, Camera. This phase was totally based on Smartphone targeting enterprises[17-19]. The second phase of Smartphone era started with the advent of iPhone, the major breakthrough Smartphone market in 2007. Apple revealed its first smart phone in 2007. This was the time when first time ever industry introduced the Smartphone for general consumers market[20].End of 2007 Google unveiled its Android

Operating System with the intention to approach the consumer Smartphone market. The emphasis during this time period was to introduce features that the general consumer requires and at the same time keep the cost at lower side to attract more and more customers. Feature like, email, social website integration, audio/video, internet access, chatting along with general features of the phone were part of these entire phone[20-23]. Third phase of Smartphone was mainly closing the gap between enterprise centric and general consumer centric Smartphone and improvement the display quality, display technology and on top of that also aiming to stabile the mobile operating system, introduce more powerful batteries and enhance the user interface and many more features within these smart devices. This phase logical started in 2008 with the upgrades in the mobile operating system and within last five years there have been several upgrades in Apple iOS, Android and Blackberry OS. The most popular mobile Operating systems (iOS, Android, Blackberry OS,Windows Mobile) and key Smartphone vendors (Apple, Samsung, HTC, Motorola, Nokia, LG, Sony etc.) are concentrating to bring features both in operating systems and devices which will provide exciting feature to enterprise and general consumers. The role of Android has been tremendous during this time period as it provided a great opportunity to all vendors to build devices using the great open source

Android technology[20-22].

2.7 Related works

2.7.1 Status of pharmacies and medicine in Sudan (study)

Drug costs are important, as they account for a substantial part of the total cost of health care, estimated at 10-15% in developed countries and up to 30-40% in some developing countries. In developing countries, most people who need medicines have to pay for them out of their own pockets. Drug prices and drug expenditures have become a major issue in the past few years in developing countries and health care policy makers are concerned that their countries are carrying a heavier burden than others in paying for drugs. Governments use a variety of approaches to try to control the cost of drugs and ensure that essential medicines are affordable and not overpriced. Measuring and understanding the medicines prices situation is the first stage in developing medicines pricing policies that would ensure availability and affordability.[24]

Sudan as develop country has 18 states, with an area of 1,886,068 km2 (728,215 sq mi), it is the third-largest country on the continent (after Algeria and Democratic Republic of the Congo) and the sixteenth-largest in the world[25]. The total population of Sudan is 38,435,252 with annual growth rate 2.53% and the urban population is 30.8%.[26]

Khartoum state is one of the eighteen states of Sudan. Although it is the smallest state by area (22,142 km2), it is the most populous (5,274,321 in 2008 census).[25]

The total number of pharmacies in Sudan is 4933 pharmacies in which The private sector contains 3,946 pharmacies, and the public sector is divided into two parts. The number of pharmacies in hospitals is 458 out of 519 hospitals, and the number of health centers is 530 health centers. the Availability rate for each 100,000 from the population is 10 pharmacies .[26] and the number of pharmacy in Khartoum state alone is 2463 pharmacies that is 49% from the total number of Community pharmacies.[27] which is almost double the pharmacies in the rest of Sudan.

And The percentage of national production in the available share through the National Medical Supplies Fund for the year 2016 is 16% and The access to essential medicine list is 50% and the median number of medicines per prescription is 2.4%.[26]

In Sudan, the availability of the surveyed medicines was extremely low in all sectors as originator and 60% or less as generics (only 39.5% in the public sector) Generic medicines have been accepted in the country as they are more available than originator brands in all sectors.[28]

Since the beginning of the year 2018, the prices of medicines in Sudan have skyrocketed at very high rates. Amounted to 300 percent increase for some items, as a result of economic policies adopted by the government that led to the decline of value of the national currency against foreign currencies, especially the US dollar, which is the most used in the process of importing medical drugs. Since the beginning of last November, many companies stopped production and so did a large number of drug importers stopped from selling their drug stocks as a result of a new government decision to cancel the adoption of the dollar price encouraging incentives to import. Since then, a significant scarcity of drugs has been registered in the country, including life-saving items.[29]

The Sudanese government relies on the National Medical Supplies Fund to provide many items of medicine, but the fund focuses its efforts more on providing life-saving drugs free of charge to accident and emergency departments, in addition to providing vaccines. At the same time, the government allows pharmaceutical companies to import the rest of the items, while providing them with some facilities. It is reported that the country produces only 30 percent locally of its overall needs .[29]

2.7.2 Pharmacy Finder app (Android Application)

Pharmacy finder is an application that provides listing of pharmacies around your location, shows all details about that pharmacies and all information of a pharmacy e.g. address, map, website and photos and can also save your nearest pharmacies, you can see a pharmacy reviews before going to it. There is also a search feature available to search for particular pharmacy.[30]

pharmacy finder app works in any city of the world it determines your location and suggest nearby pharmacies immediately.[30]

Figure 2.1: Searching Screen

2.7.3 Pharmacy Finder : Nearest Pharmacy

Pharmacy Finder and locator that shows nearest and around Pharmacy from your current location. can have list of all kind of Pharmacy with details like address, reviews… and can have so many options to compare. It shows reviews that is given by people.[31]

The mechanism for finding the location by find Nearest or Around You Pharmacy and draw route and display distance between your current location to selected Pharmacy.[31]

- Voice navigation with distance.

- Arrow navigation with distance.

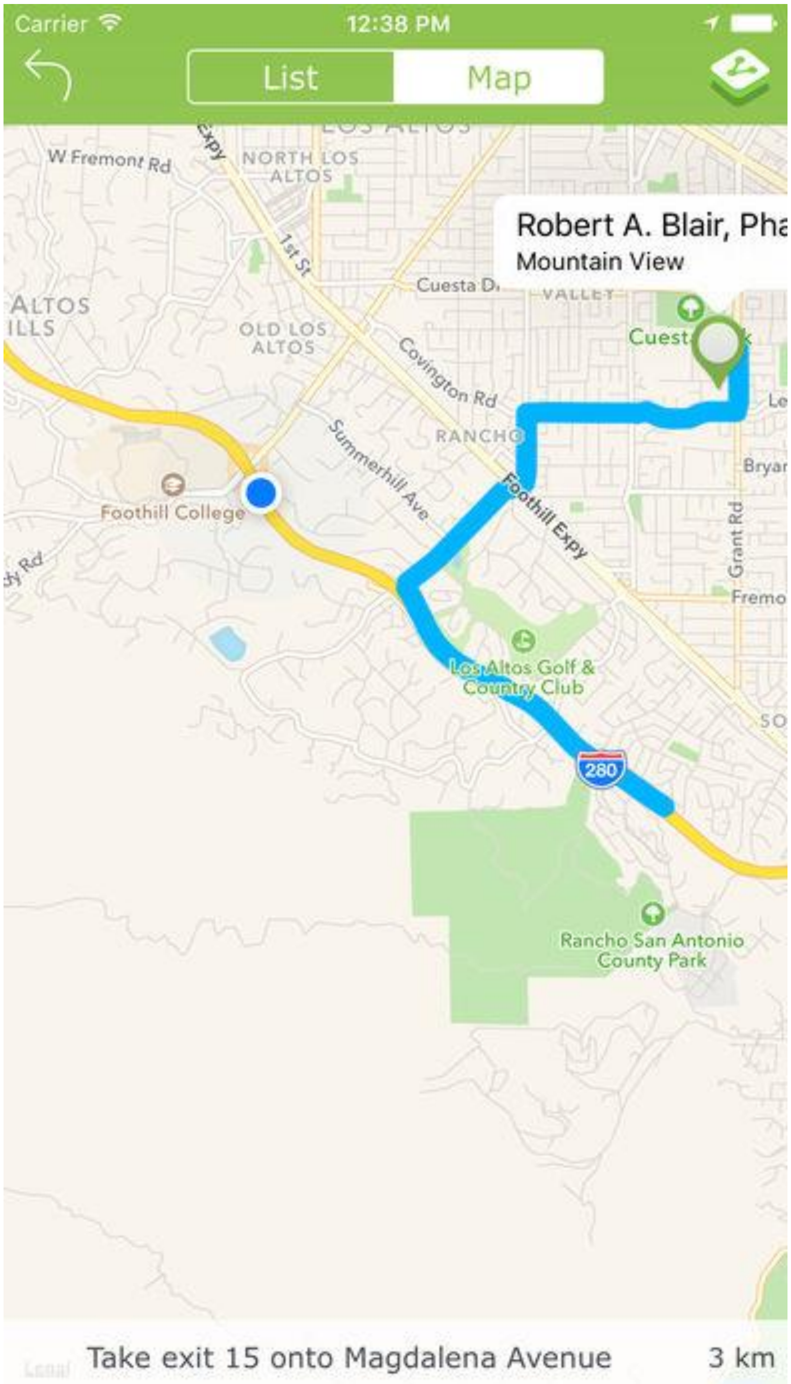

Figure 2.2: Direction to Nearest Pharmacy

2.8 Interviews with Field Specialist in the ministry of health:

2.8.1 Dr. Bashir Abdulwahab - Director of Pharmaceutical Administration Department, Khartoum state:

The number of pharmacies is lacking, along with issues in medicine distribution, most notably in the remote states of the country. With a clear condensing of pharmacies in relatively small central areas, and an ongoing problem of medicine availability. The state of Khartoum ministry of health protests on the regulation regarding the distribution of certain types of medicines (i.e. cancer treatments, kidney medication, heart disease). Also there is a need for strong government oversight.

2.8.2 Fadwa Ibrahim - head of IT of department:

A system is required to interconnect all pharmacies in the country, that stores patient data, pharmacies locations and helps connect patients with the required medication (i.e. E-health). The usual process involves the unqualified department employees answering caller questions about the whereabouts of medicines, and then manually asking around for the pharmacy that contains the medicine. This is a bad business process model.

2.8.3 Dr. Tarig Banaga - Head of Directorate of Statistics Department, Federal Ministry of Health:

The number of registered medicines in the country is more than 4,000. Considerable difficulties are in the process of transportation of medicine to the large territories of Sudan. With a fraction of the medicines not meeting the specifications. The government is negligent to the Rational Use OF Medicine. Some medications are provided freely, such as kidney medication. Formal training in the technical side for the pharmaceutical cadres is required. The National Council for Drugs And Poison has the percentage of pharmacies using online System. The National Medical Supply Funds provides the essential medicines.

Chapter 3

Research Methodology

3: Research Design and Procedure

In this chapter, we will explain the methodology to be followed to achieve the research objectives.

The research methodology contains four main phases:

i. Problem analysis and identification.
ii. Data collection.
iii. Model construction and evaluation.
iv. Instrumentation used
v. Present results.

3.1 Problem analysis and identification

Through a series of interviews with multiple health-care field personnel and experts, a broad picture will be drawn for the state of public health status in Sudan. Additionally more insight into the matter can be obtained through the analysis of official governmental reports published by the ministry of health and affiliates, and with the analysis of large databases. Our research will center on solving one prominent problem discovered from the aforementioned sources. Mainly the availability of medicine and of pharmacies in Sudan. Taking Khartoum state as a case study. With the usage of modern techniques such as data science applications, data mining of Big Data stores and location-based services, we aim to identify deficiencies in the current working system, and offer a solution suggested by the same data.

3.2 Data collection

Data will be requested from official sources. Specifically the National Medical Supply Fund, where we will conduct field visits and request data and insight along with the Federal Ministry of Health.

The types of data needed to be collected.

- Complete list of pharmacies and drug dispensaries with detailed information of their locations.
- Statistical census data of Sudan, detailing each city and all areas within the cities.
- Population density.
- Complete list of approved drugs.
- Database of all drug supplies.

3.3 Model construction and evaluation

This phase contains 2 sub-processes:

a. Using data science tools such as R statistical package, we will conduct an analysis of the collected data to find patterns in medicine and pharmacy allocation and suggest a solution.

b. Evaluating and critiquing the model to make sure it solves the problem.

3.4 Instrumentation

Instruments used in the making of this research include the following.

3.4.1 Android Studio

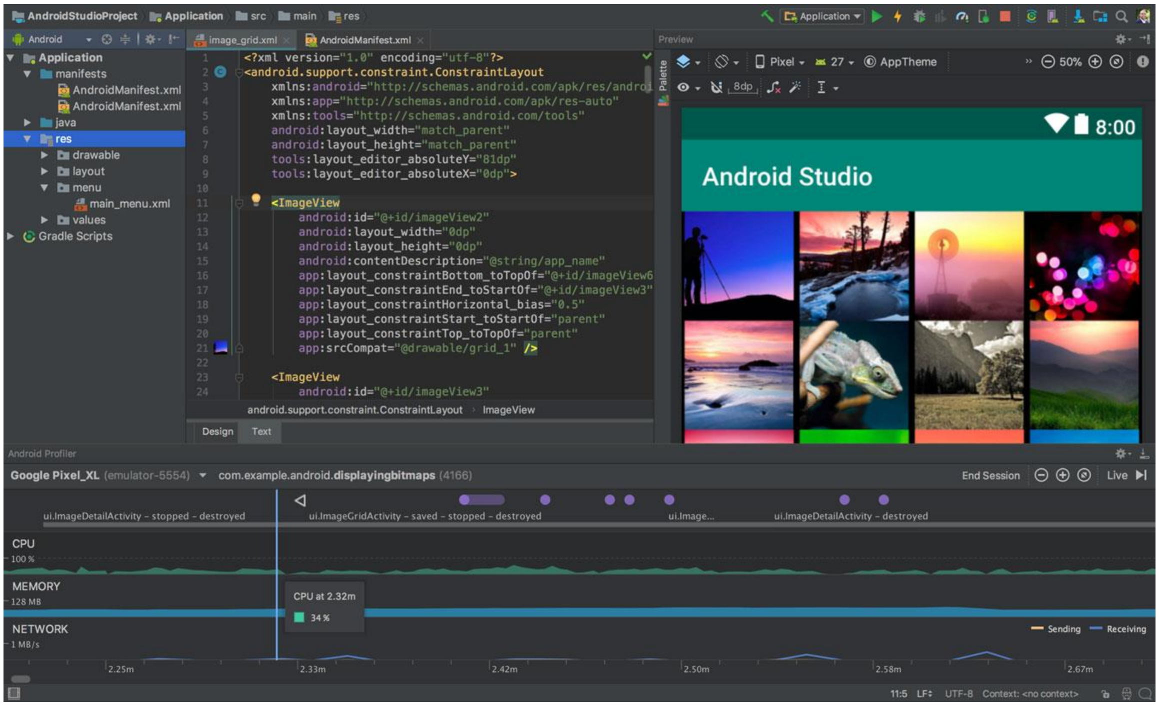

Figure 3.1: Overview of Android Studio Workspace

Android Studio is the official Integrated Development Environment (IDE) for Android app development, based on IntelliJ IDEA[32].

On top of IntelliJ's powerful code editor and developer tools, Android Studio offers even more features that enhance your productivity when building Android apps, such as:

- A flexible Gradle-based build system
- A fast and feature-rich emulator
- A unified environment where you can develop for all Android devices
- Apply Changes to push code and resource changes to your running app without restarting your app
- Code templates and GitHub integration to help you build common app features and import sample code
- Extensive testing tools and frameworks
- Lint tools to catch performance, usability, version compatibility, and other problems
- C++ and NDK support
- Built-in support for Google Cloud Platform, making it easy to integrate Google Cloud Messaging and App Engine

3.4.1.1 Instant Run

Android Studio's Instant Run feature pushes code and resource changes to the running app. It intelligently understands the changes and often delivers them without restarting your app or rebuilding your APK, so you can see the effects immediately.

3.4.1.2 Intelligent Code Editor

The code editor helps you write better code, work faster, and be more productive by offering advanced code completion, refactoring, and code analysis. As you type, Android Studio provides suggestions in a dropdown list. Simply press Tab to insert the code.

3.4.1.3 Fast and Feature-rich Emulator

The Android Emulator installs and starts your apps faster than a real device and allows you to prototype and test your app on various Android device configurations: phones, tablets, Android Wear, and Android TV devices. You can also simulate a variety of hardware features such as GPS location, network latency, motion sensors, and multi-touch input.

3.4.1.4 Configure Builds Without Limits

Android Studio's project structure and Gradle-based builds provide the flexibility you need to generate APKs for all device types.

3.4.1.5 Robust and Flexible Build System

Android Studio offers build automation, dependency management, and customizable build configurations. You can configure your project to include local and hosted libraries, and define build variants that include different code and resources, and apply different code shrinking and app signing configurations.

3.4.1.6 Designed for Teams

Android Studio integrates with version control tools, such as GitHub and Subversion, so you can keep your team in sync with project and build changes. The open source Gradle build system allows you to tailor the build to your environment and run on a continuous integration server such as Jenkins.

3.4.1.7 Optimized for All Android Devices

Android Studio provides a unified environment where you can build apps for Android phones, tablets, Android Wear, Android TV, and Android Auto. Structured code modules allow you to divide your project into units of functionality that you can independently build, test, and debug.

3.4.1.8 Code with Confidence

At every step, Android Studio helps ensure that you're creating the best code possible.

3.4.1.9 Code Templates and Sample Apps

Android Studio includes project and code templates that make it easy to add well-established patterns such as a navigation drawer and view pager. You can start with a code template or even right-click an API in the editor and select *Find Sample Code* to search for examples. Moreover, you can import fully functional apps from GitHub, right from the Create Project screen.

3.4.1.10 Intelligence

Android Studio provides a robust static analysis framework and includes over 280 different lint checks across the entirety of your app. Additionally, it provides several quick fixes that help you address issues in various categories, such as performance, security, and correctness, with a single click.

3.4.1.11 Testing Tools and Frameworks

Android Studio provides extensive tools to help you test your Android apps with JUnit 4 and functional UI test frameworks. With Espresso Test Recorder, you can generate UI test code by recording your interactions with the app on a device or emulator. You can run your tests on a device, an emulator, a continuous integration environment, or in Firebase Test Lab.

3.4.1.12 Create Rich and Connected Apps

Android Studio knows not all code is written in Java and not all code runs on the user's device.

3.4.1.13 C++ and NDK Support

Android Studio fully supports editing C/C++ project files so you can quickly build JNI components in your app. The IDE provides syntax highlighting and refactoring for C/C++, and an LLDB-based debugger that allows you to simultaneously debug your Java and C/C++ code. The build tools can also execute your CMake and ndk-build scripts without any modification and then add the shared objects to your APK.

3.4.2 R Studio

R Studio is an integrated development environment (IDE) for R, a programming language for statistical computing and graphics. It is available in two formats: RStudio Desktop is a regular desktop application while RStudio Server runs on a remote server and allows accessing RStudio using a web browser.[33]

3.4.3 Tidyverse

The tidyverse is a collection of open source R packages introduced by Hadley Wickham and his team that "share an underlying design philosophy, grammar, and data structures" of tidy data. The core packages are ggplot2, dplyr, tidyr, readr, purrr, tibble, stringr, and forcats, which provide functionality to model, transform, and visualize data. As of November 2018, the tidyverse package and some of its individual packages make up 5 out of the top 10 most downloaded R packages, and are the subject of multiple books and papers. It has been criticized by Norman Matloff and Bob Muenchen.[34]

3.5 Results Presentation

At the end of the above processes we will publish our findings establishing how our research can solve the problem, and comparing results against research objectives.

3.5.1 Methodology Flow Chart

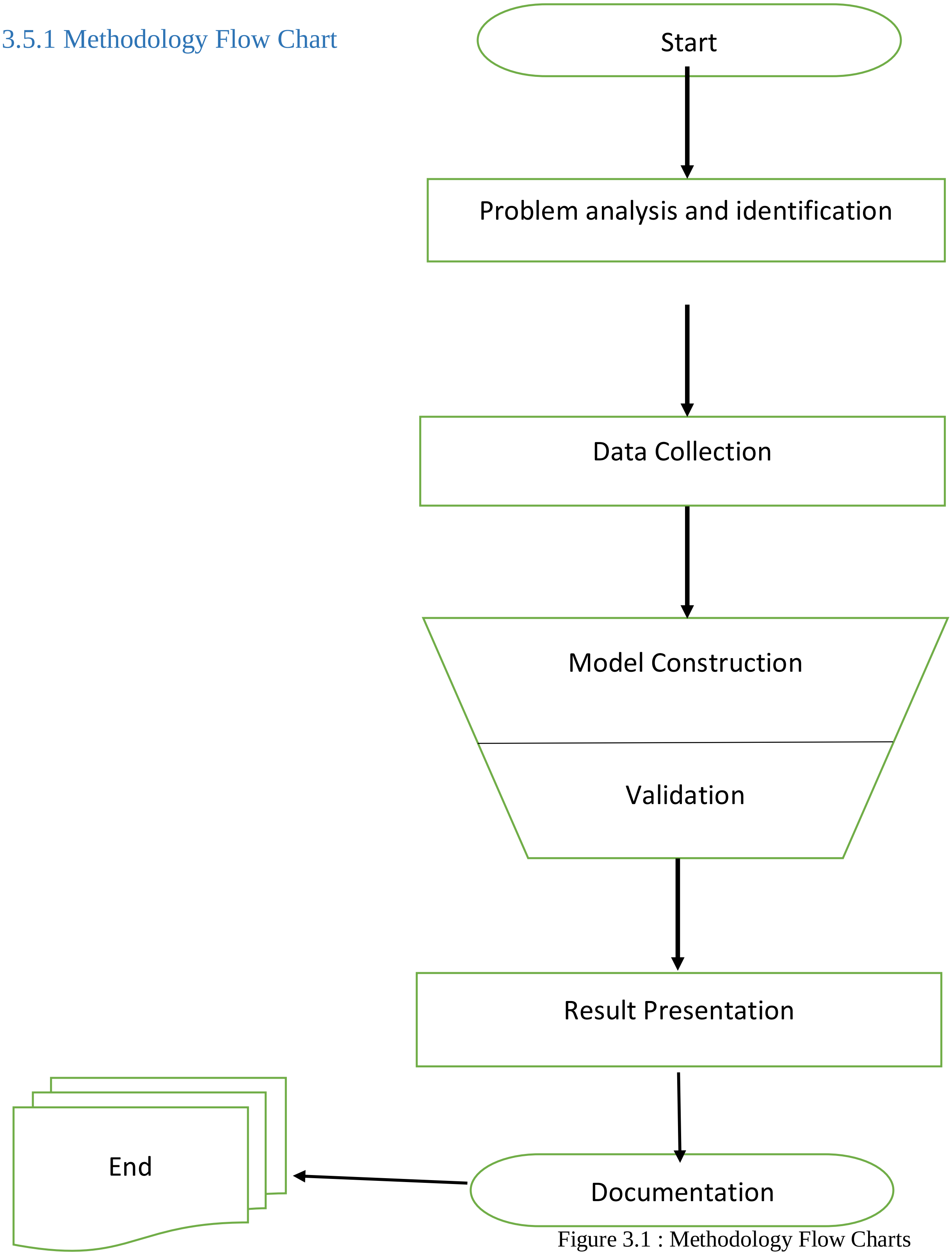

Figure 3.1 : Methodology Flow Charts

Chapter 4

Analysis

In this chapter, we will present the results of analysis of data collected from the Ministry of Health, Khartoum State and the Federal Ministry of Health useing data science techniques.

4.1 Analysis of the Current Ctatus – Using Khartoum State as a sample:

To analyze the current status, census data is needed to illustrate the issues.

Overall, Sudan has **18** states, with an area of **1,886,068 km^2** and a population of **38,435,353**.

Khartoum state is the most populous out of the 18 with an estimated **7-8** million inhabitants.

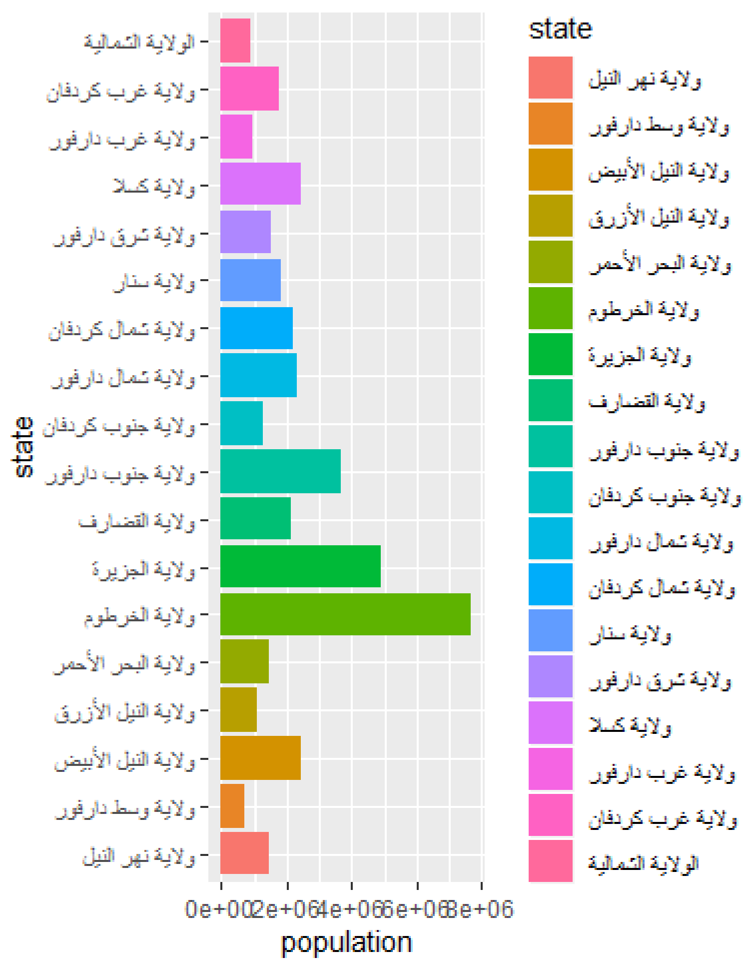

Figure 4.1: Sudan States Population

The total expenditure on health per capita in Sudan is (**97** US Dollars)[26], which was below the required international standard, but given the date of this statistic (2013), and the general regression in Sudan's local currency, we can infer that the number is lower today.

The distribution of pharmaceutical stores in the country is uneven with Khartoum state claiming the lion share of pharmacies at **2463** pharmacies or drug store, which is **49%** of total pharmacies in the country.

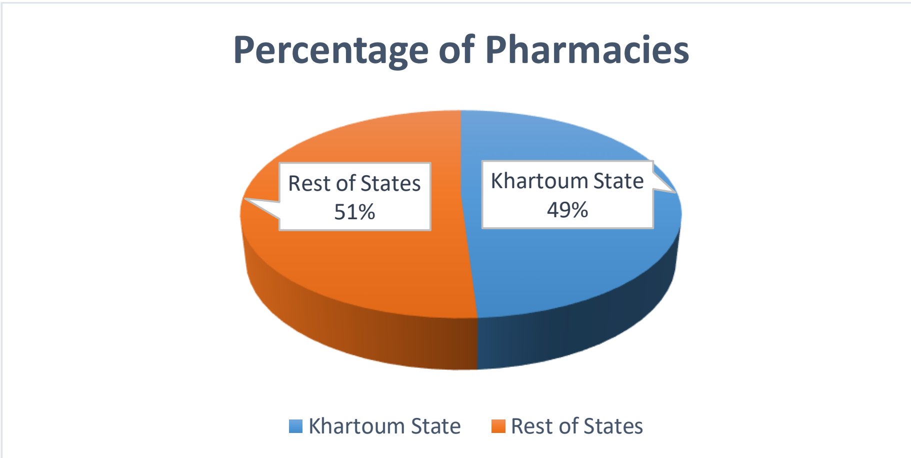

Figure 4.2: Khartoum State Compare to the Other States by Pharmacies

Moreover, Sudan has a modest pharmacy-per-capita ratio of **(6.5)** pharmacies per 100,000 persons. Which is way below the international standard. In Europe the ratio is **(82.8)**, and **(64)** in the US.

4.1.2Inside the state

Khartoum state is the smallest state by area **(22,142 km^2)**, it consists of 7 districts with the following densities (per 100,000):

District	Population	# of pharmacies	Density per 100,000
محلية الخرطوم	745,938	569	76.2
محلية جبل أولياء	1,703,950	360	21.1
محلية ام درمان	508,401	309	60.7
محلية ام بدة	1,500,000	268	17.8
محلية كرري	750,000	285	38
محلية الخرطوم بحري	533,700	317	59.4
محلية شرق النيل	1,184,000	328	27.7

Table 4.1: Information Inside Khartoum State

From the table above we can see the disproportionate distribution levels of pharmacies throughout the capital state districts, which amount to difficulties in locating pharmacies.

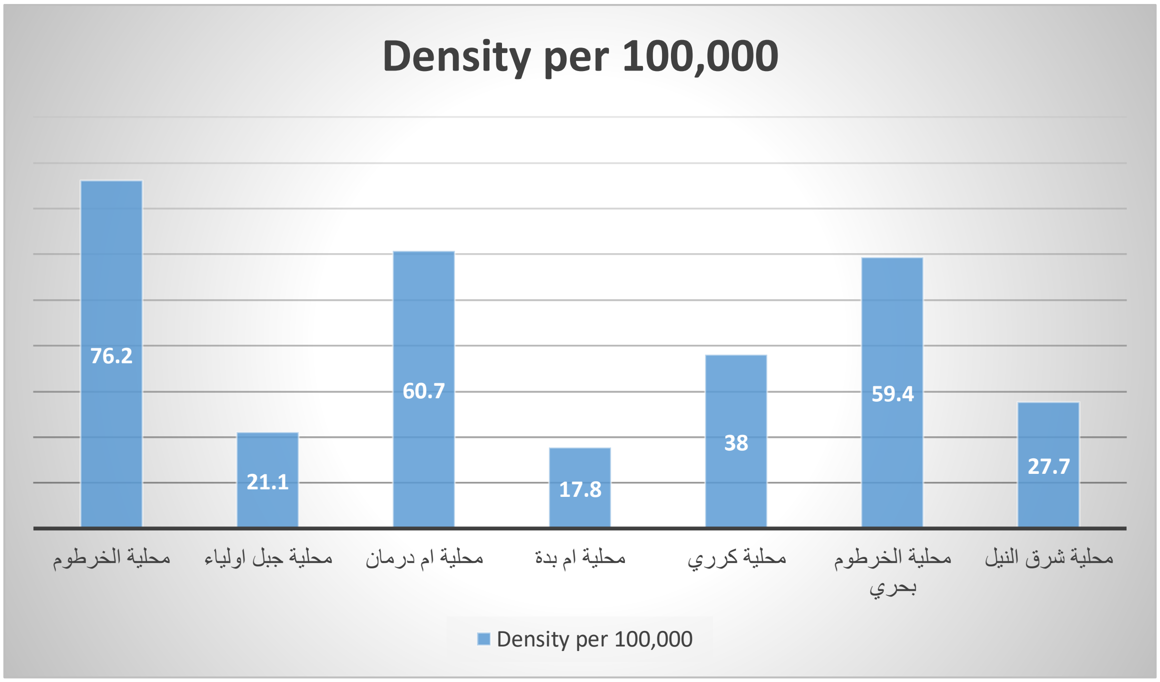

Figure 4.3: Density Per 100,000 in Khartoum State

Further Analysis of street levels shows differences in the availability of pharmacies:

Pharmacies in Khartoum state are distributed over **900** streets. With a ratio of **(2.73)** pharmacy per street. However, actual analysis show concentration of stores in a narrow band of streets:

Street or Area	# of Pharmacies	Street or Area	# of Pharmacies	Street or Area	# of Pharmacies
الشنقيطي	62	دار السلام	16	الزعيم الازهري	10
الوادي	51	الجميعاب	15	السلام	10
الردمية	49	جبرة	15	القصر جنوب	10
السوق	48	القذافي	14	المايقوما	10
الرئيسي	45	افريقيا	13	الزعيم الازهري	10
النص	44	الحرية	13	السلام	10
الأربعين	40	السلمة	13	القصر جنوب	10
الستين	32	مدني	13	المايقوما	10
كسلا	32	الانقاذ	12		
الطيار الكدرو	29	العاشرة	12		
الكلاكلة شرق	28	المواصلات	12		
الصحافة زلط	23	الوالي	12		
محمد نجيب	22	سوق ليبيا	12		
مايو	21	شارع واحد	12		
الدويم	19	السامراب	11		
المعونة	19	سليمان الشهيد مختار	11		

Table 4.2: The First 40 Entries of The Data Frame

We can see that some areas are more dense than others. To be precise the **50 most dense areas attribute to about 40% of the totall number of pharmacies in areas.** That means the remaining **1530** pharmacies are distributed on **850 locations.**

Medicine availability in the country is calculated to be at **50%[26]**. Further inpection of a random sample of pharmacies confirms that a significant portion of them fail to house more than **50%** out of the **4000** approved medicine list.

4.2 The Recommended Status for Khartoum State:

Khartoum state is the most developed sate in the country by almost all metrics. We build our recommended status first in this state and demonstrate the required level of growth to reach the international standards.

Khartoum state has **(2463)** pharmacies distributed state-wide. With an estimated population of **(7,687,500)**, the ratio of pharmacies-per-capita is calculated to be **(28.8) pharmacies per 100,000 capita**, making it the highest pharmacy-housing state in the country.

It is recommended that a spacing of 100 meters is placed between every two pharmacies according to the official ministry of health regulation in the state of khartoum.

However this particular regulation is not adhered to, owing to a lack of oversight and manpower. Addditionally, there is a need for governmental regulation to make the use of point of sale systems mandatory, since there is an obvious need for an interconnected and distrubuted database system to unify pharmaceutical market.

4.3 Recommended Growth Rate for the Rest of the states:

Equation to calculate the required growth rate to achieve the recommended standard of OCED or the rate of the state of Khartoum.

4.3.1 Creating a formula to find the required ratio of pharmacies

$$Ratio = \frac{100{,}000}{Population} \times (number\ of\ Existing\ Pharmacies)$$

The required ratio can be found using the formula:

$$Required\ Ratio = \frac{100{,}000}{Population} \times \ (Required\ number\ of\ Pharmacies)$$

And the required number of pharmacies can also be found using the formula:

$$Required\ number\ of\ Pharmacies = Required\ Ratio\ \times \frac{Population}{100{,}000}$$

4.3.2 Applying the formula to the rest of the states:

The result of applying the formula can be seen in the following table:

#	State	Area	Population	Pharmacies Per 100K	Pharmacies	Recommended number of Pharmacies	Deficit	Percentage of required Growth
1	ولاية الخرطوم	22,142	7,687,500	28.8	2463	-	-	-
2	ولاية الجزيرة	23,373	4,926,600	10.2	464	1411	947	%204
3	ولاية البحر الأحمر	218,887	1,447,800	9.6	140	403	263	%188
4	ولاية كسلا	36,710	2,438,800	5.7	161	691	530	%329
5	ولاية القضارف	75,263	2,108,500	4	86	604	518	%603
6	ولاية سنار	37,844	1,847,500	7.4	151	518	367	%243
7	ولاية النيل الأبيض	30,411	2,410,300	7.4	190	691	501	%263
8	ولاية النيل الأزرق	45,844	1,080,700	5.1	70	288	218	%311
9	الولاية الشمالية	348,765	913,500	9.8	80	259	179	%223
10	ولاية نهر النيل	122,123	1,472,300	9.8	146	403	257	%176
11	ولاية شمال كردفان	185,302	2,206,800	4.2	149	633	484	%325
12	ولاية غرب كردفان	111,373	1,737,700	3.4	75	489	414	%552
13	ولاية جنوب كردفان	79,470	1,263,400	2.6	73	345	272	%373
14	ولاية شمال دارفور	320,000	2,296,100	2	60	633	573	%956
15	ولاية غرب دارفور	23,000	995,200	2.6	32	259	227	%710
16	ولاية جنوب دارفور	72,000	3,672,400	2.3	76	1036	960	%1264
17	ولاية شرق دارفور	55,000	1,547,800	1.9	31	432	401	%1293
18	ولاية وسط دارفور	34,000	729,900	0.9	9	201	192	%2140

Table 4.3: Applying the Formula to Data

4.3.3 Results obtained from the table

We can see from Table 4.3 that there is majore problems in the availability of pharmacies in all Sudan states, All states have a severe shortage of pharmacies in relation to the number of people in the state, and this is a serious indication that the health side in the states is deteriorating compared to Khartoum State and that all states must urgently increase the number of pharmacies to meet the needs of their citizens.

for examples row 16 in Table 4.3 the Deficit is 1036 pharmacy and the Percentage of required

Growth is %1264 and this seirous problem must be taken into account, because there is problems in the availablilty of pharmacy then threfore there is also problems in the availablilty

of medicine in all states.

4.4 A model to compute the number of records in a central database

4.4.1 Creating a formula to find the number of records per day

To design a model to calculate number of records we use the formula

$$\boldsymbol{N = X * Y * Z * T}$$

Where:

N=number of records per day

X= median number of medicines per prescription.

Y= median number of transaction per hour.

Z= working hours.

T= total number of pharmacy's

4.4.2 Information needed to use the formula

The total number of pharmacy's in Sudan is **4933** The working hours is **16** hours per day divide into 2 shifts and the percentage of pharmacy's that work **24** hours per day is **1%** from the total number of pharmacy's, the median number of medicines per prescription is **2.4**, and median number of transaction per hour is 25 transactions.

4.4.3 Applying the formula

$$\boldsymbol{N = X * Y * Z * T}$$

X=**2.4**

Y= **25**

Z=**16**

T=**4933**

N= **2.4*25*16*4933**

then the number of records per day = **4,735,680** records, which will be **142,070,400** records in 1 month.

4.4.4 Results obtained by applying the formula

These amounts of data can be regarded as big data and our app will access this data through an API to get the information needed from the central database in the network.

And this typically increasing amounts quantities of data will be useful in many ways, and we can benefit from it in the analysis to show patterns of problems and provide solutions to problems that may face the health sector in the future.

Chapter 5

Medicine Locator Architecture

5.1 Anatomy of an Android App

We briefly discusses the basic components of an Android app and define the key concepts and vocabulary needed to understand the design of Medicine Locator app.

5.1.1 App Components

App components are the essential building blocks of an Android app. Each component is a different point through which the system can enter your app. Not all components are actual entry points for the user and some depend on each other, but each one exists as its own entity and plays a specific role—each one is a unique building block that helps define your app's overall behavior.

There are four different types of app components. Each type serves a distinct purpose and has a distinct lifecycle that defines how the component is created and destroyed.

Here are the four types of app components:

5.1.1.1 Activities

An activity represents a single screen with a user interface. For example, an email app might have one activity that shows a list of new emails, another activity to compose an email, and another activity for reading emails. Although the activities work together to form a cohesive user experience in the email app, each one is independent of the others. As such, a different app can start any one of these activities (if the email app allows it). For example, a camera app can start the activity in the email app that composes new mail, in order for the user to share a picture.

An activity is implemented as a subclass of Activity and you can learn more about it in the Activities developer guide.

5.1.1.2 Services

A service is a component that runs in the background to perform long-running operations or to perform work for remote processes. A service does not provide a user interface. For example, a service might play music in the background while the user is in a different app, or it might fetch data over the network without blocking user interaction with an activity. Another component, such as an activity, can start the service and let it run or bind to it in order to interact with it.

A service is implemented as a subclass of Service and you can learn more about it in the Services developer guide.

5.1.1.3 Content providers

A content provider manages a shared set of app data. You can store the data in the file system, an SQLite database, on the web, or any other persistent storage location your app can access. Through the content provider, other apps can query or even modify the data (if the content provider allows it). For example, the Android system provides a content provider that manages the user's contact information. As such, any app with the proper permissions can query part of the content provider (such as *ContactsContract.Data*) to read and write information about a particular person.

Content providers are also useful for reading and writing data that is private to your app and not shared. For example, the Note Pad sample app uses a content provider to save notes.

A content provider is implemented as a subclass of *ContentProvider* and must implement a standard set of APIs that enable other apps to perform transactions. For more information, see the Content Providers developer guide.

5.1.1.4 Broadcast receivers

A broadcast receiver is a component that responds to system wide broadcast announcements. Many broadcasts originate from the system—for example, a broadcast announcing that the screen has turned off, the battery is low, or a picture was captured. Apps can also initiate broadcasts—for example, to let other apps know that some data has been downloaded to the device and is available for them to use. Although broadcast receivers don't display a user interface, they may create a status bar notification to alert the user when a broadcast event occurs. More commonly, though, a broadcast receiver is just a "gateway" to other components and is intended to do a very minimal amount of work. For instance, it might initiate a service to perform some work based on the event.

A broadcast receiver is implemented as a subclass of *BroadcastReceiver* and each broadcast is delivered as an Intent object. For more information, see the *BroadcastReceiver* class.

A unique aspect of the Android system design is that any app can start another app’s component. For example, if you want the user to capture a photo with the device camera, there's probably another app that does that and your app can use it, instead of developing an activity to capture a photo yourself. You don't need to incorporate or even link to the code from the camera app. Instead, you can simply start the activity in the camera app that captures a photo. When complete, the photo is even returned to your app so you can use it. To the user, it seems as if the camera is actually a part of your app.

When the system starts a component, it starts the process for that app (if it's not already running) and instantiates the classes needed for the component. For example, if your app starts the activity in the camera app that captures a photo, that activity runs in the process that belongs to the camera app, not in your app's process.

Therefore, unlike apps on most other systems, Android apps don't have a single entry point (there's no *main()* function, for example).

Because the system runs each app in a separate process with file permissions that restrict access to other apps, your app cannot directly activate a component from another app.

The Android system, however, can. So, to activate a component in another app, you must deliver a message to the system that specifies your intent to start a particular component. The system then activates the component for you.

5.2 Medicine Locator UML Class Diagram:

In this section we discuss the design and architecture of the Medicine Locator app. The figure below shows a static UML class diagram of the Medicine Locator app, illustrating the key Activities, Services, Intents and inter-component dependencies.

The figure below depicts the corresponding UML class diagram:

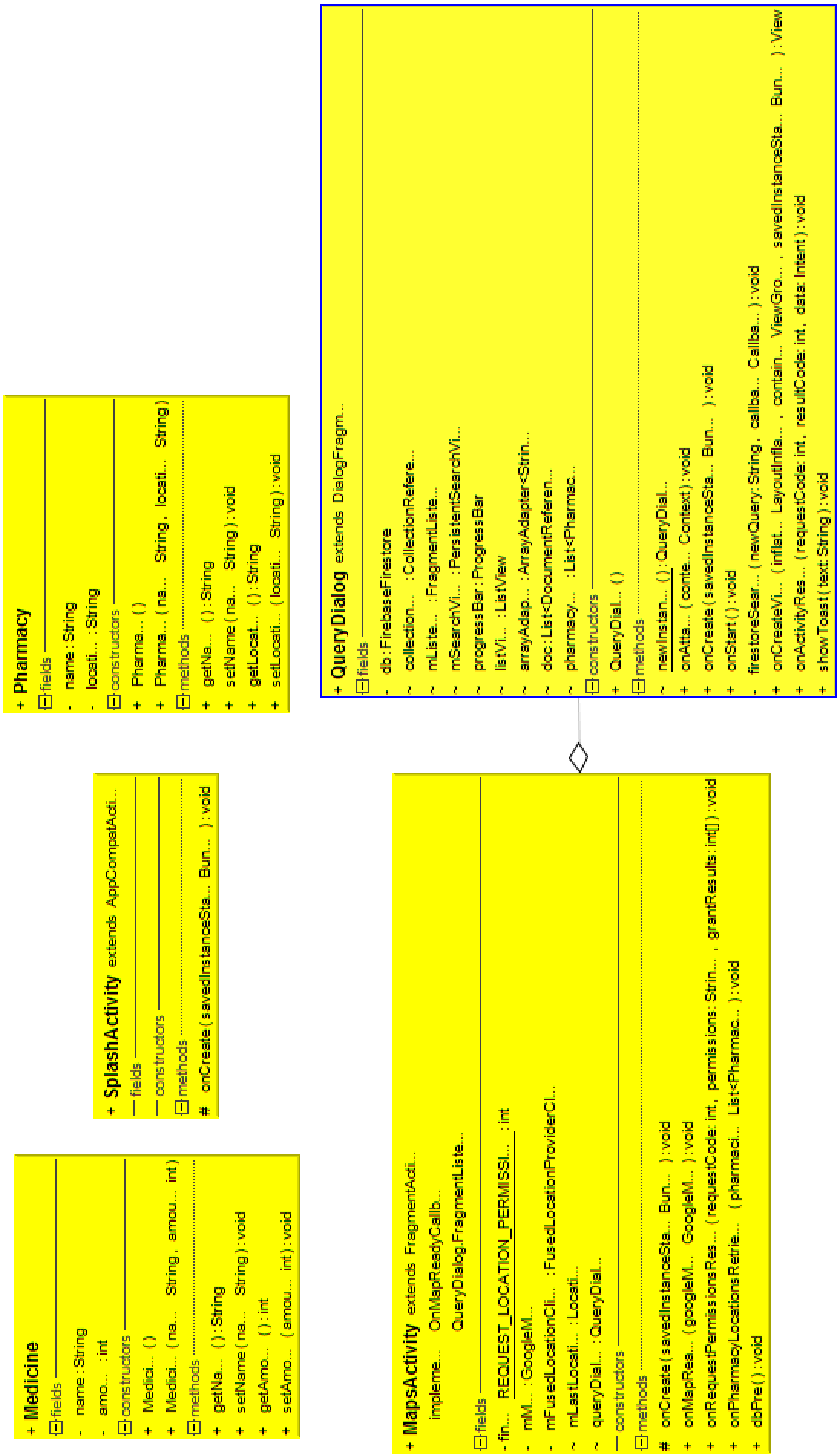

Figure: 5.1 UML Class Diagram

5.3 The Medicine locator App consists of three major parts:

5.3.1 The Google map Activity (MapsActivity.java):

Upon the running of the app the user gets greeted by the map activity. Which is the main activity of the application (launcher). The MapsActivity.java class itself consists of multiple parts, but we'll only mention the most important ones.

The figure shows a screen of the activity.

Figure: 5.2

The user is presented with a map screen that shows his current location. Using the standard Google map layer (Normal map). The goal is to establish and save his location for later by using the FusedLoacationProvider class from the map API.

Within the screen, the user is shown a red floating action button (FAB). FABs are part of the standard Android OS widgets and follow the Google Material Design philosophy.

5.3.1.1 onCreate(Bundle):

As a user navigates through, out of, and back to the app, the Activity instances in the app transition through different states in their lifecycle. The Activity class provides a number of callbacks that allow the activity to know that a state has changed: that the system is creating, stopping, or resuming an activity, or destroying the process in which the activity resides.

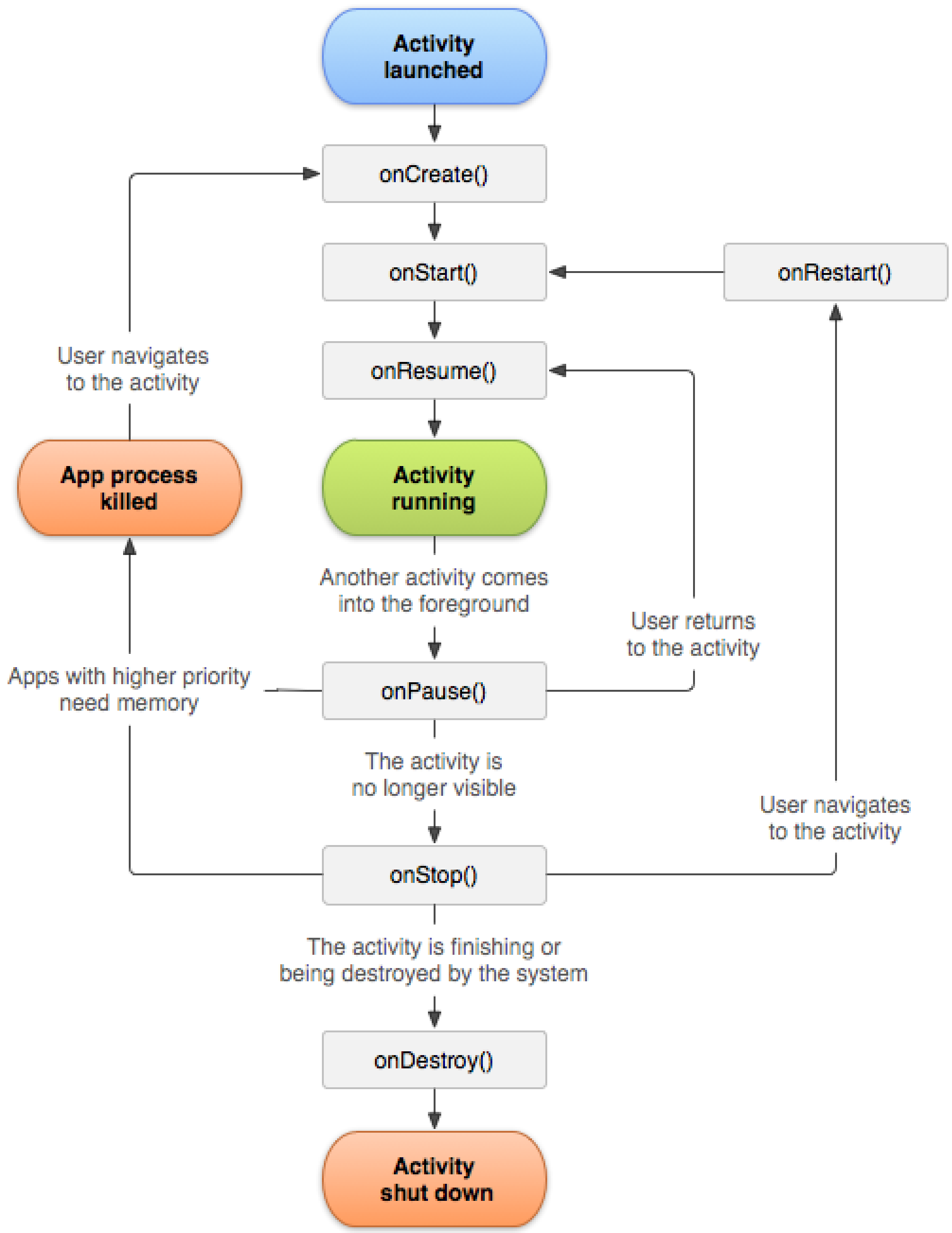

Figure: 5.3 Activity Lifecycle

onCreate is called when the activity is starting. This is where most initializations go: calling *setContentView(int)* to inflate the activity's UI, using *findViewById(int*) to programmatically interact with widgets in the UI.

Also inside *onCreate* we set the *Floating Action Button (FAB)* in the bottom right corner of the screen. The *(FAB)* is an Android widget with a shape and feel of a floating component.

We programmatically set its *onClickListener()* event handler to respond to user taps. The tap takes the user into the next Activity, which would contain the logic to search for user defined queries, as we'll show later. Then *onCreate()* binds the *mapFragment* (a container of the Google map).

In the same method we initialize the *FusedLocationProviderClient*. The Location Services API uses a fused location provider to manage the underlying technology and provides a straightforward API so that you can specify requirements at a high level, like high accuracy or low power. It also optimizes the device's use of battery power. In this step, you will use it to obtain the device's last known location. To find the device location efficiently without worrying about which provider or network type.

The *FusedLocationProviderClient* API requires run-time permissions, the purpose of a permission is to protect the privacy of an Android user. Android apps must request permission to access sensitive user data (such as contacts and SMS), as well as certain system features (such as camera and internet). Depending on the feature, the system might grant the permission automatically or might prompt the user to approve the request.

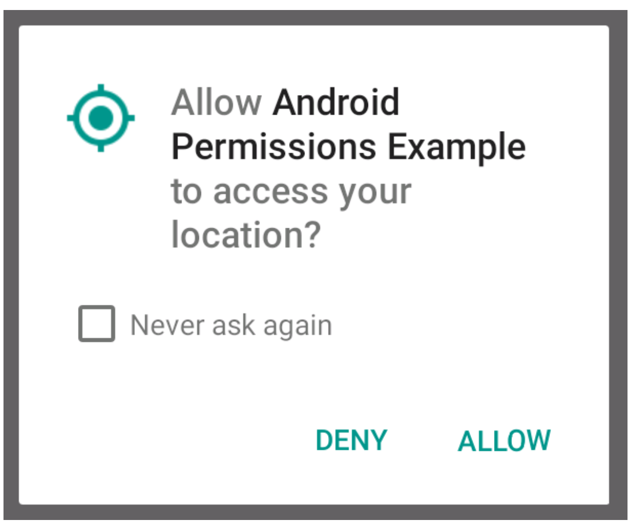

Figure: 5.4 Runtime permission

A central design point of the Android security architecture is that no app, by default, has permission to perform any operations that would adversely impact other apps, the operating system, or the user. This includes reading or writing the user's private data (such as contacts or emails), reading or writing another app's files, performing network access, keeping the device awake, and so on.

A device location request is a type of a dangerous permission. Dangerous permissions cover areas where the app wants data or resources that involve the user's private information, or could potentially affect the user's stored data or the operation of other apps. For example, the ability to request the user's contacts is a dangerous permission. If an app declares that it needs a dangerous permission, the user has to explicitly grant the permission to the app. Until the user approves the permission, your app cannot provide functionality that depends on that permission.

5.3.1.2 onMapReady(GoogleMap):

Manipulates the map once available. This callback is triggered when the map is ready to be used. This is where we can add markers or lines, add listeners or move the camera.

5.3.2 QueryDialog:

The first screen is the map activity, which contain the logic to navigate to this Activity. The QueryDialog Fragment is where the user enters his query term.

The results are shown as a list of pharmacies, or if the search came out with no match, possible alternative drugs are shown.

Each entry represents a medicine. Upon user tap, the user is taken back to the Google map where a marker is set to show the location of the pharmacies containing the drug.

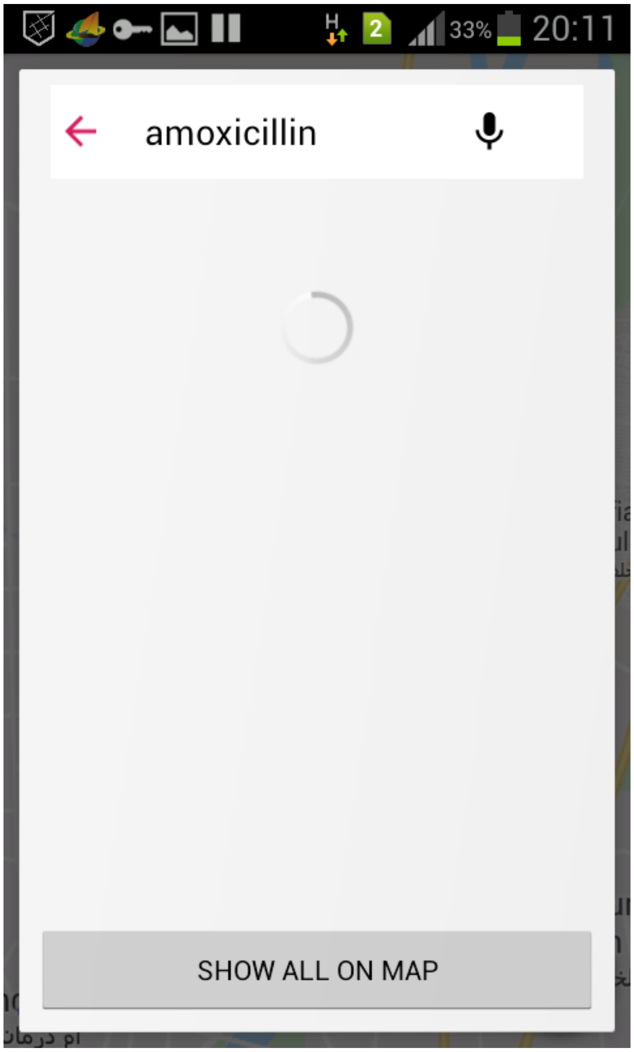

Figure: 5.5 Query Dialog fragment where user enters medicine name.

From there our model includes the data of all the approved drugs stored on a central real time NOSQL database, and we chose Google's Cloud Firestore database as our choice.

5.3.2.1 Cloud Firestore:

Cloud Firestore is a flexible, scalable database for mobile, web, and server development from Firebase and Google Cloud Platform. Like Firebase Realtime Database, it keeps your data in sync across client apps through realtime listeners and offers offline support for mobile and web so you can build responsive apps that work regardless of network latency or Internet connectivity. Cloud Firestore also offers seamless integration with other Firebase and Google Cloud Platform products, including Cloud Functions.

Figure: 5.6 Cloud Firestore

Query is transmitted to the online Cloud Firestore database where a complex query is performed. Since Firestore is a document based NoSql database, query rules are set from our account. Data is stored in the form of documents, multiple documents can be stored within a Collection.

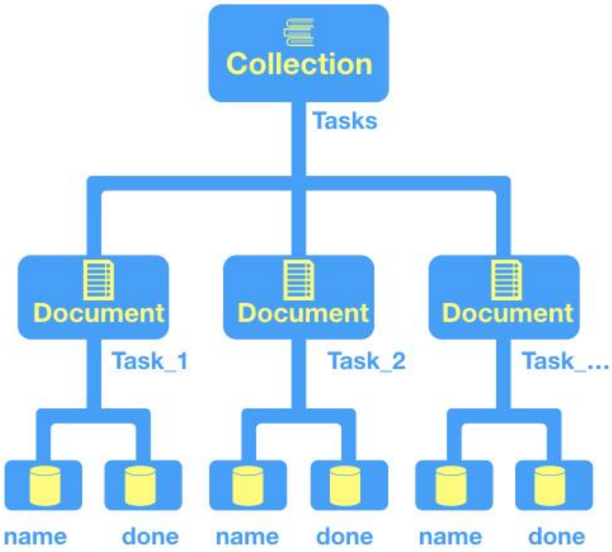

Figure: 5.7 Document Architecture.

Once the User Has entered the medicine name, an online query runs, and a list of available pharmacies containing said medicine is shown.

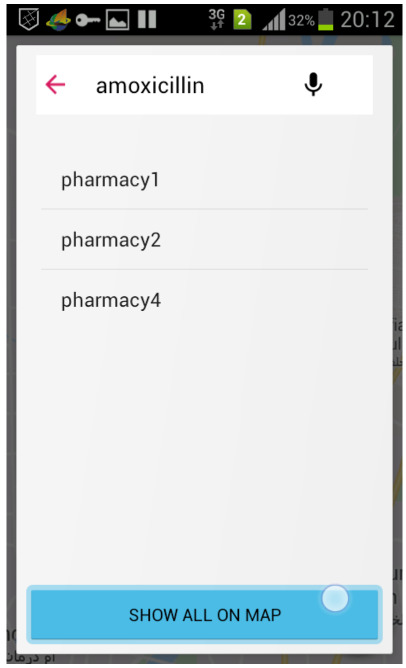

Figure: 5.8 List of pharmacies.

From There the user has the option of selecting one pharmacy or showing all of them on the screen:

Chapter 6

Conclusion

6.1 Results

After obtaining the data and analyzing it, the research provides enough information about the status of pharmacies in Sudan in terms of availability and shows that the state of Khartoum contains half the number of pharmacies country-wide compared to the rest of the states, and even in Khartoum state there are major problems in the distribution of pharmacies within the state borders.

Regarding the remaining states, the situation can be said to be catastrophic in relation to the availability of pharmacies for the population.

The number of required pharmacies is lacking, along with issues in medicine distribution, most notably in the remote states of the country. With a clear condensing of pharmacies in relatively small central areas, and an ongoing problem of medicine availability. The state of Khartoum ministry of health protests on the regulation regarding the distribution of certain types of medicines (i.e. cancer treatments, kidney medication, heart disease). Also citing a need for a stronger government oversight.

This information shows that there are serious problems in the availability of pharmacies and that reflects negatively on the health of the individual and the community.

To provide a solution for the problem, we designed an application that provides information about the nearest pharmacy to the user and also the closest pharmacy with a specific drug for the user and that reduces the time to reach the medicine.

6.2 future work

1- Develop iOS version of the app.

2- Create network infrastructure to connect all pharmacies' systems to one network.

3- Adding scan feature to the app to help interpret the prescription containing the medicine.

4- Adding information about health insurances to each pharmacy in the system.

APPENDIX:

1- Using R Statistical package:

Where **pharmacy** is a database of all pharmacies in Khartoum state. The **street_frequency** dataframe gives the frequency table showing street names and the number of pharmacies on each

```
> freq<-as.data.frame(table(pharmacy$الشارع))
> freq<- data.frame(street = freq$Var1, frequency =
freq$Freq)
> street_freq<- freq[order(freq$frequency, na.last = T,
decreasing = T), ]
> density_freq<- data.frame(table(street_freq$frequency))
> View(street_freq)
> View(density_freq)
```

App Source Code:

MapsActivity.java

```
package com.fakeplastictrees.medicinelocator;

import androidx.annotation.NonNull;

import androidx.core.app.ActivityCompat;

import androidx.core.content.PermissionChecker;

import androidx.fragment.app.FragmentActivity;

import android.Manifest;

import android.app.AlertDialog;

import android.app.Dialog;

import android.content.DialogInterface;

import android.location.Location;

import android.os.Bundle;

import android.os.Handler;

import android.util.Log;

import android.view.View;

import android.view.Window;

import com.fakeplastictrees.medicinelocator.model.Medicine;

import com.fakeplastictrees.medicinelocator.model.Pharmacy;

import com.google.android.gms.location.FusedLocationProviderClient;

import com.google.android.gms.location.LocationServices;

import com.google.android.gms.maps.CameraUpdateFactory;

import com.google.android.gms.maps.GoogleMap;

import com.google.android.gms.maps.OnMapReadyCallback;

import com.google.android.gms.maps.SupportMapFragment;

import com.google.android.gms.maps.model.LatLng;

import com.google.android.gms.maps.model.MarkerOptions;

import com.google.android.gms.tasks.OnCompleteListener;

import com.google.android.gms.tasks.OnFailureListener;
```

```
import com.google.android.gms.tasks.OnSuccessListener;
import com.google.android.gms.tasks.Task;
import com.google.android.material.floatingactionbutton.FloatingActionButton;
import com.google.firebase.firestore.DocumentReference;
import com.google.firebase.firestore.FirebaseFirestore;
import com.google.firebase.firestore.QuerySnapshot;
import java.util.ArrayList;
import java.util.List;

public class MapsActivity extends FragmentActivity implements OnMapReadyCallback,
    QueryDialog.FragmentListener {

  private static final int REQUEST_LOCATION_PERMISSION = 1984;
  private GoogleMap mMap;
  private FusedLocationProviderClient mFusedLocationClient;
  Location mLastLocation;
  QueryDialog queryDialog;

  @Override
  protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_maps);
    dbPre();
    FloatingActionButton fab = findViewById(R.id.fab);
    fab.setOnClickListener(new View.OnClickListener() {
      @Override
      public void onClick(View view) {
        queryDialog = QueryDialog.newInstance();
        queryDialog.show(getSupportFragmentManager(), "TAG");
      }
    });
```

```
    if (PermissionChecker.checkSelfPermission(this,
            Manifest.permission.ACCESS_FINE_LOCATION) != PermissionChecker.PERMISSION_GRANTED) {
        ActivityCompat.requestPermissions(this,
                new String[]{Manifest.permission.ACCESS_FINE_LOCATION},
                REQUEST_LOCATION_PERMISSION);
    }
    // Obtain the SupportMapFragment and get notified when the map is ready to be used.
    SupportMapFragment mapFragment = (SupportMapFragment) getSupportFragmentManager()
            .findFragmentById(R.id.map);
    mapFragment.getMapAsync(this);
    mFusedLocationClient = LocationServices.getFusedLocationProviderClient(this);
    mFusedLocationClient.getLastLocation().addOnSuccessListener(
            new OnSuccessListener<Location>() {
                @Override
                public void onSuccess(Location location) {
                    if (location != null) {
                        mLastLocation = location;
                        LatLng latLng = new LatLng(mLastLocation.getLatitude(), mLastLocation.getLongitude());
                        mMap.moveCamera(CameraUpdateFactory.newLatLng(latLng));
                        mMap.animateCamera(CameraUpdateFactory.zoomTo(13));
                    }
                }
            });
}
/**
 * Manipulates the map once available.
 * This callback is triggered when the map is ready to be used.
 * This is where we can add markers or lines, add listeners or move the camera. In this case,
 * we just add a marker near Sydney, Australia.
 * If Google Play services is not installed on the device, the user will be prompted to install
 * it inside the SupportMapFragment. This method will only be triggered once the user has
```

```
 * installed Google Play services and returned to the app.
 */
@Override
public void onMapReady(GoogleMap googleMap) {
   mMap = googleMap;
   if (PermissionChecker.checkSelfPermission(this,
         Manifest.permission.ACCESS_FINE_LOCATION) == PermissionChecker.PERMISSION_GRANTED) {
      mMap.setMyLocationEnabled(true);
   }
}
@Override
public void onRequestPermissionsResult(int requestCode, @NonNull String[] permissions,
                              @NonNull int[] grantResults) {
   // Check if location permissions are granted and if so enable the location data layer.
   switch (requestCode) {
      case REQUEST_LOCATION_PERMISSION:
         if (grantResults.length > 0
               && grantResults[0] == PermissionChecker.PERMISSION_GRANTED) {
            break;
         } else {
            new AlertDialog.Builder(this)
                  .setTitle("Request Permission Result")
                  .setMessage("Location Permission not granted!")
                  .setPositiveButton("OK", new DialogInterface.OnClickListener() {
                     @Override
                     public void onClick(DialogInterface dialog, int which) {
                        //...
                        dialog.dismiss();
                     }
                  });
         }
```

```
        }
        super.onRequestPermissionsResult(requestCode, permissions, grantResults);
    }
    @Override
    public void onPharmacyLocationsRetrieved(List<Pharmacy> pharmacies) {
        if (mMap != null) {
            mMap.clear();
            for (Pharmacy ph : pharmacies) {
                String[] loc = ph.getLocation().split(",");
                LatLng latLng = new LatLng(Double.parseDouble(loc[0]), Double.parseDouble(loc[1]));
                mMap.addMarker(new MarkerOptions().position(latLng));
            }
            mMap.animateCamera(CameraUpdateFactory.zoomOut());
        }
    }
    public void dbPre() {
        FirebaseFirestore db = FirebaseFirestore.getInstance();
    }
}
```

QueryDialog.java

```
package com.fakeplastictrees.medicinelocator;
import android.app.Dialog;
import android.content.Context;
import android.content.Intent;
import android.os.Bundle;
import androidx.annotation.NonNull;
import androidx.annotation.Nullable;
import androidx.fragment.app.DialogFragment;
import androidx.fragment.app.Fragment;
import android.speech.RecognizerIntent;
import android.view.LayoutInflater;
import android.view.View;
import android.view.ViewGroup;
import android.widget.AdapterView;
import android.widget.ArrayAdapter;
import android.widget.Button;
import android.widget.ListView;
import android.widget.ProgressBar;
import android.widget.Toast;
import com.fakeplastictrees.medicinelocator.model.Pharmacy;
import com.google.android.gms.tasks.OnCompleteListener;
import com.google.android.gms.tasks.OnFailureListener;
import com.google.android.gms.tasks.OnSuccessListener;
import com.google.android.gms.tasks.Task;
import com.google.android.gms.tasks.Tasks;
import com.google.firebase.firestore.CollectionReference;
import com.google.firebase.firestore.DocumentReference;
import com.google.firebase.firestore.DocumentSnapshot;
import com.google.firebase.firestore.FirebaseFirestore;
import com.google.firebase.firestore.QueryDocumentSnapshot;
```

```java
import com.google.firebase.firestore.QuerySnapshot;
import org.cryse.widget.persistentsearch.DefaultVoiceRecognizerDelegate;
import org.cryse.widget.persistentsearch.PersistentSearchView;
import org.cryse.widget.persistentsearch.VoiceRecognitionDelegate;
import java.util.ArrayList;
import java.util.List;
import static android.app.Activity.RESULT_OK;

/**
 * A Query {@link Fragment} where users search for drugs.
 */
public class QueryDialog extends DialogFragment {
    private FirebaseFirestore db;
    CollectionReference collectionRef;
    FragmentListener mListener;
    PersistentSearchView mSearchView;
    ProgressBar progressBar;
    ListView listView;
    ArrayAdapter<String> arrayAdapter;
    List<DocumentReference> doc;
    List<Pharmacy> pharmacyList = new ArrayList<>();

    public QueryDialog() {
        // Required empty public constructor
    }

    static QueryDialog newInstance() {
        return new QueryDialog();
    }
    @Override
    public void onAttach(@NonNull Context context) {
```

```
    super.onAttach(context);
    if (context instanceof MapsActivity) {
        mListener = (FragmentListener) context;
        //mListener.onPharmacyLocationsRetrieved();
    }
}

@Override
public void onCreate(@Nullable Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setStyle(STYLE_NO_TITLE, 0); //R.style.query_dialog_style);
    db = FirebaseFirestore.getInstance();
    collectionRef = db.collection("pharmacy");
    doc = new ArrayList<>();
}

// To get Fullscreen dialog
@Override
public void onStart() {
    super.onStart();
    super.onStart();
    Dialog dialog = getDialog();
    if (dialog != null) {
        int width = ViewGroup.LayoutParams.MATCH_PARENT;
        int height = ViewGroup.LayoutParams.MATCH_PARENT;
        dialog.getWindow().setLayout(width, height);
    }
}

// Query Firebase db and return arraylist of text.
private void firestoreSearch(String newQuery, final Callback callback) {
```

```
db.collectionGroup("medicines")
    .whereEqualTo("name", newQuery.toLowerCase())
    .whereGreaterThan("amount", 0)
    .get()
    .addOnCompleteListener(new OnCompleteListener<QuerySnapshot>() {
      // onSuccessful is asynchronous, could be called before it finishes.
      @Override
      public void onComplete(@NonNull Task<QuerySnapshot> task) {
        if (task.isSuccessful() && (!task.getResult().isEmpty())) {
          for (QueryDocumentSnapshot document : task.getResult()) {
            doc.add(document.getReference().getParent().getParent());
          }
          List<Task<DocumentSnapshot>> tasks = new ArrayList<>();
          if (!doc.isEmpty()) {
            for (final DocumentReference document : doc) {
              //db.document(document.getPath())
              Task<DocumentSnapshot> documentSnapshotTask = document.get();
              tasks.add(documentSnapshotTask);
            }
            Tasks.whenAllSuccess(tasks)
                .addOnSuccessListener(new OnSuccessListener<List<Object>>() {
                  @Override
                  public void onSuccess(List<Object> objects) {
                    if (!objects.isEmpty()) {
                      showToast("received pharmacies!");
                      for (Object obj : objects) {
                        Pharmacy ph = ((DocumentSnapshot) obj)
                            .toObject(Pharmacy.class);
                        pharmacyList.add(ph);
                      }
                    }
```

```
                            callback.onCallback(pharmacyList);
                        }
                    })
                    .addOnFailureListener(new OnFailureListener() {
                        @Override
                        public void onFailure(@NonNull Exception e) {
                            showToast("Failed to retrieve results!");
                            progressBar.setVisibility(View.GONE);
                        }
                    });
            }
        } else {
            showToast("Failed to retrieve results!\nPlease Check your connection.");
            progressBar.setVisibility(View.GONE);
        }
    }
});
}
@Override
public View onCreateView(LayoutInflater inflater, ViewGroup container,
                         Bundle savedInstanceState) {
    View view = inflater.inflate(R.layout.fragment_query, container, false);
    mSearchView = (PersistentSearchView) view.findViewById(R.id.searchview);
    progressBar = view.findViewById(R.id.progressbar);
    progressBar.setVisibility(View.GONE);
    Button showAllBtn = view.findViewById(R.id.button_all);
    listView = (ListView) view.findViewById(R.id.listview);
    arrayAdapter = new ArrayAdapter<String>(getActivity(),
            android.R.layout.simple_list_item_1);
    listView.setAdapter(arrayAdapter);
    listView.setVisibility(View.GONE);
```

```
mSearchView.setSearchListener(new PersistentSearchView.SearchListener() {
    @Override
    public void onSearchCleared() {
        pharmacyList.clear();
        arrayAdapter.clear();
        arrayAdapter.notifyDataSetChanged();
    }
    @Override
    public void onSearchTermChanged(String term) {
    }
    @Override
    public void onSearch(String query) {
        if (!query.equals("")) {
            pharmacyList.clear();
            doc.clear();
            arrayAdapter.clear();
            arrayAdapter.notifyDataSetChanged();
            progressBar.setVisibility(View.VISIBLE);
            //listView.setVisibility(View.INVISIBLE);
            //progressBar.setVisibility(View.VISIBLE);
            firestoreSearch(query, new Callback() {
                @Override
                public void onCallback(List<Pharmacy> pharmacyList) {
                    if (!pharmacyList.isEmpty()) {
                        for (Pharmacy pharma : pharmacyList) {
                            arrayAdapter.add(pharma.getName());
                        }
                        progressBar.setVisibility(View.GONE);
                        arrayAdapter.notifyDataSetChanged();
                        listView.setVisibility(View.VISIBLE);
                    } else {
```

```
                    progressBar.setVisibility(View.GONE);
                    showToast("Found No Results!");
                }
            }
        });
    }
}
@Override
public void onSearchEditOpened() {
}
@Override
public void onSearchEditClosed() {
}
@Override
public boolean onSearchEditBackPressed() {
    return false;
}
@Override
public void onSearchExit() {
}
});

listView.setOnItemClickListener(new AdapterView.OnItemClickListener() {
    @Override
    public void onItemClick(AdapterView<?> parent, View view, int position, long id) {
        List<Pharmacy> l = new ArrayList<Pharmacy>();
        String s = (String) listView.getItemAtPosition(position);//v.getText().toString();
        showToast("Pharmacy chosen is: " + s);
        for (Pharmacy p : pharmacyList) {
            if (p.getName().equals(s)) {
                l.add(p);
```

```
            }
          }
          mListener.onPharmacyLocationsRetrieved(l);
          dismiss();
        }
      });

      showAllBtn.setOnClickListener(new View.OnClickListener() {
        @Override
        public void onClick(View v) {
          if (pharmacyList != null && !pharmacyList.isEmpty()) {
            mListener.onPharmacyLocationsRetrieved(pharmacyList);
            dismiss();
          }
        }
      });
      VoiceRecognitionDelegate delegate = new DefaultVoiceRecognizerDelegate(this,
          1984);
      if (delegate.isVoiceRecognitionAvailable()) {
        mSearchView.setVoiceRecognitionDelegate(delegate);
      }
      mSearchView.setHomeButtonVisibility(View.VISIBLE);
      // Inflate the layout for this fragment
      return view;
    }
    // Callback interface to be executed after onComplete method finishes.
    public interface Callback {
      void onCallback(List<Pharmacy> pharmacy);
    }
    public interface FragmentListener {
      void onPharmacyLocationsRetrieved(List<Pharmacy> pharmacies);
```

```
    }

    @Override
    public void onActivityResult(int requestCode, int resultCode, Intent data) {
        if (requestCode == 1984 && resultCode == RESULT_OK) {
            ArrayList<String> matches = data
                    .getStringArrayListExtra(RecognizerIntent.EXTRA_RESULTS);
            if (matches != null) {
                mSearchView.populateEditText(matches);
            }
        }
        super.onActivityResult(requestCode, resultCode, data);
    }
    public void showToast(String text) {
        Toast.makeText(getContext(), text, Toast.LENGTH_LONG).show();
    }
}
```

SplashActivity.java:

```java
package com.fakeplastictrees.medicinelocator;

import androidx.appcompat.app.AppCompatActivity;

import android.content.Intent;

import android.os.Bundle;

public class SplashActivity extends AppCompatActivity {

  @Override

  protected void onCreate(Bundle savedInstanceState) {

    super.onCreate(savedInstanceState);

    Intent intent = new Intent(this, MapsActivity.class);

    startActivity(intent);

    finish();

  }

}
```

Pharmacy.java

```
package com.fakeplastictrees.medicinelocator.model;
import com.google.firebase.firestore.PropertyName;

public class Pharmacy {
  @PropertyName("name")
  private String name;
  @PropertyName("location")
  private String location;
  public Pharmacy() {}
  public Pharmacy(String name, String location) {
    this.name = name;
    this.location = location;
  }
  public String getName() {
    return name;
  }
  public void setName(String name) {
    this.name = name;
  }
  public String getLocation() {
    return location;
  }
  public void setLocation(String location) {
    this.location = location;
  }
}
```

Medicine.java:

```java
package com.fakeplastictrees.medicinelocator.model;
import com.google.firebase.firestore.PropertyName;

public class Medicine {
  @PropertyName("name")
  private String name;
  @PropertyName("amount")
  private int amount;
  public Medicine() {}
  public Medicine(String name, int amount) {
    this.name = name;
    this.amount = amount;
  }
  public String getName() {
    return name;
  }
  public void setName(String name) {
    this.name = name;
  }
  public int getAmount() {
    return amount;
  }
  public void setAmount(int amount) {
    this.amount = amount;
  }
}
```

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