SCHOOL OF PUBLIC HEALTH

COLLEGE OF HEALTH SCIENCES

UNIVERSITY OF GHANA

DEVELOPMENT OF AN ANDROID APPOINTMENT BOOKING APPLICATION FOR RHEMA RAPHA MEDICAL CENTRE (RHEMA RAPHA APP.)

BY

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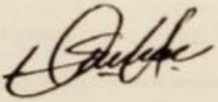
THIS HEALTH INFORMATICS PRACTICUM IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN HEALTH INFORMATICS.

NOVEMBER, 2020.

DECLARATION

I, Isaac Nkrumah hereby declare that apart from references to other people's work which have been duly acknowledged, this project is as a result of my independent work undertaken under supervision, and no previous submission either whole or part of this project has been made elsewhere for a degree in any institution. I, therefore, submit this project to the Department of Biostatistics, School of Public Health, and the University of Ghana in Partial fulfilment of the award of Master of Science in Health Informatics.



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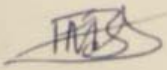

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LIST OF ABBREVIATION

ART	Antiretroviral therapy
HIS	Health Information Systems
HIT	Health Information Technology
IDE	Integrated Development Environment
IOM	American Institute of Medicine
IT	Information Technology
MOTECH	Mobile Technology for Community Health
OPD	Out Patient Department
SDLC	System Development Life Cycle
TB	Tuberculosis
WHO	World Health Organization

ABSTRACT

INTRODUCTION: the adoption of health information is a key driving force to the quality of health care delivery. Health information system such as appointment systems, records management system among others helps clinicians and health facilities to provide better and safe patient care. Patient care management is an important part of health care improvement in the health care industry. Managing the flow of patients in clinics and hospitals is a crucial aspect of patient care. The introduction of appointment systems helps in streamlining patient flow into health facilities. Good appointment system matches client demand with the facility's capacity to well utilize facilities resources. Online appointment booking system helps Patients to conveniently and securely book their appointments online, significantly increase patient satisfaction with clinic registration, reduce total waiting time and reduce appointment no-show through reminder messages.

Rhema Rapha Medical Centre currently has challenges in their traditional appointment booking system which includes, errors in the entry or no entry, calls received are sometimes not recorded or has errors in the records, lack of convenience for the client, complaints of calls not being answered and time-consuming to book an appointment. This project aims to develop an android mobile appointment booking application for clients of Rhema Rapha Medical Centre.

METHODS: The study adopted the evolutionary prototyping model of the system development life cycle as the process to follow to accomplish the objectives. The appointment application will run on an Android operating system, Windows 10 as the operating system for the development of the application, visual studio code as the IDE, the Nodejs and Dart as the programming language and the PostgreSQL for the development of the database side of the application.

A prototype of the system was made and user feedback incorporated to develop an android mobile appointment booking application.

RESULTS: The appointment system has various features, the main function is to book an appointment to see a doctor. Other functions are, providing reminder messages to the client, giving a client the option of cancelling an appointment, allowing doctors to view booked appointment and also booking a follow-up appointment for a client. The admin can add or delete a doctor and also update information in the database.

CONCLUSION: The android appointment system is an improvement on the existing paper-based system. The appointment system when implemented will help reduce appointment no-show by providing reminders to the client before their appointment due time. It will also help to efficiently manage employee working hours.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Advancements in technology have led to a substantial improvement in health service delivery worldwide by ensuring quick access to health information. Information technology has become a significant part of any growing business. As a developing industry, the health sector needs to have exact data and vital innovation for taking care of issues and to meet consistently developing client needs (Symey et al., 2013).

Low-income and middle-income countries have seen improvement in health outcomes in the past years, however changing health needs of clients, growing patient's expectations and advanced technology have raised the bar in health care delivery. A driving force behind quality health care is the adoption of information technology that enables clinicians to provide better patient care and higher levels of client safety (Payne et al., 2016).

According to Kruk et al., (2018), using health information technology in the health care process such as patient records management, payment systems, medical diagnosis, and patient appointments scheduling system, provides benefits such as quick health care delivery, reduction in human errors in diagnosis and prescribing and also help to save time, reduce the cost for both the facility and clients, support and improve the health care service delivery through the introduction of advanced imaging technology.

Cao et al., (2011) on the other hand indicates that Health Information Technology (HIT) increases provider capabilities and helps physicians to care for patients remotely and enhances accurate diagnosis leading to improvement in the quality, efficiency, and tools to help tackle the

ever-changing client needs and expectations within the health service delivery sector. The outpatient department's service delivery is a significant component of the health care process. Efficient and effective management of the flow of clients to and from the outpatient unit is very crucial in quality health care and client satisfaction.

Managing the patients flow requires tackling three facets of an outpatient unit: patient's arrival, the service provision process, and the queuing process. Working on the arrival of patients includes controlling the number of patients coming to the facility at a specific time, balancing patient volumes with available consulting staff (doctors on duty), and achieving desirable patient arrival patterns (Yeon, Taesik, and Jang, 2010). A good appointment system has the target of matching client demand with the facility's capacity and capabilities to well utilize the facilities' scarce resources. Appointment refers to assigning a period in a schedule to particular patients' visits. Appointment management is a very important aspect of health care and quality health service delivery. Appointment plus (www.appointmentplus.com) describes an appointment system as an online system or application that allows clients to conveniently and securely book an appointment with a facility or a doctor directly through a web connectable device such as phones, computers, and tablets.

Recently, private clinics have become more central in health delivery systems because of the emphasis on short hospital stays, and quality service delivery. Appointment systems are significant aspects of efficient healthcare delivery at clinics. As such, there should be an efficient system to help clinics appropriately manage the flow of clients (Khalid et al, 2018). Appointment systems have numerous benefits for clinics and clients. Mardiah and Basri (2013) point out the reduction in long queues in facilities, which go a long way to reduce patient waiting time in the out-patient department. Appointment applications also provide flexibility by making it easier for

clients to access the services and improving the reservation process and giving clients a straightforward health care flow.

Akinode (2017) also observed that appointment systems help save time for both the facility and the client. Time savings can be expressed into financial benefits to both the facility and the client. That is, the facility can minimize the staff time for part-time staff (consultants or specialists doctors, and part-time nurses) as well as facility usage expenses for the time saved. The client also saves time to do their work and the cost of moving from their homes to book an appointment through the traditional walk-in appointment system. It was further indicated that online or mobile appointment systems provide clients with a quick and convenient way to access health care as compared to the traditional walk-in appointment system. Appointment applications with alert or reminders (SMS/Email) will prompt the client before the appointment date and time, hence helps to reduce patient's no-show up for their appointment (Idowu et al., 2014).

The mobile industry has seen a rapid expansion and uses in Ghana. According to GSMA (https://www.gsma.com) "as of the third quarter of 2019, Ghana counted 16.7 million unique mobile subscribers, 15.1 million smartphone devices, and 10.7 million mobile internet users in the country". As such most organizations are currently relying on mobile applications to solve many issues and improve service provision within the service delivery industry. Hence adopting mobile technology in the management of patient appointments will give patients and potential clients the convenience and ease to access the services of the clinic no matter their location or time and also provide the facility with the opportunity to manage its resources efficiently.

The proposed project aims to develop an android mobile appointment booking application for Rhema Rapha medical Centre, which would ease off appointment scheduling for clients and give better client experience. The proposed system offers a mobile appointment booking application,

to view doctors list, services provided by the clinic, to cancel, and receive email reminders of appointment due dates to Rhema Rapha Medical Centre.

1.2 Problem Statement

Patient growth in a growing competitive sector such as the health care sector certainly is beneficial for the healthcare business. However, there are challenges (such as long waiting time, overcrowding) it presents to facility administrators and staff. The appointment process, especially in specialized service provision clinics, is challenging. Managing the appointment process is often a huge task that requires a lot of time and staff resources to manage. The current functional booking method available at the facility is either a walk-in booking or over the telephone (call-in). The appointment is then recorded into an appointment book.

This method, even though used by few clients has several challenges such as;

- Errors in the entry or no entry - due to the various human factors involved, calls received are sometimes not recorded in the appointment book and wrong dates or time are booked. Also, specialists are not informed on time, hence clients have to waste several minutes waiting for the arrival of the specialist.
- Time-consuming- front desk staff and clients have to spend time on the phone to book appointments, checking for availability of a doctor, checking the calendar, and taking clients' information to book an appointment.
- Lack of convenience – the phone is only available for appointment booking during working hours hence clients don't have access to the service after that time.
- Some clients also complain of their calls not being answered and have to drive to the facility for services at times where the specialist is not scheduled to be around.

In improving health care service provision, technology must be given a great deal of thought. Providers ought to enable individual patients to easily and conveniently access services at any time and place. Due to the advancement in mobile technology and motivated by the rapid growth in the use of mobile smartphones in the country, most organizations in the service industry have taken advantage to develop mobile applications to help solve the need for client convenience, time-saving, and reduction of human errors in booking appointments and provision of services. An android appointment system for clients of Rhema Rapha medical Centre will help solve issues of convenience in accessing services, long time spent in the facility, and errors in the existing appointment system.

1.3 Objectives of the study

1.3.1 General objective.

This project aims to develop a mobile (android) client appointment application for Rhema Rapha Medical Centre.

1.3.2 Specific objectives

To define requirements for an android clinic appointment booking system.

To develop an Android clinic appointment booking system for clients of Rhema Rapha Medical Centre.

1.4 Scope of the project

The study covers the analysis of the requirements for the designing and development of the android appointment booking application. The system will not be implemented as part of this current project. However, unit testing will be conducted on the proposed android appointment system.

1.5 Significance of the study

Rhema Rapha currently runs a paper-based appointment system. This mobile (android) appointment application is designed to manage the client appointment scheduling being handled by the paper-based system. The android appointment application will provide an opportunity for clients to book appointment to see a doctor, reschedule booked appointments, cancel an existing appointment, information on the services of Rhema Rapha Medical Centre, and have email notification of clients' appointments. The appointment booking application will help Rhema Rapha to efficiently manage employee working hours, thereby making it save financial resources paid to specialists with no work done.

The mobile application will ensure a higher level of customer service, help reduce long waiting times for clients, reduce human errors in the paper-based system and provide clients with the convenience to access the services of the clinic. It will also serve as an advertisement tool for the facility. The mobile appointment application when implemented will reduce the patient waiting time, thereby reducing overcrowding and increase client satisfaction at the facility.

1.6 Organization of the study

Chapter one presents the background of the study, covering the problem statement, the aims and objectives, the scope, and the significance of the study, and ends at the organization of the study report.

Chapter two presents the health information system adoption, quality of care, appointment management and its related key terms. It will also explore the research of the other existing knowledge related to the study topic.

Chapter three covers the study setting, methodology employed to carry out the study. It also presents the various stages of the system development life cycle (SDLC) method adopted that will be followed to develop the Android mobile appointment application.

Chapter four presents the results from the design of the Rhema Rapha appointment application which includes the use case diagrams, context diagrams, data flow diagrams and entity relational diagram. Results from the unit testing of the system are presented in the concluding part of this chapter.

Chapter five of the report presents the conclusion and recommendation on the study and as well as the limitation of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Health Information Systems

Reliable and accurate data is the backbone for health decision making and essential for healthcare policy formulation, health research, patient data analysis, health education and efficient service delivery. Advancement in technology has led to the development of health information systems in both developed and developing countries (WHO, 2008). A health information system is a system designed to capture, store, manage, and transmit health data or information. Healthcare information system helps in the collection, processing, use, and reporting of healthcare data/information (Kuhn, K. A., & Giuse, D. A., 2001).

A strong health information system, according to Measure Evaluation https://www.measureevaluation.org, (2017) is essential for countries in meeting their health goals. It further stated that "a strong health information system is supposed to be well-defined, comprehensive, functional, adaptable, resilient and scalable". Health information is an important factor in monitoring, tracking and tackling most of the world's crucial health challenges.

According to the WHO, (2008) health information system provides underpinnings for health delivery decision-making and has four main and important functions, which are data generation, compilation, analysis, communication, and use. In addition to serving as an underpinning to decision making, the healthcare information system also provides an alert and early warning capabilities, enabling patients and health care providers to well manage challenging health needs.

Examples of health information systems include the pharmacy information system for drug dispensing, inventory management systems, billing systems, medical appointment systems, radiology information system, nursing information system for the collection and storing of nursing information, clinic administration or management system, laboratory information system created for the ordering of laboratory tests, and to report test results. Health information systems have great potential to improve patient's health and the performance of health care providers. The implementation of health information systems leads to efficiency in healthcare management and improves the quality of patient care.

2.1.1 Challenges of health information system adoption and Implementation

The adoption of health information system is critical and has the potential of improving health care delivery, however, the adoption of health information systems has various challenges its presents.

Kuhn & Giuse, (2001) identified three main challenges associated with the adoption and implementation of HIS in health facilities, which include;

- Lack of financial support

  They make the argument that though health care providers accept the need for the adoption of health information systems to some point, they are not fully convinced on its strategic importance and the need to accept the high financial responsibilities in adopting HIS.

  Both the investors and governments in developing countries are more convinced in investing to improving physical infrastructures (buying beds, building new units, and

employing staff among others) with their scarce resources rather than investing in information systems.

- Difficulty to demonstrate return on investment

  Due to the intangibility of the health information system demonstrating the return on investment at the adoption stage becomes a difficult task,

  hence management at that stage is not well convinced to accept due to the huge financial resources needed to implement full health information systems.

- Difficulty in recruiting and retaining high quality IT staff.

  Recruitment and retention of high quality and experience IT personnel to lead the implementation of health information systems was one of the main challenges identified, this is due to the high competition and low financial commitment to support the implementation of HIS.

Korgaonkar, R. B. (2014) in his study also identified lack of financial support from both private investors and government as one of the main challenges affecting the adoption and implementation of health information systems in India and other developing economies. He further advanced three common health information system implementation failure scenarios; the implementation may start but may not be completed because of the inflexibility of the HIS, inexperienced implementation team and weak management or administrative involvement and will. Also, the adoption and implementation may be completed successfully but only some part of the information system will be functional due to weak supervision and staff unwillingness to use the system.

Finally, the implementation may be done and the system in full use but abandoned along the line due to the software not being user friendly, workflow not well planned or workforce not being part of the planning and development of the system.

Ngafeeson, M., (2014) also stated a range of challenges or issues with HIS adoption and implementation such as low adoption rates due to associated cost requirements, perceived lack of returns on investments in HIS, issues of privacy and security, lack of system coordination or interoperability, and health professionals resistance to use of technology.

2.1.2 Benefits of Health Information system Adoption

According to Ngafeeson, M., (2014), the adoption of health information systems (HIS) by health facilities has enormous benefits which include;

- Provision of accurate and complete statistics on morbidity and mortalities.
  Health information systems help gather, compile and analyse data from different departments and facilities hence decision-makers can have access to complete health statistics such as morbidity and mortalities.
- Elimination or reduction in the problem of loss of information in the paper-based or traditional systems due to poor filling systems.
- reduction in duplicate testing due to poor storage and retrieval systems
- Cost savings to both the facility and their client that is the adoption of appointments systems helps facilities to manage their staff time thereby reducing the cost of staff salaries for no work done.
- Collaborative and continuity of care: Patients sometimes need to attend different facilities or providers, health information systems such as health information exchange providers

the platform for health professionals to access the health records of the patient to continue care anywhere they visit.

The client, on the other hand, does not have to drive to the health facility or waste a long time on telephone calls to book appointments. Increase the efficiency of the health facility by reducing the number of times a client has to wait in the health facility and also facilitate administrative controls (Buntin et al.., 2011).

2.2 Quality of Care

Quality of care according to Fenny et al., (2014) is difficult to both define and measure. They further stated that if a patient can receive the kind of services they need and if the services provided are of benefit to the patient the quality of healthcare is assured. The American Institute of Medicine (IOM) defines the quality of care as "the degree to which health services for populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge". The IOM in their user's manual provided six main aims for improvement or measuring service quality, which are;

- Safety: patients who visit a facility ought to be safe, that is the absence of preventable injuries, errors in health care, and theft. They should be safe in the health facility as they are in their houses or homes.
- Effectiveness: the health services provided should match the science of care, there should be the avoidance of ineffective care practice, provide the best available procedures, devices and drugs for patient care.
- Patient-centeredness: health care provider should have the patient involved in decision making, respect the patients' choices, culture, social context, beliefs and specific needs.

- Efficiency: to prevent or reduce waste in health care delivery, thereby reducing the total cost to the patient and the facility, for instance, waste of supplies, equipment among others. Efficiency implies how optimal a health institution makes use of its input to produce the desired outcome.
- Equity: the health care system should seek to provide equal services to every patient no matter the race, ethnic group, religion and social status.
- Timeliness: health facilities should continually seek to reduce the patient waiting time within the facility. Waiting time in recent times is major customer satisfaction and measure of the quality of health care delivery.

2.2.1 Waiting time

Outpatient which is also commonly referred to the treatment of patients in a health facility that does not require an overnight stay in the health facility. The clients go for health care and return home on the same day. Outpatient services are important components of health delivery. The increase in the population and the number of people seeking healthcare has led to overcrowding at the OPD thereby causing the patient to wait for a long time before they are served (Mardiah et al., 2013). Waiting time as a measure of quality care refers to the time a patient waits in a health facility from entry to the time the patient receives care to the time the patient leaves the facility (Oche and Adamu, 2013). A clinic waiting time is an important indicator of a client's satisfaction, comfort to access its services, and the quality of care provided by the facility. Clinic waiting time has a great impact on the health care delivery process.

Studies by Egbujie et al., (2018) and, Cao et al., (2011) have indicated that long waiting time is a major cause of patient dissatisfaction in health care delivery, it also discourages the patient from visiting clinics in time to receive appropriate care at the onset of a disease. Sriram &

Noochpoung, (2018) also indicated that long waiting time may lead to serious consequences such as worsening health conditions of clients,

a decrease in the quality of life of a patient affects the mental health of patients, causes depression, and sometimes may lead to the death of patients.Oche and Adamu, (2013) asserted that any health organization that seeks to deliver exceptional healthcare services must strive to manage their client's waiting time effectively.

2.2.1.1 How to reduce long waiting time

Research has shown that the implementation of an effective and easy to access online appointment system has a major reduction on client waiting time. Egbujie et al., (2018) in their study observed that "changes were positive when a clinic appointment system was implemented". That is the implementation of efficient online appointment systems leads to a reduction in patient waiting time. Also, Mardiah and Basri, (2013) recommended the adoption of an online appointment management system to help reduce waiting time and manage staff time. This would help reduce payment made to employees, especially part-time specialist for no work done.

Furthermore, Mensah and Asamoah, (2014) recommended Nkawie Government hospital and Animwaa Health Centre to implement an online appointment system as one of the ways to reduce long clients waiting time of 80 minutes and over and to optimize patient flow into these facilities. Finally, Cao et al., (2011) concluded in their study that an online appointment could significantly reduce total waiting time and increase patient satisfaction.

2.3 Appointment Management

The appointment is described as "the period allocated in the schedule to a particular patient's visit and service time" (Mardiah et al., 2013). Appointment scheduling has evolved and become complex in health care delivery.

Idowu et al., (2013) enumerated few reasons that have given rise to this complication, which are a heavy flow of patients and health officers who practice in different health facilities and moves from one facility to the other to consult at different times.

An ineffective appointment management system could lead to time overlaps, patient dissatisfaction, an increase in the number of clients not showing up for appointments and revenue lost, and the cost incurred to the health facility through the payment of employees for no work done. Health facilities in recent times are moving from paper-based appointment to the adoption of online appointment systems, intending to make it convenient to access their services, improve quality of service and maximize revenue (Cao et al., 2011).

2.3.1 Types of appointment systems

2.3.1.1 Traditional Appointment Scheduling

The traditional booking system encompasses the walk-in where clients drive to the health facility, queue to book an appointment, and the phone call into the facility to solicit for available doctors and book appointments with the Doctor. Robinson and Chen (2009) observed in their study that the traditional system has lots of inconveniences and also most of the time has long appointment lead time (weeks, or Month in advance), which may lead to a high probability of no-shows. They further noted that in solving these uncertainties, providers normally over-book for each day. This strategy also leads to long waiting times and long queues at the OPD.

2.3.1.2 Online appointment scheduling

The online appointment booking or scheduling system is a system through which a client or patient can access the website or mobile software of the doctor or facility to easily book appointments to see the doctor. According to Khalid et al., (2018) online appointment system helps patients provide additional information to the doctor, which makes the doctor aware of their situation when needed.

An online appointment booking system helps patients to conveniently and securely book their appointments online, increase patient satisfaction with clinic registration, and reduces patient waiting time. Comparing the traditional paper-based appointment to the internet-based appointment system. The internet-based system enables easy generation of reports and auto-generated email or short message service (SMS) reminders to minimize appointment no-shows (Yan et al., 2015).

2.3.2 Benefits of appointment system adoption in health care

Online appointment system has various benefits to both the patient who will book the appointment and the facility. Appointment-Plus. (2012) and Nazia, S., & Sarda, E. (2014) enumerated several benefits the adoption of an appointment system brings to a health facility.

- Appointment system gives clients the flexibility to schedule and sometimes cancel the appointment for various medical care units within a facility.
- Appointment systems also provide daily, weekly and monthly patient schedule to the facility ahead of time.
- Helps management or administrators to track the flow of patients into the facility.

- Time and monetary savings; An online appointment system reduces the time spent on the phone by the front desk to book or reschedule or cancel appointment which helps free up working hours to do other task and sometimes reduces staff numbers needed at the front desk. It also saves the client time spent on the phone to book, cancel, and Reschedule appointments to do other important tasks. Time savings leads to monetary savings to both the facility and clients.
- Online appointment booking with automated email reminders reduces no-shows, over-booking patients and late cancellations.

2.3.3 Challenges of appointment system adoption in health care

Though appointment booking systems provide several benefits to both the client and the implementing facility, it also presents the facility with some challenges that need to be tackled. Various studies such as Lacy et al., 2004, Alyaha, Hijazi and Nusairat 2016, and Anisi et al., 2018 identified appointment no-shows as the major challenge of appointment system adoption, with unpunctuality been the other challenge needed to be addressed.

2.3.3.1 Appointment No-Shows

An appointment no-show refers to missed appointments by a patient within the time booked by the patient, and made no contacts to any staff in the clinic or reschedule or cancel the appointment. No-show for an appointment is a major challenge in the implementation of appointment systems (Lacy et al., 2004). No-shows have great effects on the patients and the health facility in the health delivery process. No-shows prolongs health care, lead to poor adherence to treatment, it also leads to loss of revenue, low productivity among staff.

In a study, the mean no-show prevalence from 62 studies was 23.8%, with 27.1% occurring in North America, 14.9% in Europe, and 24.3% from studies in Asia (Alyaha, Hijazi and Nusairat 2016). Anisi et al., (2018) in their study enumerated few reasons for patient no-shows which include transportation issues, improvement in health, miscommunication, and inability to leave work, and long appointment lead time without reminders. They further concluded that appointment lead time is the major predictor of appointment no-show and recommended the deployment of the reminder system and cancellation policy as a way to reduce no-show.

2.3.3.2 Unpunctuality

Appointment unpunctuality is defined as the arrival of a patient earlier or later than the appointment time (Zhu, H., Chen, Y. frank, Leung, E., & Liu, X., 2018). Some patients arrive earlier than their appointment time for care which may lead to a clash of patients.

Others also arrive later than the time they booked, making it difficult for health care providers to manage the appointment process. Patient unpunctuality has negative effects on the appointment scheduling process thereby reducing the efficiency and limits the ability of a clinic to serve its patients as planned.

2.4 Appointment Reminders

Appointment reminders are short messages or phone calls to draw clients' attention to pending appointment hours or days before the appointment due date. Studies have shown that the addition of reminders to appointment applications helps reduce the main challenges of the appointment system that is no-shows for appointments and unpunctuality by encouraging customers to reschedule or cancel appointments.

A study by Horvath et al., (2011) observed that monthly no-show and unpunctuality rates in the study clinics reduced significantly among clients who received email reminders. Also, Darden and Sperry (2020) concluded that auto-generated appointment reminders were found to have large reductions in appointment no-show rates among all kinds of patients.

2.5 Ownership and use of smartphones for health care in Ghana

In recent years, mobile phone ownership in sub-Saharan Africa has gone up considerably. Approximately "747 million sim connections in sub-Saharan Africa representing 75% of the population" (GSMA.com). In Ghana statistics from the GSMA (https://www.gsma.com) shows that as of the "third quarter of 2019, Ghana counted 16.7 million unique mobile subscribers, 15.1 million smartphone devices, and 10.7 million mobile internet users in the country", which makes Ghana the country with the highest mobile penetration in West Africa.The healthcare sector has been experiencing a rapid increase in the use of mobile platforms in the health care process.

In Ghana, mobile health (the use of portable devices with software applications to provide health services) has seen significant progress in the Ghana Health Service with the introduction of MOTECH. The mobile technology for community health, the E-tracker for HIV/AIDS ART, TB, and maternal and child health are deployed to aid inefficient health care delivery (Willcox et al., 2019). The expansion in the mobile industry has led to the development of several mobile applications for health care by the private sector like the Bisa application.

2.6 Android Application

Android is a Linux-based open-source operating system and is used to develop different kinds of applications for portable or mobile devices. The platform is designed for the development of various applications according to the user requirement (Choudhari et al. 2014).

Android according to GSMA.com is the most used mobile operating system in Ghana. Various studies have attempted the use of the android platform in developing appointment systems.

Choudhari, S. B., Kusurkar, C., Sonje, R., Mahajan, P., & Vaz, J. (2014) proposed an android application for Doctor's appointment. The proposed system was made of two main panels which include the patient's panel, where the patient registers with the system, and log in to the system and book the appointment.

The doctor's panel on the other hand helps the doctor to view all requests from their patients and responds to the patient's request by accepting the appointment request or rejecting the request and rescheduling the request. Bhuvaneswari, N., Latha, M., & Ranjith, E. (2017) also developed an android mobile system that allows the clients to register and log in to the system, book an appointment with a doctor, and can make complaints through the system.The application also allows the doctor to log in, and view appointments and clients' complain as well as provide solutions to the complaints.

Furthermore, Jain, A., Paraskar, N., & Kolhe, A. (2016) android application of patient appointment system. Proposed the development of an android appointment application system for patients, the system is a mobile android based medical appointment app. The main focus and scope of this study were to encourage patient-doctor interaction and communication. The system provides an avenue for patients to book an appointment with their doctors. The system also helps the patient to interact with a doctor through a messaging system. Modules in this system include the client registration, login, search for an available doctor, and request appointment. The system generates a QR code for the patient and accepts the appointment, the doctor then logs in and scans the QR code generated for the patient to view patient details.

Finally, Ajayi, O. O., Samuel, O., Samuel, O., & Paulina, A. O. (2019) in their study developed a mobile application for booking an appointment and consulting. The system allows the patient to book an appointment by fixing only date and time, and the system will allocate an available doctor at that particular time and date. The system also integrates a live consultation with doctors.

The study implemented the mobile application using the Android studio. The research played a major role in the field of medicine by allowing clients to book an appointment in real-time and allow patients and doctors to interact safely and securely.

Android has a built-in database and provides connectivity applications using some type of API's and a server, which makes the platform easy to use in the development of mobile applications such as appointment booking application.

CHAPTER THREE

METHODOLOGY

3.1 The Study Setting

The study was carried out at the Rhema Rapha Medical Center, an ultra-modern health facility established in 2017, located in Tse-Addo, La-Accra. Rhema Rapha Medical Centre provides specialized pediatric services (comprehensive child clinic), dental services, speech therapy, fertility clinic, vaccination, walk-in laboratory, eye specialist, nutritionist, postnatal and general and family care. The clinic also has two special products for its clients i.e. well-man clinic for annual health screening for the healthy man and well-woman clinic for annual health screening for the healthy woman. The facility has the vision to become the preferred provider of quality general, specialized, and diagnostic services in Ghana and a good corporate citizen to the communities it serves. With the mission to provide quality patient-centered general, specialized, and diagnostic services using competent, friendly, and well-motivated health personnel contributing to a healthy population. Rhema Rapha medical Centre has a customer base of generally middle and high-income earners with most being corporate organizations who use private health insurance for their employees.

3.2 System development life cycle

The development of software usually requires certain procedures to follow to achieve the set target or proposed system. The system development life cycle (SDLC) is an organizational procedure used in developing or maintaining a system. The SDLC models provide an overall list of processes required to complete a system development project.

To develop a system that best meets the user requirement specifications, the evolutionary prototype model of the System Development Life Cycle was used as a guide for the development of the proposed appointment system. The prototyping model is a systems development method in which a prototype, an early form of a final system is developed, tested, and then reworked incorporating the user feedback until an acceptable prototype is finally achieved from which the complete system or product can now be developed. The System Development Life Cycle in the evolutionary prototype model process includes the requirements gathering, analysis, prototype development, user evaluation, design, coding, and testing. The whole evolutionary prototyping process is an iterative model. Also, the first four stages (requirement, analysis, prototyping, and user evaluation) of the evolutionary prototype model will be repeated until an appropriate prototype that meets all the user's requirement is achieved.

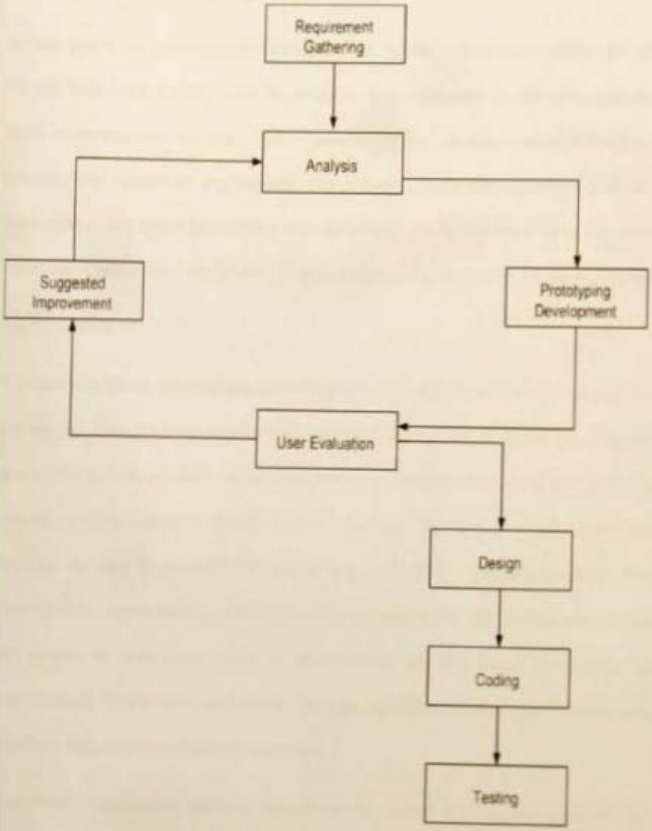


Figure 3.1 Evolutionary Prototyping Model

3.2.1 Requirement Gathering

At this phase, an investigation was carried out by the researcher to gather an initial requirement for the prototype. Existing similar projects were reviewed. Aside from the review of existing work an unstructured interview was conducted as well as observation of the current appointment process, and review of appointment paper forms. To better understand client requirements a prototype of the actual application was developed for the end-user to assess and feedback given to be incorporated into the system. The evolutionary prototype is an iterative process.

3.2.2 Analysis

The analysis phase involves the identification of functions of the system and the requirement of the system. Based on the requirement gathered, this phase of the process was divided into sub-phases the content analysis, interaction analysis, functional analysis and technical analysis. The content analysis indicates the content the user will provide. The proposed appointment system requires the user to provide registration and login details which include the name of the user, date of birth, email address, phone number and password. The interaction between the user and the system is paramount, there is an interface for the client to register, login and book appointment. The doctors and admin have an interface to view appointment details and for the admin to add, delete and modify contents.

Functional requirement analysis: based on the initial requirement gathered for the proposed appointment application, the system was divided into three sub-functions: which are the registration, login, selection of department, selection of doctor, date, and time by the client.

The reminder notification function, to provide auto-generated email messages to the client and the back-end section that will allow the doctor to view the appointment details, and for the admin

to add data, delete, modify and backup. The modification and backup are necessary to maintain the consistency of the database to meet the actual requirement.

Technical requirement analysis: this details the system development environment and tools. With the proposed appointment system, considering the system security and simplicity of the system, the Android platform (android 7 and above) was used as the operating system to run the programme, Windows 10 as the operating system (OS) for the development of the application, Visual studio code 1.5 as the IDE, the Nodejs and Dart as the programming language and for the back-end database, the PostgreSQL was used.

3.2.3 Prototyping

At this phase, an early approximation of the actual system referred to as prototype was developed using the information gathered during the requirement gathering and analysis stage. The initial prototype covered the registration and login section of the proposed appointment system. The prototype underwent multiple iterations by incorporating the user feedback from the initial prototype until the final prototype was agreed upon.

3.2.4 User Evaluation

At this phase, the prototype was implemented by the users with support from the researcher for an initial evaluation. This helped the developer to find out the strength and the weakness of the prototype. Suggestions and comments were collected from the users. This is to help the researcher to clearly understand the requirement specifications of the user.

3.2.5 System design

In order to well incorporate the user requirement into the system design the evolutionary prototyping model of the system development life cycle was adopted in the development of the proposed system. The design of the system was divided into two parts, the system application design, and the database design.

The context diagram, Use case diagrams were built to represent the system application and flow chart diagram, and the Entity relationship diagram to represent the database design. The design implementation is necessary to ensure all requirements are met before the final coding of the proposed system.

3.2.6 Coding

The system coding phase is the stage where developers start with the actual development of the system using selected programming languages. At this phase, the appointment system was divided into smaller units, and codes generated for each unit.

3.2.6.1 Programming languages

The programming language used for the appointment applications was NodeJS and Dart. Node.js is a JavaScript runtime built on Chrome's V8 JavaScript engine and JavaScript is an object-oriented programming language. Node.js is designed to build scalable network applications. To achieve good performance, Node.js uses an event-driven, non-blocking I/O paradigm. The backend of the appointment application was developed with this very robust programming language with the help of the NestJs framework.

NestJs gives you genuine adaptability by permitting the utilization of some other libraries because of modular architecture.it also exploits the latest JavaScript features, bringing configuration designs and mature solutions for node.js world.

The Mobile Application side of the system was built with Dart with the help of Flutter. Dart is an object-oriented, class-based, garbage-collected language with C-style syntax. Dart can compile to either native code or JavaScript. Dart is a client-optimized programming language for application with multiple platforms. Dart was built by Google to be used in developing desktop, mobile, web and server applications.

3.2.6.2 IDE: Integrated Development Environment

Visual Studio Code is a strong lightweight source code editor that is able to run on desktop and is available for Linux, Windows and macOS was the IDE for this project. VS Code has built-in support for JavaScript, typescript, and Node.js and has a rich ecosystem of extensions for other languages (such as C++, C#, Java, Python, PHP, Go) and runtimes (such as .NET and Unity). That is why the developer chose it as the IDE. Aside from its built-in support Visual Studio Code also has auto-complete features that automatically completes the syntax when developing. It has NodeJs and Flutter plugins that help you get all syntax and auto-complete widgets when developing. With its built-in Node.js debugging is very easy, the VS code permits the programmer to debug the application by putting breakpoints for monitoring run-time behaviour. GitHub together with Visual Studio Code, help to save progressive changes to the cloud. Which VSCode has a plugin that got the application covered.

3.2.6.3 Database Management System

PostgreSQL is the database management system to manage the database of the Mobile Appointment App (Rhema Rapha App). PostgreSQL is one of the most advanced open source relational database. One of the major reasons for choosing PostgreSQL is its open-source object-relational database system with a strong reputation for reliability, robustness and performance due to years of active development. PostgreSQL also permits developers to implement security policies such as, who can see which information and under what circumstances.

3.2.6.4 PgAdmin

The main administrative console for PostgreSQL, that will help to create database objects, view the data within the database, transfer data between databases, configure user accounts, replication and performs backups is the PgAdmin.

3.2.6.5 Operating System

In the development and implementation of the mobile appointment application, Windows 10 was adopted as the operating system platform. Windows 10 was selected to run the program because it provides a universal application platform, which is a developer can write the program on different platforms and still can run it on windows 10, hence few codes for the programmer to write and the system runs on different platforms. Windows 10 also provides a user-friendly interface and is designed to handle all devices regardless of the screen size, type, and function. After the development is done the app will run on the Android Operation System.

3.2.7 Testing

At this phase, testing is done to make sure the system works smoothly. Developers do testing to find out whether the codes and programming work meets the requirement of the users or customers. Various forms of testing include quality assurance testing, system integration, system testing, unit testing among others (Ajayi et al, 2019). Unit testing was adopted to test the functionality of the various modules within the appointment system.

3.3 Conclusion

With the evolutionary prototyping for the proposed system, the first four of the process were repeated until a final prototype was agreed upon between the researcher and the users. The prototype evolves into the final system through iterative incorporation of the user suggestions or feedbacks, hence the final prototype was evolved into the final designs.

CHAPTER FOUR

RESULTS

4.1 Features of the system

The main features the system will exhibit or possess as identified during the analysis phase are shown in the diagram below. The system provides time and dates the doctor is available for patient to select to book an appointment, the patient is able to cancel booked appointment and also receives email reminders.

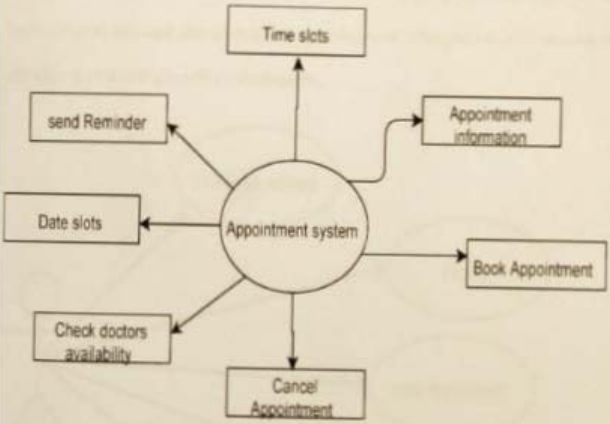


Figure 4.0 Main features of the proposed system

4.2 Use case diagrams

Use case diagram is used in presenting a pictorial system requirement of a proposed application or system. Use cases are an exact and or realistic representation of the activities of the system. The communications between the actor and the use cases are also explained using the use case diagram. The use case diagrams of the proposed system (Rhema Rapha app.) are presented in figures below.

Figure 4.1 Proposed Use Case model for Patient

The patient registers to the system to create log in details, logs in to the system, books appointment and can cancel booked appointment. The patient also manages his or her profile by providing or editing profile information.

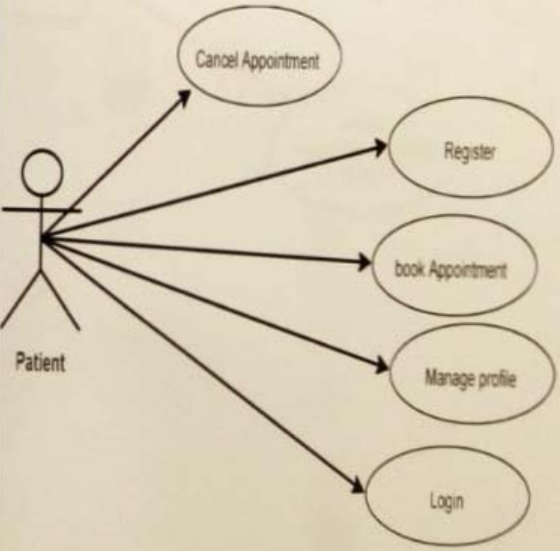


Figure 4.2 proposed Use Case model for Doctor

The doctor logs in to the system, view list of appointments booked to see him or her. The doctor is also allowed to book a follow-up appointment for a client.

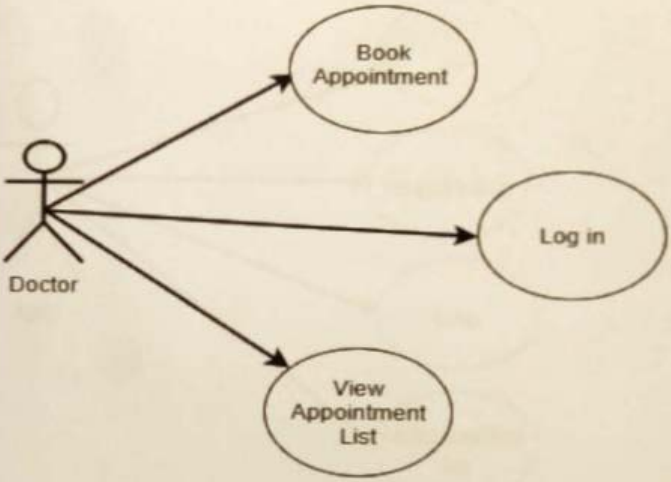
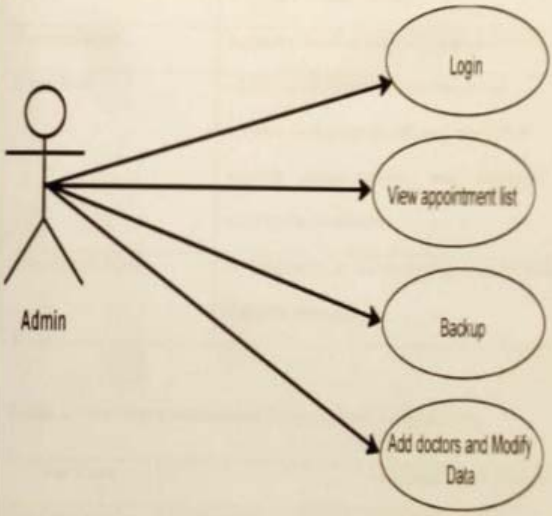


Figure 4.3 proposed Use Case model for Admin.

The admin logs in to the system, adds and delete a doctor to the system, admin is able to view appointment list, modifies data in the system and performs back up in the system.



4.2.1 Use Case specifications for the proposed system

Table 1. Use Case specifications for Login

Use Case	Login
Brief description	To login to the application
Actor	Admin, Patient, Doctor
Pre-condition	An actor needs a valid ID and password
Main flow	-Actor must enter ID and Password -system validates the ID and Password -system grants access and displays the Home screen after successful validation
Alternative Flow	If validation is unsuccessful system denies access and displays a warning message.

Table 2. Use Case specification for new Doctor registration

Use Case	Register New Doctor
Brief description	To register a new Doctor in the system
Actor	Admin
Pre-condition	An actor needs to login into the system
Main flow	- Enter personal details of a new Doctor - Select a department for doctor -Confirm Registration and new Password
Alternative Flow	Any invalid details entered, system display warning message

Table 3. Use Case specifications for patient registration

Use Case	Patient Registration
Brief description	To register a new patient to the system
Actor	Patient
Pre-condition	The actor needs to open the appointment application
Main flow	-Enter all needed personal details -Submit registration, a successful registration message will be displayed.
Alternative Flow	If any invalid details are entered, a warning message will display.

Table 4. Use Case specification for appointment booking

Use Case	Booking appointment
Brief description	To book an appointment with the system
Actor	Patient
Pre-condition	The actor must log in to the system
Main flow	- Actor must select a department -Actor must select a doctor -Actor must select the appointment type -Actor must select the Date and time available -Actor can write a brief description -Actor needs to submit the appointment -System displays successfully appointment message
Alternative Flow	If any invalid details entered, a prompt message display

Table 5. Use Case specification for manage profile

Use Case	Manage profile
Brief description	To manage the profile of the patient
Actor	Patient
Pre-condition	The actor has to login into the system
Main flow	-Actor to select Profile -Actor can edit the profile with personal details required -Actor can save changes to the system -System displays successfully saved profile message
Alternative Flow	If any needed detail is invalid, a warning message is displayed

Table 6. Use Case specification for cancel appointment

Use Case	Cancel Appointment
Brief description	To cancel booked appointment
Actor	Patient
Pre-condition	The actor has to login into the system
Main flow	- Actor must open booked appointments -Actor has to select an appointment to cancel -Actor can cancel the booked appointment -Successful cancellation message display
Alternative Flow	If cancel is unsuccessful, prompt message display

4.3 Context Diagram

Context diagrams define the part of the system and its environment. It shows the entities that communicate with the system. In the proposed system the patient identifies the doctor and the department and make the appointment, the system verifies the appointment details and the availability of the doctor and confirms the appointment. The doctor and or the admin can see the appointment and patient details once they log in to the system.

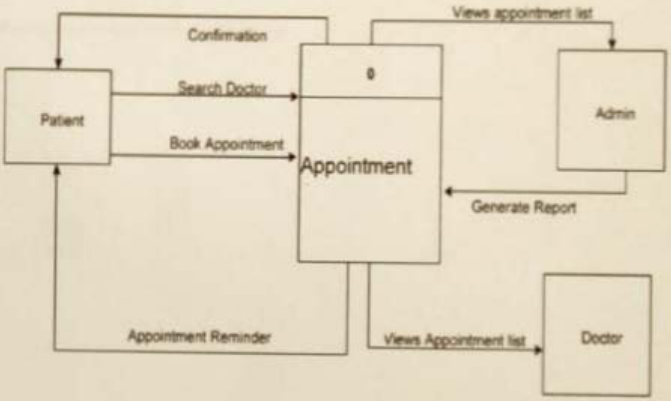


Figure 4.4 Proposed Context Diagram of the application.

4.4 Flow chart diagram

A flow diagram depicts how data flows in a system and the sequence of activities in a process. Flow charts do not normally show decisions, just the flow of data. The system flow chart for the proposed system is shown in figure 4.5. The chart below shows the process in the system by flow symbols, at start an existing user logs in to the system, new users have to create account or register to the system to be able to log in to the system. Based on the type of user the functionalities are accessed respectively after log in, for instance a patient after logging in selects department, select doctor, select date and time, enters a description or any other information if any and select submit to book appointment.

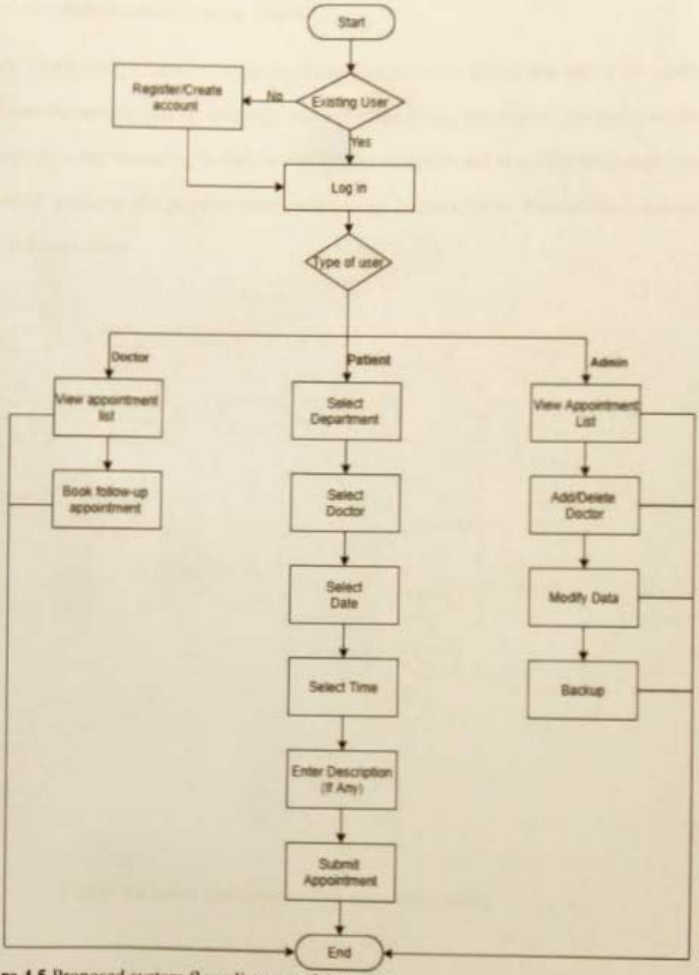


Figure 4.5 Proposed system flow diagram of the system

4.5 Entity Relationship Diagram (ERD)

Entity Relationship diagram is a graphical representation of a system that shows the relationship between the people, places, concepts, and activities within the system. An entity-relationship diagram is a data modelling technique that defines processes and is used as the foundation for a relational database. The proposed entity relationship diagram for the Rhema Rapha appointment app. is shown below.

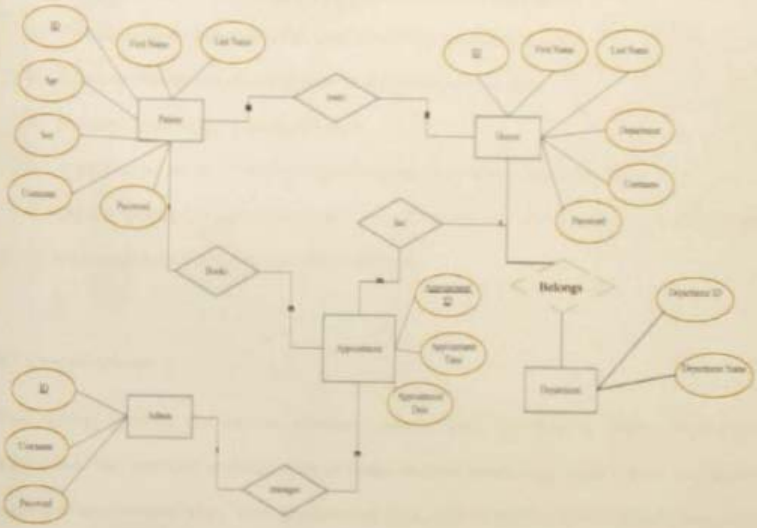


Figure 4.6 Entity Relationship Diagram of the system

4.6 Business rules

1. A patient can have only one account in the system
2. A patient can book more than one appointment with the same doctor on the same day.
3. Consultation hours by a visit of weekdays begin at 8 am to 4:30 pm and 8.30 am to 2.30pm on Saturdays for pediatric and general practice, and consultation hours by voice or on phone on weekdays begin at 8:30 am to 6:30pm and 7am to 8pm on Saturdays.
4. An appointment can be made at least 24hours or more in advance.
5. Priority is given to people with appointment than walk-in clients
6. Email reminders are sent 6hours to the appointment due time.
7. A doctor must belong to a department
8. A patient can cancel an appointment 24hours to the appointment due time.
9. On the average a consultation last for 15minutes for one on one visit and 10mins maximum for a voice call (on phone consult).

4.7 User interfaces

This section presents the various interface outputs from the Rhema Rapha appointment application. The interface is made of up of forms such as home page, login screen, registration page, new appointment page, view appointment page, patient profile, doctor details, and admin page. Sample auto-generated email reminder message from the system is also shown below.

4.7.1 Home page

Figure 4.7 shows the home page of the appointment application. Here when the patient knows the Doctor he/she selects the doctor from the list of doctors and makes the appointment, otherwise, the patient will have to click on book appointment select the department or service and select an available doctor to book an appointment.

Figure 4.7 home Screen

4.7.2 Log in Screen

Figure 4.8 shows the login screen of the system. If a client is new to the application, he/she will have to create an account to be able to log in. Existing clients will need their email address and password used for the registration to log in.

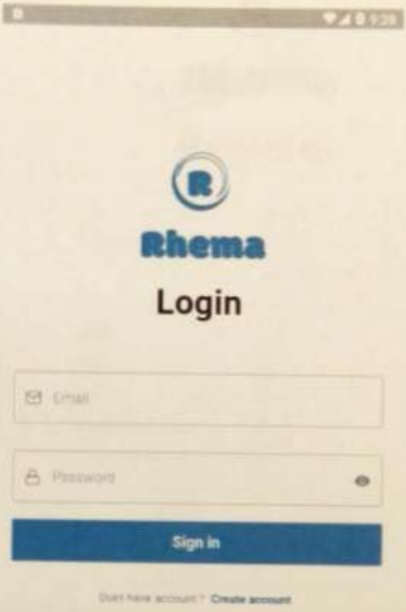


Figure 4.8 Login page

4.7.3 Registration Page.

Figure 4.9 shows the registration page. A patient has to provide all the information (full name, Email, Phone number, Date of Birth, and password) to be able to register.

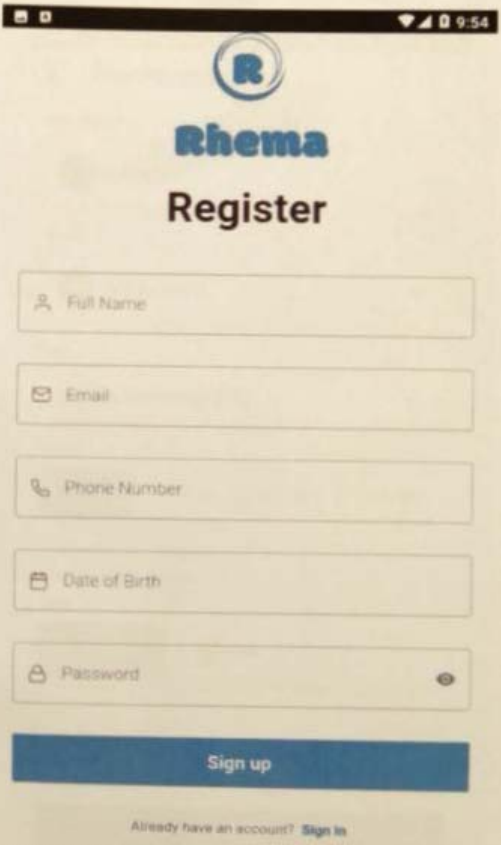


Figure 4.9 Registration page

4.7.4 New Appointment Page

Figure 5.0 shows the appointment page, it shows the processes to go through for a patient to book an appointment. It shows the department, available doctors, date, time, time of appointment, and a brief note if any, then submit the appointment.

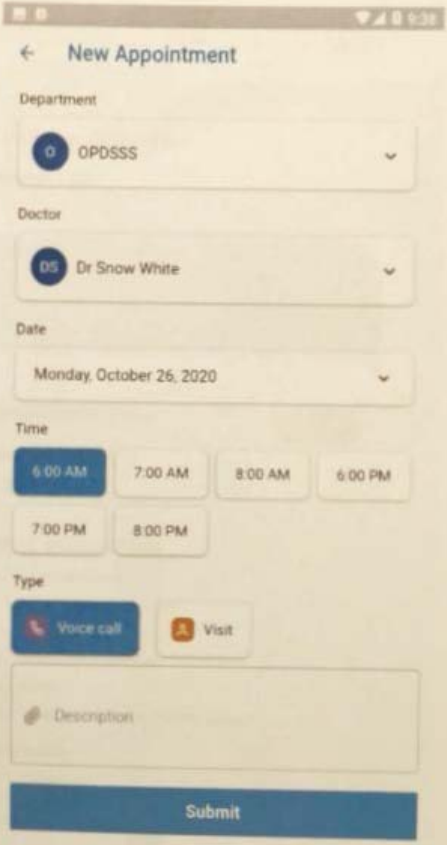


Figure 5.0 New Appointment Page

4.7.5 View appointment Page

Figure 5.1 shows details of a booked patient appointment, it shows the type of appointment, doctors, and the client information for the doctor. This page allows the patient to cancel the appointment by clicking the red cancel button and clicking ok for the warning message.

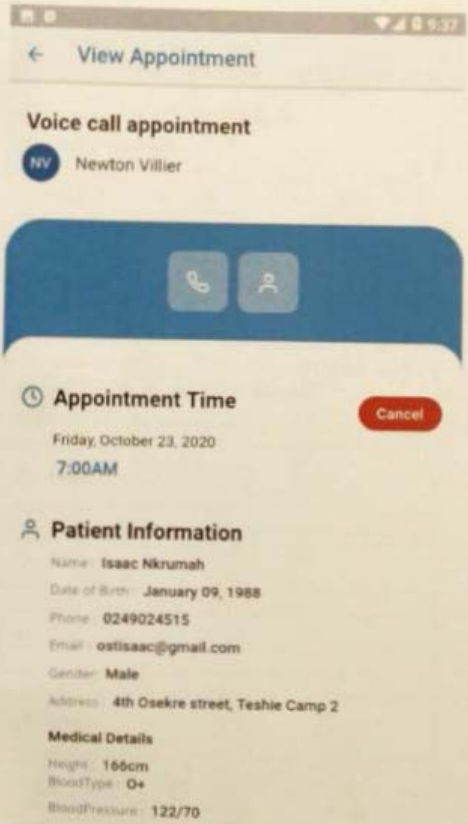


Figure 5.1 View appointment page

4.7.6 Patient profile page

Figure 5.2 shows the patient profile, where the patient provides extra information and details about the User.

Figure 5.2 Profile page

4.7.7 Doctor details

Figure 5.3 shows the details of the doctor, that is phone number, available days, time, department, etc. Once the patient views the information he/she can book an appointment with the doctor from this page by clicking on the make appointment button on this page to book appointment.

Figure 5.3 Doctor Details

4.7.8 Admin page

Figure 5.4 shows the back-end managed by the Administrator to view, update, delete, and add doctors to the system. The admin is allowed to edit or modify information in the database and also view all appointments booked. The doctor is given access to the back-end to view appointment booked to him/her and he can also book an appointment for a client. The doctor can change the password and his details after he has been added by the admin.

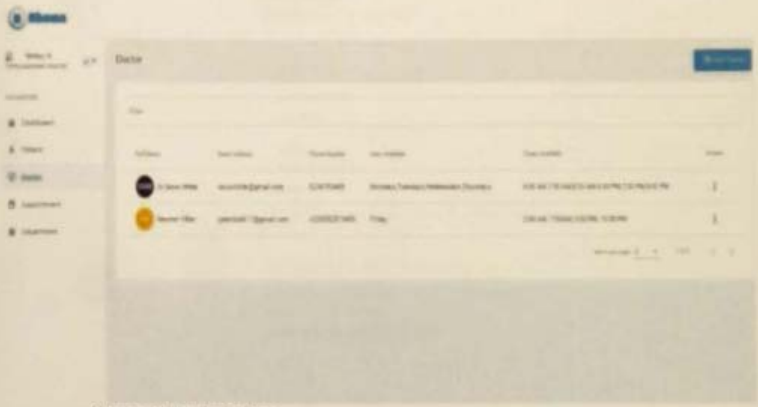


Figure 5.4 Admin Page

4.7.9 Reminder message

Figure 5.5 shows the reminder message sent to the client 12hours and 6 hours to the appointment due time.

Figure 5.5 Reminder message

4.8 Testing Results.

Testing is done to make sure the system achieves its set out goals and also ensures it works smoothly. The results show a 100% success rate for the eight main units of the system tested. Below are the results of the unit testing conducted on Rhema Rapha appointment booking application.

Table 7 shows the testing done on the appointment application (Rhema Rapha appointment Application).

MODULES TESTED	EXPECTED RESULTS	FINAL RESULTS
Log in module	Allows users to log in to the system, by taking their username and password.	Successful
Patient Registration	Allows patients to enter details needed and registers patient.	Successful
Appointment Booking	Allows the patient to fill in the appointment information and book an appointment.	Successful
Cancelling Appointment	Allows a patient to cancel a booked appointment.	Successful
Update profile	Allows the user to add and update personal information in their profile.	Successful
View appointment list	Allows Admin/Doctor to view the appointment list.	Successful
Register new doctor by Admin	Allows admin to enter new doctors' information and register him/her.	Successful
Send a reminder message to the client/patient	Sends reminder message to the email of the patient 6 hours to the appointment time.	Successful

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The purpose of this study was to develop a mobile (android) client appointment booking application for Rhema Rapha Medical Centre, specifically, to define requirements for an android clinic appointment booking system and to develop an Android clinic appointment booking system for clients of Rhema Rapha Medical Centre. Results from the study demonstrate a successful requirement definition for an android appointment application (registration, log in, appointment booking interface requirement, an interface for doctor and admin to view appointment list, interface for admin to modify, add or delete and backup data, and requirement to provide clients with reminder messages). The project was successfully executed to achieve the objective of developing an android mobile appointment booking system for the clients of Rhema Rapha Medical Centre and provide email reminders to patients on their appointment due time.

With the development of this android appointment booking system for Rhema Rapha, Its is anticipated that a full implementation of the appointment system will accrue various benefits for the facility, which includes; patients will no longer have to spend lots of time on phone calls or drive to the facility to book an appointment, the application will provide a quick view of appointments booked by the patient and will also provides email reminder messages, which will help reduce the number of missed appointment or appointment no-shows. The system will further reduce the workload on the front desk personnel who use the paper-based system. Finally, the system is capable of providing easy and effective storage of information for clients who come to the facility with appointments.

5.2 Recommendation

The following recommendation could be considered in the future for successful implementation and long use of the application at the facility.

- Future expansion from just android to IOS and windows.
- Improvement to include mobile money payment platform for clients who book an appointment to pay their consultation fee, especially for voice call appointment.
- Training of staff on the use and importance of the system.
- Provides quick introduction of the system to clients who visit the facility.
- Inclusion of SMS reminders to the email reminders.

5.3 Limitation of the Study

The main limitation of the study was the short time within which the study was executed.

The outbreak of the coronavirus (COVID-19) was also a major limitation due to various restrictions in movements.

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