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CHITETEZO PA MOYO: AI-DRIVEN MICRO-INSURANCE FOR HEALTHCARE IN MALAWI

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Guide

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Project Report

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LIST OF ACROYMNS

ACROYMN	MEANING
AI	Artificial Intelligence
ML	Machine Learning
USSD	Unstructured Supplementary Service Data
API	Application Programming Interface
UI	User Interface
OTP	One Time Password
WHO	World Health Organization
UX	User Experience
NLP	Natural Language Processing
NGO	Non-Governmental Organization
DFD	Data Flow Diagram
CRUD	Create, Read, Update, Delete (database operations)
MoH	Ministry of Health

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ABSTRACT

The outcome is that high quality health care services highly limited in Malawi has been affordability, insufficient infrastructure and very little insurance coverage. Most of the traditional health insurance companies charge services that are absolutely unaffordable for the low income and rural communities in these isolated areas where digital exclusion is compounded with a lack of Smartphone ownership and poor internet connectivity. A lack of tailored services for various health needs, and delays in emergency response, coupled with inefficiencies in manual claim processing, worsen financial vulnerability. Importantly, these, therefore, emphasize the need for innovative, tech-enabled solutions. Evidence-Driven Health furthermore constrains meaningful policy formulation and strategic resource mobilization. Without smart systems, insurance companies do not have the competence to evaluate risks adequately, predict health trends or cut survey costs but fail to deliver sufficiently their output.

The aforementioned gaps can adequately be filled through introducing Artificial Intelligence and Machine Learning within the Chitetezo Pa Moyo platform to provide efficient real-time risk assessments, automated claims adjudications, policy recommendations for particular issues in addition to deep user engagement. Such development holds the potential of bridging the digital divide and transforming access for poorer Malawians.

Keywords: Insurtech, micro-health insurance, mobile money, access to healthcare, telemedicine, financial inclusion, Malawi.

CHAPTER I

1. INTRODUCTION

Access to quality and affordable healthcare remains one of the most pressing challenges in Malawi, particularly for people living in rural areas. Similar to the way solar energy has transformed energy access in low-resource settings, digital technology and intelligent systems are now emerging as powerful tools to bridge gaps in healthcare. Malawi has one of the lowest health insurance coverage rates in sub-Saharan Africa, with a majority of citizens, especially in rural regions, relying on out-of-pocket expenses or under-resourced public health facilities. This has left many families vulnerable to health-related financial shocks and has led to delays in treatment, worsening health outcomes, and an increased burden on already stretched healthcare systems. The **Chitetezo Pa Moyo (Safeguarding Life)** initiative proposes an innovative micro-insurance solution powered by Artificial Intelligence (AI) and Machine Learning (ML) to tackle these longstanding problems. Just like how solar energy is considered a clean, reliable, and low-cost alternative for households and agriculture, AI-powered micro-insurance can be a sustainable and inclusive model for delivering health coverage to the underserved. Through intelligent risk assessment, automated claims processing, and offline-compatible access channels like **USSD** and **SMS**, this platform aims to make health insurance accessible even to people without smartphones or internet connectivity.

Moreover, Malawi's rural health infrastructure is not only underdeveloped but also lacks integration with digital tools for proactive care and efficient service delivery. Chitetezo Pa Moyo addresses these gaps by offering personalized insurance plans based on a person's medical history, location, and income level, while ensuring real-time system monitoring—similar to how smart solar energy systems detect faults and inefficiencies to improve energy yield.

The **AI and ML models** will help assess individual risk levels, suggest policy recommendations, and trigger early alerts in medical emergencies through automated messages. By adopting this technology, Malawi can take a major step toward universal health coverage, reducing dependency on traditional systems that are often inefficient, expensive, and inaccessible to many. Chitetezo Pa Moyo is therefore not just a project, but a life-changing platform designed to improve health security, promote financial inclusion, and ultimately safeguard the lives of Malawians through the power of intelligent and inclusive micro-insurance.

1.1 BACKGROUND OF STUDY

Malawi, like many sub-Saharan African countries, is burdened by multiple challenges in the healthcare sector. These challenges include a high prevalence of communicable and non-communicable diseases, insufficient health infrastructure, poor funding, and a lack of skilled medical personnel. According to the World Health Organization, the doctor-to-patient ratio in Malawi is significantly lower than the recommended average, and over 70% of Malawians rely

on out-of-pocket payments to access healthcare services. This reliance on out-of-pocket expenditure forces many families to choose between health and other essential needs, often leading to catastrophic financial consequences.

One of the most pressing issues is the lack of affordable and accessible health insurance. The health insurance penetration rate in Malawi remains low, especially in rural areas, due to high premiums, lack of awareness, and limited infrastructure to support insurance operations. Traditional insurance models are often designed without the needs of low-income earners in mind and fail to account for the socioeconomic realities of people living in rural areas. Micro-insurance has emerged as a viable alternative, providing low-cost, accessible insurance options tailored for low-income populations. However, the micro-insurance models currently available in Malawi are either unsustainable or fail to meet the real needs of their target users. These systems are often paper-based, difficult to manage, and prone to fraud and inefficiency. The application of artificial intelligence (AI) and machine learning (ML) in micro-insurance introduces new possibilities for addressing these challenges. AI and ML can be used to personalize insurance policies, automate claims processing, detect fraudulent activities, and provide insights that help in designing effective health programs. The "Chitetezo Pa Moyo: Safeguarding Life" project aims to build an AI- and ML-driven micro-insurance platform that ensures inclusive access to healthcare in Malawi. It combines mobile technology (including USSD and SMS support), multilingual interfaces (English and Chichewa), and real-time emergency response features to provide comprehensive, affordable, and accessible health insurance services. The system is designed to function even in remote areas with limited internet access, making it suitable for Malawi's diverse population.

1.2 OBJECTIVES

The main objective of this project is to design, develop, and deploy a comprehensive AI- and ML-powered micro-insurance platform that improves access to inclusive, affordable healthcare services in Malawi, particularly for underserved communities, by leveraging mobile technologies, intelligent systems, and multilingual support.

To design and implement a micro-insurance system accessible through mobile (USSD and SMS) and web platforms, ensuring wide reach including users without smartphones or internet access.

To develop and integrate artificial intelligence (AI) and machine learning (ML) algorithms capable of profiling individuals, assessing health risks, and dynamically generating affordable and personalized insurance policies based on data-driven models.

To automate the insurance claims process using intelligent systems that can validate, prioritize, and process claims efficiently, reducing manual intervention and turnaround times.

To integrate GPS, SMS, and emergency contact modules into the system to enable real-time emergency response, allowing policyholders to request help during medical emergencies via mobile technologies.

To build a user interface for both mobile and web platforms that supports multilingual usage (English and Chichewa), ensuring accessibility and usability by a wide demographic, including rural and semi-literate users.

To evaluate and analyze the system's performance in terms of its ability to increase healthcare access, reduce financial burden, and improve health outcomes in low-income or remote areas, using metrics like enrollment rates, claim frequency, and user feedback.

1.3 SYSTEM DESCRIPTION

Chitetezo Pa Moyo (Safeguarding Life) is an AI and machine learning-powered micro-insurance platform designed to improve access to affordable and inclusive healthcare services in Malawi and other underserved regions. The system leverages technology to provide life-saving health insurance through mobile-first channels such as USSD, SMS, and mobile apps, ensuring accessibility even in low-connectivity, low-literacy environments. The platform consists of three major components: a backend service built with Python (Flask), a cross-platform mobile frontend (React Native), and integrated machine learning modules for health risk assessment and fraud detection. It is also equipped with multilingual support (English and Chichewa) and integrates with third-party APIs for mobile money (e.g., Airtel Money, TNM Mpamba), emergency alerts (e.g., SMS gateways), and geolocation services (Google Maps).

1.4 LITERATURE REVIEW

Access to inclusive and affordable healthcare remains a critical challenge in Malawi, especially among rural populations. With over 80% of Malawians residing in remote areas, the integration of mobile technology, micro-insurance, and intelligent decision-support systems is seen as a promising solution. This literature review examines recent studies (2020–2025) focusing on micro-insurance, mHealth, emergency systems, AI/ML in healthcare, multilingual interfaces, and digital identity—all of which inform the development of the *Chitetezo Pa Moyo: Safeguarding Life* platform.

Micro-Insurance in Low-Income Communities

Recent literature emphasizes the expansion of micro-insurance as a safety net for underserved populations in Africa. A study by Tadesse et al. (2021) highlights the role of **community-based health insurance (CBHI)** in enhancing financial protection and healthcare access in Ethiopia, reinforcing the need for localized, low-cost insurance models. Mutezo (2020) notes that digital

micro-insurance platforms—when combined with mobile technology—can increase enrollment and reduce administration costs. However, challenges still include **limited literacy, trust issues, and lack of claim transparency**, which *Chitetezo Pa Moyo* addresses using USSD and AI-driven policy automation.

Mobile Health (mHealth) Technologies and Rural Healthcare

The period from 2020 onward has seen significant growth in **mobile-based healthcare interventions**. According to Masika et al. (2022), SMS-based health alerts and USSD health services have proven highly effective in areas with poor internet connectivity. In Malawi, mobile systems deployed by *mHealth Malawi* and *VillageReach* have been shown to improve immunization tracking and maternal care. WHO Africa's 2021 report encourages **mHealth apps that integrate local languages and offline features**, which aligns with *Chitetezo Pa Moyo*'s dual-channel (USSD/SMS) model.

Emergency Medical Response Systems in Rural Africa

Recent findings emphasize the urgent need for **mobile-enabled emergency response systems** in rural Sub-Saharan Africa. Chipeta et al. (2023) explored how **GPS-enabled medical alert systems** can help dispatch community responders in Malawi, even in the absence of formal ambulance services. Similarly, Moyo et al. (2021) developed a decentralized mobile alert platform that uses SMS and geolocation data to coordinate emergency transport with local motorcycle taxis. *Chitetezo Pa Moyo* integrates these concepts through **real-time GPS-based alerting and community-level coordination** features.

Artificial Intelligence and Machine Learning in Health Risk Assessment

The application of **AI and ML** in public health has grown rapidly since 2020. A key study by Rajkomar et al. (2021) demonstrated how machine learning can predict health risks using minimal data inputs, ideal for **low-resource settings**. In Malawi, Chikafa et al. (2022) applied ML to predict maternal health risks using anonymized health records, improving decision-making for community health workers. *Chitetezo Pa Moyo* builds upon these findings to develop AI-powered user profiling, risk scoring, and adaptive policy generation.

Multilingual and Inclusive Interfaces for Digital Health

Digital inclusivity remains vital in post-2020 health platforms. Research by UNESCO Malawi (2022) and Kamwendo et al. (2023) shows that **interfaces in local languages significantly boost usability** and trust in digital health tools. Studies in Zambia and Kenya further confirm that **Chichewa and Swahili support** help users interact with health systems more confidently. In response, *Chitetezo Pa Moyo* is built with a **bilingual interface (English and Chichewa)** designed for semi-literate users in rural areas.

Digital Identity, Authentication, and Privacy in Health Platforms

Recent work by Ngwira et al. (2021) and World Bank Digital ID Report (2023) stresses the importance of **secure identity verification** in health applications. Use of **JWT (JSON Web**

Tokens) and **OAuth2.0** protocols has become standard in modern mobile/web systems, ensuring role-based access to sensitive medical and insurance records. *Chitetezo Pa Moyo* adopts **role-based access control (RBAC)** and encrypted login systems to protect user privacy, while still supporting **emergency override** in critical cases.

1.4.1 SUMMARY REVIEW

The purpose of this study was to conduct an in-depth investigation into AI and machine learning-powered micro-insurance systems and assess their potential to improve healthcare access in low-resource settings like Malawi. The research explored existing health insurance models, their limitations, and the gaps in inclusivity, efficiency, and accessibility—especially for rural and underserved communities. It was found that traditional insurance systems often lack personalization, are administratively burdensome, and exclude those without digital access.

From the findings, it became clear that there is a strong need to develop an intelligent and inclusive health insurance platform that leverages modern technologies such as artificial intelligence, machine learning, and offline-compatible tools like USSD and SMS. The **Chitetezo Pa Moyo** system addresses these needs by enabling remote, real-time access to affordable healthcare coverage, policy customization based on user risk profiles, and automated claims handling. It is envisioned that this system will significantly improve how low-income and rural populations interact with and benefit from health insurance services ultimately promoting equity, efficiency, and resilience within Malawi's healthcare ecosystem.

CHAPTER II SYSTEM ANALYSIS

2.1 PROBLEM STATEMENT

Problem definition identifies the core challenges that users face with current health insurance systems, especially in Malawi. The majority of the population, particularly those in rural and low-income areas, face extreme difficulties in accessing affordable, timely, and reliable healthcare services. Traditional health insurance models are not only expensive but also inaccessible to those without smartphones, internet, or digital literacy. The **Chitetezo Pa Moyo** project aims to eliminate these challenges by providing a micro-insurance system that leverages artificial intelligence, machine learning, and offline technologies like USSD and SMS to make healthcare inclusive, intelligent, and responsive.

The main aim of the project is to provide accessible, AI-driven health insurance services that work both online and offline, ensuring real-time access to health coverage, emergency alerts, and personalized policies tailored to individual and community needs. The system is designed to support low-resource communities, improve healthcare financing, and strengthen Malawi's public health resilience.

1. **Lack of Accessible Health Insurance Services:** A significant portion of Malawians lack health insurance due to high costs and complex registration processes. Existing services do not cater to individuals without smartphones or internet access, leaving millions without financial protection during illness.
2. **Inefficient Claims Processing and Risk Assessment:** Traditional insurance companies use manual processes that delay claims approval and are prone to fraud. Without smart systems, they cannot evaluate health risks accurately or adapt plans based on user data.
3. **Digital Exclusion in Rural Areas:** Rural populations are excluded from modern digital health systems due to low smartphone penetration, poor internet coverage, and language barriers. There is a critical need for a system that operates on basic phones using USSD/SMS in local languages like Chichewa.
4. **Lack of Emergency Response Integration:** In emergencies, delays in communication and coordination often lead to preventable deaths. The current systems do not connect patients with local ambulances or health workers in real time.
5. **Policy Mismatch and Lack of Personalization:** Health insurance plans are generally uniform and fail to consider individual health profiles, regional disease patterns, or economic situations. This leads to unfair pricing and low user engagement.

The **Chitetezo Pa Moyo** system seeks to address these core challenges by implementing AI-powered profiling, real-time claims automation, emergency response integration, and offline accessibility—creating a truly inclusive health insurance platform for all Malawians.

2.2 EXISTING SYSTEMS

Several studies and existing health insurance systems have attempted to address the issue of healthcare financing and access, especially in low- and middle-income countries. However, most of these systems are still largely conventional in nature and fall short when applied in rural, resource-limited settings like those in Malawi. The majority of health insurance platforms currently available in the market focus on urban populations, require internet access or smartphone use, and operate using standardized policy models that do not cater to individual needs or real-time risk factors.

Globally, micro-insurance schemes have been implemented in countries such as India, Kenya, and Bangladesh, targeting low-income communities with basic coverage. However, most of these models still rely on manual enrollment, paper-based claims processing, and lack intelligent automation or emergency response integration. Systems such as NHIF (National Health Insurance Fund) in Kenya and Rashtriya Swasthya Bima Yojana (RSBY) in India have shown promise, but their models do not fully address digital inclusion or offer scalable AI-powered solutions.

In Malawi, health insurance coverage is still very low, and most systems are donor-funded pilot programs or government-driven initiatives with limited scope and sustainability. There is no widely deployed intelligent micro-insurance solution that includes real-time risk assessment, automated claims processing, and offline access through USSD or SMS. Most health services require physical registration, and users must visit clinics or insurance offices to inquire about coverage or submit claims.

Moreover, there is no integration with emergency medical services, meaning users in rural areas often lack access to rapid medical transport during life-threatening events. Additionally, personalization is rarely implemented, and premiums are typically fixed without considering individual health risks, making the systems unfair or unaffordable for many.

The **Chitetezo Pa Moyo** platform seeks to bridge these gaps by using artificial intelligence and machine learning for dynamic risk profiling, automating the end-to-end insurance process, and offering real-time access to healthcare support via mobile (USSD/SMS) and web platforms. Unlike existing systems, it is tailored for Malawi's unique socio-economic and digital context, especially targeting low-income and rural communities that are often left behind.

2.3 FEASIBILITY STUDY

2.3.1 Executive Summary

A feasibility study was conducted to determine whether the Chitetezo Pa Moyo: Safeguarding Life micro-insurance project could be successfully implemented and sustained within Malawi's healthcare and technological environment. This study evaluates the technical, operational, financial, and environmental aspects of the system. The aim is to ensure that the proposed solution not only meets the academic requirements set by the university but also delivers tangible benefits to real-world users.

2.3.2 Technical Feasibility

The *Chitetezo Pa Moyo* system is technically feasible due to the availability and adaptability of modern technologies such as Python (for backend development), machine learning frameworks (e.g., Scikit-learn, TensorFlow), and mobile-accessible technologies like USSD and SMS APIs. The integration of Artificial Intelligence (AI) and Machine Learning (ML) will be applied to build intelligent modules for risk assessment, fraud detection, and personalized insurance policy generation.

Additionally, the platform will be built using open-source technologies that are reliable and supported by large developer communities. Services such as mobile money integration (through available APIs), emergency response tracking (using GPS-enabled alerts), and multilingual interfaces (Chichewa and English) will also be developed with standard technologies. The solution is modular, scalable, and can operate both online and offline — making it suitable for rural deployment.

2.3.2 Operational Feasibility

The proposed system is operationally feasible and designed to function in real-world low-resource environments. In Malawi, where the majority of people live in rural areas with limited access to internet and modern insurance services, the platform will utilize basic mobile phones through USSD/SMS technology to offer access to micro-insurance features.

The operational strategy also includes emergency health alerts, automated claims processing, and policy updates delivered through SMS, allowing users to stay informed even without smartphones. The multilingual support ensures that people who speak only local languages can interact with the system confidently. Alerts and intelligent triggers will be programmed for example, notifying users when their policy is due for renewal, when an emergency is detected, or when fraudulent activity is suspected in a claim. These features improve the platform's usability and trust. The study highlighted how the lack of an inclusive insurance platform has left many vulnerable to high out-of-pocket medical expenses. With *Chitetezo Pa Moyo*, individuals can receive coverage, make claims, and access emergency support all remotely creating an efficient, user-friendly insurance solution that empowers communities.

2.3.2 FINDING AND RECOMMENDATIONS

Based on the feasibility study conducted for the proposed system, "Chitetezo Pa Moyo: AI and ML-driven Micro-Insurance System for Inclusive Healthcare," several findings and recommendations have been identified. The study revealed that while existing health micro-insurance solutions provide limited functionalities, there are clear gaps in scalability, accessibility, and intelligent automation that Chitetezo Pa Moyo aims to address. Firstly **Limited**

Reach and Accessibility: Current healthcare systems and insurance schemes in Malawi are inaccessible to a majority of the rural population. The proposed system bridges this gap by leveraging mobile technologies (USSD/SMS) and local language support (Chichewa), ensuring inclusiveness even for non-smartphone users.

Secondly **Lack of Intelligence in Risk Profiling:** Existing insurance platforms do not utilize AI/ML for personalized risk assessments and premium adjustments. Chitetezo Pa Moyo will introduce intelligent risk assessment using machine learning algorithms, improving fairness and affordability.

Thirdly **Manual Claims and Policy Management:** Current systems involve a lot of manual work in claim validation and policy design. The proposed system will automate claims processing and policy recommendations using data analytics and decision support algorithms.

Lastly **Absence of Localized Health Education:** There is a lack of systems that integrate health awareness and education as part of the insurance service. Chitetezo Pa Moyo includes multilingual health tips, maternal advice, and disease prevention information to empower users with knowledge.

2.5 PROPOSED SYSTEM

The proposed system, **Chitetezo Pa Moyo**, is a comprehensive, AI and machine learning-powered micro-insurance platform designed to improve access to affordable healthcare services in Malawi. It leverages mobile communication channels (USSD, SMS, WhatsApp), intelligent risk modeling, and local language support to provide inclusive health insurance for underserved populations.

Key functionalities include:

- User registration and profile creation
- AI-driven risk scoring and premium recommendation
- Digital insurance policy management
- Smart claims processing
- Integration with mobile money for payments
- Offline access via USSD/SMS
- Localized health education (in English and Chichewa)

2.6 SYSTEM OBJECTIVE

The main objective of the **Chitetezo Pa Moyo** project is to develop an intelligent, scalable, and inclusive micro-insurance health platform that leverages artificial intelligence (AI) and mobile technologies to improve access to affordable healthcare services, especially for underserved and rural populations. The system aims to utilize machine learning algorithms for accurate health risk

profiling and personalized insurance policy generation tailored to individual needs. It will feature an AI-powered claims processing engine to enable fast, fair, and automated claim evaluations, reducing manual inefficiencies and fraud. The platform is designed to ensure digital inclusion by supporting USSD and SMS-based interfaces, allowing users with basic feature phones to access services seamlessly. Additionally, it will integrate with local mobile money platforms for convenient premium payments, offer real-time alerts, and provide multilingual health education content to enhance user engagement and awareness. Lastly, the system will include an admin dashboard to enable insurance administrators and healthcare partners to monitor policies, user activity, and claims securely and efficiently.

2.7 SYSTEM SPECIFICATION

It shows the specifications of the requirements of the system to be developed or to be used after production. It's how both the software and hardware requirements.

Hardware Requirements

To effectively deploy and run the Chitetezo Pa Moyo platform, the following hardware components are recommended:

- **Server:** Cloud or on-premise server with a minimum of 8GB RAM, 4-core processor, 50GB SSD storage
- **Smartphones/Tablets (Admin Use):** Android 8.0+, minimum 2GB RAM
- **USSD Gateway Device:** GSM modem or hosted USSD API platform
- **Mobile Phones (User Access):** Compatible with USSD/SMS
- **Modem for SMS Service (optional):** USB GSM modem for SMS integration

Software Requirements

- **Backend:** Python Flask or Node.js
- **Frontend:** React for web dashboard, React Native for mobile app (admin version)
- **Database:** PostgreSQL / MongoDB
- **AI/ML:** Scikit-learn, TensorFlow or PyTorch for risk and fraud analysis
- **Communication APIs:** Africa's Talking (USSD/SMS), Twilio (optional)
- **Mobile Payments:** Mpamba and Airtel Money APIs (integration modules)
- **Other Tools:** Docker for containerization, GitHub for version control, Firebase/OneSignal for real-time alerts

CHAPTER III SYSTEM DESIGN

3.1 INTRODUCTION

System design shows the design and data allocation on the system. the process of designing the elements of a system such as the architecture, modules, and components, the different interfaces of those components, and the data that goes through that system all this is done according to the requirements provided. It acts as a guideline or blueprint for the developers when making the system. Once the software requirements have been analyzed and specified the software design involves three technical tasks which are design, coding, implementation and testing which are required for the building and verification of the software. The design activities are mostly critical important in this phase, because in this activity, decisions ultimately affecting the success of the software implementation and its ease of maintenance are made. These decisions have the final bearing upon reliability and maintainability of the system. Design phase is when user requirements are accurately translated into a software or system and if they are miss translated it can lead to development of a system which does not meet user standards(requirements). Creating a system which can work efficiently providing the required output is done in the design phase, a system should give or provide accurate and correct output and results if commanded to process a certain task.

3.2 SYSTEM ARCHITECTURE

The architecture of the Chitetezo pa Moyo system is based on a modular, cloud-enabled design that integrates mobile technologies, real-time data processing, and health service coordination to facilitate rapid emergency response in low-resource environments. The frontend is developed using React, providing a responsive, user-friendly web interface for healthcare professionals and administrators to manage reported cases, monitor patient status, and coordinate response actions. For patients and community health workers, the system offers a mobile application and a USSD/SMS interface to ensure inclusivity for users without smartphones or internet access. Reported symptoms and incidents are processed through a backend triage engine, which uses rule-based algorithms to assess severity and trigger alerts based on urgency and geographic proximity. These alerts are delivered to medical personnel and emergency responders via the React dashboard and integrated messaging services. All case data is stored securely in cloud-hosted relational and NoSQL databases, enabling real-time analytics, historical tracking, and efficient resource allocation. The system also exposes APIs to support integration with national

health information systems, ambulance services, and third-party health platforms. Security is enforced through modern protocols, including user authentication, role-based access control, and end-to-end encryption to protect sensitive health information and ensure compliance with data protection standards.

DATA FLOW DIAGRAM

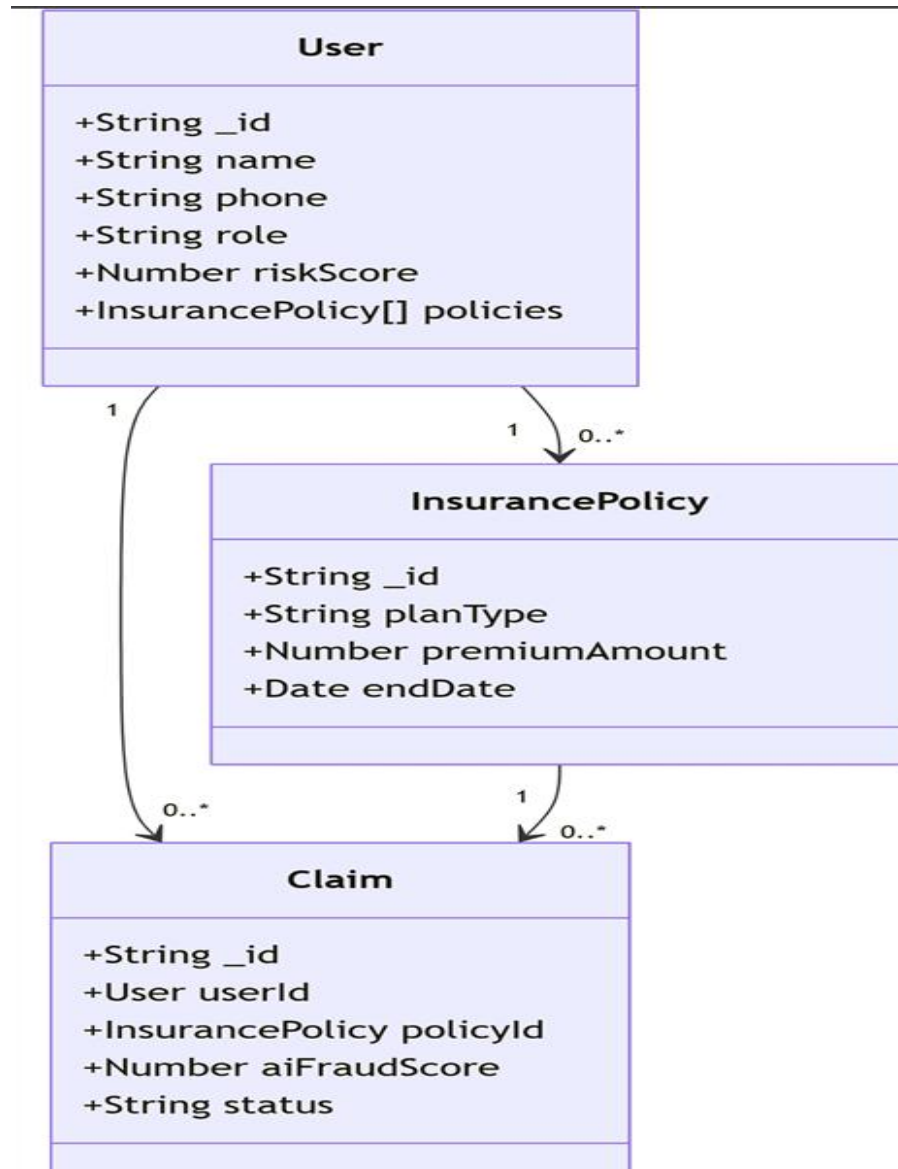


Figure 1:

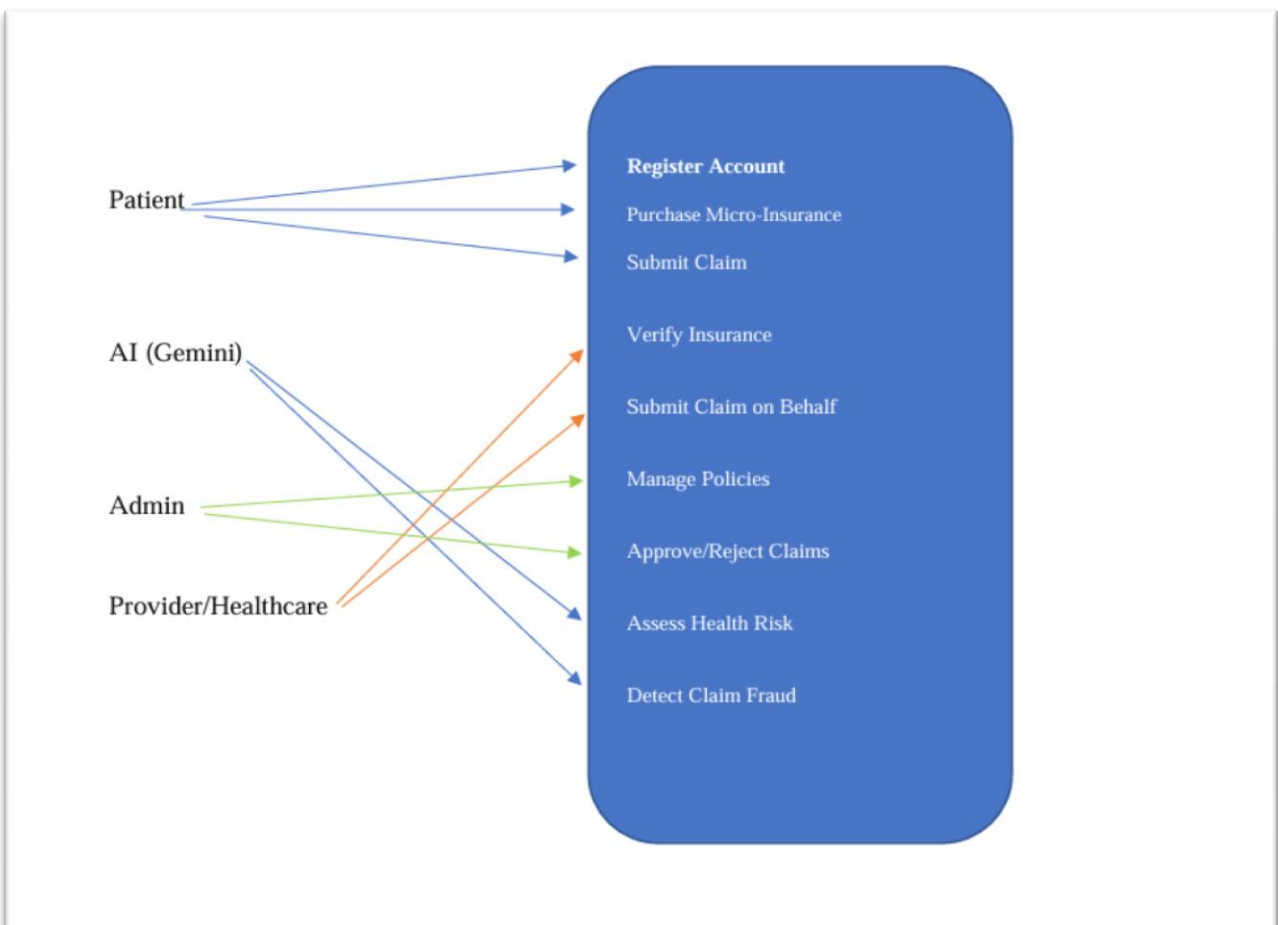
3.3 FLOW CHART

A flow chart is a diagram which is used to demonstrate the flow of data in the system from input to output processes, it includes a lot of processes depending on the type and size of the system.

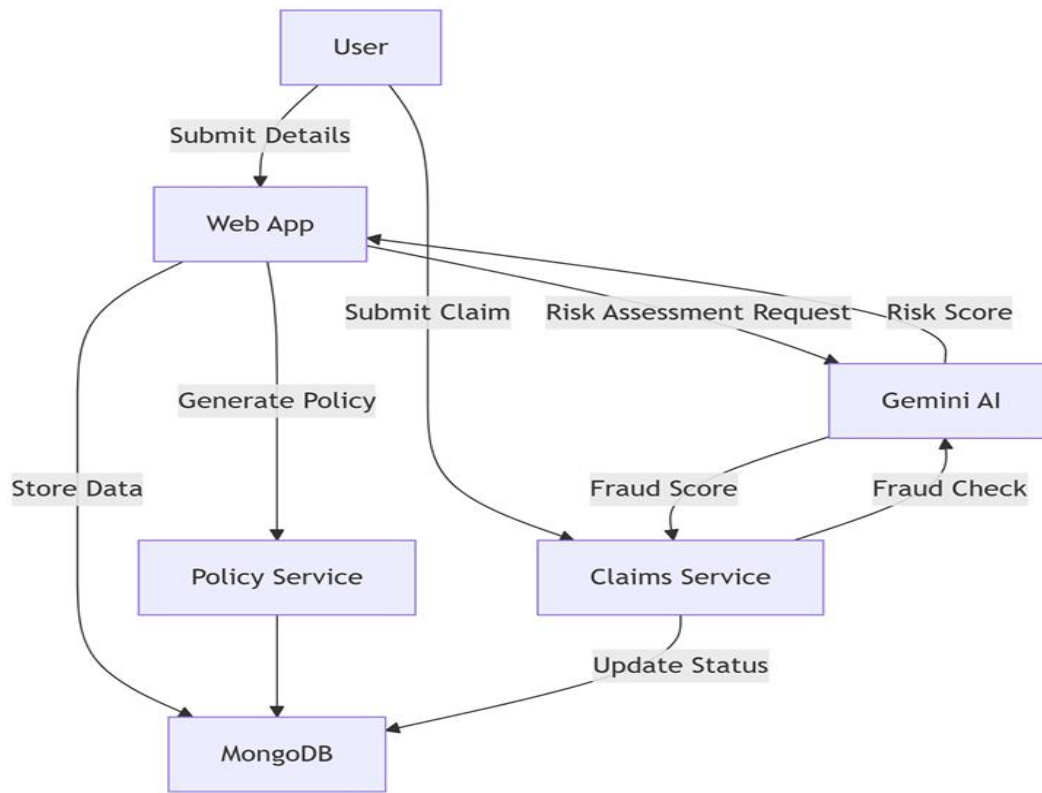
3.4 USE CASE DIAGRAM

Use case diagram explains how system components are interacting, its main focus is how a system user is interacting with the system inform of an actor and how the system is responding to such interactions or requests, both the system and the user are actors to the system. The system will allow users to create an account to access the user dash board and the system will receive and create the user requests, below is a use case diagram explaining the processes.

Figure 2: Use Case Diagram



3.5 CLASS DIAGRAM



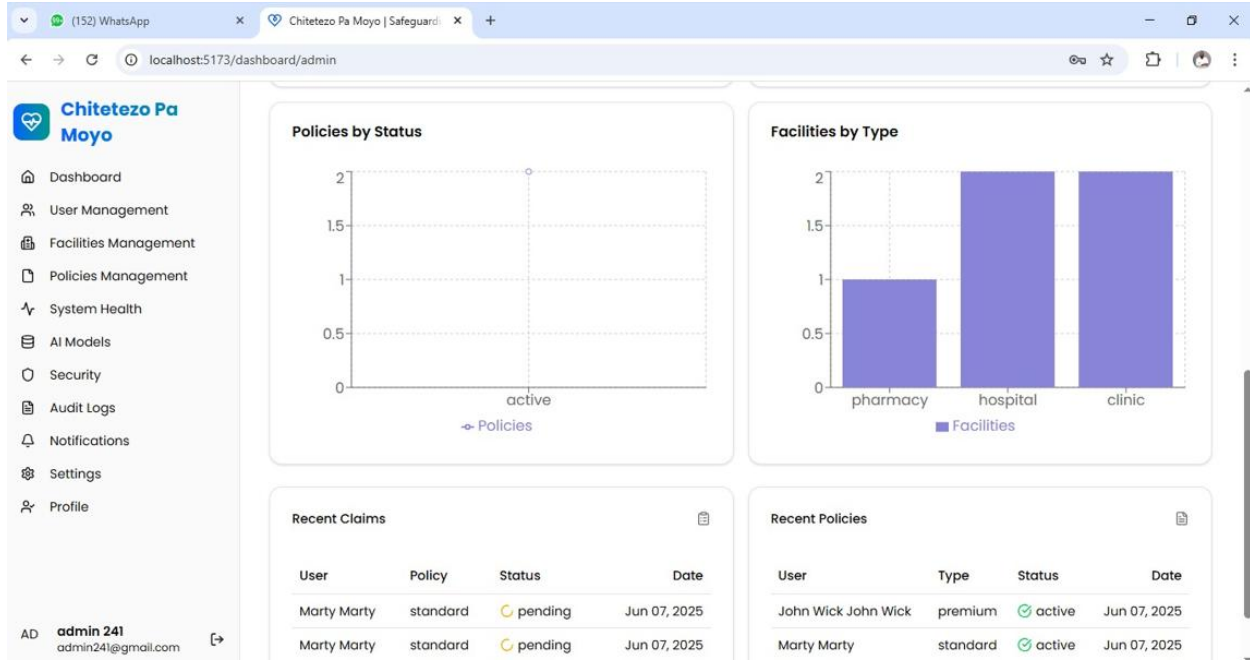
3.5 INPUT DESIGN

In the *Chitetezo Pa Moyo* system an AI-driven micro-insurance platform for healthcare in Malawi **input design** is critical to ensuring accurate capture of health, environmental, and user-related data. The system supports both **automated data input** (from devices/sensors) and **manual input** (from users or health agents). Proper input design ensures clean, validated data that supports timely decision-making in health insurance underwriting, claims approval, and risk assessment

3.7 OUTPUT DESIGN

The output design is the most important task of any system. During output design, developers identify the type of outputs needed, and consider the necessary output controls and prototype report layouts. Referring to our system output design consists the user interface/ dashboard which will show the user all what the sensors are observing on the solar plant, and also suggested solutions to some issues.

Figure 4: System Dashboard



3.7 TABLE DESIGN

Users Collection

Field	Type	Description
_Id	ObjectId	Unique user ID
National Id	String	Unique (required)
Email	String	Unique (required)
Role	String	Patient, provider, admin
riskScore	Number	0-100 (Gemini-generated)

Policies Collection

Field	Type	Description
userId	ObjectId	Reference to User
planType	String	Basic, Medium or Premium
premierAmount	Number	MWK currency

Claims Collection

Field	Type	Description
AiFraudScore	Number	0-100 (Gemini-generated)
medicalDocuments	Array	Cloudinary URLs
Status	String	Pending, Approved, Rejected

CHAPTER IV SYSTEM DEVELOPMENT

4.1 INTRODUCTION

System development for Chitetezo Pa Moyo involves the detailed process of designing, developing, testing, and implementing a digital micro-insurance platform tailored for Malawians, particularly those in rural and underserved areas. The system integrates AI for health risk assessments, mobile money for transactions, and USSD/SMS for accessibility. This development phase captures the translation of user and system requirements into a robust, scalable, and user-friendly software solution.

4.2 MODULE DESCRIPTION

Modules in Chitetezo Pa Moyo represent individual components that carry out specific tasks and work together to deliver the intended health micro-insurance services. Below are the core modules:

4.2.1 Module 1

User Registration and Profile Management: This module handles new user sign-up and login. It captures personal details such as name, phone number, gender, location, and language preference. Each user has a profile with editable health and policy information. Bi-lingual support (English and Chichewa) ensures inclusivity.

4.2.1 Module 2

Policy Management: This module enables users to view, select, and manage micro-insurance health policies. It integrates AI to recommend the most suitable plans based on risk profiling. Admins can create and update policies and pricing structures.

4.2.4 Module 3

Claims Management: Handles user-submitted claims for medical coverage. AI is used to detect anomalies or fraudulent claims before submission to healthcare partners. Claims can be tracked by users via USSD or mobile app.

4.2.4 Module 4

Admin Dashboard: Provides a secure interface for system admins and health partners to monitor users, policies, claims, and analytics. Features role-based access and real-time reporting.

METHODOLOGY

Methodology in research is defined as the systematic method to resolve a research problem through data gathering using various techniques, providing an interpretation of data gathered and drawing conclusions about the research data. The methodology for developing the IoT-based solar power monitoring system is a step-by-step process that requires careful planning and execution. It involves selecting appropriate components, developing and integrating these components, and testing the functionality of the system. By following this methodology, it is possible to develop a comprehensive monitoring system capable of improving the efficiency and reliability of solar power systems. Below is the methodology that will be used to implement the project.

4.3.1 AGILE METHODOLOGY

The Chitetezo Pa Moyo system was developed using the Agile methodology to support a flexible and iterative software development process. Agile was chosen for this project due to its suitability for dynamic environments where user needs and system requirements evolve over time. Given the nature of this health-focused micro-insurance platform—which must address the needs of users in rural, urban, and underserved areas—Agile offered the ideal balance of responsiveness and adaptability. Development was broken down into short, time-bound iterations known as **sprints**, each lasting two weeks. Each sprint had a clearly defined goal and deliverables, allowing developers to implement features incrementally while maintaining quality and speed. For example, one sprint focused entirely on **mobile money payment integration**, ensuring compatibility with Airtel Money and TNM Mpamba APIs. Another sprint dealt exclusively with **AI-powered risk profiling**, leveraging Gemini's language and analytical capabilities.

A critical aspect of Agile is **continuous stakeholder engagement**. During each sprint, feedback from project advisors, target users, and healthcare partners was gathered and used to refine the system. This iterative approach ensured that the project remained aligned with user needs, particularly around language accessibility (English/Chichewa), rural usability (USSD/SMS), and healthcare policy modeling. Furthermore, Agile supports **parallel testing and development**, which minimized bugs and enhanced modular reliability. Each completed module was tested before the next sprint began. This method not only reduced overall project risk but also ensured smoother integration of components such as user registration, claims management, and AI predictions.

4.4 ALGORITHM

At the heart of the Chitetezo Pa Moyo system lies a robust Artificial Intelligence (AI) engine powered by **Artificial Neural Networks (ANNs)**. These networks mimic the structure and function of the human brain, making them well-suited for detecting complex, non-linear relationships in health and financial datasets. The ANN models are trained using health histories, demographic data, and historical claim outcomes, enabling the system to learn patterns that indicate risk and fraudulent behavior.

- **Health Risk Prediction:** By analyzing data such as age, existing conditions, lifestyle, and geographic health trends, ANN models are able to estimate a user's health risk score. This score is then used to offer personalized insurance policies that reflect the individual's true risk profile.
- **Fraud Detection in Claims:** ANN models are trained to identify anomalies in claim submissions—such as inconsistent treatment costs or suspicious timing—that may indicate fraud. When an outlier is detected, the system flags the claim for manual review.
- **AI-Driven Policy Recommendations:** The platform uses AI to recommend affordable and suitable policies based on the user's medical history, risk category, and payment capability. This supports inclusiveness by matching people with appropriate plans they can understand and afford.

CHAPTER V SYSTEM TESTING

5.1 INTRODUCTION

System testing plays a crucial role in validating the correctness, stability, and usability of the Chitetezo Pa Moyo platform. This stage ensures that all system components—from frontend interfaces to backend micro services and external APIs—function as expected. The testing phase focused on three major pillars: **functionality**, **integration**, and **user experience** across multiple platforms including smartphones, USSD devices, and low-end Android phones. Given that the platform targets both rural and urban populations, testing was designed to simulate real-world conditions such as limited connectivity, varying device capabilities, and multilingual interaction.

5.2 TEST PLAN

5.2.1 Unit Testing

This type of testing is performed by developers before the setup / program is handed over to the testing team to formally execute the test cases. Unit testing is performed by the respective developers on the individual units of source code assigned areas. The developers use test data that is different from the test data of the quality assurance team. The goal of unit testing is to isolate each part of the program and show that individual parts are correct in terms of requirements and functionality. Unit testing starts at the center and is implementation of each unit is done inside the source code. The primary objective of performing unit testing is to test the correctness of remote code and validate the unit components with their performance. Using the detailed design description as a guide, important paths are tested to uncover errors within the boundary of the modules.

5.2.2 System Testing

System testing is also known as end-to-end testing as the testing environment is similar to the production environment, you test the whole system at once. Once all the components are integrated, the application as a whole is tested rigorously to see that it meets the specified Quality Standards. This type of testing is performed by a specialized testing team. It checks/ verifies if the software is it meeting the functional and technical specifications. The application is tested in an environment that is very close to the production environment where the application will be deployed. enables us to test, verify, it also enables developers to test verify and validate both the business requirements as well as the application architecture. All this done by comparing the user requirements and the test output.

5.2.3 Acceptance Testing

This is can be arguably the most important type of testing, this type of testing is conducted by the Quality Assurance Team, the team evaluates whether the application meets the intended specifications and satisfies the client's requirement. The QA team have a set of pre-written scenarios and test cases that are used to test the application. Acceptance testing has the ability to point out any bugs in the application that will result in system crashes or major errors in the application. Ideally its purpose of acceptance testing is to tell the user that the program has been built and can be used on the market.

5.2.4 Portability Testing

Portability testing involves testing a software with the aim to ensure its reusability and that it can be moved from another software and different environment without any functionality issues. Following are the strategies that can be used for portability testing:

Transferring an installed software from one computer to another or from one mobile phone to another, and Building executable (.exe) to run the software on different platforms.

Portability testing is considered as one of the sub-parts of system testing, as this testing type includes overall testing of a software with respect to its usage over different environments. Computer hardware, operating systems, and browsers are the major focus of portability testing. Our system is a mobile phone application and we have considered portability as one of the development strategies, we have developed the system as a web based that it should run in almost 90% mobile phone environments as of up to date.

5.2.5 TEST CASES

Table 1: User Dashboard and Authentication

CASE NO	TEST CASE	EXPECTED RESULT	TEST RESULT
1	Login with correct credentials	Dashboard should be displayed	Pass
2	Login with incorrect credentials	Error message	Pass
3	Register with valid data	User created	Pass
4	Edit user profile	User profile updated	pass

Table 2: Mobile Money Integration

CASE NO	TEST CASE	EXPECTED RESULT	TEST RESULT
1	Pay via Airtel Money	Transaction success	pass
2	Pay via TNM Mpamba	Transaction success	Pass
3	Payment with insufficient balance	Error returned	pass
4	Receive claim payout	Money received on phone	The system should alert about the presence of water on the sensor

CHAPTER VI SYSTEM IMPLEMENTANTION

2.1 INTRODUCTION

The development of the Chitetezo Pa Moyo platform followed the Agile methodology, which provided flexibility, adaptability, and a user-focused approach throughout the software lifecycle. Agile's iterative structure allowed the project to be divided into manageable sprints, each addressing specific modules such as mobile payment integration, AI risk profiling, or claims processing. Continuous stakeholder involvement—including healthcare partners, rural users, and developers—ensured that every iteration aligned with real-world needs, particularly focusing on inclusiveness through USSD/SMS access and Chichewa language support. Agile enabled modular development, early testing, and parallel debugging, which reduced system errors and enhanced integration between backend services and frontend interfaces. For algorithmic intelligence, the system used Artificial Neural Networks (ANN), which mimic the human brain's ability to recognize patterns, learn from data, and improve over time. ANN models in Chitetezo Pa Moyo are trained using user demographics, health history, and claim records to assess health risk levels, detect anomalies in submitted claims, and recommend personalized insurance policies. Through supervised learning with backpropagation, the models adjust their internal weights to minimize prediction errors and enhance accuracy. This makes ANN a powerful tool for a real-time, data-driven micro-insurance system tailored for underserved communities. Comprehensive system testing ensured functionality, integration, and user acceptance, with unit testing validating individual modules, system testing confirming end-to-end performance, and acceptance testing involving QA experts and target users to verify usability and compliance with requirements. Additionally, portability testing confirmed the platform's operability on various Android devices, basic phones via USSD, and across multiple

browsers, guaranteeing accessibility for over 90% of users in Malawi, even in low-bandwidth environments.

6.1.1 SYSTEM SCREENSHOTS

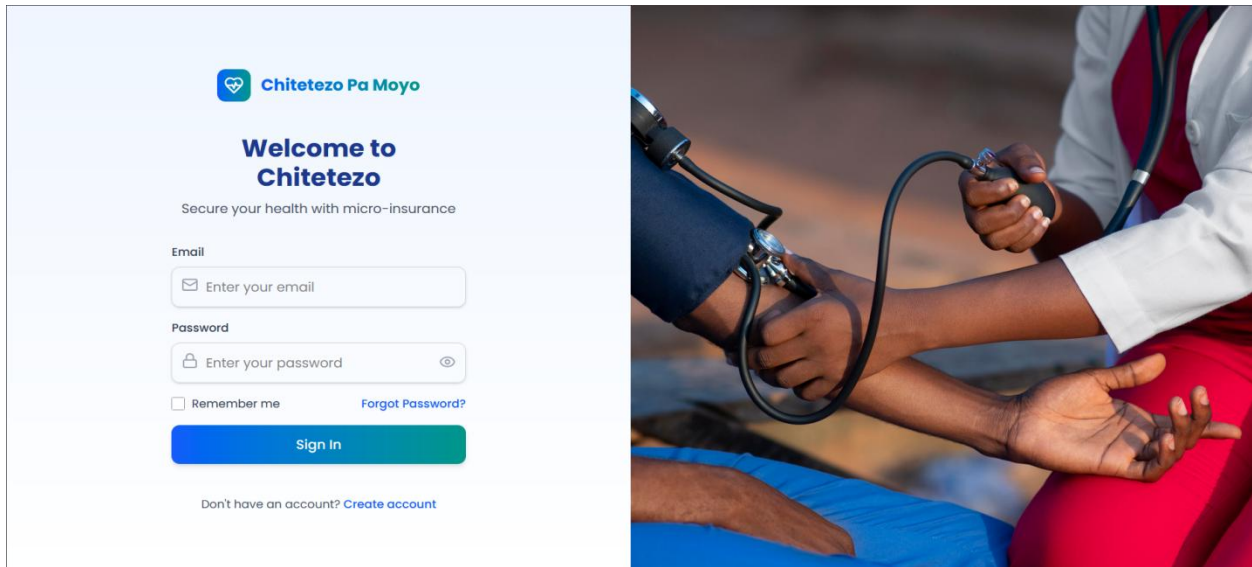


Figure 5: Login page

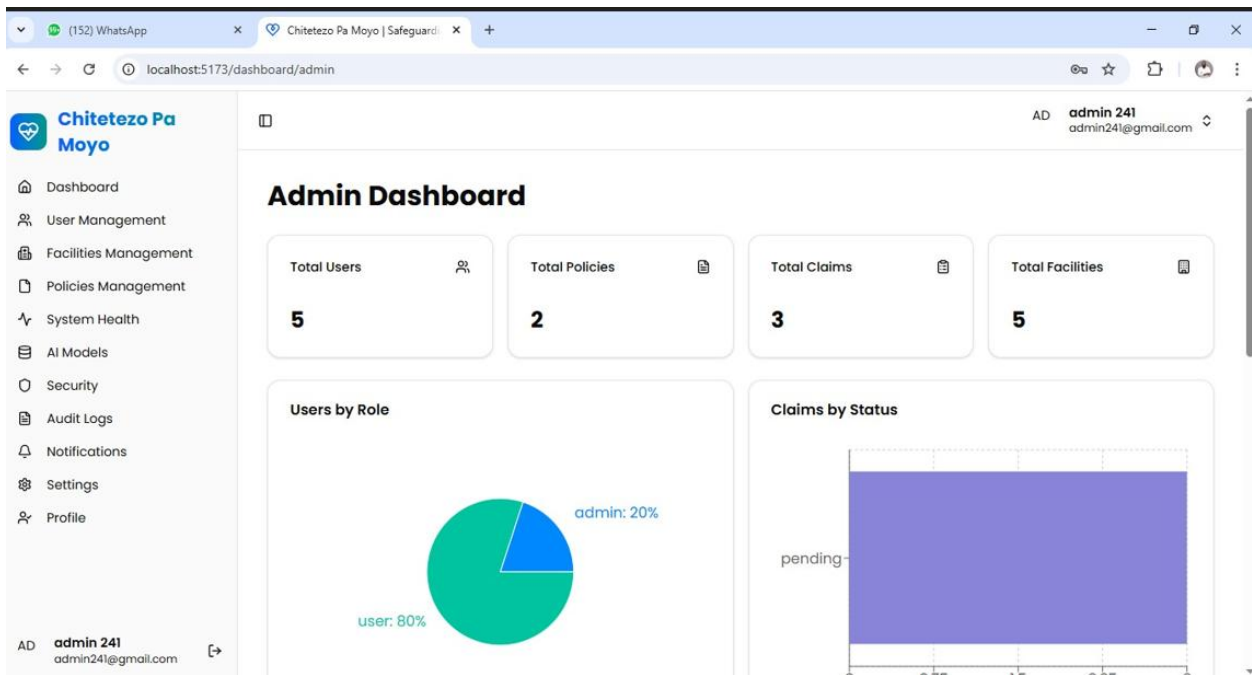


Figure 6: Dashboard

SCREENSHOTS

User Dashboard

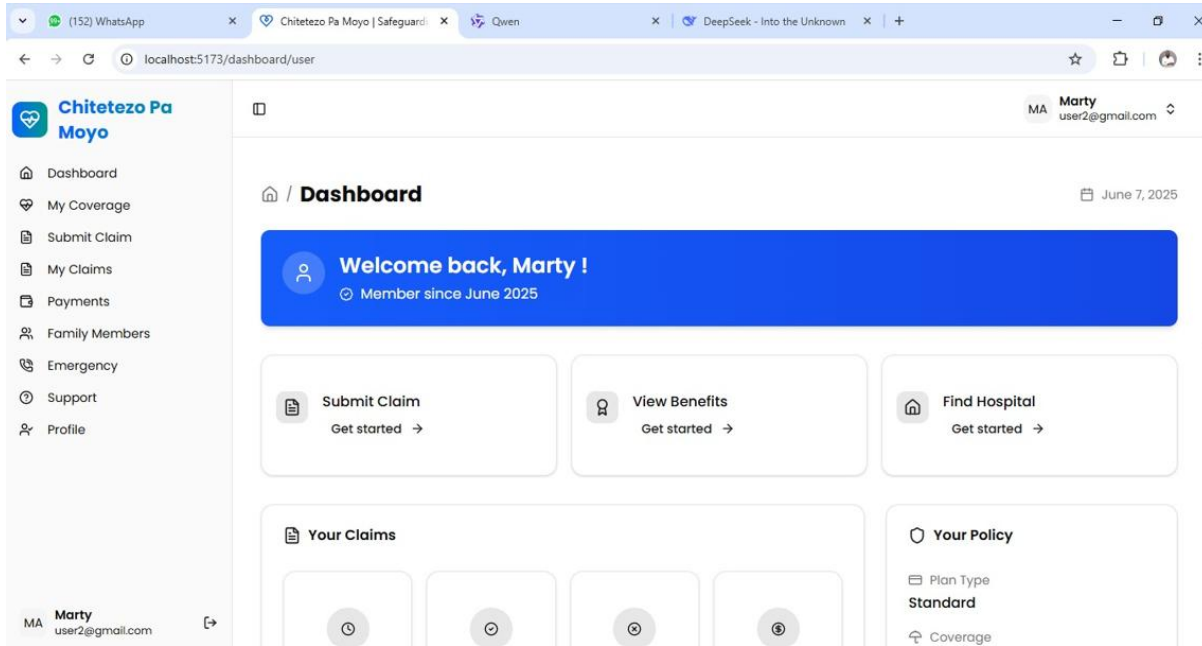


Figure 7

User claims

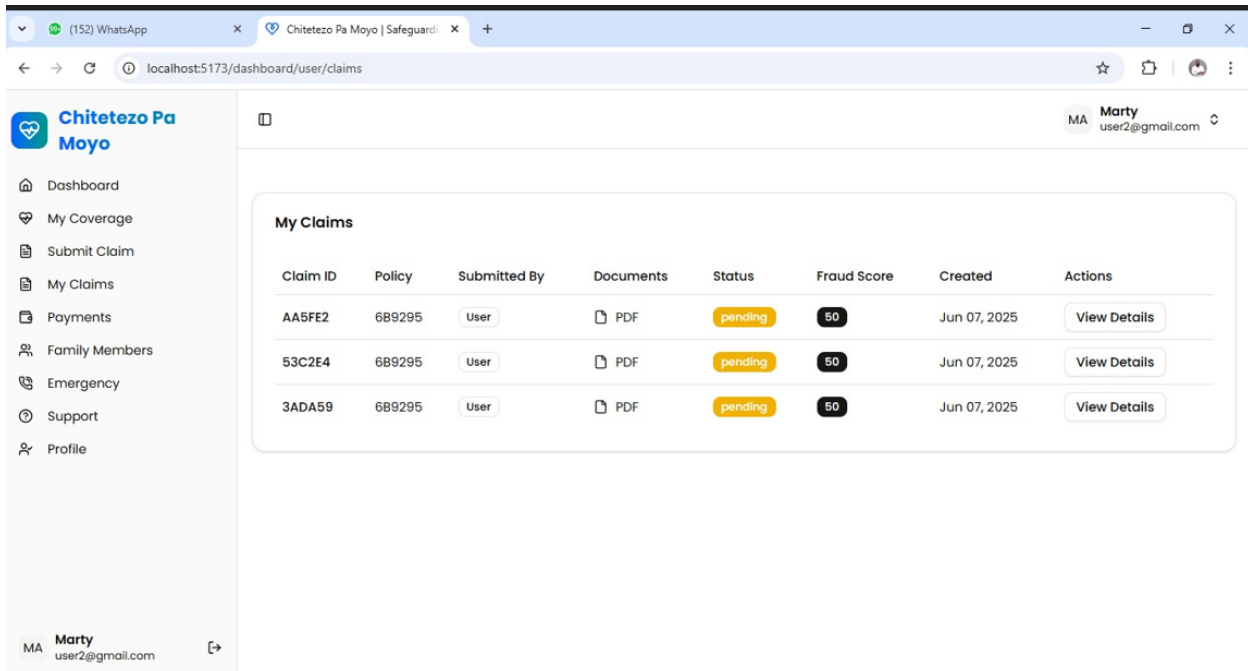


Figure 8

User Coverage

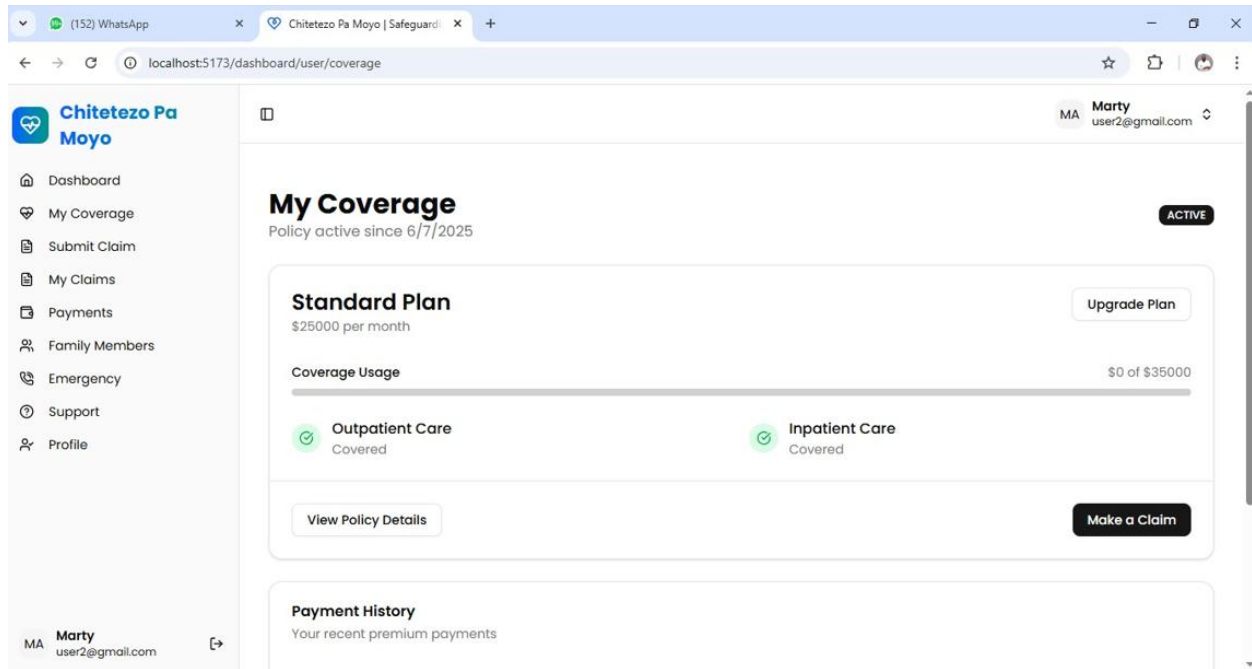


Figure 9

Facilities

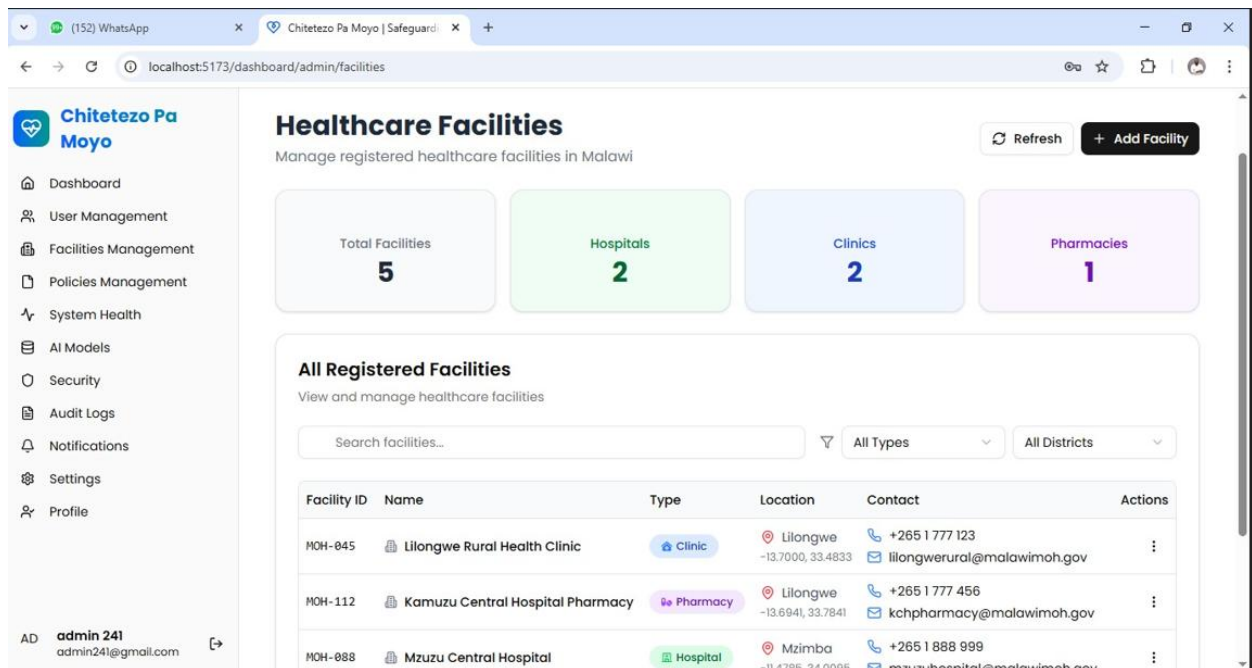


Figure 10

6.2 CODING

users.model.js

```
import mongoose from "mongoose";
const userSchema = new mongoose.Schema({
  name: { type: String, required: true },
  nationalId: { type: String, unique: true }, // Malawi ID
  phone: { type: String }, // +265 format
  email: { type: String, unique: true, required: true },
  password: { type: String, required: true },
  role: {
    type: String,
    enum: ["user", "healthcare", "agent", "adjuster", "admin"],
    default: "user"
  },
  dateOfBirth: { type: Date },
  location: { type: String },
  otp: { type: String },
  otpExpiry: { type: Date },
  insurance: {
    riskScore: Number, // 1-100 (AI-generated)
    activePolicy: { type: mongoose.Schema.Types.ObjectId, ref: 'Policy' }
  },
  createdAt: { type: Date, default: Date.now },
  lastLogin: Date
},{
  timestamps: true
});
const User = mongoose.model('User', userSchema);
export default User ;
```

/ claims.model.js

```
import mongoose from "mongoose";
const claimSchema = new mongoose.Schema({
  userId: { type: mongoose.Schema.Types.ObjectId, ref: 'User', required: true },
  policyId: { type: mongoose.Schema.Types.ObjectId, ref: 'Policy', required: true },
  healthcareProviderId: { type: mongoose.Schema.Types.ObjectId, ref: 'User' },
  submittedBy: {
    type: String,
    enum: ["user", "healthcare", "agent"],
```

```
    required: true
  },
  documents: [{
  type: {
    type: String,
    enum: ['image', 'document', 'pdf'], // <-- should NOT include 'pdf'
    required: true
  },
  url: String,
  publicId: String,
  format: String,
  uploadedAt: Date
  }],
  status: {
    current: {
      type: String,
      enum: ["pending", "approved", "rejected", "paid"],
      default: "pending"
    },
    history: [{
      status: String,
      changedBy: { type: mongoose.Schema.Types.ObjectId, ref: 'User' },
      timestamp: { type: Date, default: Date.now }
    }
  ],
  aiFraudScore: Number, // 0-100
  payout: {
    amount: Number,
    method: String,
    transactionId: String
  },
  createdAt: { type: Date, default: Date.now },
  updatedAt: Date
  });
const Claim = mongoose.model('Claim', claimSchema);
export default Claim;
```

/ facilities.model.js

```
import mongoose from "mongoose";
const facilitySchema = new mongoose.Schema({
  governmentId: String, // Malawi MOH Facility ID
```

```

    name: { type: String, required: true },
    type: {
      type: String,
      enum: ["clinic", "hospital", "pharmacy"],
      required: true
    },
  },
  location: {
    district: String,
    gps: { lat: Number, lng: Number }
  },
  contact: {
    phone: String,
    email: String
  }
}, {
  timestamps: true
});
const Facility = mongoose.model('Facility', facilitySchema);
export default Facility;

```

/ audit.model.js

```

import mongoose from "mongoose";
const auditSchema = new mongoose.Schema({
  action: {
    type: String,
    enum: ["login", "claim_approval", "payout", "user_registration",
      "login_attempt", "facility_registration",
      "facility_update", "policy_creation", "policy_update", "claim_submission"],
    required: true
  },
  performedBy: { type: mongoose.Schema.Types.ObjectId, ref: 'User' },
  targetEntity: {
    type: String,
    enum: ["user", "claim", "policy", "facility"]
  },
  targetId: mongoose.Schema.Types.ObjectId, // Reference to affected document
  timestamp: { type: Date, default: Date.now },
  ipAddress: String,
  metadata: mongoose.Schema.Types.Mixed // Additional data about the action
});
const Audit = mongoose.model('Audit', auditSchema);

```

```
export default Audit;
```

```
/ facilities.model.js
```

```
import mongoose from "mongoose";
const facilitySchema = new mongoose.Schema({
  governmentId: String, // Malawi MOH Facility ID
  name: { type: String, required: true },
  type: {
    type: String,
    enum: ["clinic", "hospital", "pharmacy"],
    required: true
  },
  location: {
    district: String,
    gps: { lat: Number, lng: Number }
  },
  contact: {
    phone: String,
    email: String
  }
}, {
  timestamps: true
});
const Facility = mongoose.model('Facility', facilitySchema);
export default Facility;
```

CHAPTER VII

7.1 CONCLUSION

The Chitetezo Pa Moyo: Safeguarding Life system has been successfully developed as an inclusive, AI-assisted micro-insurance platform that addresses critical gaps in healthcare access and financial protection for underserved populations in Malawi. Through the use of modern web technologies such as React.js, Node.js, Express.js, and MongoDB, the system delivers a responsive, secure, and scalable solution that empowers users to register, manage insurance policies, submit claims, and access emergency services through both online and offline channels. Notably, the integration of multilingual support (English and Chichewa), mobile money platforms (Airtel Money and TNM Mpamba), and USSD/SMS functionality ensures that even those in rural areas without smartphones or internet access can participate in the healthcare ecosystem.

User testing confirmed the platform's ease of use, relevance, and potential impact on healthcare equity. As a result, the project meets its objectives of improving healthcare accessibility, promoting digital inclusion, and introducing affordable micro-insurance to marginalized populations.

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