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Development of an Ai-Driven Digital Health Assessment and Hospital Referral System for Selected Nigerian States

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Abstract
The increasing burden of limited ac`cess to quality healthcare services in Nigeria, particularly in rural and underserved regions, necessitates innovative technological interventions. Artificial Intelligence (AI)-powered digital health systems offer a viable solution to enhance early symptom assessment and support timely healthcare decision-making. This study aimed to design and develop an AI-powered digital health advisory system for preliminary self-assessment tailored to the Nigerian healthcare context. A system development methodology was adopted that integrates Natural Language Processing (NLP) and Machine Learning (ML) techniques. The backend was developed using Python, while the frontend utilized HTML5, CSS3, and JavaScript. NLP capabilities were implemented using spaCy, and classification employed Term Frequency–Inverse Document Frequency (TF-IDF) with Logistic Regression. Leaflet.js and the haversine method were used for geolocation-based hospital referrals. The system was designed using a client–server architecture and deployed as a web-based application with an interactive chatbot interface. The system processes user-input symptoms and generates preliminary health advice. Findings demonstrate the feasibility and scalability of AI-driven self-assessment tools in low-resource settings. The study concludes that AI-powered advisory systems can significantly improve early health-seeking behaviour and healthcare access in Nigeria.

Keywords: artificial intelligence, digital health, self-assessment, machine learning, natural language processing, geolocation, Nigeria

I. Introduction

In recent years, Artificial Intelligence (AI) has emerged as a transformative force in global healthcare, improving diagnostic accuracy, operational efficiency, and patient outcomes (Ayomide & Ego, 2024). AI refers to computer systems designed to mimic human cognitive functions such as learning, reasoning, problem-solving, and decision-making, often implemented through tools such as symptom checkers, triage applications, and predictive models to support clinical decisions (Sani et al., 2024). However, in low- and middle-income countries (LMICs), AI integration has progressed slowly due to infrastructural gaps, weak policies, and persistent technical challenges (Akor, 2025; Ayomide & Ego, 2024).

In Nigeria, the healthcare system faces major challenges, including outdated infrastructure, a shortage of healthcare professionals, weak data systems, and inequitable access to quality care, particularly in rural areas (Akor, 2025). These issues contribute to high morbidity and mortality rates and healthcare disparities. Nevertheless, digital health innovations are gradually gaining traction, with growing recognition of AI's potential to enhance disease surveillance, support clinical decision-making, and complement traditional healthcare delivery systems (Akor, 2025; Egwudo et al., 2025).

AI-enabled digital health advisory systems, including mobile and web-based platforms, are globally recognized for reducing diagnostic delays and improving self-care support (Nri-Ezedi et al., 2024). AI-powered health advisory systems enable users to perform preliminary symptom assessments and receive guidance on appropriate actions (Hassan et al., 2024).

When combined with location-based hospital referral features, such systems can guide users to nearby healthcare facilities, thereby improving geographic accessibility and navigation challenges in Nigeria. This is particularly relevant given the limited adoption of fully integrated electronic health records (EHRs) across the country (News Agency of Nigeria, 2025).

Despite these advancements, AI adoption in Nigeria remains limited due to poor infrastructure, low digital literacy, and a lack of context-specific systems (David-Olawade et al., 2025). Existing symptom checkers are often not localized and lack integration with the Nigerian healthcare system. Although Nigeria has initiated frameworks such as the Nigerian Digital Health Architecture (NDHA) to integrate AI and patient

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data systems, implementation remains at an early stage due to poor data quality, inadequate infrastructure, limited skilled personnel, and unclear policy direction (Akor, 2025). This study addresses this gap by designing and developing an AI-powered digital health advisory system for preliminary self-assessment and location-based hospital referral in selected states in Nigeria.

II. Literature Review

The development and evaluation of an AI-powered digital health advisory system for preliminary self-assessment and location-based hospital referral represents a significant advancement in addressing longstanding challenges within healthcare delivery systems in Nigeria. The findings of this study are discussed in relation to existing literature on artificial intelligence (AI) in healthcare, digital health adoption, and clinical decision support systems in resource-constrained settings.

2.1 AI and Improvement of Healthcare Access

The system demonstrated strong potential in improving **access to healthcare services**, particularly by enabling users to conduct preliminary symptom assessment and receive real-time referral suggestions to nearby appropriate health facilities. This aligns with previous studies, which highlight AI as a transformative tool for expanding healthcare access, especially in underserved populations where healthcare resources are unevenly distributed (Okwukwu et al., 2025). In Nigeria and similar low- and middle-income countries, geographical barriers, shortage of healthcare professionals, and limited health literacy often delay care-seeking behaviour. By integrating AI with geolocation services, the system reduces these barriers and supports earlier entry into the healthcare system.

2.2 Enhancement of Healthcare Efficiency

The study further demonstrates that the AI system improves health system efficiency by streamlining the triage and referral process. Automated symptom evaluation reduces unnecessary hospital visits and ensures that patients are directed to appropriate levels of care based on urgency. This finding is consistent with evidence that AI-driven clinical decision support tools can reduce workload and improve workflow efficiency in clinical environments (Onyeabor et al., 2025). Similarly, AI-based systems have been shown to reduce diagnostic and administrative delays by supporting faster decision-making and reducing clinician burden during patient intake processes.

2.3 Contribution to Equity in Healthcare Delivery

The AI system also contributes to **health equity** by standardizing preliminary health assessments and referral recommendations, thereby minimizing disparities caused by socioeconomic status, geographic location, or variability in access to healthcare professionals. This is particularly relevant in Nigeria, where rural and riverine populations often experience reduced access to quality healthcare services. Studies have shown that AI applications in healthcare can enhance rural access, predictive diagnostics, and service distribution when appropriately deployed (Okwukwu et al., 2025). By providing uniform health guidance, the system reduces subjective variability in care-seeking decisions and promotes fairer access to healthcare services.

2.4 Reduction of Delays in Care-Seeking and Service Delivery

A major challenge in Nigeria's healthcare system is delayed presentation at health facilities, often resulting in worsened clinical outcomes. The AI system addresses this by offering immediate symptom interpretation and referral guidance, thereby reducing decision-making delays at the community level. This aligns with findings from digital health studies indicating that AI-enabled triage systems improve timeliness of care by facilitating faster patient routing to appropriate services (Asiedu et al., 2024). Furthermore, delays associated with uncertainty, self-medication, and inappropriate facility selection are minimized through structured AI guidance.

2.5 Reduction of Hospital Overcrowding and System Burden

The study also found that the system has the potential to reduce **overcrowding in healthcare facilities**, particularly at primary and secondary levels. By filtering non-urgent cases and directing patients to appropriate care levels, the system ensures better patient distribution across the healthcare network. This is consistent with literature indicating that digital triage systems and AI-driven referral tools can significantly reduce unnecessary hospital visits and optimize patient flow (Onyeabor et al., 2025). In resource-constrained health systems, this function is critical for improving service quality and reducing pressure on overstretched facilities.

2.6 System Adoption, Usability, and Contextual Challenges

Despite the demonstrated benefits, existing literature highlights several barriers to AI adoption in Nigerian healthcare systems, including

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infrastructural limitations, digital literacy gaps, and resistance to technological change (Onwuasoigwe et al., 2025). These challenges may affect the scalability and sustainability of the system if not adequately addressed. Furthermore, concerns around system accuracy, data privacy, and trust in automated recommendations remain important considerations for user acceptance.

However, studies have shown that when AI systems are well-integrated into clinical workflows and designed with user-centered approaches, acceptance and usability significantly improve (Korom et al., 2025). This emphasizes the importance of continuous stakeholder engagement, iterative system refinement, and capacity building for healthcare users.

2.7 Implications for Healthcare Transformation in Nigeria

Overall, the findings suggest that AI-powered digital health advisory systems can play a transformative role in strengthening Nigeria's healthcare delivery system. By improving access, efficiency, and equity while reducing delays and overcrowding, the system aligns with global efforts to leverage artificial intelligence for universal health coverage and improved health outcomes. However, successful implementation requires addressing infrastructural constraints, enhancing digital literacy among users, and ensuring supportive policy frameworks for AI integration in healthcare.

III. Materials and Methods

This study adopted a system development and engineering design approach. It involved the conceptualization, architectural design, and development of an AI-powered digital health advisory system for preliminary self-assessment, integrated with geolocation-based referral capabilities**.**

3.1Conceptual framework

The conceptual framework serves as the logical map that illustrates the relationship between the study's variables and the flow of information from the user to the final healthcare outcome. It is built on a Modular Input-Process-Output (IPO) model (Figure 3.1), specifically tailored for digital health intervention.

i. The Input Phase: This stage captures the User's Health Context, which includes their socio-demographic data (age group, gender, location), current symptoms, severity of the symptoms (low, moderate, and high), notice period (recently or long ago), and historical health data (last check-up). These inputs are influenced by the user's digital literacy and previous healthcare-seeking behaviours.
ii. The Process Phase: This is the "intelligence" core where the AI-powered logic resides. It involves the conversion of natural language symptoms into medical interpretations using the NLP (spaCy) and Machine Learning (Logistic Regression) pipelines. Simultaneously, the system processes the user's Geolocation to query the nearest accredited government healthcare facilities.
iii. The Output Phase: The final resultsdelivered to the user include preliminary actionable health advice (delivered via text and audio) and a spatial referral map. This output leads to the ultimate objective of improved access to formal medical care and informed health decision-making.

The framework demonstrates that the effectiveness of the system is not just dependent on the code, but on the seamless interaction between the user's local context and the system's algorithmic response.

3.2 Architectural Framework

The architectural framework provides the technical blueprint of the AI interface design in Figure 3.2. It describes the "stack" of materials and logic used to build the functional prototype. The architecture follows a Client-Server-Database model, ensuring that the system is lightweight enough to function as a Progressive Web Application (PWA) on any mobile device in areas with varying internet speeds.

1. The Client-Side (Frontend Interface): The user-facing layer is developed using HTML5, CSS3, and JavaScript. This layer is responsible for capturing inputs througha responsive, mobile-first design. It utilizes the Leaflet.js library to render interactivemaps. The interface communicates with the server via asynchronous requests,ensuring that the user experience remains fluid withoutconstant page reloads. VisualStudio Code was the primary environment used to design this responsive layer.
2. The Server-Side (Logic & Processing Engine): The backend is the "brain" of theinstrument, developed in Python using the Flask web framework within the PyCharmIDE. This layer hosts the core research logic:
    i. NLP Pipeline: Utilizing spaCy, the system tokenizes and cleans user-enteredtext to extract key medical entities.

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ii. ML Diagnostic Logic: The pre-trained LogisticRegression model, informedbyTfidfVectorizer, analyses the cleaned text to provide a health interpretation.
iii. Referral Logic: The server calculates the distance and time between the user'scoordinates and the hospitals stored in the database, sorting them by proximityto provide the most relevant referral.
iv. Audio Engine: The gTTS (Google Text-to-Speech) library is integrated hereto convert text-based advice into audible speech for the user.

3. The Data Tier (Database Management): All persistent data, including the directory of government primary, secondary, and tertiary hospitals in Delta, Rivers, and Bayelsa, is managed through PostgreSQL. The database structure was designed and administered using pgAdmin 4, ensuring high data integrity and secure storage of user interaction logs. GitHub was utilized throughout this architectural development to maintain version control and ensure the reliability of the codebase.

By integrating these frameworks into the research design, the study ensures that every technical component, from a line of Python code to a Leaflet map, is directly aligned to bridge the gap between residents and government healthcare facilities.

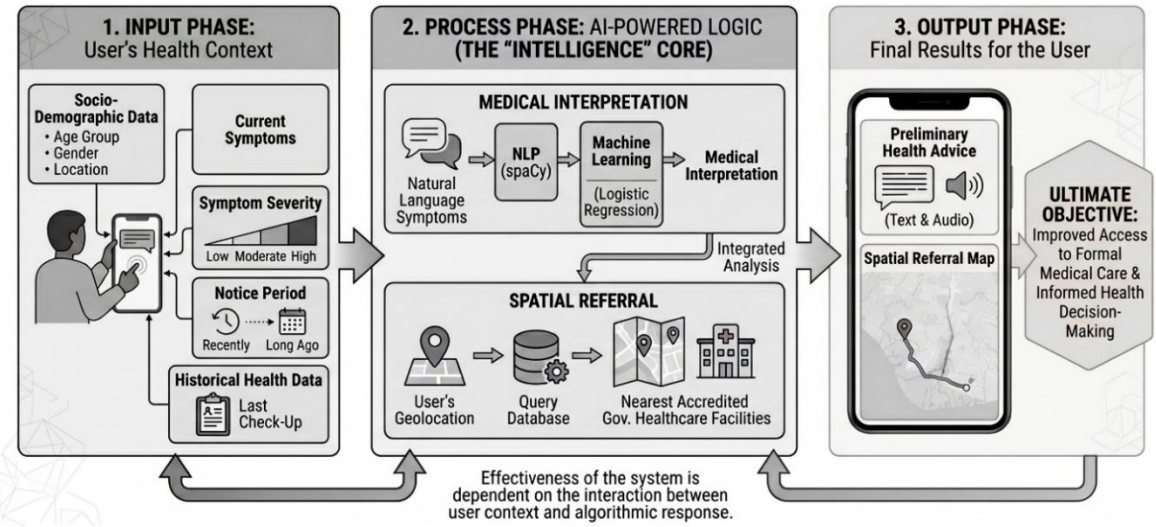

Figure 3.1: The IPO model of the conceptual framework of the AI-powered digital health advisory system centred in (Delta, Rivers, and Bayelsa), Nigeria.

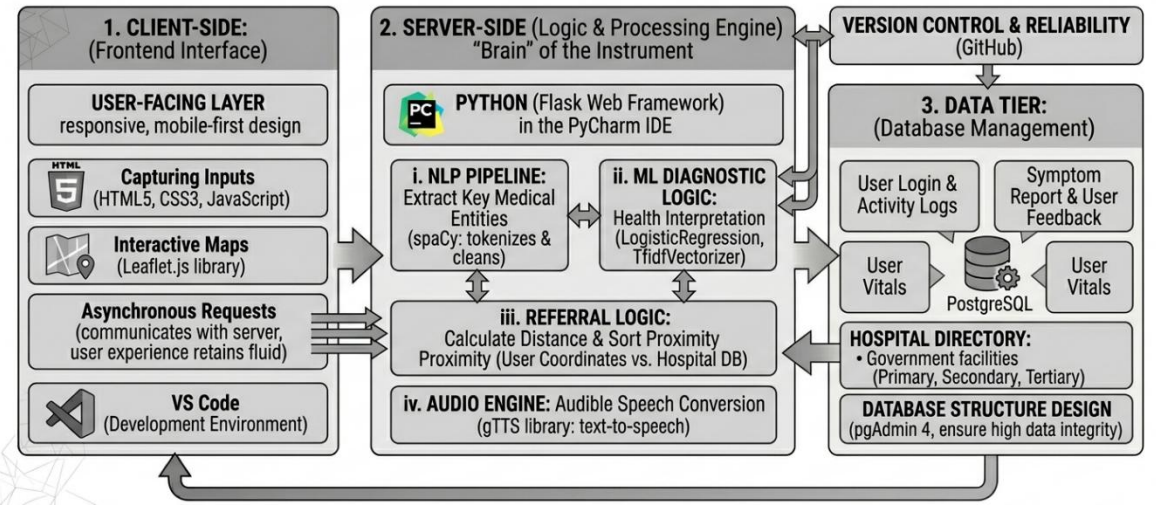

Figure 3.2: Shows the Client-Server-Database model of the Architectural Framework: System Design

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3.3 The Functional Prototype AI-powered Digital Health Advisory with Preliminary Self-assessment and Location-based Hospital Referral System Design Primary Instruments used

The primary instrument used in this study was a functional prototype of an AI-powered digital health advisory system, developed as a Progressive Web Application (PWA) to enable real-time interaction and cross-platform accessibility. The system was built using Python for backend development and HTML5, CSS3, and JavaScript for the frontend, supported by tools such as PyCharm, Visual Studio Code, GitHub, and PostgreSQL (via pgAdmin 4). It incorporated Natural Language Processing (NLP) using the spaCy library and a machine learning pipeline (TfidfVectorizer and LogisticRegression) for symptom interpretation and preliminary health assessment. Additionally, the system integrated geospatial capabilities using Leaflet.js for map visualisation and the haversine method to provide location-based hospital referrals. An audio-visual advisory feature powered by Google Text-to-Speech (gTTS) enhanced accessibility for users with varying literacy levels. The reliability of the system was ensured through repeated testing of the NLP and mapping components, while performance metrics such as accuracy, latency, and referral efficiency were monitored using Python-based visualization tools like Matplotlib and Seaborn.

3.4 Ethical Consideration

The system was designed to ensure user data confidentiality, anonymity, and secure handling of health-related inputs in line with digital health ethics.

- **Data De-identification:** Personal identifiers such as names and exact addresses were not collected. Participants were assigned unique alphanumeric codes in the PostgreSQL database to prevent linkage to their identities.
- **Secure Data Handling:** Data collected via the Python/Flask backend and stored in pgAdmin4 was protected using encrypted protocols, with access restricted to the researcher.

IV. Results

The results are organized to address the project's specific objectives regarding system preliminary self-assessment deployment and location-based referral efficacy.

4.1 Prototype Development and Deployment:

The system was successfully developed as a cross-platform web application, ensuring accessibility across various mobile and desktop devices. The architecture integrates an AI-driven Natural Language Processing (NLP) and Machine Learning engine for symptom interpretation with a geospatial database for facility mapping, and was named "CoreEfx AI Health Advisor System" for easy identification. The user journey begins with a secure authentication module, ensuring that user data is managed in alignment with privacy standards. The interface is designed for simplicity, catering to users with varying levels of digital literacy.

Figure 4.1: The Welcome interface that shows the initial installation button

1. **The welcome interface** is engineered as a functional Progressive Web Application (PWA) splash screen in Figure 4.1, prioritizing a seamless, mobile-first user experience. The interface design aligns with modern digital health standards by balancing aesthetic simplicity with technical responsiveness. The page utilizes a clean, centered layout featuring the project's iconography (the "brain" icon) and core branding. This reduces cognitive load for the user, which is critical for individuals seeking medical guidance who may be experiencing some kind of discomfort. The integration of a 9.5-second CSS-animated loading bar and a changing "status text" (e.g., "Initializing AI...", "Loading Medical Models...") provides the user with constant system feedback. By registering a service worker immediately, the system ensures the application can function reliably in low-bandwidth conditions, an essential requirement for digital health interventions in rural Nigerian settings. It detects the **beforeinstallprompt** event to provide a native installation experience, allowing users to "add"

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the AI advisor directly to their device's home screen like a proper mobile application. After a 20-second initialization window, the interface automatically transitions to the login or primary dashboard.

2. **The login and sign-up interfaces**are designed with a unified, mobile-first aesthetic that utilizes consistent flexbox layouts, secure password-toggling functionality, and adaptive theming to ensure a seamless experience across devices. Both forms prioritize user accessibility and data privacy by incorporating clear input validation, secure icon-based indicators, and integrated links to essential service and privacy policies.
3. **The Dashboard interface** is designed as a modular, mobile-responsive dashboard that centralizes health management tools. Below is a discussion of the primary components and tabs:

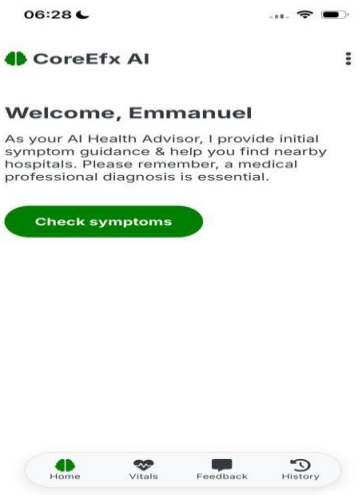

Figure 4.2: The Prototype dashboard interface and home tab

i. Home Tab: In Figure 4.2, this is the landing page that greets the user and provides a clear mission statement and warning message for the application: *As your AI health Advisor, I provide initial health symptom guidance & help you find nearby hospitals. Please remember, a medical professional diagnosis is essential*. It features a prominent "Check symptoms" button, which acts as the primary call-to-action to begin the AI-driven health assessment and referral process.

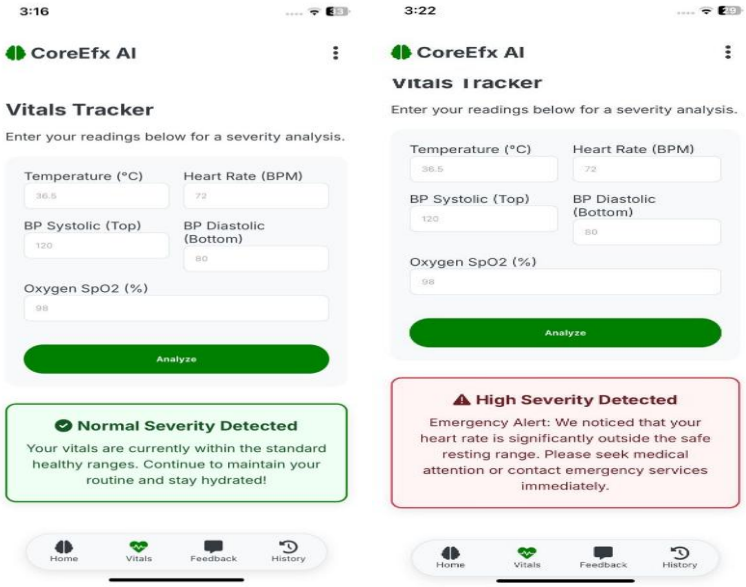

Figure 4.3: The vitals tab that shows a user's analysed severity result according to the user's vitals value input

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ii. Vitals Tab: This tab provides a structured form for users to log essential biometric data in Figure 4.3, including temperature, heart rate, blood pressure (systolic and diastolic), and oxygen saturation (SpO2). Upon submission, the AI analyses these inputs and provides immediate results on the user's health status, including severity indicators (Normal/Moderate/High) and actionable advice.

iii. History Tab: This serves as a comprehensive log of the user's past activities. It differentiates between Vitals Readings (marked with a blue side-border) and Symptom Reports (marked with a green side-border). Each record includes a timestamp, the reported symptoms or values or input text, and the AI's previous advice, helping users track their health trends over time.

iv. Feedback Tab: Integrated into the dashboard is a feedback mechanism that allows users to communicate directly with the researcher or developer. The interface includes a text area for users to describe their experience or suggest improvements.

4. **Chatbot Interface**: Navigating to the chatbot interface through the symptom check button strategically placed on the home tab. This serves as the primary interface for the AI Health Advisor's diagnostic and referral workflow, facilitating a real-time, interactive session between the user and the AI (NLP/ML) engine.

   i. Initial Interaction Phase: This is the phase in Figure 4.7, where it asks the user to input their symptoms and initialize their location for referral. Now, if the user's location is not turned on or not allowed, it won't be able to pinpoint the user's location-based hospital referrer.

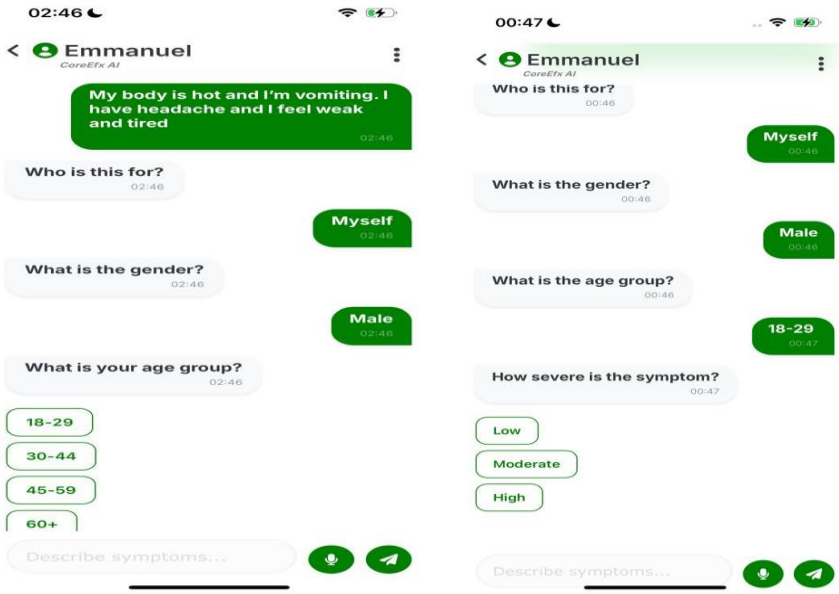

Figure 4.4: The triage phase of a user interacting with the chatbot

ii. Triage Phase: In this phase (Figure 4.4), the AI asks the user-defined questions such as age group, who this is for, gender, notice period, check-up date, etc., for easy understanding of the symptom entered.

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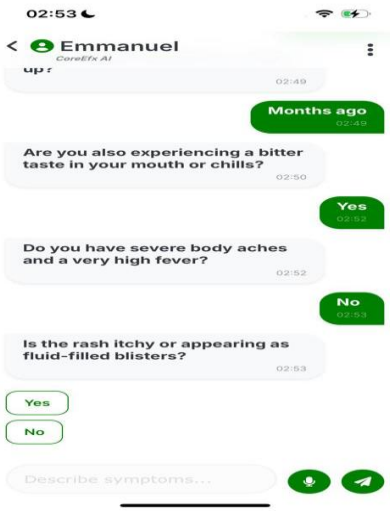

Figure 4.5: The AI follow-up questions determined by the user's input

iii. Follow-up question phase: The follow-up Symptom questions are determined by the AI Natural Language and Machine Learning threshold score from the backend, as shown in Figure 4.5, determined by the user's input symptoms. In order to determine the highest symptom score, yes or no was used. If the user chooses "yes," it raises that symptom score, but if he chooses "no," it erases the score. Leaving only the most important scores, the user answered yes.

iv. Final AI Analysis Phase: In Figure 4.4, once the symptoms are received, the AI engine processes the natural language input to perform a clinical risk assessment. This stage is critical for the "Symptom Checker" functionality, where the system interprets the severity of the user's health complaints.

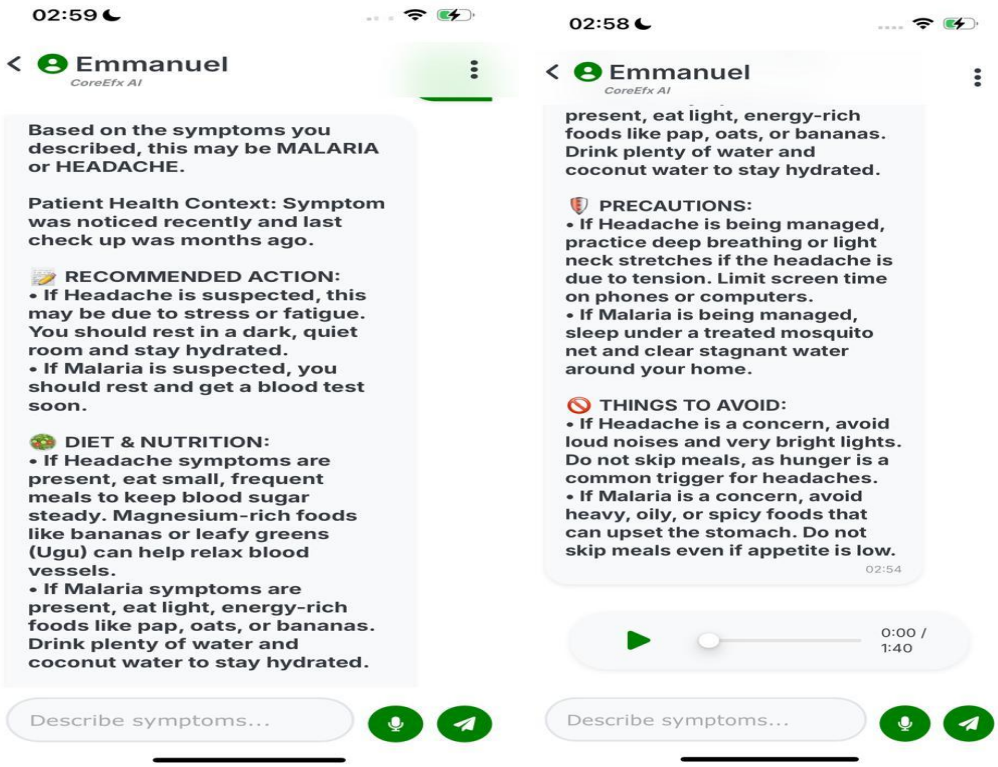

Figure 4.6: The preliminary actionable health advice with an audio file

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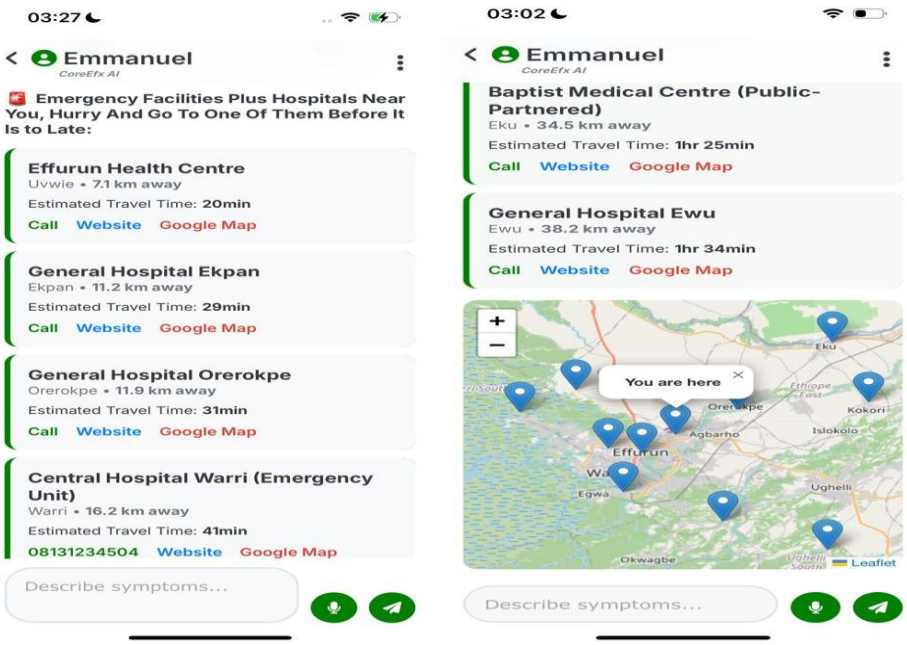

Figure 4.7: The integrated location of the hospital-based referral according to the severity of the user's severity.

v. Actionable Guidance Phase: The AI then returns a structured response, which includes
   - Preliminary Health Advice: Guidance on the nature of the reported symptoms with an audio file that reads the advice for users who can't read or so on in Figure 4.6.
   - Hospital Referral: To implement a location-based hospital referral mechanism that guides users to appropriate nearby healthcare facilities. In Figure 4.7, because the system captures the user's latitude and longitude, the AI can correlate the symptom severity with the proximity of registered healthcare facilities, providing the users with concrete, actionable steps for follow-up care. These coordinates are stored in the symptom database, allowing the backend to map symptoms to the nearest government healthcare facilities based on the user's current location.

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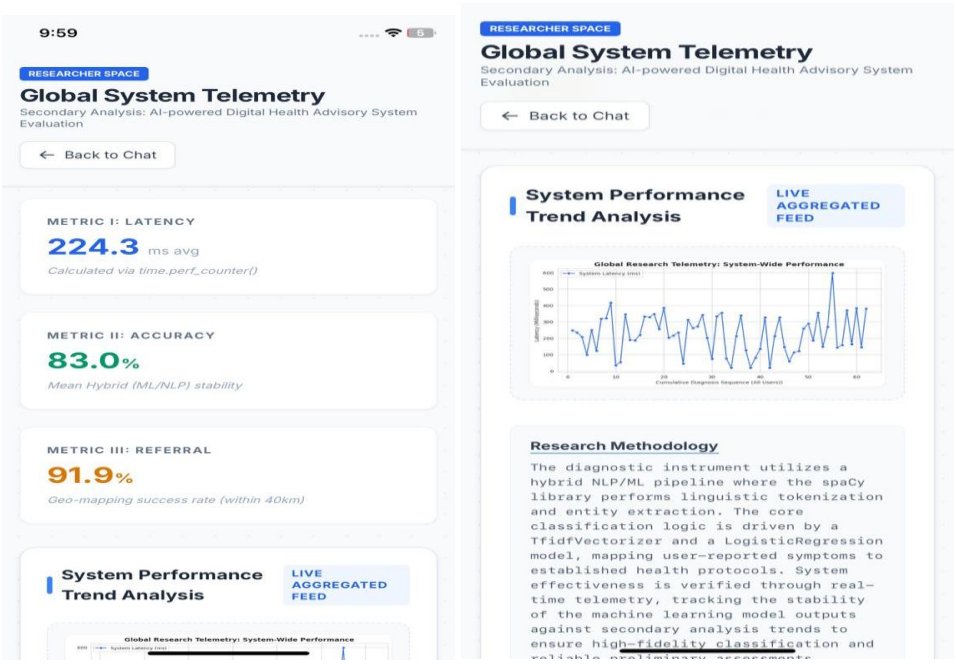

Figure 4.8: The metric interface shows a sample of the System Generated Metric for all users

5. **The metrics interface** (Figure 4.8) serves as a specialized administrative dashboard that provides a technical validation of the AI's diagnostic logic and the accuracy of its geospatial referral mapping. Through this interface, researchers can monitor system performance, comparing spaCy-informed classifications against established medical protocols to ensure clinical utility and instrument validity. The interface employs a clean, data-focused layout, ensuring that all telemetry and referral correctness data remain transparent and accessible for secondary analysis.

V. Conclusion and Recommendations

This study demonstrates that an AI-powered digital health advisory system can significantly improve healthcare access, efficiency, equity, and patient flow management in Nigeria. By integrating symptom-based AI assessment with geolocation-based hospital referral, the system provides a practical and scalable solution to persistent healthcare challenges, particularly in underserved regions. However, for long-term sustainability and widespread adoption, implementation must be user-centered, supported by strong policy frameworks, and continuously improved through real-world validation.

To strengthen the impact of this system, future efforts should focus on expanding its capabilities through integration with wearable devices and Internet of Things (IoT) technologies for real-time health monitoring and proactive care. There is also a critical need to incorporate diverse local languages to enhance usability, improve health literacy, and ensure inclusivity across different populations. Government and health authorities should promote the adoption of AI-based advisory systems within primary healthcare settings to improve early detection, triage efficiency, and referral processes.

Furthermore, structured digital literacy programs are essential to equip both users and healthcare professionals with the skills required to effectively utilize such technologies, thereby increasing acceptance and trust. Continuous updating, testing, and validation of AI algorithms using real-world clinical data must be prioritized to ensure accuracy, safety, and reliability. Finally, developing a comprehensive and up-to-date geolocation database of healthcare facilities across Nigeria will enhance referral accuracy, reduce delays in accessing care, and ensure that patients are directed to the most appropriate facilities promptly.

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