



# Imhotep-III: AI, Blockchain & DeFi-Powered Maternal and Child Health Platform for Africa

## 1. Problem Statement

Maternal and child healthcare across Africa faces three interconnected challenges:

### 1. Scattered and fragile health records

Maternal and child health information is often recorded on paper cards and clinic books. These easily get lost, damaged, or split across multiple facilities. When records are missing, providers may repeat tests, miss vaccinations, or lack continuity of care.

### 2. Reactive rather than proactive healthcare

Many mothers and caregivers only seek care when problems become severe. Even when records exist, they are written in clinical language and are not easily understood. Without clear, personalised insight into their own data, families cannot act early on risks or follow-up recommendations.

### 3. Affordability and financial barriers to care

Poverty, food insecurity, and high healthcare costs make it difficult for mothers to maintain good nutrition, pay for clinic visits, or afford health insurance premiums (e.g., Kenya's SHA). These financial constraints directly affect maternal and child outcomes.

There is a need for a patient-centred solution that makes health information understandable, creates a trusted digital trail for records, and introduces incentives that support healthy behaviour and financial access to care.

## 2. Project Overview

Imhotep-III is a web-based app that combines AI, blockchain anchoring, and DeFi-inspired incentives to support maternal and child health in Africa.

The platform allows users to:

- **Upload or enter maternal and child health records**  
e.g., clinic visit notes, pregnancy information, test results, immunisation history.
- **Ask an AI health assistant questions such as:**
  - “What are the key issues in my pregnancy records?”
  - “What risks should I be aware of?”
  - “What follow-up should I discuss with my doctor?”
- **Receive personalised insights, risks, and recommendations**  
Generated via **Genkit connected to Google's Gemini 2.5 Flash**, using **Retrieval-Augmented Generation (RAG)** over the user's own stored records.
- **Anchor their records on the XRPL**  
Cryptographic hashes (“anchors”) of records are immutably written to the XRPL as proof of integrity, while the actual health data remains in Firestore.
- **Lay the foundation for future DeFi incentives (IMT token)**  
In a future phase, an IMT token will reward positive health-seeking behaviours (e.g., attending antenatal visits, completing immunisation schedules). Mothers can eventually off-ramp these tokens to buy nutritious food and pay for healthcare or micro-insurance premiums.

The project demonstrates how developers can build patient-centred, AI-first, and blockchain-aware health tools that are practical, privacy-conscious, and aligned with real constraints faced by African families.

### **3. Objectives**

#### **3.1 Apply Google technologies and AI to a real health problem**

- Use **Genkit** to orchestrate prompts, tools, and flows for the AI health assistant.
- Connect Genkit to **Gemini 2.5 Flash** to summarise and reason over maternal and child health records using RAG.
- Use **Firestore and Cloud Run** for a secure, scalable backend and hosting.

#### **3.2 Enable proactive maternal and child healthcare**

- Convert raw clinical text into clear, contextual summaries that mothers can understand.
- Provide question-answering over a user's own stored records using RAG, so families can act early on health warnings and suggested follow-ups.

#### **3.3 Demonstrate trust and integrity using blockchain anchoring**

- Hash key health record events and anchor them on the XRPL.
- Allow users and providers to verify that records have not been silently modified, without exposing raw medical data on-chain.

#### **3.4 Explore financial inclusion via DeFi mechanisms**

- Define a model where an IMT token can be minted (in future work) to reward positive health behaviours.
- Provide a path for mothers to off-ramp tokens to purchase nutritious food and pay for healthcare or insurance premiums, addressing affordability.

#### **3.5 Prototype a solution that can be extended into a real product**

- Design the architecture so it can scale to more users, clinics, and countries.
- Provide a foundation for future integrations (mobile app, offline-first, multi-clinic support, DeFi rails).

## 4. Target Users and Impact

### Primary Users

- Pregnant women and mothers of young children.
- Community health volunteers and nurses who help households manage follow-ups.

### Secondary Users

- Clinics and health facilities.
- NGOs and public health programmes focused on maternal and child health.
- Health-tech startups and insurers experimenting with AI and DeFi for health.

### Expected Impact

- **Reduce missed vaccinations and follow-ups**  
By making health histories easier to access, understand, and discuss.
- **Increase proactive health-seeking behaviour**  
Through personalised insights, risk explanations, and suggested questions to ask healthcare workers.
- **Build trust in digital health systems**  
Via XRPL-based anchoring that proves records have not been tampered with.
- **Lay groundwork for financially-inclusive care**  
Via future IMT token rewards to help mothers afford food and healthcare.

## 5. System Architecture and Technologies

### Frontend (Web App)

- Plain JavaScript frontend (`public/app.js`) with a simple, mobile-friendly UI.
- Main capabilities:
  - Generate or reuse a pseudonymous `USER_ID`.
  - Upload or paste maternal and child health record text.
  - Trigger saving and anchoring of records.
  - Display XRPL wallet balance and latest anchored transactions.
  - Provide a chat-like interface to interact with the AI health assistant.

### Backend

- Node.js / Express API deployed on Google Cloud Run.
- Integrations:
  - Firestore (via Firebase Admin SDK)
    - Stores user health records, AI interaction history, and metadata.
  - XRPL JavaScript SDK
    - Creates and submits transactions to the XRPL.
    - Anchors hashes of records on-chain.
  - Genkit + Gemini 2.5 Flash + RAG
    - Retrieves relevant records from Firestore.
    - Builds context.
    - Calls Gemini 2.5 Flash for:

- Summarising uploaded health records.
- Answering user questions using RAG over the user's own data.

## **Data and Privacy**

- Health records are stored in Firestore under a randomised **USER\_ID**; no real names are required in this prototype.
- The blockchain receives only hashed anchors (e.g., hash of record ID and timestamp), not raw medical data.
- This pattern enables privacy-preserving audit trails, which could be adapted to real clinical deployments under appropriate regulations.

## **6. Innovative Use of Technologies**

- Genkit + Gemini 2.5 Flash + RAG
  - Genkit orchestration simplifies the definition of flows that:
    1. Retrieve relevant records from Firestore.
    2. Construct prompts with context.
    3. Call Gemini 2.5 Flash to generate safe, understandable explanations.
  - RAG ensures responses are grounded in the user's actual stored data, not only model knowledge.
- Google Cloud Platform
  - Cloud Run hosts the backend as a fully managed, scalable container.
  - Firestore provides serverless NoSQL storage for records and logs.
  - Native GCP monitoring and logging help observe performance and issues.

- **XRPL Blockchain**
  - The XRPL provides fast, low-cost transactions for anchoring.
  - Anchoring hashes allows verification of record integrity without compromising privacy.
- **DeFi and IMT token (future work)**
  - The design anticipates an IMT token for rewarding positive health practices, fertility of future integrations with off-ramping solutions and health financing.

## 7. Sustainability and Scalability

- **Scalable architecture**

Using Cloud Run and Firestore means the app can scale from a few early adopters to thousands of mothers and clinics while paying only for usage.
- **Modular AI flows**

Genkit workflows can be extended to:

  - Additional health use cases (e.g., chronic disease).
  - Multi-language support for African languages.
  - Stronger safety checks and prompt templates.
- **Sustainable business model (future)**
  - **B2B2C:** NGOs, insurers, or clinics pay for hosting and advanced analytics.
  - **Token-based incentives:** IMT tokens reward adherence; partners fund the token pool or subsidise health services.
  - **Freemium for mothers:** basic insights free, while organisations pay for dashboards, analytics, and integrations.

## 8. Future Work

- Integrate **SMS/USSD/WhatsApp** reminders for visits and vaccinations.
- Add **offline-first mobile** support for remote areas.
- Integrate with **national immunisation registries** where available.
- Implement and test the **IMT token** smart contract and off-ramp flows.
- Enhance AI safety and evaluation frameworks to responsibly handle medical content.

## 9. Conclusion

Imhotep-III demonstrates how **Genkit, Gemini 2.5 Flash with RAG, XRPL anchoring, and GCP services** can be combined to address real gaps in maternal and child health in Africa. It directly targets scattered records, reactive healthcare behaviour, and affordability concerns.

Even as a prototype, Imhotep-III shows a clear path towards a **production-ready, patient-centred platform** that respects data privacy, empowers mothers and caregivers, and uses incentives to support better health and financial outcomes.