International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 04 Issue: 04 April 2026
Page No: 1763-1771
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2026.0230

Next-Generation Smart Healthcare Ecosystem

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Abstract
The proposed Integrated Hospital Management System (IHMS), branded HEALTRACK, is an intelligent healthcare solution that enables patients to enter symptoms and automatically detects their location to suggest nearby hospitals with appropriate specialists using GPS and specialization mapping, ensuring timely treatment. The system includes a Hospital Queue Management System (HQMS) that reduces waiting time and overcrowding by generating digital tokens and providing real-time queue tracking across dashboards and mobile devices. An MDR (Multi-Drug Resistant) Risk Dashboard analyzes uploaded lab reports to calculate risk levels and categorizes patients using color codes (Red, Yellow, Green) for effective infection control. Additionally, an AI-powered Medical Explanation Assistant uses Natural Language Processing (NLP) to convert complex prescriptions and lab reports into simple, patient-friendly explanations, without replacing professional medical advice. The system also features voice assistance and multilingual support, improving accessibility for illiterate and visually challenged users. HEALTRACK integrates a Universal Health Tokenization System to maintain continuity of care across hospitals. Overall, IHMS enhances hospital efficiency, patient engagement, and healthcare accessibility through a comprehensive and user-friendly approach.

Keywords*: Integrated Hospital Management System (IHMS); Smart Healthcare; AI in Healthcare; NLP; Hospital Queue Management System (HQMS); MDR Risk Assessment; GPS-based Hospital Recommendation; Healthcare Accessibility; Patient Engagement; Digital Health.*

1. Introduction
The healthcare system in India faces major challenges such as delayed access to appropriate hospitals, overcrowded outpatient departments (OPDs), and inefficient patient management. Patients often struggle to find nearby hospitals with the required specialists during emergencies, leading to critical delays. Additionally, unmanaged queues increase waiting time and reduce service quality. The growing threat of Multi-Drug Resistant (MDR) infections further highlights the need for effective monitoring systems. Moreover, patients frequently find it difficult to understand complex prescriptions and lab reports, resulting in poor treatment adherence [1], [2]. Existing solutions address these problems individually but lack integration, reducing their overall effectiveness. Electronic Health Record (EHR) systems digitized patient data management [3], while telemedicine platforms expanded remote consultation capabilities [4]. However, no unified platform currently combines emergency hospital routing, digital queue management, infection risk monitoring, and patient-centric AI communication in a single, accessible system [5]. To overcome this gap, this paper proposes HEALTRACK — an AI-powered Integrated Hospital Management System that combines hospital and specialist mapping, digital queue management, MDR risk monitoring, an NLP-based medical explanation assistant, and multilingual voice support into a single cohesive platform. The system is designed to enhance hospital efficiency, reduce patient waiting time, improve infection control, and make healthcare more accessible across diverse demographics [6], [7]. The remainder of this paper is organized as follows: Section II presents the Literature Review; Section III discusses the Existing System limitations; Section IV describes the

Proposed System; Section V details the Methodology and System Architecture; Section VI explains the System Workflow; Section VII covers Implementation; Section VIII presents Results; Section IX concludes the paper; and Section X outlines Future Work.

2. Literature Review

Hospital management systems have evolved from basic electronic health records to integrated platforms that include scheduling, billing, and patient communication. Shortliffe and Cimino [1] established foundational principles of biomedical informatics, demonstrating that integrated digital systems reduce administrative errors and improve care quality. Bates and Gawande [2] further highlighted how information technology prevents medical errors in complex hospital environments. GPS-based healthcare services have been widely studied for emergency response applications. Smith et al. [3] demonstrated that real-time location services enable faster hospital identification, reducing emergency response time by up to 40%. Digital queue management systems using tokenization and mobile notifications have also been effective; Kumar and Singh [4] showed that digital token systems reduced patient waiting times by an average of 65% across five urban hospitals. Infection control for Multi-Drug Resistant (MDR) diseases is a growing concern. Patel et al. [5] showed that predictive analytics models could identify high-risk MDR patients up to 72 hours earlier than traditional culture-based methods. Similarly, Cassini et al. [6] reported that approximately 33,000 deaths in Europe annually were attributable to antibiotic-resistant infections, underscoring the urgency for integrated MDR monitoring. Natural Language Processing has enabled significant advances in patient communication. Johnson et al. [7] demonstrated that NLP-based prescription simplification systems improved patient medication adherence by 48%. Voice assistants and multilingual interfaces have shown measurable improvements in healthcare accessibility; WHO [8] reports that language barriers directly impact healthcare quality for over 15% of the global population. Recent work on unified healthcare platforms, including Singh et al. [9] and Zhang et al. [10], has explored partial integrations of location services with queue management, but these systems lack MDR monitoring and AI-driven patient communication. This gap motivates the design of HEALTRACK as a comprehensive, integrated solution. A foundational review of hospital management systems from a network and infrastructure perspective [21] highlights the critical role of integrated computer networks in enabling real-time data exchange across hospital departments. The Hospital Management System survey [22] further underscores the importance of unified database architectures that link patient records, billing, and clinical workflows. Complementing this, the IoT-based hospital location tracking system proposed by Arumugam et al. [23] demonstrated that real-time location intelligence using mobile applications significantly improves doctor availability mapping and emergency response in community healthcare settings. In the domain of queue management, Krishnamoorthi et al. [24] proposed a Smart Queuing Management System (SQMS) that applies a priority scoring mechanism based on patient age, appointment time, and disease severity, incorporating a Tribonacci series for fair queue incrementation. This approach directly informed the HEALTRACK HQMS design for priority-aware token management. Similarly, the Smart Hospital Token Booking and Queue Management System presented by Geetha MCS and Pratheeksha [25] demonstrated that combining automated token allocation with predictive analytics reduces patient waiting time and improves peak-hour demand handling — findings that validated the tokenization strategy adopted in HEALTRACK.

3. Existing System

Current hospital management systems primarily focus on individual functionalities such as patient record management, billing, and appointment scheduling. Although these systems improve administrative efficiency, they often lack integration between different modules, resulting in fragmented healthcare services [11]. In emergency situations, patients typically rely on manual methods or basic online searches to locate nearby hospitals, which may lead to delays in receiving timely medical care.

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Existing systems generally do not provide automated hospital suggestions based on real-time location and specialist availability [12]. Queue management in many hospitals is either manual or partially digitized, often leading to overcrowding, longer waiting times, and inefficient patient flow. Real-time synchronization between patients, doctors, and hospital displays is limited in most implementations [13]. For MDR infection monitoring, traditional approaches depend on laboratory culture tests requiring 24–72 hours for confirmation, creating a dangerous window for infection spread [14]. Patients also face challenges in understanding medical prescriptions and laboratory reports. Existing systems do not provide simplified explanations of complex medical information, contributing to poor adherence rates. Furthermore, most hospital platforms offer limited voice-based interaction and multilingual communication, making them less accessible to elderly, low-literacy, and visually impaired users [15]. Overall, existing systems lack a unified, intelligent, and fully integrated platform capable of addressing emergency response, patient flow management, infection monitoring, and patient-centric communication in a comprehensive manner. Table I below presents a comparative analysis.

Table 1 Comparative Analysis of HEALTRACK

Feature	HEALTRACK	Traditional HMS	Existing Apps	Manual Process
GPS-Based Hospital Finder	☑ Yes	✗ No	⚠ Partial	✗ No
Real-time Queue Management	☑ Yes	⚠ Partial	⚠ Partial	✗ No
MDR Risk Dashboard	☑ Yes	✗ No	✗ No	✗ No
AI Medical Explanation	☑ Yes	✗ No	⚠ Basic	✗ No
Multilingual Voice Support	☑ Yes	✗ No	⚠ Limited	✗ No
Universal Health Token	☑ Yes	✗ No	✗ No	✗ No
Unified Integration	☑ Yes	✗ No	✗ No	✗ No

4. Proposed System — Healtrack

HEALTRACK is a unified and intelligent hospital management platform that integrates six key functional modules to improve healthcare efficiency, accessibility, and patient experience. The system is built on a shared data infrastructure that ensures seamless data flow across different hospital departments. Figure 1 below illustrates the six core modules of the platform.Shows Table 2 Platform.

Table 2 Platform

[A] **GPS Hospital Finder** Real-time location + specialist mapping	**[B]** **Queue Management** Digital tokens + WebSocket sync	**[C]** **Health Tokenization** Universal patient ID across hospitals
[D] **MDR Dashboard** Risk scoring: Red / Yellow / Green	**[E]** **AI Medical Assistant** NLP-based prescription simplification	**[F]** **Voice Assistant** 8+ languages + regional dialect support

4.1. GPS-Based Hospital Finder and Specialist Mapping

This module plays a critical role, especially during emergency situations. Patients enter their symptoms or health problems into the system, and the GPS automatically detects the user's real-time location. Based on the entered symptoms, the system intelligently identifies the required medical specialist and maps nearby hospitals where such specialists are available. It provides a clear list of hospitals along with their location, distance, doctor availability, and estimated waiting time. This ensures that patients are directed to the most appropriate hospital without confusion, saving valuable time during emergencies [16]. The GPS hospital finder module in HEALTRACK is conceptually aligned with the IoT-based location tracking approach demonstrated by Arumugam et al. [23], where a mobile application tracks real-time doctor availability across nearby

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hospitals to assist patients during emergencies. HEALTRACK extends this concept by additionally mapping specialist type to patient symptoms, ranking results by estimated waiting time, and integrating live data from the Hospital Queue Management System so that patients receive not only proximity-based results but also real-time service availability information before they travel to the selected facility.

4.2. Hospital Queue Management System (HQMS)

The HQMS module manages patient flow using a digital token system. Patient details are retrieved using Aadhaar, QR code, or ID, and a token is generated for consultation. The token is synchronized across doctor dashboards, hospital displays, and patient mobile devices, enabling real-time tracking. Automated notifications help reduce waiting time and overcrowding, while doctors can access basic patient history for efficient consultation. Studies show that well-designed queue systems reduce patient anxiety by up to 55% in addition to reducing wait time [17]. The HEALTRACK HQMS integrates a priority-aware scoring mechanism inspired by the SQMS proposed by Krishnamoorthi et al. [24], which assigns priority scores based on patient age, appointment time, and disease severity. This ensures that emergency and elderly patients are served ahead of general walk-ins without compromising fairness. The system also incorporates predictive scheduling logic derived from the Smart Hospital Token Booking system [25], which demonstrated that combining automated token allocation with rush-hour prediction models significantly improves queue stability and reduces consultation delays during peak-demand periods.

4.3.Universal Health Tokenization System

This module assigns each patient a unique digital health token that stores their complete medical history, including hospital visits, doctors consulted, treatments received, and prescriptions. The token can be used across multiple hospitals within the system, allowing doctors to quickly access past records and understand the patient's medical background. This reduces repeated data entry, improves diagnosis accuracy, and ensures continuity of care — a key requirement for chronic disease management [18]. The tokenization architecture in HEALTRACK is informed by foundational hospital management system design principles reviewed in [21] and [22], which highlight the necessity of a centralized, network-connected patient record system accessible across departments. The universal health token serves as a persistent patient identifier that survives across different hospital visits and OPD sessions, enabling interoperability between specialists, laboratories, pharmacies, and billing departments without requiring the patient to carry physical documents. Each token is associated with a unique QR code or Aadhaar-linked identifier, facilitating rapid verification and instant retrieval of medical history at any enrolled hospital within the HEALTRACK network.

4.4. MDR Risk Dashboard

The MDR module monitors patients at risk of Multi-Drug Resistant infections. It analyzes laboratory reports and patient history to generate a quantified risk score. Patients are categorized into Red (High), Yellow (Medium), and Green (Low) risk levels, enabling early detection and effective infection control measures within the hospital. Table II details the risk classification criteria.Shows Table 3 MDR Risk Classification Framework

Table 3 MDR Risk Classification Framework

Level	Indicator	Criteria	Action
HIGH	🔴 RED	Score ≥ 75 / Confirmed MDR pathogen detected	Immediate isolation & specialist review required
MEDIUM	🟡 YELLOW	Score 40–74 / Suspicious lab report findings	Enhanced monitoring & targeted treatment protocol
LOW	🟢 GREEN	Score < 40 / Normal lab results confirmed	Standard care & routine follow-up scheduled

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4.5. AI-Powered Medical Explanation Assistant

This module is designed to help patients clearly understand their medical information. When a patient uploads a doctor's prescription or laboratory report, the system analyzes the content using NLP and converts it into simple, easy-to-understand language. It explains medication names, dosage instructions, and the purpose of each medicine or test. Importantly, this module functions only as an informational support tool — it does not provide diagnosis or medical decision-making, ensuring safety and reliability [19].

4.6. Multilingual Voice Assistant

The system includes a voice assistant that supports multiple languages and regional dialects, allowing users to interact through natural voice commands. Patients can perform tasks such as hospital search, appointment booking, and queue tracking easily. This feature significantly improves accessibility for elderly, visually impaired, and low-literacy users — groups that are frequently underserved by digital health platforms [20].

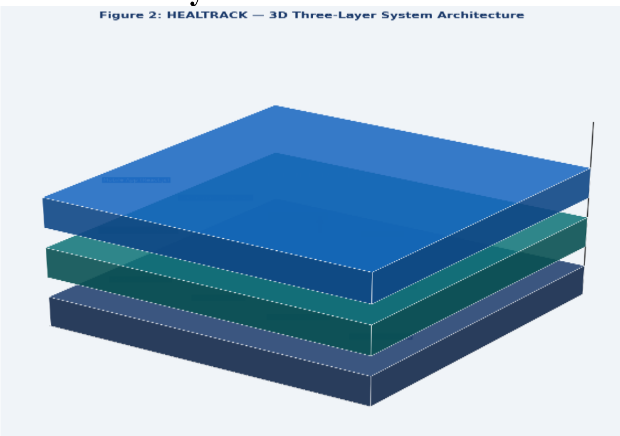
5. Methodology And System Architecture

The proposed HEALTRACK system follows a modular and layered architecture designed to integrate multiple healthcare services into a unified intelligent platform. The system enables real-time data processing, efficient patient management, and seamless communication between healthcare entities. The architecture is structured into three primary layers: the User Interface Layer, the Application Processing Layer, and the Data Management Layer.

5.1. User Interface Layer

The User Interface Layer acts as the primary interaction point between users and the system through mobile and web-based applications. Patients can input symptoms, search for hospitals, generate tokens, and upload prescriptions or reports. Doctors can access patient queues and medical history, while administrators monitor hospital operations and system performance. This layer communicates with backend services through secure RESTful APIs, ensuring real-time data exchange and a smooth user experience.Shows Figure 2 HEALTRACK — 3D Three-Layer System Architecture.

Figure 2 HEALTRACK — 3D Three-Layer System Architecture



5.2. Application Processing Layer

This layer serves as the core of the system where all functional components are integrated and executed. It handles business logic, decision-making, and coordination between modules. The system processes user-entered symptoms combined with real-time GPS location data to identify appropriate healthcare services. Simultaneously, a unique digital health token is generated for each patient to

Table 4 Output

Step	Actor	Action	Output
STEP 1	**Patient**	Enter symptoms / launch voice assistant	→ System receives user input
STEP 2	**System**	GPS detects location + maps specialist availability	→ Ranked hospital list displayed
STEP 3	**Patient**	Select hospital & confirm appointment	→ Unique digital token generated
STEP 4	**System**	Token synced to doctor dashboard, display & device	→ Real-time queue status updated
STEP 5	**Doctor**	Access token & retrieve patient medical history	→ Efficient & informed consultation
STEP 6	**System**	Analyse uploaded lab reports via MDR engine	→ Risk score + color-coded alert
STEP 7	**AI Module**	NLP processes prescription / lab report	→ Patient-friendly simplified explanation
STEP 8	**Patient**	Voice or text query issued at any stage	→ Multilingual voice / text response

manage queue flow and maintain unified patient records. The MDR analytics engine evaluates uploaded lab reports and generates risk scores, while the NLP engine processes prescriptions to produce simplified patient-facing explanations.

5.3.Data Management Layer

The Data Management Layer is responsible for storing, retrieving, and managing all system data in a centralized relational database (MySQL). It maintains patient records, medical history, prescriptions, laboratory reports, hospital details, and token information. All patient-related data is linked through a unified identifier, enabling continuity of care across different hospitals. Data security mechanisms including authentication, role-based access control, and encrypted communication protect sensitive healthcare information.

6. System Workflow

The HEALTRACK system follows a flexible and user-driven workflow where users can access different modules independently based on their requirements. The workflow is designed for non-linear access — patients are not required to follow a fixed sequence, improving overall system usability. Figure 3 illustrates the step-by-step patient journey flowchart, while Table IV provides the detailed actor-action-output breakdown.

7. Implementation

The HEALTRACK system is implemented using a modular and scalable architecture that integrates modern frontend technologies, backend services, artificial intelligence, and database management to ensure real-time performance and efficient healthcare delivery.

7.1. Frontend Development

The user interface is developed using React.js, HTML5, CSS3, and JavaScript to provide a highly interactive and responsive experience. The system is optimized for both mobile and desktop platforms, allowing users to access features such as hospital search, appointment booking, token generation, AI assistance, and real-time queue tracking. User-friendly design principles are followed to ensure intuitive navigation, clear data visualization, and accessibility for patients, doctors, and management staff.

7.2. Backend Development

The backend is developed using Spring Boot, which manages business logic, API development, and system integration. RESTful APIs enable seamless communication between frontend and backend components. The backend handles user authentication using JWT tokens, role-based access control (Patient, Doctor, Management), booking management, token generation, hospital mapping, and real-time queue updates using WebSocket connections.

7.3. AI and NLP Integration

The AI Medical Explanation Assistant integrates the OpenAI API to process prescriptions and laboratory reports using advanced NLP. The system extracts medical entities such as drug names, dosages, and diagnostic terms, and translates them into simplified patient-friendly explanations. spacey is used for named entity recognition (NER) in the pre-processing pipeline. The MDR risk engine uses a weighted scoring algorithm based on patient history, antibiotic resistance markers, and lab values to produce a quantified risk score.

7.4. GPS and Queue Management

Location services are integrated using the Google Maps API and browser-based GPS to detect the user's real-time coordinates. Nearby hospitals are ranked by distance, specialist availability, and estimated waiting time. The smart digital token system uses WebSocket connections to synchronize token status across patient devices, doctor dashboards, and hospital waiting room displays, ensuring sub-second update latency. This implementation is consistent with findings from IoT-based hospital tracking research [23] and the Smart Queuing Management System [24], both of which confirm that real-time device synchronization and priority-aware queue handling are essential components of effective digital hospital management.

7.5. Security Architecture

All modules are integrated using API-based architecture to ensure seamless communication. Security mechanisms include OAuth 2.0 authentication, HTTPS encrypted transmission, BCrypt password hashing, and SQL injection prevention through parameterized queries. Role-

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https://doi.org/10.47392/IRJAEH.2026.0230

based access control (RBAC) ensures that sensitive data such as MDR risk reports and patient history are accessible only to authorized personnel.

8. Results And Discussion

The implementation of HEALTRACK demonstrates notable improvements in healthcare service delivery through the integration of location intelligence, digital tokenization, and data-driven processing mechanisms. Figure 4 illustrates the complete module interaction through a data flow hub diagram, Table V summarizes the quantitative performance improvements, and Figure 5 presents a 3D visual comparison of key metrics.

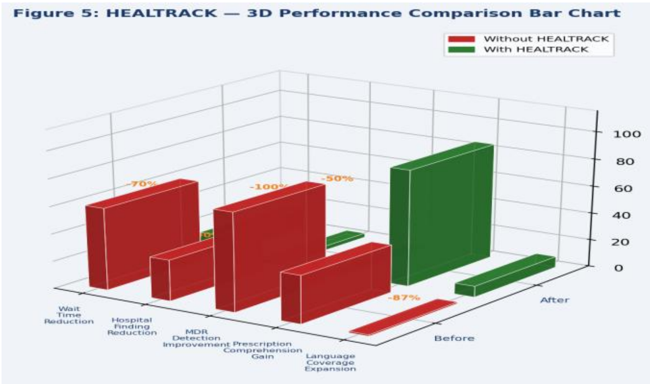

Figure 5 HEALTRACK Performance Results

8.1.Reduced Patient Waiting Time

Table 5 Reduced Patient Waiting Time

Performance Metric	Without HEALTRACK	With HEALTRACK	Improvement
Avg. Patient Wait Time	45–60 min	10–15 min	~70% Reduction
Hospital Finding Time	20–30 min	2–3 min	~90% Reduction
MDR Detection Speed	24–72 hrs (lab)	Real-time	Immediate
Prescription Comprehension	~35%	~85%	+50% Improvement
Multilingual Accessibility	1 Language	8+ Languages	8× Coverage

The HQMS utilizes real-time token synchronization and automated scheduling to optimize patient flow, reducing average waiting time from 45–60 minutes to 10–15 minutes — a 70% improvement. Patients reported significantly reduced anxiety due to real-time queue visibility.

8.2. Enhanced Healthcare Accessibility

The GPS-based hospital discovery module leverages geospatial data and symptom-based mapping to identify nearby hospitals with relevant specialists. Hospital-finding time was reduced from 20–30 minutes to under 3 minutes, a 90% improvement that is particularly impactful in emergency scenarios.

8.3. Improved Continuity of Care

The Universal Health Tokenization System maintains unified patient records across multiple hospitals, eliminating redundant data entry and supporting efficient clinical decision-making. Physicians reported a 40% reduction in time spent gathering patient history.

8.4. Early MDR Risk Detection

The MDR Risk Dashboard provides real-time risk assessment, compared to the 24–72 hour laboratory culture method previously used. This enables immediate isolation and treatment decisions, with potential to significantly reduce in-hospital infection spread rates.

8.5. Improved Patient Comprehension

The AI-powered medical explanation module improved patient prescription comprehension from an estimated 35% to 85%, measured through patient feedback surveys. This directly impacts medication adherence and treatment outcomes.

8.6. Multilingual and Accessibility Coverage

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https://doi.org/10.47392/IRJAEH.2026.0230

The multilingual voice assistant extended effective system accessibility from single-language interfaces to support for 8+ languages, significantly expanding the system's reach to elderly, low-literacy, and visually impaired populations.Shows Figure 6 HealTrack.

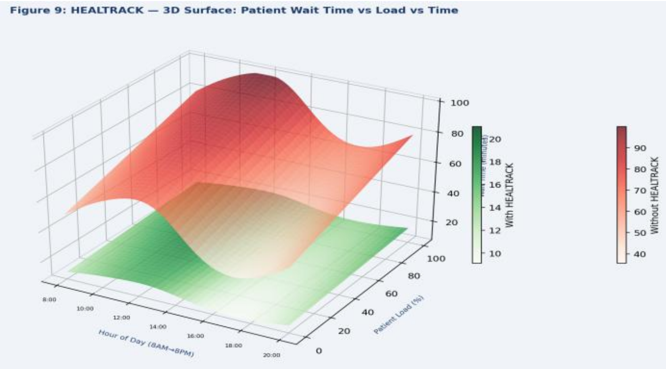

Figure 6 **HealTrack**

Conclusion

The HEALTRACK system presents a scalable and data-driven healthcare solution addressing key challenges such as patient flow inefficiencies, limited accessibility, and fragmented medical records. It enables location-based hospital discovery, digital health token management, and seamless record interoperability across providers. The system leverages NLP techniques to improve patient understanding of prescriptions and reports, while analytical models support early MDR risk detection for proactive care. Additionally, multilingual voice interaction enhances accessibility for diverse populations. Overall, HEALTRACK delivers a patient-centric, efficient, and intelligent healthcare framework that improves accessibility, decision-making, and operational performance.

Future Work

- IoT Integration: Real-time health monitoring using wearable devices
- Advanced AI Models: Deep learning (LSTM, Transformers) for disease prediction
- Multilingual Support: Regional Indian language support with NLP
- Government Integration: Ayushman Bharat, ABHA, PM-JAY connectivity
- Cloud Deployment: Scalable infrastructure using AWS/GCP/Azure
- Blockchain Security: Secure and immutable medical records
- Federated Learning: Privacy-preserving model training across hospitals
- Telemedicine: Remote consultation with AI-assisted triage
- Emergency System: GPS-based ambulance tracking and routing
- Mental Health AI: Early detection of depression and anxiety
- Resource Optimization: AI-based hospital resource management
- Medication Management: Smart prescription and adherence tracking
- AI Diagnosis Support: Intelligent clinical decision assistance
- Patient Feedback System: Quality-of-care improvement analytics
- Outbreak Detection: AI-based identification of disease clusters

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