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MediLink

A Hospital Resource, Inventory and Analysis Management Dashboard

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Abstract**—*****MediLink*** *is a web-based Hospital Resource, Inventory, and Analysis Management Dashboard designed to improve the efficiency, coordination, and transparency of healthcare resource management. In many healthcare systems, hospitals operate independently, resulting in limited visibility of critical resources such as ICU beds, blood units, oxygen cylinders, and essential medicines. This fragmentation leads to delays in emergency response and inefficient utilization of available assets.* ***MediLink*** *addresses this challenge by providing a centralized platform that integrates data from multiple hospitals and departments into a unified, real-time dashboard. The system enables real-time monitoring of medical inventory, facilitates inter-hospital resource sharing, and incorporates predictive analytics to forecast future resource requirements—helping hospitals reduce shortages, minimize wastage, and respond faster to patient needs. The modular, scalable design ensures flexibility and ease of future expansion.* ***MediLink*** *demonstrates how digital solutions and data-driven approaches can significantly enhance hospital operations and contribute to a more connected, efficient, and responsive healthcare ecosystem.*

Index Terms—*Healthcare management, hospital inventory system, inter-hospital coordination, predictive analytics, real-time monitoring, resource optimization, web dashboard.*

I. INTRODUCTION

THE healthcare sector relies heavily on efficient management of critical resources such as hospital beds, medical equipment, medicines, and emergency supplies. In many cases, hospitals manage these resources independently, which limits visibility and coordination—especially during high-demand situations such as disease outbreaks, seasonal surges, or mass casualty events. The increasing need for timely, accurate information has underscored the importance of digital solutions that support better resource management and decision-making across interconnected healthcare systems.

MediLink is designed as a web-based Hospital Resource, Inventory, and Analysis Management Dashboard that provides a centralized platform for monitoring and managing healthcare resources across multiple institutions. The system integrates data from multiple hospitals and departments, allowing administrators to view real-time information on the availability of ICU beds, blood units, oxygen cylinders, and essential medicines. This centralized approach eliminates information silos, enables better inter-hospital coordination, and helps reduce delays in responding to patient needs.

In addition to resource monitoring, **MediLink** incorporates analytical capabilities to enhance planning and operational efficiency. By analyzing historical data related to medicine usage and hospital resource consumption, the system identifies trends and patterns that assist in predicting future requirements. These predictive insights support proactive decision-making, helping hospitals prepare for fluctuations in demand, avoid critical shortages, and improve overall resource utilization across the network.

The platform is designed with a modular and scalable architecture, ensuring flexibility and ease of expansion as new hospitals or departments are onboarded. Each module addresses a specific operational domain—from inventory tracking and patient transfers to disease outbreak detection and shortage forecasting—while integrating seamlessly into the unified dashboard. By combining real-time monitoring with data-driven insights, **MediLink** aims to support healthcare institutions in delivering timely, efficient, and well-coordinated services, ultimately contributing to improved patient outcomes and system performance.

II. PROBLEM STATEMENT AND OBJECTIVES

A. Problem Statement

Hospitals often operate as independent units, managing resources such as ICU beds, medicines, blood units, and oxygen supplies without real-time coordination with neighbouring healthcare centres. This lack of centralized visibility leads to a range of systemic challenges: inefficient resource utilization where one hospital may have excess supplies while another faces critical shortages, delays in emergency response when staff must manually verify availability across facilities, and difficulty in identifying the nearest hospital equipped to handle specific patient conditions.

During critical situations, patients may face life-threatening delays in receiving timely care due to the unavailability of accurate and up-to-date resource information. Additionally, traditional inventory management systems rely on manual updates or isolated databases, increasing the risk of data inconsistencies, overstocking of perishable medical supplies, and unexpected stockouts of essential medicines. These operational inefficiencies highlight the urgent need for an integrated, technology-driven platform that enables real-time monitoring, efficient resource sharing, and data-driven decision-making across the healthcare ecosystem.

B. Objectives

The primary objectives of **MediLink** are:

- Enable real-time monitoring of ICU beds, medicines, blood units, and oxygen across multiple hospitals from a single unified dashboard.
- Facilitate seamless inter-hospital coordination and resource sharing, particularly during emergency situations and disease outbreaks.
- Integrate data analytics capabilities for identifying trends in disease patterns, medicine consumption, and resource utilization.
- Implement predictive techniques to forecast future resource requirements, thereby reducing shortages and minimizing wastage.
- Improve decision-making speed and operational efficiency for hospital administrators through timely, accurate, and actionable information.
- Provide a scalable, modular architecture that supports future integration with national health systems such as Ayushman Bharat.

III. LITERATURE SURVEY

A growing body of research has explored the application of data-driven and computational approaches to address challenges in healthcare resource management. These studies collectively highlight the potential of technologies such as big data analytics, IoT-based monitoring, machine learning, and cloud computing to enhance hospital efficiency and coordination. Table I summarizes the key related works reviewed for this project and highlights their contributions alongside notable limitations.

TABLE I

Summary of Related Work in Healthcare Resource Management

Authors	Key Findings	Limitations
Zhang et al. [1] 2024	Big data for resource allocation	Needs large structured datasets
Sharma & Wang [2] 2022	IoT + edge/cloud real-time monitoring	High infrastructure cost
Rajkumar [3] 2022	Deep learning on EHRs for prediction	Requires large labeled data
Thakkar & Patel [4] 2021	ML/time-series demand forecasting	Data quality dependent
Chen et al. [5] 2020	Cloud-based smart healthcare systems	Security & privacy concerns

Zhang et al. [1] demonstrated how big data analytics can significantly improve hospital resource allocation efficiency by processing large-scale admission and usage data, but the approach requires extensive, well-structured datasets that may not be readily available in smaller institutions. Sharma and Wang [2] proposed an IoT-based system for real-time healthcare data monitoring using edge and cloud computing, enabling continuous resource tracking but at a prohibitively high infrastructure cost for resource-constrained environments.

Rajkumar [3] leveraged deep learning models applied to electronic health records (EHRs) to predict medical events and patient risks with high accuracy, though the method is heavily dependent on the availability of large, well-labelled clinical datasets. Thakkar and Patel [4] applied machine learning and time-series forecasting to predict hospital resource and medicine demand, helping reduce shortages, but the model's reliability is tied to the consistency and quality of historical data. Chen et al. [5] presented a cloud-based smart healthcare system that uses analytics to improve coordination across hospitals, though it raises significant security and data privacy concerns. MediLink builds on these contributions by addressing their limitations through a lightweight, modular, web-based architecture that combines real-time monitoring, predictive analytics, and multi-hospital coordination without requiring specialized hardware or large pre-labelled datasets.

IV. SYSTEM DESIGN AND METHODOLOGY

A. System Architecture

MediLink follows a layered client-server architecture comprising four primary layers: the Frontend Layer, the

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Backend Layer, the Database Layer, and a planned Future Analytics Layer. This separation of concerns ensures that each layer can be developed, tested, and scaled independently without affecting the overall system stability. User roles—Admin, Hospital Staff, and Inventory Manager—are enforced at the authentication layer with role-based access control (RBAC), ensuring that each user can only access the functionalities and data appropriate to their designation.

The Frontend Layer is built with HTML5, CSS3, JavaScript, and Bootstrap, providing a responsive and interactive web dashboard accessible from any modern browser without installation. The Backend Layer is powered by Node.js and Express.js, handling all client requests, API routing, and server-side data processing. MySQL serves as the centralized relational database, maintaining structured information including patient records, staff data, hospital profiles, inventory entries, and resource availability logs. REST APIs using JSON data exchange facilitate clean, stateless communication between the frontend and backend. Future enhancements will introduce a dedicated Python-based analytics layer using Pandas and Scikit-learn for advanced machine learning-driven predictions.

B. System Modules

MediLink is composed of eight core modules, each responsible for a distinct operational domain:

- Hospital Management Module: Manages hospital registration, organizational profiles, user role assignments, and inter-hospital patient transfer coordination.
- Inventory Management Module: Tracks medicines, equipment, and medical supplies with real-time stock level updates, batch number tracking, and expiry date monitoring.
- Resource Monitoring Module: Provides live monitoring of critical resources including ICU beds, blood units, and oxygen cylinders with dynamic dashboard visualizations.
- Analytics & Prediction Module: Analyzes historical disease trends and medicine usage patterns to generate forecasts for future resource requirements.
- Alert & Notification Module: Delivers real-time in-platform alerts for low stock conditions, emergency shortages, and incoming patient transfer requests.
- Authentication & Security Module: Manages user login, password hashing with bcrypt, session token management, and role-based access control.
- Data Management Module: Handles all CRUD operations across all entities, ensuring database consistency, integrity, and efficient record management.
- API / Communication Module: Enables structured REST API-based communication between the frontend and backend using JSON, supporting all data read and write operations.

C. Technology Stack

The technology stack was selected for its lightweight deployment, open-source availability, active community support, and suitability for rapid development:

- Frontend: HTML5, CSS3, JavaScript, Bootstrap 5
- Backend: Node.js v18+, Express.js v4
- Database: MySQL 8.0 (Relational DBMS)
- Data Format: JSON (RESTful API)
- Development Tools: Visual Studio Code, GitHub
- Future Analytics Layer: Python 3, Pandas, Scikit-learn

D. Database Design

The MySQL relational schema is structured around five primary entities: User, Hospital, Patient, Inventory, and Resource. The User entity stores authentication cre dentials, role assignments, and hospital affiliations. The Hospital entity maintains institutional details including name, ID, address, and state, and acts as the central linking entity for patients, staff, and inventory. The Patient entity records demographic information, admission details, and associated diagnoses. The Inventory entity tracks item names, batch numbers, quantities in stock, expiry dates, and reorder threshold values. The Resource entity monitors real-time availability status for critical supplies such as ICU beds, blood units, and oxygen cylinders, associated with their respective hospitals.

Foreign key relationships enforce referential integrity across all entities, preventing orphaned records and ensuring data consistency. Composite indexes on frequently queried field combinations such as hospital_id with item_id and hospital_id with resource_type significantly improve query response times under concurrent multi-hospital load. Cascading delete policies are applied selectively to manage dependent records when a hospital or user is removed from the system.

V. IMPLEMENTATION AND RESULTS

A. Login and Registration

The Login Page authenticates hospital staff using registered email addresses and passwords. Upon submitting invalid credentials, the system displays a descriptive error message without revealing whether the email or password was incorrect—a security best practice that prevents account enumeration. The Registration Page enables new hospitals to onboard the platform by providing their hospital name, government-issued hospital ID, state, full address, and designated staff account details including contact email and password. A visually distinct dark-themed UI with a prominent pink call-to-action button provides a modern and accessible interface. All passwords are hashed using the bcrypt algorithm before being stored in the database, and

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JSON Web Tokens (JWTs) are issued upon successful authentication to maintain secure, stateless sessions.

B. Dashboard and Resource Monitoring

Upon successful login, users are directed to the main Dashboard, which presents a real-time overview of the logged-in hospital's critical metrics: available ICU beds, total bed capacity, blood units in stock, oxygen cylinders available, current ICU occupancy percentage, and system-level alert status. Four dynamic time-series and summary charts are embedded in the dashboard: ICU Occupancy Trend, Blood Usage Trends, Oxygen Demand Analysis, and Bed Availability Overview—all of which auto-refresh to reflect the latest data. The dashboard also supports a hospital selection toggle, enabling authorized users to switch from the individual hospital view to an aggregated All Hospitals view. This feature provides system-wide situational awareness, displaying combined resource statistics across all registered institutions and supporting coordinated emergency response decisions.

C. Inventory Management

The Inventory Management screen presents a comprehensive tabular view of all medicines and medical supplies registered under the logged-in hospital, displaying item name, batch number, current quantity, and hospital assignment. Administrators can add new inventory entries, edit existing quantities or batch details, and remove obsolete records through inline action buttons. Items whose current stock quantity equals or falls below the configured reorder threshold are automatically highlighted in a warning color, drawing immediate attention to supply risks before they escalate into critical shortages. The module ensures accurate, continuously updated stock tracking, enabling procurement teams to act proactively and maintain uninterrupted availability of essential supplies.

D. Patient Transfer System

The Patient Transfer module enables structured, auditable inter-hospital patient coordination. When a hospital determines that a patient requires a level of care unavailable at the current facility, staff can raise a new transfer request by filling in patient name, age, gender, diagnosis or condition, urgency classification (Normal, Urgent, or Critical), source hospital, destination hospital, and additional clinical notes. Upon submission, the destination hospital receives a real-time alert modal within their active dashboard session, displaying all submitted patient details and prompting the receiving coordinator to either Accept or Reject the transfer with a single click. Accepted transfers trigger a confirmation popup at the originating hospital. A dedicated Transfer History tab maintains a fully searchable, chronological audit log of all past transfers, including patient demographics, diagnosis, routing path, urgency level, approval status, and precise timestamps—supporting clinical accountability and continuity of care reviews.

E. Disease Prediction

The Disease Prediction Engine continuously monitors real-time inventory dispensing rates to detect unusual surges in medicine consumption that may indicate an emerging disease outbreak within the hospital's catchment area. The engine compares current daily dispensing rates against rolling baseline averages and flags medicines whose usage exceeds a configurable high-use threshold. For example, simultaneous elevated consumption of ORS (518 units/day), Paracetamol (300+ units/day), and Aspirin triggers a composite outbreak alert. The system currently generates predictive condition alerts including Gastrointestinal Outbreak (81% confidence), Cardiovascular Issues (78%), Fever/Viral Infection (68%), and Possible Multi-Disease Outbreak (65%). An Active Alerts & Insights panel consolidates all flagged medicines and predicted conditions, prompting healthcare administrators to initiate early outbreak investigations, adjust procurement plans, and coordinate with public health authorities as necessary.

F. Shortage Prediction

The Medicine Shortage Prediction module addresses one of the most critical operational risks in hospital inventory management: running out of essential medicines before restocking can occur. The module forecasts stock depletion timelines for each medicine by dividing the current stock quantity by the calculated average daily consumption rate. Administrators can configure the forecast window to display projected shortages over the next 7, 14, or 30 days, enabling both short-term procurement decisions and longer-term planning. The Shortage Risk by Medicine panel categorizes each item as Critical (zero or near-zero days remaining), Warning (approaching threshold), or Adequately Stocked. The Reorder Recommendations section provides specific, actionable restock quantities for each at-risk item—for instance, ordering 8,810 units of Paracetamol, 4,448 units of Salbutamol, and 15,220 units of ORS within the next 24 hours. Items flagged as "0 days left" are prominently highlighted to ensure procurement teams can prioritize critical restocking and prevent supply disruptions that could directly impact patient care.

VI. COMPARATIVE ANALYSIS

To contextualize MediLink's contributions within the existing landscape of healthcare management tools, Table II presents a structured feature-level comparison against two categories of existing systems: traditional Hospital Management Systems (HMS) and IoT-based real-time monitoring platforms. The comparison covers seven capabilities identified as critical for modern, multi-institution healthcare coordination.

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TABLE II

Comparative Analysis: MediLink vs. Existing Systems

Feature	Existing HMS	MediLink
Multi-hospital centralized view	No	Yes
Real-time resource monitoring	Partial	Yes
Inter-hospital resource sharing	No	Yes
Predictive analytics / ML	No	Yes
Disease outbreak detection	No	Yes
Patient transfer workflow	Manual	Yes
Lightweight open-source stack	No	Yes

Traditional HMS solutions such as those commonly deployed in Indian government and private hospitals effectively handle administrative tasks within a single institution—patient records, billing, appointment scheduling, and basic inventory management—but are inherently siloed. They offer no cross-hospital visibility, no predictive analytics, and no structured patient transfer workflow beyond manual phone-based coordination. IoT-based monitoring systems provide real-time sensor data on facility conditions and equipment status but typically require significant hardware investment and do not incorporate inventory management, disease prediction, or patient transfer coordination features.

MediLink bridges these gaps by delivering a comprehensive, software-only platform that unifies multi-hospital resource visibility, real-time inventory tracking, intelligent shortage and disease prediction, and structured patient transfer management within a single web-based interface. Unlike IoT systems, MediLink requires no specialized hardware, making it immediately deployable in facilities of all sizes and resource levels. This positions MediLink as a practical, scalable solution for improving healthcare coordination across both urban and rural hospital networks.

VII. TESTING

A. Unit Testing

TABLE III

Unit Test Cases and Results

ID	Test Case	Result
TC-01	Login with valid credentials	Redirect to dashboard
TC-02	Login with invalid password	Error message displayed
TC-03	Register hospital — missing fields	Validation error shown
TC-04	Add new inventory item	Item appears in list
TC-05	Edit existing inventory quantity	Updated quantity reflected
TC-06	Delete inventory item	Item removed from list
TC-07	Raise patient transfer request	Visible to receiving hospital
TC-08	Accept transfer request	Status updated to Approved
TC-09	Reject transfer request	Status updated to Rejected
TC-10	Disease prediction on high ORS usage	Gastrointestinal alert triggered
TC-11	Shortage: 0 days left item	Critical flag + reorder shown
TC-12	All-hospitals aggregated view	Combined data displayed correctly

A systematic unit testing approach was applied to each of MediLink's modules independently before system-level integration testing. Test cases were designed to cover both valid (happy-path) and invalid (edge-case) inputs for every major functional flow. For each test, a specific input state was defined, the system was exercised against that input, and the actual output was compared against the expected result. The testing covered the Authentication module (valid and invalid login credentials, duplicate registration), the Inventory module (add, edit, delete operations, reorder threshold highlighting), the Patient Transfer module (request creation, acceptance, rejection, and history logging), the Disease Prediction module (high-consumption detection and alert generation), and the Shortage Prediction module (depletion forecasting accuracy and reorder quantity calculation). Table III provides a detailed summary of the 12 primary test cases executed and their pass/fail outcomes.

B. Performance Evaluation

Response time benchmarks were measured across all major system operations under a simulated concurrent multi-hospital load to assess the system's responsiveness under realistic usage conditions. The test environment included data from three hospitals with a combined inventory of over 50 medicine types, 334 total beds, and 210 oxygen cylinders. Each operation was executed 20 times and the median response time was recorded. The target thresholds were established based on standard web application usability guidelines (sub-2-second response for user-initiated actions). Table IV summarizes the benchmark results.

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TABLE IV
System Performance Benchmarks

Operation	Target	Actual
Dashboard Load	< 1.5 s	1.2 s
Inventory CRUD	< 500 ms	320 ms
Patient Transfer Request	< 1 s	650 ms
Disease Prediction Alert	< 2 s	1.8 s
Shortage Prediction (7-day)	< 2 s	1.5 s
All-Hospitals Aggregation	< 2 s	1.7 s

All six benchmarked operations met their target thresholds comfortably, with the fastest being the Inventory CRUD operation at 320 ms and the slowest being the Disease Prediction Alert at 1.8 seconds, still well within the 2-second target. These results confirm that the system is responsive and suitable for real-time hospital use. Edge cases including simultaneous transfer requests from multiple hospitals, zero-stock inventory entries, and concurrent dashboard loads were all handled correctly without data inconsistencies or server errors.

VIII. CONCLUSION AND FUTURE SCOPE

A. Conclusion

MediLink provides an efficient and centralized solution for managing hospital resources and medical inventory across multiple healthcare institutions. By integrating data from multiple hospitals into a single real-time dashboard, the system enables continuous monitoring of critical resources including ICU beds, medicines, blood units, and oxygen supplies, eliminating the information silos that characterize traditional hospital management approaches. The platform significantly improves coordination between healthcare centers, supports faster and better-informed decision-making during emergencies, and reduces the response time for inter-hospital patient transfers through a structured, real-time request and approval workflow.

The incorporation of predictive analytics modules—for both disease outbreak detection and medicine shortage forecasting—transforms MediLink from a passive monitoring tool into a proactive management platform. The comparative analysis confirms that MediLink addresses critical capability gaps present in both traditional HMS solutions and existing IoT-based systems, while remaining deployable without specialized hardware. The system's performance benchmarks demonstrate its suitability for real-world hospital environments. Overall, MediLink demonstrates how a thoughtfully engineered, data-centric approach can optimize resource utilization, reduce operational delays, strengthen inter-hospital coordination, and meaningfully improve the quality and efficiency of healthcare services.

B. Future Scope

MediLink can be further enhanced through the following planned directions:

- Integration of advanced AI/ML models such as LSTM networks and Random Forest classifiers for more accurate, context-aware prediction of disease trends and resource demands based on seasonal and historical outbreak patterns.
- Development of a cross-platform mobile application for Android and iOS using React Native, enabling on-the-go dashboard access, push notifications, and transfer approvals for healthcare professionals outside the facility.
- Integration with national government healthcare systems and databases including Ayushman Bharat to enable large-scale, state-level resource coordination and policy-driven allocation.
- Real-time SMS and push notification alerts combined with GPS-based hospital discovery to support faster emergency patient routing and ambulance coordination.
- An automated resource allocation engine that dynamically redistributes supplies across hospitals based on real-time shortage signals and predicted demand differentials.
- Strengthened data security architecture via end-to-end encryption of all API communications, comprehensive audit logging, and access control mechanisms aligned with ISO 27001 standards for healthcare data protection.
- Multi-language and accessibility support to improve usability for healthcare professionals across diverse linguistic regions of India.

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Both authors worked jointly on the design, development, and implementation of the project, combining their skills to build an efficient and scalable solution.