

SMARTCURE - Smart Hospital Queue, Bed and Admission Management System with City-Wide Integration

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ABSTRACT

Millions of patients face long OPD queues, uncertainty in real-time bed availability, delayed admissions, and limited transparency over hospital services. SmartCure is a unified web-based hospital management platform designed to address these gaps by integrating OPD queuing, live bed tracking, and digital admission workflows into a single city-wide ecosystem using Next.js and Neon PostgreSQL. The platform enables patients to check live OPD token progress, view available beds with timestamped updates, and apply for OPD tokens online through a user-friendly portal. Hospital administrators can efficiently manage online and offline OPD bookings, update bed occupancy, and maintain structured admission records through a secure dashboard. Newly enhanced features include detailed Hospital Service Feedback & Rating system and a Hospital Service Cost module to bring financial transparency to medical services. SmartCure improves patient decision-making and hospital operational efficiency while ensuring a scalable foundation for future expansion toward state and national healthcare networks.

Keywords: Online OPD Token Booking, Live OPD Token Tracking, Bed Tracking System, Feedback & Rating, Hospital Service Cost Transparency, Next.js.

I. INTRODUCTION

Healthcare delivery is one of the most vital services in any society, directly influencing quality of life, economic productivity, and social stability. As urban populations continue to grow rapidly, hospitals and healthcare facilities are increasingly burdened with high patient volumes, limited infrastructure, and constrained medical resources [1]. In metropolitan and semi-urban regions, patients frequently encounter long waiting times, overcrowded outpatient departments, unavailability of hospital beds, delayed admissions, and lack of transparency in hospital operations. These challenges significantly impact patient satisfaction, healthcare outcomes, and the efficiency of medical staff.

In traditional hospital environments, queue management, bed allocation, and patient admission processes are often handled manually or through isolated software systems. Such systems typically operate independently within a single hospital and lack interoperability with other healthcare facilities [2]. As a result, real-time information regarding patient flow, bed availability, and admission capacity is not readily accessible, leading to inefficient decision-making and resource utilization. During emergencies, accidents, pandemics, or natural disasters, the absence of a centralized healthcare coordination mechanism can result in critical delays in patient care, unnecessary patient transfers, and even loss of life. The evolution of digital technologies has opened new avenues for transforming healthcare systems into intelligent, interconnected, and patient-centric platforms. Technologies such as

cloud computing, Internet of Things (IoT), big data analytics, mobile applications, and real-time monitoring systems have the potential to streamline hospital operations, improve transparency, and enhance coordination among healthcare providers [3].

The queue management component of SMART CURE is designed to reduce patient waiting times by providing structured, transparent, and real-time queue updates. Patients can register digitally, track their queue position, and receive automated notifications, thereby minimizing overcrowding and improving patient experience. The bed management module continuously monitors bed availability across departments and hospitals, ensuring optimal allocation based on urgency, specialization, and availability. The admission management module automates patient registration, documentation, and bed assignment, significantly reducing administrative workload and processing time.

A distinguishing feature of SMART CURE is its city-wide integration capability, which enables seamless communication and coordination between hospitals, clinics, emergency services, and health authorities. This integration ensures that healthcare resources are utilized efficiently at the city level rather than being confined to individual institutions [4]. In emergency situations, the system can quickly identify the nearest hospital with available beds and required facilities, enabling faster patient transfers and timely treatment. By combining automation, real-time monitoring, and centralized coordination, SMART CURE aims to enhance operational efficiency, improve patient satisfaction, reduce healthcare delays, and support smarter healthcare governance. The system represents a significant step toward building intelligent healthcare infrastructure aligned with the vision of smart cities and digital health ecosystems.

II. LITERATURE SURVEY

In recent years, the rapid growth of urban populations and increasing demand for healthcare services have led to significant challenges in hospital management systems. Traditional hospital operations, including patient queue handling, bed allocation, and admission processes, often rely on manual or semi-digital approaches, resulting in inefficiencies, delays, and poor resource utilization. To address these issues, researchers have explored various technology-driven solutions such as hospital management systems, smart healthcare platforms, Internet of Things (IoT)-based monitoring, and cloud-based healthcare integration systems [5].

Early research in hospital management primarily focused on digitizing administrative tasks such as patient registration, appointment scheduling, and record maintenance. Web-based hospital management systems enabled centralized storage of patient data and improved accessibility for healthcare staff. However, these systems were limited in scope and often operated within individual hospitals without real-time coordination across departments or facilities [6]. Queue management in such systems was typically static and based on first-come, first-served approaches, which failed to prioritize emergency cases or optimize patient flow effectively. With advancements in technology, researchers introduced online appointment scheduling systems to reduce overcrowding in hospitals. These systems allowed patients to book appointments remotely, thereby minimizing physical waiting times. While these approaches improved outpatient department efficiency, they did not address inpatient challenges such as bed allocation and admission management. As a result, hospitals continued to face issues related to delayed admissions and inefficient utilization of available resources.

The integration of IoT technologies further enhanced hospital management capabilities by enabling real-time monitoring of resources. IoT-based bed management systems utilized sensors and connected devices to track bed occupancy and availability. These systems improved accuracy and reduced manual errors in bed tracking. However, most implementations were limited to individual hospitals and lacked integration with other healthcare facilities, restricting their effectiveness in large-scale healthcare environments. Recent studies have emphasized the importance of cloud computing and centralized healthcare platforms to enable real-time data sharing and coordination between hospitals [7, 8]. City-wide hospital integration models have been proposed to connect multiple healthcare facilities through a unified system, allowing efficient resource distribution and improved emergency response. These systems demonstrated the potential to reduce overcrowding in certain hospitals while utilizing resources in others. However, many of these models focused primarily on data sharing and lacked detailed mechanisms for queue management and admission workflow automation.

Furthermore, digital admission management systems have been developed to automate patient registration, document verification, and record maintenance [9]. These systems significantly reduced paperwork and administrative workload while improving data accuracy. Despite these advancements, admission systems often operate independently of queue and bed management modules, leading to fragmented workflows and limited efficiency improvements.

Recent research trends highlight the need for integrated healthcare management systems that combine multiple functionalities such as queue management, bed tracking, admission automation, and inter-hospital coordination [10]. While individual components have been explored extensively, there is still a lack of comprehensive systems that provide end-to-end patient flow management. The integration of these components into a unified platform is essential for improving healthcare delivery, especially in urban and smart city environments. Overall, the literature indicates that technology-driven hospital management solutions have significantly improved certain aspects of healthcare operations. However, most existing systems address specific functionalities in isolation rather than providing a holistic solution. This limitation motivates the development of SMART CURE, which aims to integrate queue management, real-time bed tracking, admission processes, and city-wide coordination into a single intelligent platform.

2.1 Research Gap

A thorough review of existing literature on hospital management systems reveals significant advancements; however, several critical research gaps remain unresolved. Most existing systems focus on individual components such as queue management, bed monitoring, or admission processes, without providing an integrated solution that combines all these functionalities into a unified framework. This lack of integration leads to fragmented workflows and limits the overall efficiency of hospital operations. Another major gap is the limited coordination between hospitals at a city-wide level. Many systems operate within a single hospital environment and do not support real-time sharing of information such as bed availability, queue status, or emergency capacity across multiple healthcare facilities. This results in uneven distribution of patients, with some hospitals being overcrowded while others remain underutilized.

Additionally, there is an absence of real-time, end-to-end patient flow management systems that can monitor and optimize the entire patient journey, from registration and queue handling to admission and treatment. Existing solutions often lack dynamic prioritization mechanisms for emergency cases, leading to delays in critical care. Furthermore, insufficient attention has been given to emergency response optimization and resource utilization. Most systems do not provide intelligent decision-making

capabilities to identify the most suitable hospital based on availability and urgency. These gaps highlight the need for a comprehensive, scalable, and integrated healthcare management system such as SMART CURE.

2.2 Challenges in Existing Systems

Despite advancements in digital healthcare technologies, several challenges continue to hinder the effectiveness and adoption of existing hospital management systems. One major challenge is the lack of real-time data synchronization, which leads to outdated information regarding queue status and bed availability. This results in inefficient decision-making and delays in patient care. Another challenge is poor resource utilization. Hospitals often face issues such as bed shortages in some departments while others remain underutilized due to the absence of centralized monitoring systems. This imbalance affects patient admission and overall healthcare efficiency.

Scalability is also a significant concern, as many existing systems are designed for single-hospital environments and cannot be easily extended to support city-wide integration. This limits their applicability in large urban healthcare systems where coordination between multiple hospitals is essential. Additionally, many systems rely heavily on manual intervention, leading to increased administrative workload, human errors, and delays in processing patient information. The lack of automation in admission and queue management processes further reduces operational efficiency.

Data security and privacy remain critical challenges, as healthcare systems handle sensitive patient information. Inadequate security measures can lead to data breaches and loss of patient trust. Moreover, limited user-friendly interfaces and lack of transparency in hospital operations reduce patient satisfaction. These challenges emphasize the need for an integrated, real-time, and intelligent healthcare management system that can enhance efficiency, improve resource utilization, and provide better patient care, which are the primary objectives addressed by SMART CURE.

III. PROPOSED METHODOLOGY

The proposed methodology presents a unified and systematic framework for the SMART CURE system, designed to manage hospital queue operations, real-time bed allocation, and automated admission processes in an integrated and efficient manner. The framework ensures scalability, real-time coordination, and optimized resource utilization across multiple hospitals within a city. It consists of sequential stages including data acquisition, preprocessing, intelligent queue management, bed tracking, admission automation, system integration, and performance monitoring. The overall architecture of the system enables seamless interaction between patients, hospital staff, and centralized healthcare authorities.

3.1 Data Acquisition

The system collects patient-related data through web-based interfaces and hospital systems. This includes patient personal details, visit type (OPD/IPD), symptoms, and priority level. Additionally, hospital data such as bed availability, department information, and staff details are continuously collected. The system supports data input from multiple hospitals, enabling a centralized repository for city-wide healthcare coordination.

3.2 Data Preprocessing

Data preprocessing ensures accuracy, consistency, and reliability of the collected data. Missing or inconsistent values are handled through validation and correction techniques. Patient and hospital data are standardized into structured formats suitable for system processing. Sensitive information is secured, and duplicate records are eliminated. The processed data is then stored in a centralized database for further operations.

3.3 Intelligent Queue Management

The queue management module dynamically assigns patients to queues based on arrival time, medical priority, and department workload. Emergency and critical patients are prioritized using rule-based algorithms. The system continuously updates queue status in real time and provides estimated waiting times. Patients receive notifications regarding their queue position, reducing congestion and improving transparency.

3.4 Real-Time Bed Management

The bed management module continuously monitors the availability and occupancy of hospital beds across different departments such as general wards, ICUs, and emergency units. Bed status is automatically updated during patient admission, discharge, or transfer. This ensures efficient bed allocation and helps administrators make quick decisions, especially during peak hours or emergencies.

3.5 Admission Management Process

The admission management module automates patient admission workflows. It includes digital registration, document verification, and automatic bed assignment. Patient records are securely stored and accessible to authorized personnel. This reduces manual paperwork, minimizes errors, and accelerates the admission process, ensuring timely patient care.

3.6 City-Wide Integration

A key component of the proposed methodology is city-wide integration, where multiple hospitals are connected through a centralized platform. The system enables real-time sharing of information such as bed availability, queue load, and emergency capacity. In critical situations, patients can be redirected to the nearest hospital with available resources, improving response time and healthcare delivery efficiency.

3.7 System Architecture and Implementation

The SMART CURE system follows a three-tier architecture consisting of:

- **Presentation Layer:** User interfaces for patients, doctors, and administrators
- **Application Layer:** Business logic, queue algorithms, and API services
- **Data Layer:** Centralized database for storing patient and hospital data

The system is implemented using modern technologies such as Next.js, REST APIs, and PostgreSQL to ensure scalability, performance, and reliability.

3.8 Security and Access Control

To ensure data privacy and security, the system incorporates authentication mechanisms and role-based access control. Sensitive patient data is encrypted, and only authorized users can access specific system functionalities. Secure communication protocols are used to prevent unauthorized access and data breaches.

3.9 System Workflow

Algorithm: SMART CURE Healthcare Management System

Input: Patient details, hospital data

Output: Queue status, bed allocation, admission confirmation

The system begins by collecting patient data and validating it through preprocessing techniques. Patients are then assigned to queues based on priority and availability. Simultaneously, the system checks real-time bed availability and updates hospital records accordingly. If admission is required, the system automates document verification and assigns a suitable bed. All updates are synchronized across hospitals through the centralized platform. Finally, the system provides real-time updates and notifications to patients and healthcare staff.

3.10 Advantages of the Proposed Methodology

The proposed methodology provides an integrated and scalable solution for modern healthcare management. It improves operational efficiency by automating queue handling, bed allocation, and admission processes. Real-time monitoring enhances decision-making and emergency response. The system reduces patient waiting time, optimizes resource utilization, and ensures better coordination between hospitals. Its modular and secure design makes it suitable for large-scale implementation in smart city healthcare systems.

IV. METHODOLOGY

4.1 Environment and Tools

The SMART CURE system is developed and evaluated using modern web-based technologies in a standard development environment. The implementation is carried out using JavaScript and full-stack frameworks that support both frontend and backend integration. The system utilizes Next.js for application development, Tailwind CSS for user interface design, and REST APIs for communication between system components. The backend services interact with a PostgreSQL database for efficient data storage and retrieval.

The experimental setup is deployed on a cloud-based platform to ensure scalability, reliability, and real-time accessibility. The system is executed on a modern operating system with sufficient processing power, memory, and storage to support concurrent users and real-time data synchronization. To maintain consistency and reliability, standardized workflows and uniform data handling procedures are followed across all modules of the system.

4.2 Datasets

The SMART CURE system operates on real-time and simulated hospital datasets that include patient information and hospital resource data. The dataset consists of patient-related attributes such as patient

ID, name, age, gender, symptoms, visit type (OPD/IPD), and priority level. Additionally, hospital-related data includes bed availability, department details, queue status, and admission records. The system manages both structured and dynamic data generated during hospital operations. Queue data includes token number, department allocation, waiting time, and patient priority. Bed management data includes bed ID, type (general, ICU, emergency), and occupancy status. Admission data includes patient admission details, assigned bed, and discharge records. These datasets are continuously updated in real time, enabling accurate monitoring and efficient decision-making.

4.3 Performance Metrics

To evaluate the effectiveness of the SMART CURE system, several performance metrics are used. These metrics assess system efficiency, responsiveness, and resource utilization in real-world healthcare scenarios.

4.3.1 Queue Waiting Time

Queue waiting time measures the average time a patient spends waiting before receiving medical attention. It is calculated as:

$$\text{Average Waiting Time} = \frac{\sum \text{Waiting Time of All Patients}}{\text{Total Number of Patients}} \quad \text{Equ. (1)}$$

This metric evaluates the efficiency of the queue management system in reducing patient waiting time.

4.3.2 Bed Utilization Rate

Bed utilization rate measures how effectively hospital beds are used over a period of time.

$$\text{Bed Utilization Rate} = \frac{\text{Number of Occupied Beds}}{\text{Total Number of Beds}} \times 100 \quad \text{Equ. (2)}$$

A higher utilization rate indicates better resource management.

4.3.3 Admission Processing Time

Admission processing time measures the time required to complete the patient admission process, including registration, verification, and bed allocation.

$$\text{Admission Time} = \text{Time of Admission Completion} - \text{Time of Registration} \quad \text{Equ. (3)}$$

This metric evaluates the efficiency of the automated admission module.

4.3.4 System Response Time

System response time measures how quickly the system responds to user actions such as queue updates, bed status checks, and admission requests.

$$\text{Response Time} = \text{Time of Output} - \text{Time of Request} \quad \text{Equ. (4)}$$

Lower response time indicates better system performance and user experience.

4.3.5 Resource Optimization Efficiency

This metric evaluates how effectively hospital resources are utilized across multiple hospitals.

$$\text{Efficiency} = \frac{\text{Utilized Resources}}{\text{Total Available Resources}} \times 100 \quad \text{Equ. (5)}$$

It reflects the system's ability to balance load and avoid overcrowding in hospitals.

4.3.6 Evaluation Consistency

All system modules are evaluated under the same conditions, including identical data inputs, processing methods, and evaluation metrics. This ensures consistency, fairness, and reliability in assessing system performance. The standardized evaluation approach supports accurate comparison of system efficiency across different operational scenarios.

V. RESULTS AND DISCUSSION

The following section presents the execution results of the SmartCure system through various user interface screens. These screenshots demonstrate the working of different modules, including user interaction, hospital administration, appointment booking, token generation, and real-time bed management. Each screen highlights how the system automates hospital operations and improves efficiency in handling patient flow and resource allocation.

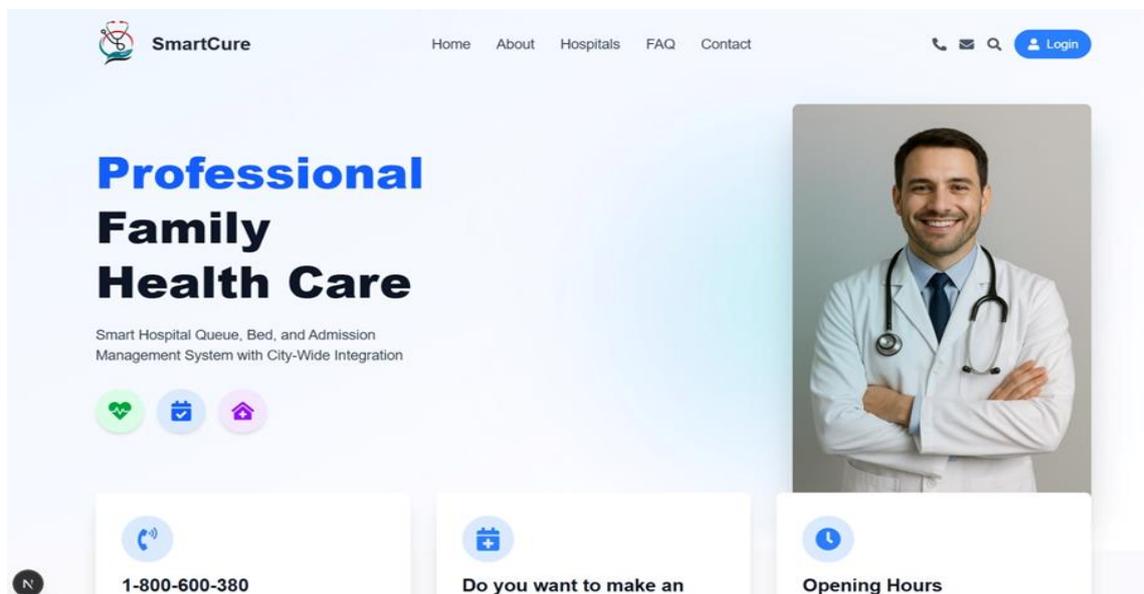


Figure 1: Home Page – SmartCure Landing Interface

This screen represents (Fig. 1) the main landing page of the SmartCure system. It provides an overview of the platform with navigation options such as Home, About, Hospitals, FAQ, and Contact. The interface highlights the system's purpose managing hospital queues, bed availability, and admissions. It includes quick access icons and a login option, offering a user-friendly entry point for patients and administrators.

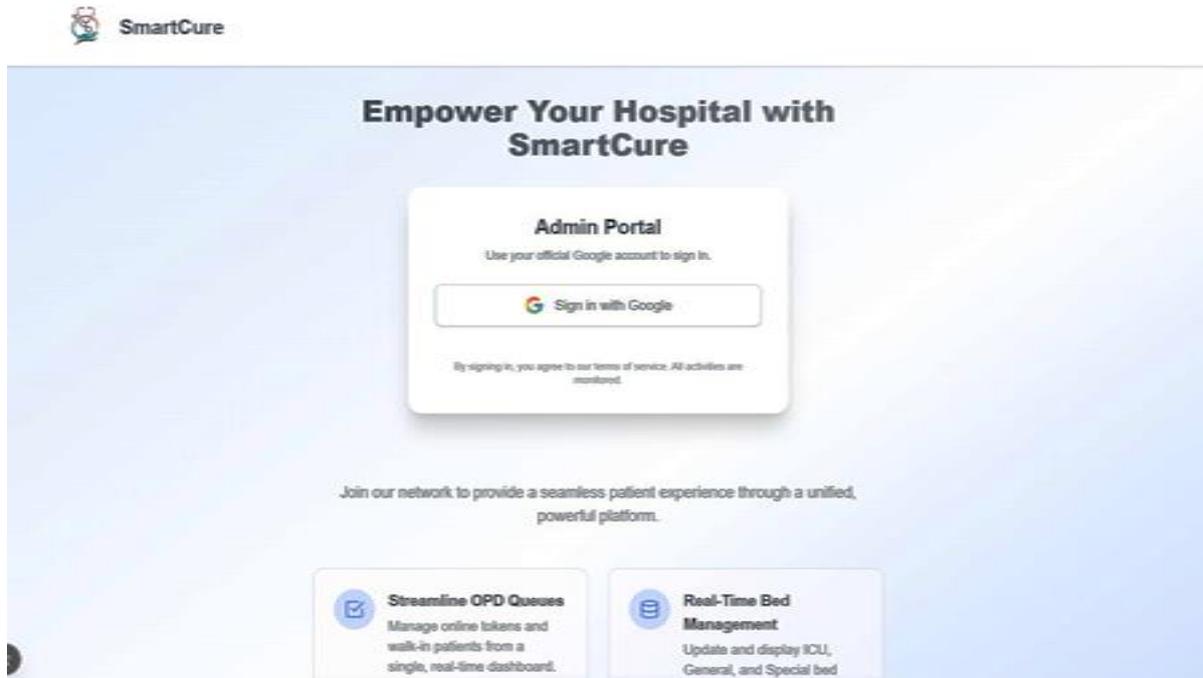


Figure 2: Admin Portal Login (Google Authentication)

Fig. 2 shows the Admin Portal login page where authorized hospital administrators can securely access the system using Google Sign-In. It ensures authentication and restricts access to verified users only. This feature enhances security and simplifies login management.

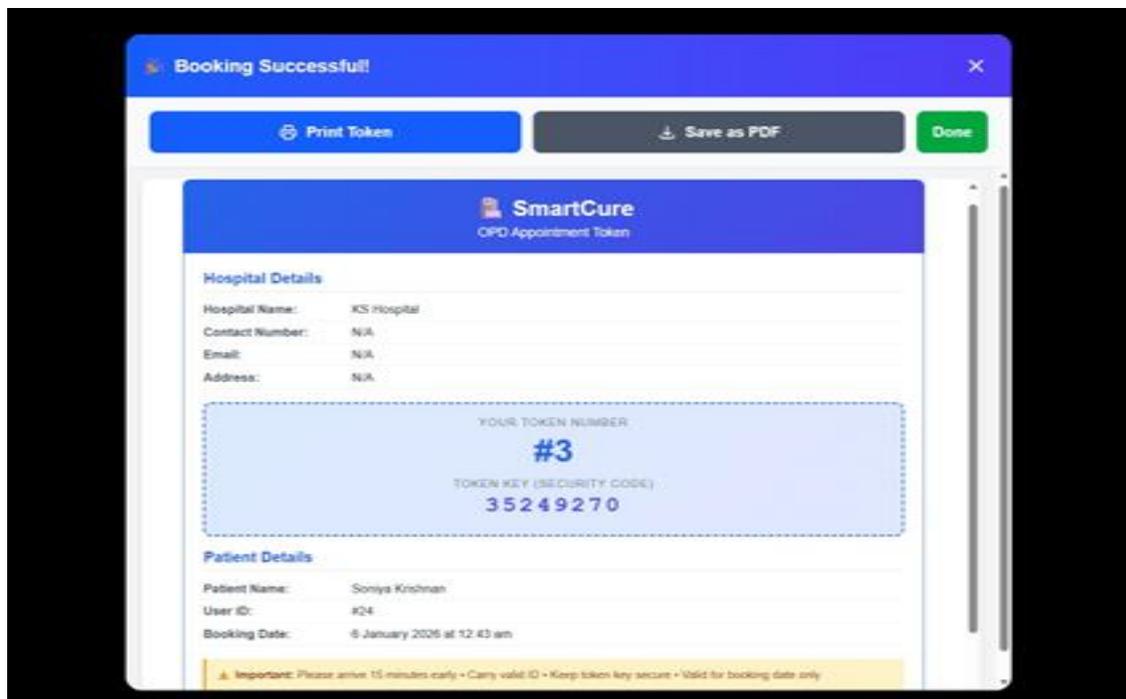


Figure 3: Booking Confirmation & Token Generation

Fig. 3 screen displays the successful appointment booking confirmation. It generates a unique token number and a secure token key for the patient. The page also provides options to print the token or save it as a PDF, ensuring easy access during hospital visits.



Figure 4: Developer Admin Secure Login

Fig. 4 interface is used by system-level administrators (developers) to access restricted functionalities. It requires email and password authentication, ensuring that only authorized personnel can manage backend operations and system configurations.

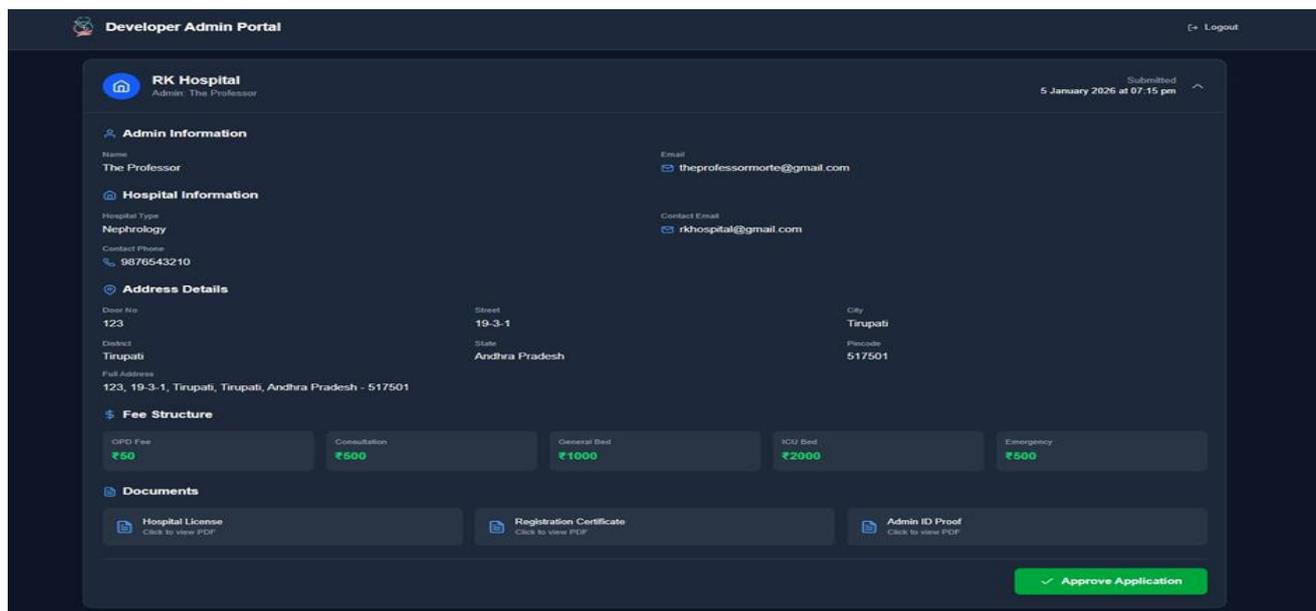


Figure 5: Hospital Approval Dashboard (Admin Panel)

Fig. 5 screen shows detailed hospital registration information submitted by an admin. It includes hospital details, contact information, address, fee structure, and uploaded documents. The system allows higher authorities to review and approve hospital applications, ensuring data authenticity.

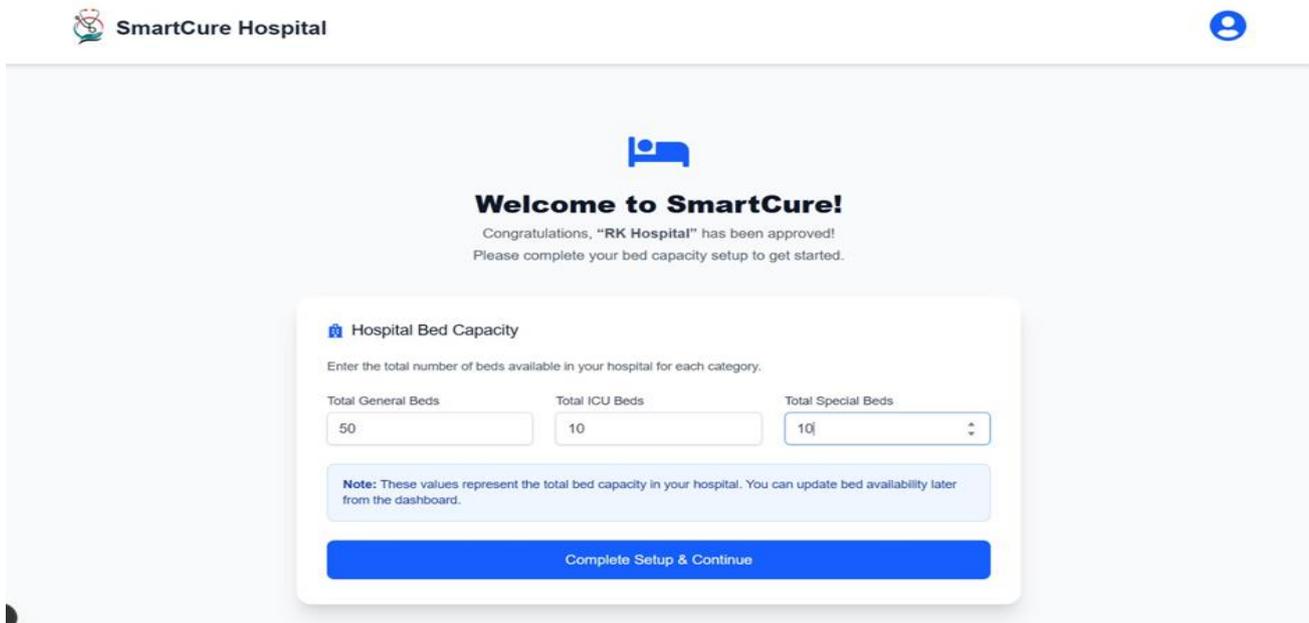


Figure 6: Hospital Bed Capacity Setup

After approval, hospitals configure their bed capacity using this interface (Fig. 6). It allows administrators to input the number of general, ICU, and special beds available. This data is used for real-time tracking and efficient bed allocation.

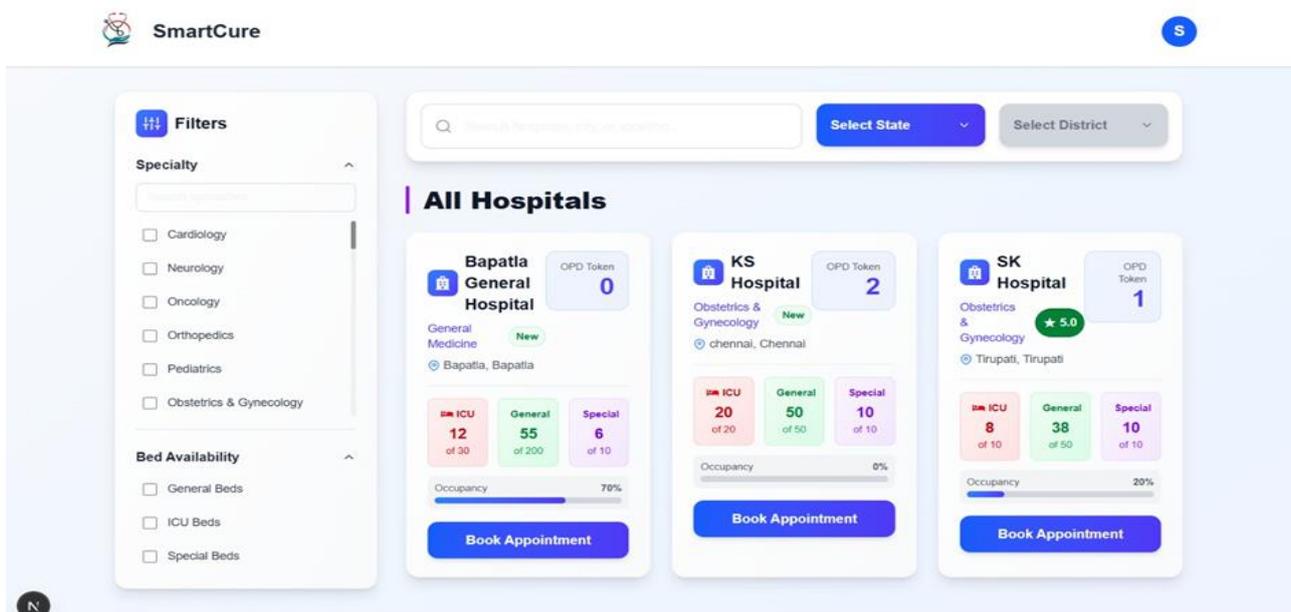


Figure 7: Hospital Listing & Filtering System

Fig. 7 displays all registered hospitals with filtering options based on specialty, location, and bed availability. Each hospital card shows OPD tokens, available beds, occupancy levels, and a “Book Appointment” button, enabling users to make informed decisions.

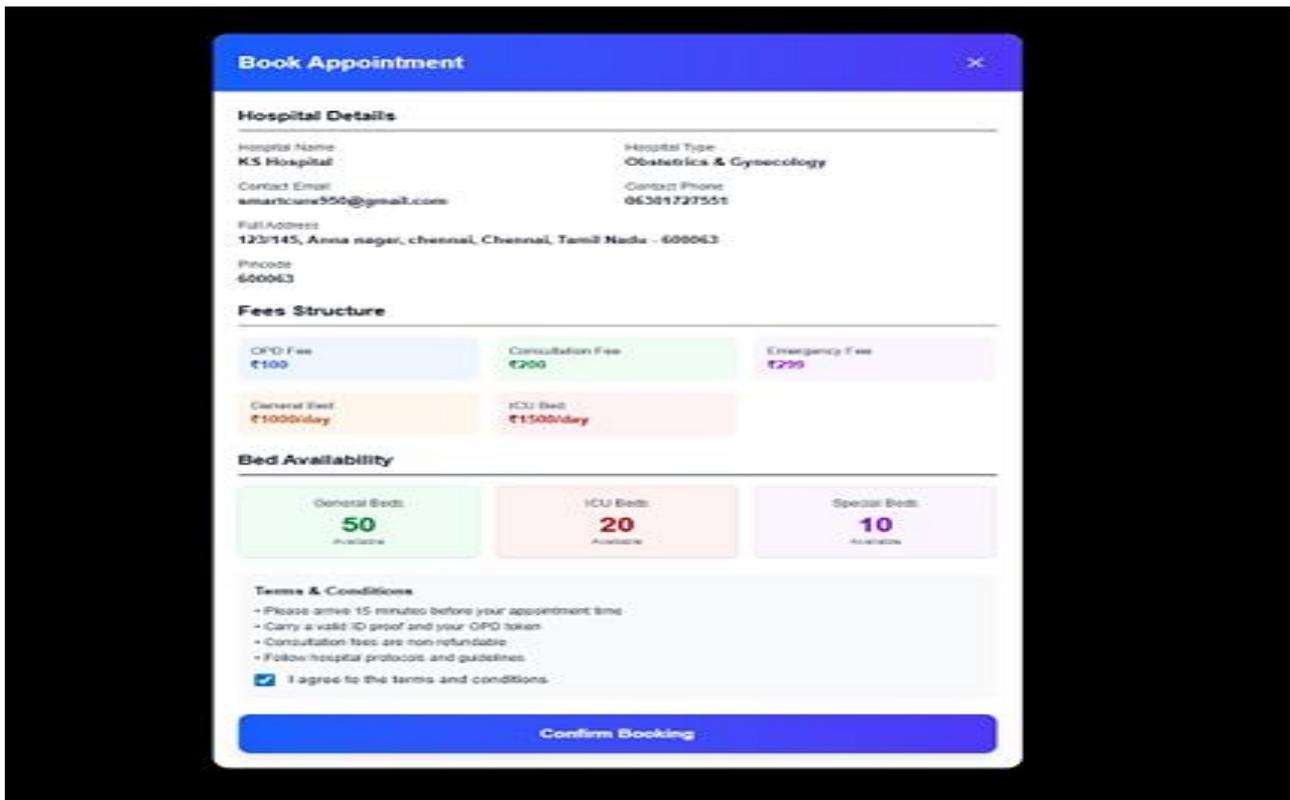


Figure 8: Appointment Booking Interface

This interface (Fig. 8) provides detailed hospital information including fees, bed availability, and terms & conditions. Patients can review all details before confirming their appointment, ensuring transparency and informed booking.

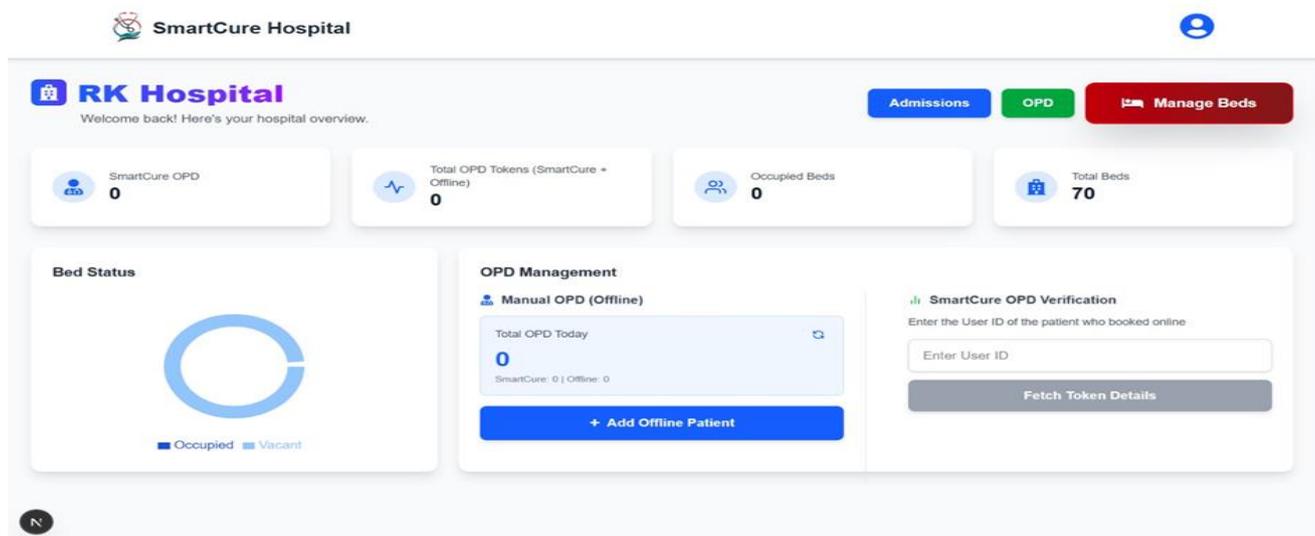


Figure 9: Hospital Dashboard Overview

This dashboard (Fig. 9) provides an overview of hospital operations including total beds, occupied beds, and OPD tokens. It also includes features like offline patient entry and real-time monitoring, helping administrators manage hospital workflows efficiently.

VI. CONCLUSION

The Hospital Management System project has been successfully developed to address key challenges in hospital operations such as patient queue management, bed allocation, admission processes, and service transparency. By replacing traditional manual methods with an integrated, web-based system, it improves efficiency, reduces errors, and enhances patient experience. The system integrates multiple modules including patient management, hospital administration, bed and admission management, feedback analysis, and city-wide coordination, enabling real-time data access and better resource utilization. Security features such as role-based access control and data encryption ensure the protection of sensitive patient information. Overall, the system is reliable, scalable, and capable of handling real-world scenarios, demonstrating how technology can improve hospital efficiency and deliver more effective, transparent, and patient-centric healthcare services.

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