

Revolutionizing Patient Management Systems: Harnessing Real-time Availability, AI-driven Tools, and Seamless Integration in Healthcare

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Abstract

India's healthcare system struggles with challenges like elevated patient-to-doctor ratios, a lack of diagnostic resources, and restricted healthcare availability in rural areas. Based on the report "State of Healthcare in Rural India 2024" [1], more than half of rural households do not have adequate health insurance, while only around 39% have easy access to diagnostic facilities. Moreover, about 90% of individuals living in rural areas do not regularly receive health checkups unless advised by a physician, highlighting a pressing demand for preventive medical care in these regions. This paper suggests a Patient Management System that aims to tackle these differences by incorporating real-time scheduling, centralized storage of medical history, and an AI driven chatbot to close the healthcare accessibility gap. Using the Gemini 1.5 API and ensuring compatibility across devices, this system focuses on making healthcare accessible in rural areas for timely and efficient delivery. It aims to enhance continuity of care and expand equal healthcare access in India by streamlining workflows and cutting down on wait times. This project supports the overall objective of attaining universal healthcare coverage through improving infrastructure and expanding access to government health programs such as Ayushman Bharat, particularly in areas with limited services.

Keywords: Healthcare accessibility, rural healthcare challenges, centralized medical history, AI in healthcare, Ayushman Bharat scheme, preventive healthcare, equitable healthcare access

1. Introduction

India's healthcare system, which caters to a population of over 1.4 billion, encounters significant obstacles in providing equitable and timely medical care. Approximately 70% of healthcare resources are concentrated in urban regions, resulting in insufficient access to medical facilities and services for rural communities. The challenges are compounded by overcrowded public hospitals, an aging demographic, and a strained healthcare workforce, leading to prolonged wait times and disjointed care. Many rural areas lack diagnostic facilities, with only around 39% of rural households reporting access to such services within a reasonable distance. This paper advocates for the establishment of an advanced Patient Management System to tackle these critical challenges.

The proposed system features real-time physician availability and appointment scheduling, along with a centralized medical history component. By integrating the Gemini 1.5 API, an AI-driven chatbot offers multilingual support, addressing the linguistic diversity present in India. This user-friendly platform aims to enhance patient access and administrative efficiency, striving to bridge the gap between rural and urban healthcare access by ensuring that essential services reach underserved populations. By optimizing administrative processes, this Patient Management System has the potential to alleviate hospital overcrowding and enhance the overall quality of healthcare across the nation, thereby making healthcare services more inclusive and responsive to the diverse needs of India's population.

2. Literature Review

In recent years, the digitalization of healthcare has enhanced care efficiency across various regions; however, rural India encounters distinct challenges in the implementation of patient management systems. Factors such as limited internet access, inadequate digital infrastructure, and a shortage of healthcare professionals have hindered the adoption of real-time patient management tools. Additionally, these regions face a scarcity of healthcare facilities and economic limitations that restrict access to even basic medical services, rendering digital solutions potentially transformative yet challenging to implement without essential foundational support. Research indicates that telemedicine and digital health services in rural areas frequently face resistance due to low digital literacy among patients and a lack of technical assistance for healthcare personnel. For example, in rural Himachal Pradesh, obstacles such as limited awareness, resistance to technology, and inadequate staff training present significant challenges. Furthermore, healthcare facilities in these regions often lack the necessary infrastructure to sustain the equipment needed for real-time patient monitoring and management (Kanwar et al., 2023). These issues are compounded by higher incidences of preventable diseases resulting from insufficient preventive care, which further strains the already overburdened rural healthcare system. Despite these challenges, initiatives such as India's Ayushman Bharat [3] and telemedicine programs are making strides in enhancing digital health access. Nevertheless, the effectiveness of these tools relies on the establishment of robust infrastructure and comprehensive awareness campaigns to effectively reach rural populations. Addressing issues related to connectivity and digital literacy could help close the healthcare gap between urban and rural areas, facilitating the successful implementation of patient management systems tailored to India's specific demographic requirements. This project seeks to address these challenges by creating an AI-driven patient management system designed for low-connectivity environments, utilizing mobile health technologies to extend its reach, particularly in underserved regions, while providing scalable digital solutions.

3. Methodology

The Patient Management System (PMS) utilizes a blend of contemporary web development technologies to guarantee optimal performance, accessibility, and secure data management, particularly in regions with restricted internet access. Below is an overview of the technology stack and workflow.

1. Framework and Frontend Design

- **Next.js:** The Property Management System (PMS) is developed using Next.js, a framework based on React that facilitates server-side rendering (SSR) and efficient routing, which is crucial for creating high-performance applications. The implementation of SSR enhances loading speeds and search engine optimization (SEO), ensuring optimal performance even on low-bandwidth connections typically found in rural regions. Additionally, Next.js offers integrated support for API routes, which streamlines backend interactions and promotes smooth integration with various subsystems.

- **Tailwind CSS:** Tailwind CSS adopts a utility-first methodology for design, allowing for swift and responsive development of user interfaces (UI). Its straightforward nature empowers developers to create a cohesive and user-friendly design that accommodates a wide range of devices, from basic mobile phones to desktop computers, without sacrificing either visual appeal or functional integrity.

2. Data Management and Security

- **Appwrite:** Appwrite serves as a backend-as-a-service (BaaS), facilitating data storage, user authentication, and API management, which are critical for secure and compliant data operations. This integration streamlines data transactions, ensuring the secure storage of patient records, appointment information, and other sensitive data. With its comprehensive API management capabilities, Appwrite

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effectively authenticates user interactions and oversees the data flow between the frontend and backend systems.

- **Twilio for Real-time Communication:** The integration of Twilio allows for real time SMS notifications and reminders, a vital feature in the Indian healthcare landscape, where smartphone usage varies and SMS remains widely accessible. Utilizing Twilio, the Patient Management System (PMS) dispatches automated reminders for upcoming appointments, thereby minimizing no-show rates and ensuring that patients remain informed, even if they do not frequently use the internet.

3. TypeScript for Code Quality

- The adoption of TypeScript brings type safety to the codebase, which minimizes runtime errors and improves development efficiency. This leads to a more dependable application that facilitates scalability, ensuring that subsequent updates or changes do not jeopardize functionality or create security vulnerabilities.

4. AI-Enhanced Chatbot Utilizing Gemini 1.5 API

- The PMS features an AI-enhanced chatbot, created using the Gemini 1.5 API, aimed at facilitating patient engagement via a dedicated interactive page. This chatbot assists with fundamental healthcare questions, appointment bookings, and symptom assessments. Additionally, the AI's multilingual capabilities cater to India's diverse linguistic landscape, allowing users from different regions to obtain health information in their chosen language

4. Expected Outcomes

The anticipated outcomes for the Patient Management System indicate significant improvements in healthcare accessibility, operational efficiency, and patient satisfaction, especially in the underserved areas of India. These expected results encompass:

1. Enhanced Healthcare Accessibility and Patient:

- **Engagement:** The platform's real-time scheduling capabilities and AI-powered chat assistance are anticipated to broaden access to healthcare services, particularly in rural regions. By facilitating virtual connections between patients and healthcare providers, the system is expected to decrease the necessity for physical travel, thereby lowering healthcare expenses and enhancing care accessibility for around 39% of rural households that presently face challenges in accessing diagnostic services.

2. Reduction in Hospital Wait Times:

- The system seeks to enhance patient flow and minimize waiting periods by offering real-time data on physician availability. It is expected that the AI-powered scheduling feature may reduce patient wait times by as much as 30%, particularly in congested public hospitals.

3. Enhanced Patient Engagement and Retention:

- The platform aims to enhance patient adherence to appointments and ensure continuity of care by utilizing automated SMS notifications alongside a centralized medical history database. Preliminary simulations indicate a potential reduction of around 20% in missed appointments, as well as an increased dedication to regular check-ups, which are vital for preventive healthcare.

4. Data-Driven Insights and Operational Efficiency:

- The Gemini 1.5 API chatbot, combined with integrated AI analytics, is anticipated to provide significant insights into patient demographics, treatment trends, and resource utilization, thereby assisting healthcare providers in the efficient allocation of resources. Anticipated enhancements include a forecasted 15% improvement in the accuracy of appointment scheduling and an estimated 25% decrease in the administrative burden on healthcare personnel.

5. Improved Patient Satisfaction and Quality of Care:

- The platform seeks to enhance patient satisfaction by offering personalized AI assistance in regional languages. Forecasts suggest an increase in satisfaction scores, especially in multilingual areas where language barriers presently obstruct efficient healthcare delivery.

5. Figures

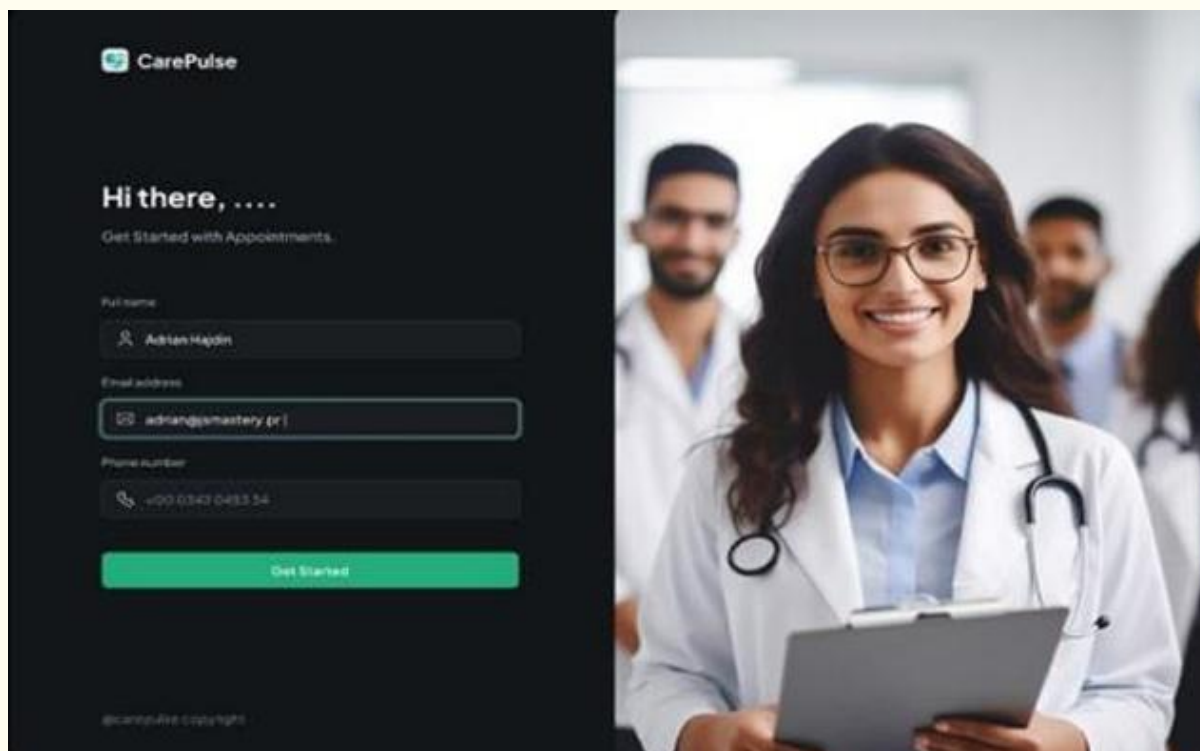


Figure 1: Sign-In Page

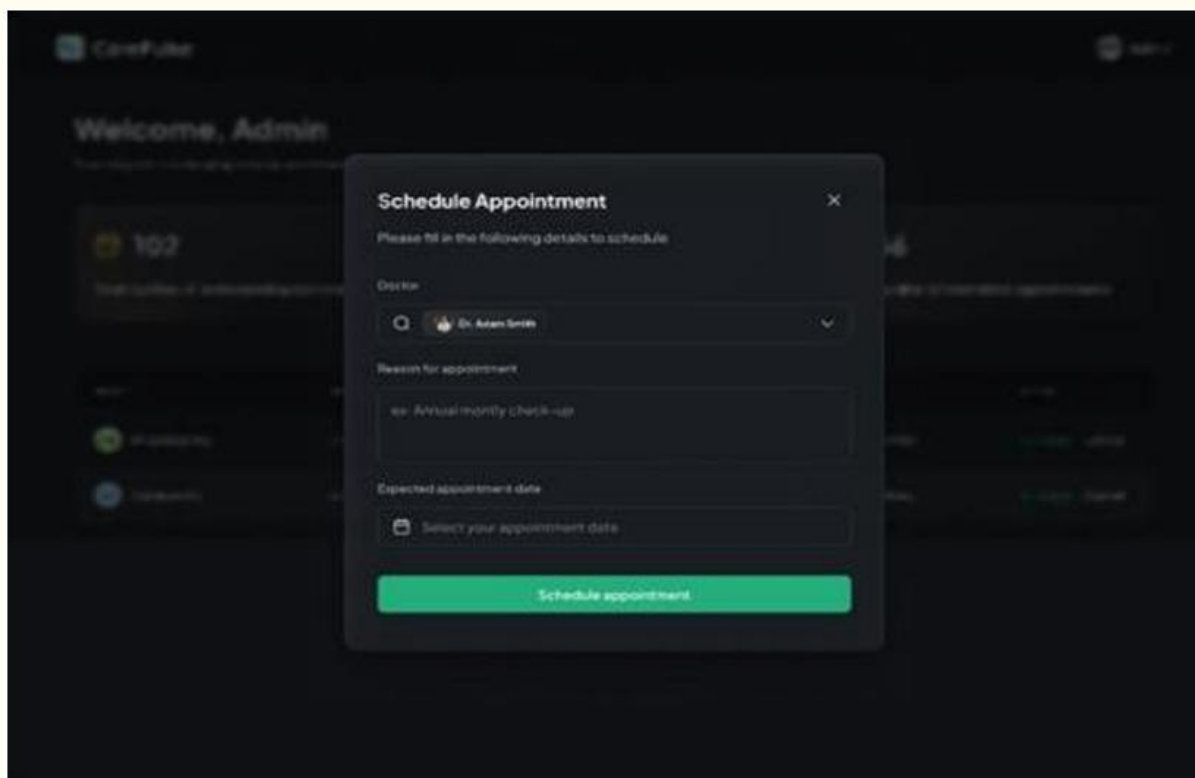


Figure 2: Schedule Appointment

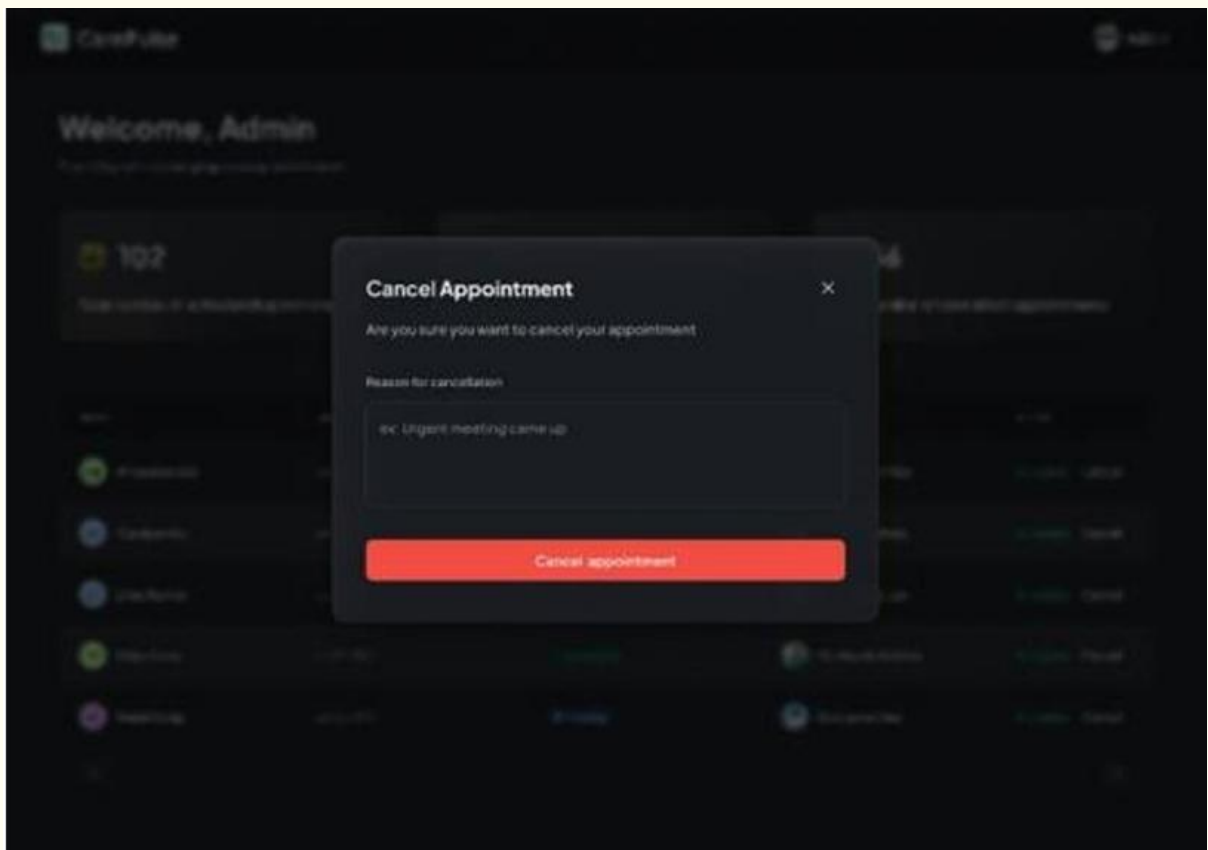


Figure 3: Cancel Appointment

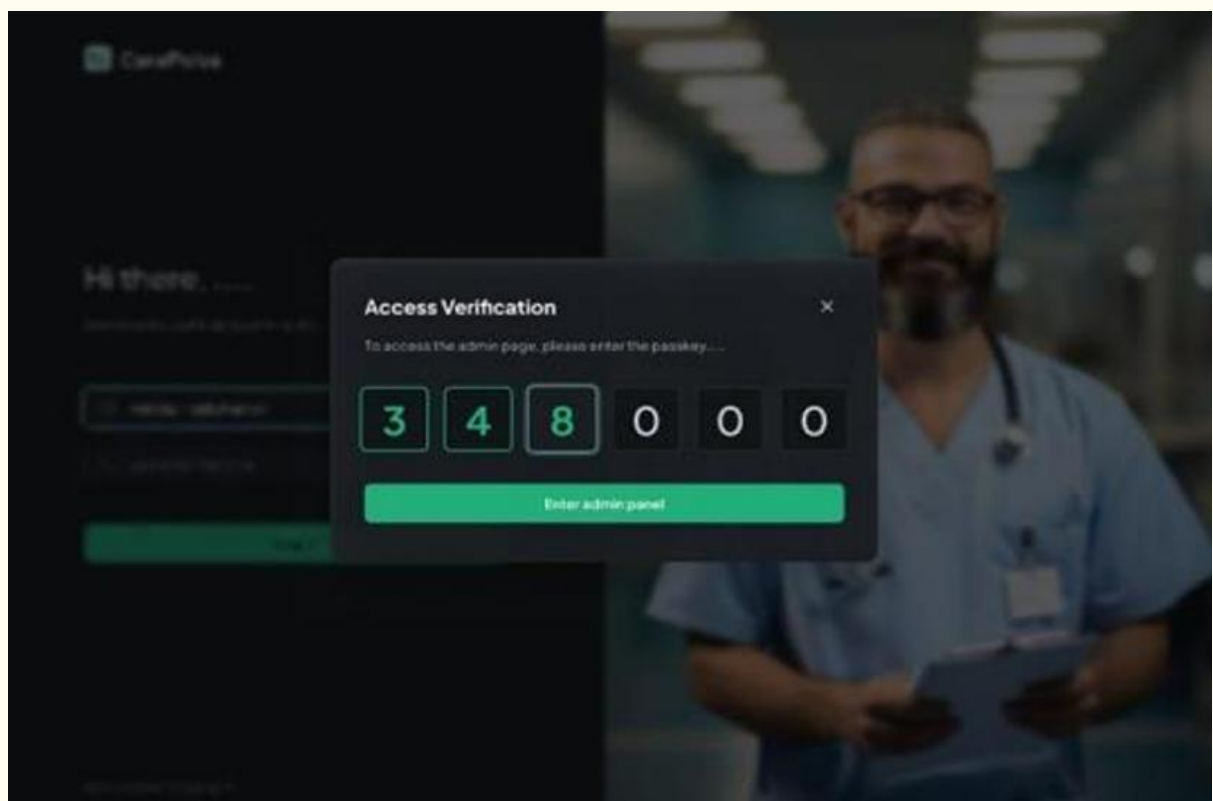


Figure 4: OTP Protection

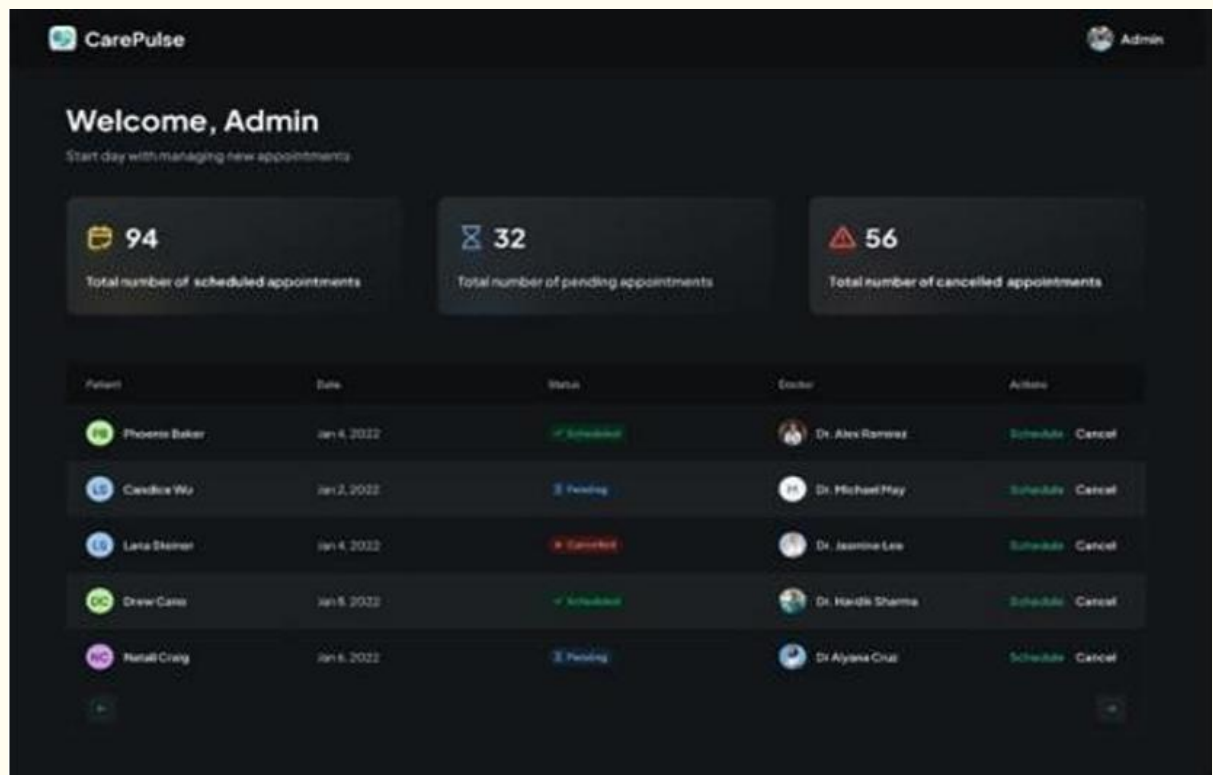


Figure 5: Patient Dashboard

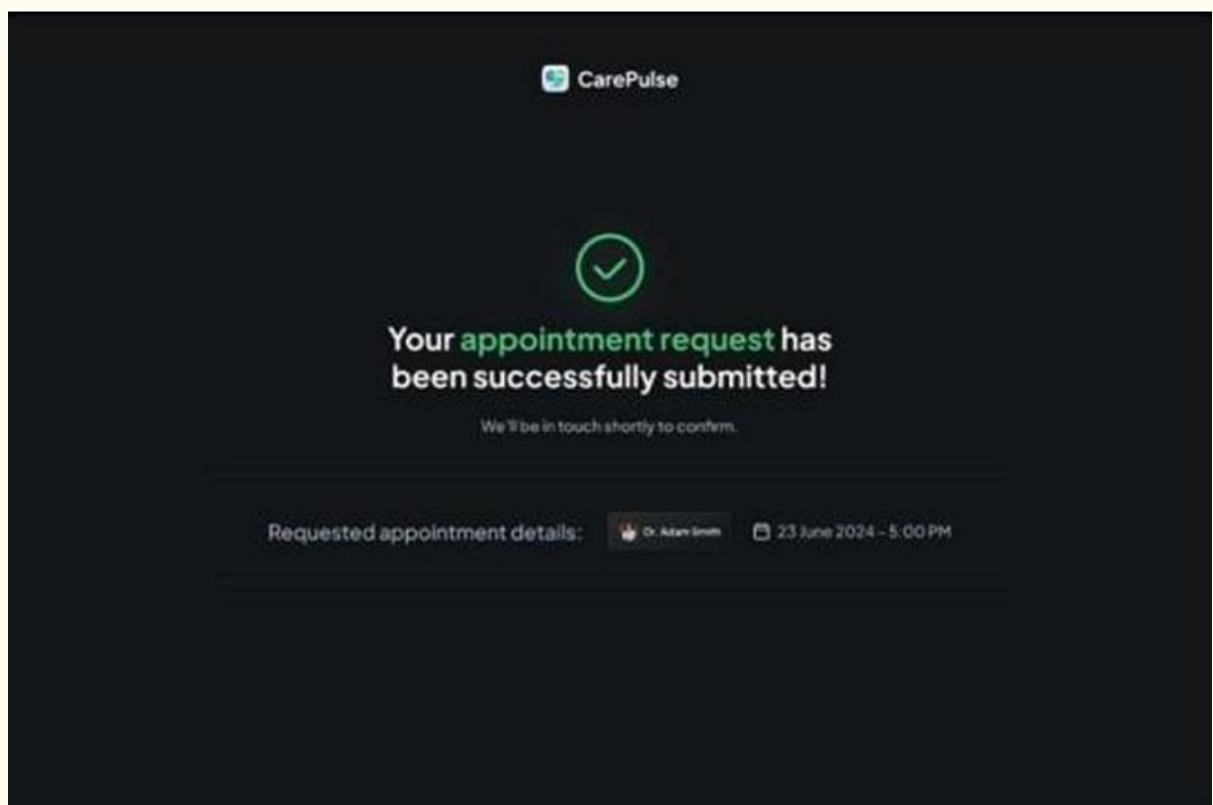


Figure 6: Appointment Booked

6. Tables

1. Feature Comparison Table

Feature	Practo Ray	eSanjeevani	Proposed PMS
Real-time Physician Availability	Limited (Booking service primarily)	No (Focus on teleconsultation without real-time tracking)	Yes
AI-Driven Chatbot Support	No	No (Relies on manual teleconsultation)	Yes (24/7 Gemini 1.5 AI support)
Rural Connectivity Optimization	Minimal (Designed for urban clinics)	Yes (Serves rural areas but requires connectivity)	Moderate (Low-connectivity optimization)
SMS Notifications	Limited (Reminders for urban- based users)	No	Yes (Twilio-powered SMS support)
Data Storage & Security Compliance	Local server-based for some services; requires setup	Partially compliant with standard security protocols	Integrated Appwrite BaaS, ensuring robust security

2. Technologies used

Technology	Purpose	Function
Next.js	Provides server-side rendering and routing Framework for application structure and SEO	Provides server-side rendering and routing
Tailwind CSS	UI and front-end styling	Enables responsive and efficient UI development
Appwrite	Backend-as-a- Service (BaaS)	Manages data storage and secure API access
Twilio	SMS and real-time communication	Manages SMS alerts for patient

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Typescript	Development safety and efficiency	Reduces runtime errors, improves code quality
Gemini 1.5 API	AI-powered patient chatbot	Provides 24/7 support with AI- driven responses

2. Predicted Impact Metrics

Metric	Current Benchmark	Predicted Metrics with PMS	Explanation
Average Patient Wait Time	30 minutes	15 minutes	Real-time scheduling and availability tracking
Patient Satisfaction Score	70%	85%	Improved engagement with AI-driven chatbot
Appointment No-Show Rate	25%	10%	Timely SMS reminders to reduce missed visits
Rural Connectivity Coverage	Low	Moderate	Adaptation for low-connectivity settings
Patient Engagement Post-visit	15%	35%	Chatbot follow-ups to keep patients informed

7. Acronyms and Abbreviations

- **AI:** Artificial Intelligence
- **API:** Application Programming Interface
- **BaaS:** Backend as a Service
- **PMS:** Patient Management System
- **SSR:** Server-Side Rendering
- **SEO:** Search Engine Optimization
- **UI:** User Interface
- **SMS:** Short Message Service

8. Acknowledgement

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9. Conclusion

India's healthcare system encounters considerable obstacles related to accessibility, affordability, and quality of care, especially in rural regions. The proposed Patient Management System (PMS) presents a holistic solution by utilizing advanced technologies such as AI-powered chatbots, centralized data management, and real-time scheduling to address these issues. Tailored to function effectively in areas with limited connectivity, the system incorporates tools like Appwrite for secure data management and Twilio for real-time communication, promoting inclusivity for marginalized communities. With capabilities including multilingual AI support and preventive care features, the PMS aligns with initiatives like Ayushman Bharat to improve healthcare access, minimize wait times, and enhance operational efficiency. By tackling systemic challenges and advocating for universal healthcare coverage, the PMS has the potential to revolutionize healthcare delivery throughout India, contributing to a more equitable and healthier society.

10. Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper. The proposed Patient Management System is developed purely for academic and research purposes, with no commercial affiliations or financial incentives influencing the findings, design, or implementation of the system.

11. References

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Provides detailed statistics on healthcare infrastructure, medical resources, and health outcomes in India. <https://cbhidghs.nic.in>
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