
SMART AUTOMATED DIGITAL HOSPITAL FOR HEALTHCARE MANAGEMENT SYSTEM

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Article Received: 5 February 2026

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Article Revised: 25 February 2026

Assistant Professor, Department of Electronics & Communication Engineering,

Published on: 18 March 2026

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DOI: <https://doi-doi.org/101555/ijrpa.2591>

ABSTRACT

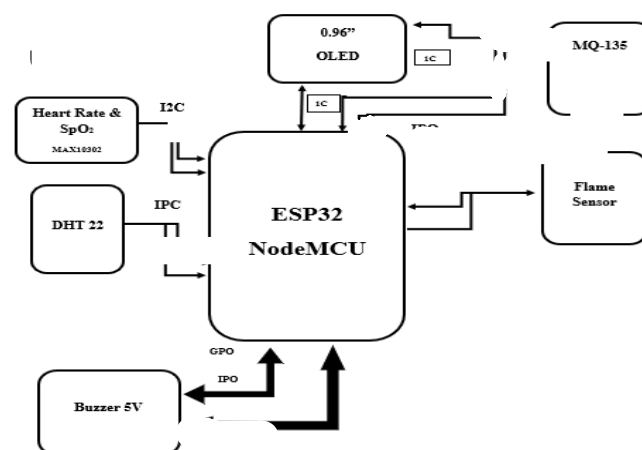
The Smart Automated Digital Hospital Monitoring System operates by continuously collecting data across two primary sensor networks—patient and environmental—and processes this information using pre-set, rule-based logic and fixed thresholds for detection and notification, without relying on machine learning. Wearable and near-patient sensors constantly track vital physiological data, specifically Heart Rate (HR) and Blood Oxygen Saturation (SpO₂), comparing these readings directly to established medical safety ranges (e.g., triggers a critical event). Simultaneously, fixed ambient sensors monitor critical environmental factors, including Air Quality (detecting and VOCs, which are compared to safe parts-per-million limits), Fire (via smoke/heat sensors, which trigger on fixed temperature or particle density levels), Humidity (compared to a narrow acceptable range for patient comfort and equipment integrity), and abnormal Sound (which triggers based on exceeding a pre-set decibel level or frequency characteristic of distress). This sensor data is streamed wirelessly to a central gateway, which is programmed to execute an "IF-THEN" notification protocol: if any parameter crosses its defined critical threshold, a high-priority alarm is instantly escalated to medical staff's mobile devices and the central nursing dashboard; concurrently, an informational or advisory message is delivered directly to the patient's bedside display, ensuring prompt, rule-based intervention and maintaining patient awareness within the digitally monitored environment.

1. INTRODUCTION

The rapid advancement of Internet of Things (IoT) technologies has significantly transformed various sectors, particularly healthcare. However, despite technological progress, many healthcare facilities still rely on fragmented monitoring systems consisting of expensive, standalone medical equipment and manual data recording processes. Such systems often result in delayed emergency response, increased risk of human error in documentation, and inadequate monitoring of environmental parameters that directly influence patient recovery and safety.

To overcome these limitations, this paper proposes a Smart Automated Digital Hospital Management System, designed as an integrated, real-time IoT-based surveillance and monitoring platform. The system leverages low-cost, Wi-Fi-enabled embedded technology to create a unified healthcare monitoring framework that enhances operational efficiency and patient safety.

At the core of the proposed system is the NodeMCU (ESP32) microcontroller, which functions as an intelligent gateway for dual-spectrum monitoring. The system simultaneously monitors patient health parameters—such as Heart Rate and Oxygen Saturation (SpO₂)—under the Internet of Medical Things (IoMT) paradigm, while also tracking critical environmental factors including air quality, fire/smoke presence, humidity and temperature through IoT-based sensing modules.



All collected data is transmitted wirelessly to a cloud platform where automated, threshold-based logic continuously analyses incoming readings. In the event of abnormal health conditions or environmental hazards, the system generates instant, high-priority alerts that are

delivered directly to healthcare personnel via mobile devices. This proactive alert mechanism significantly reduces response time, minimizes risks, and enhances the overall quality of patient care.

2. Internet of Medical Things (IoMT)

The **Internet of Medical Things (IoMT)** represents an advanced extension of the Internet of Things (IoT) specifically tailored for healthcare applications. It refers to an interconnected ecosystem of medical devices, wearable sensors, software applications, and healthcare information systems that communicate over network infrastructures to collect, transmit, and analyze patient data in real time.

IoMT enables continuous monitoring of physiological parameters such as heart rate, oxygen saturation (SpO₂), blood pressure, temperature, and electrocardiogram (ECG) signals. These devices are typically embedded with sensors and wireless communication modules that transmit collected data to cloud-based platforms for storage, processing, and intelligent analysis. By integrating automation and threshold-based alert mechanisms, IoMT systems can immediately notify healthcare professionals when abnormal conditions are detected, thereby reducing response time and improving patient outcomes.

One of the major advantages of IoMT is its ability to support remote patient monitoring (RPM), which minimizes hospital visits while ensuring continuous supervision of patients with chronic illnesses. Additionally, IoMT enhances clinical decision-making by providing accurate, real-time data analytics and historical health records. In smart hospital environments, IoMT contributes to operational efficiency, patient safety, and optimized resource management.

However, despite its transformative potential, IoMT faces challenges such as data privacy concerns, cybersecurity risks, interoperability between heterogeneous devices, and network reliability issues. Addressing these challenges is essential for ensuring secure and scalable healthcare systems.

3. Existing System

In the existing healthcare infrastructure, patient monitoring is largely dependent on manual observation and standalone medical devices for measuring vital parameters such as Heart Rate and Oxygen Saturation (SpO₂). Healthcare staff are required to periodically check and record these readings, which increases the risk of human error and delays in identifying

critical conditions. There is no automation or real-time alert mechanism to notify medical personnel immediately in case of abnormalities, resulting in slower emergency response times. Additionally, patient data is often maintained in paper-based records or stored locally, making tracking, retrieval, and long-term analysis inefficient and unreliable.

Moreover, traditional hospital systems do not continuously monitor environmental factors such as air quality, fire or smoke presence, humidity, and noise levels, which can significantly impact patient recovery and safety. These parameters are typically assessed only during routine inspections rather than through continuous surveillance. The absence of an integrated communication system further limits coordination between monitoring devices and healthcare professionals. As a result, the overall system remains fragmented, staff-dependent, and less efficient in ensuring proactive patient care and hospital safety.

4. Proposed System

The proposed system introduces a Smart IoT-based Hospital Management and Monitoring System that utilizes the ESP32 microcontroller as a central gateway for integrated healthcare surveillance. The system enables real-time monitoring of critical patient vital parameters, including Heart Rate and Oxygen Saturation (SpO₂), ensuring continuous supervision without manual intervention. In addition to patient health monitoring, the system incorporates environmental sensing modules to track air quality, fire or smoke presence, humidity levels, and sound intensity. This dual monitoring approach enhances both patient safety and hospital environmental control within a unified digital framework.

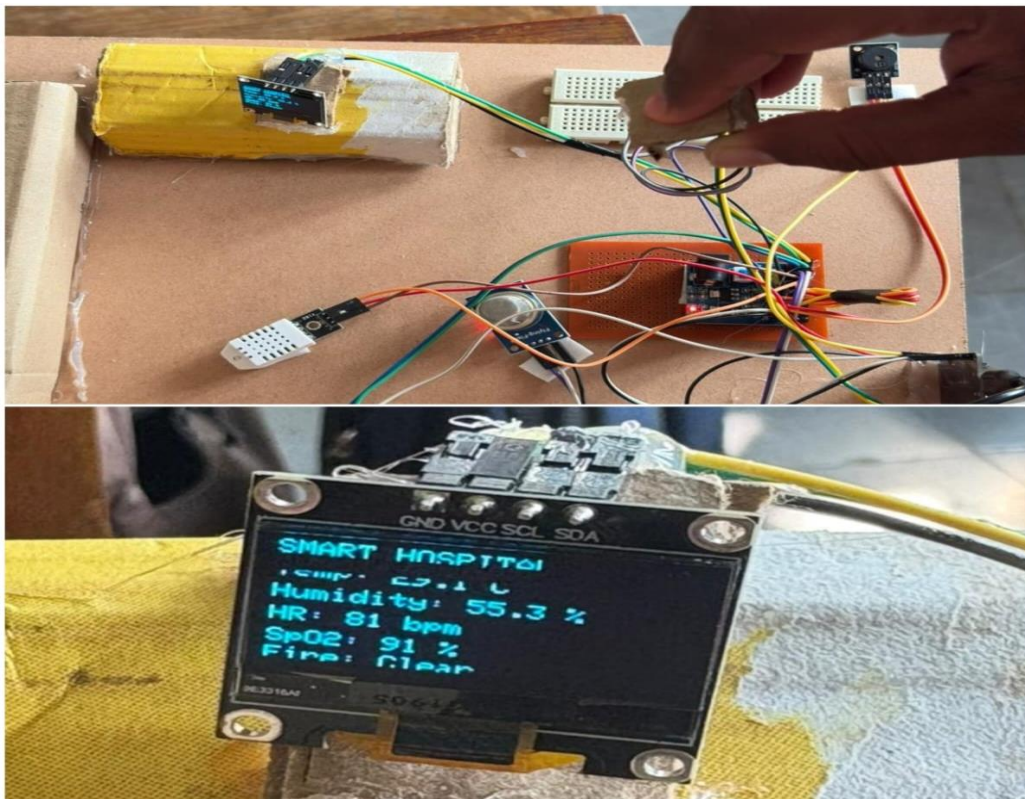
All collected data is transmitted to a cloud platform for centralized storage, analysis, and remote accessibility. The system implements automated threshold-based alert mechanisms that instantly notify medical staff through connected devices whenever abnormal conditions are detected. This real-time alerting capability significantly reduces response time, supports faster clinical decision-making, and minimizes risks associated with delayed intervention. By integrating patient monitoring, environmental surveillance, cloud analytics, and automated communication, the proposed solution establishes a digitally connected, data-driven, and scalable hospital ecosystem.

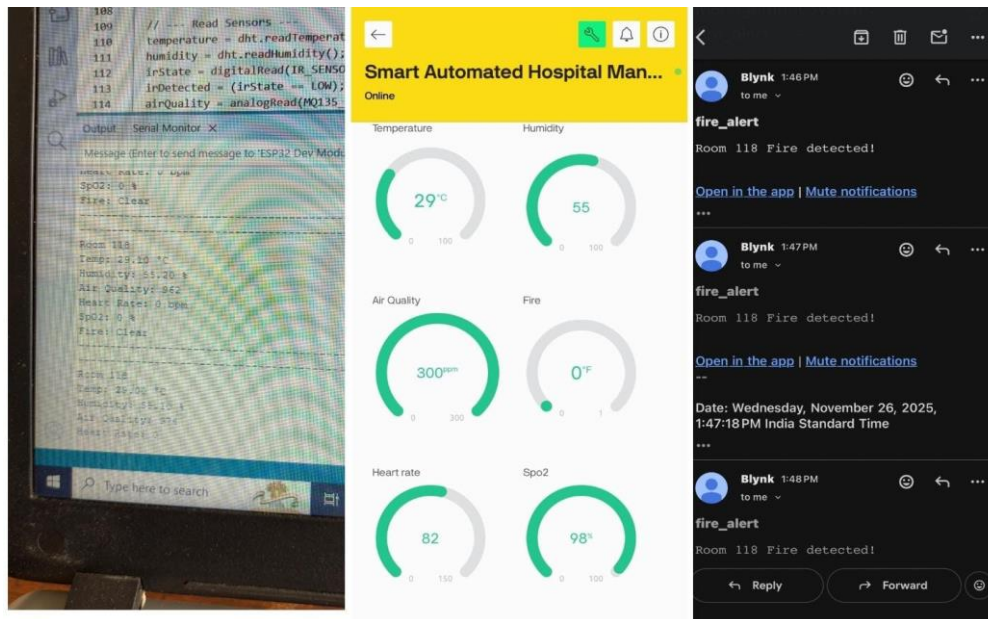
5. RESULTS AND DISCUSSIONS

The Smart Automated Digital Hospital Monitoring System is designed as an integrated IoT based framework that continuously monitors both patient health parameters and

environmental conditions within a hospital environment. The system combines hardware, software, and communication modules to ensure real-time data acquisition, intelligent processing, and automated alert generation. Its primary objective is to reduce manual intervention, improve response time, and create a digitally connected healthcare ecosystem.

The hardware architecture consists of two major sensor networks: patient monitoring and environmental monitoring. The patient monitoring network uses the MAX30102 sensor to measure Heart Rate and Oxygen Saturation (SpO₂), which is interfaced with the ESP32 microcontroller for continuous data collection. The environmental monitoring network includes the MQ-135 air quality sensor, DHT22 temperature and humidity sensor, fire or flame detection sensor, and a sound sensor for abnormal noise detection. The ESP32 functions as the central processing and communication hub, while an OLED display provides real-time parameter visualization at the bedside. A buzzer alarm ensures immediate local alerts during emergency conditions, supported by a stable power supply for uninterrupted operation.





The software workflow follows a rule-based, threshold-driven mechanism implemented within the ESP32 microcontroller. During system initialization, all sensors and communication modules are activated, and predefined safety threshold values are loaded into memory. The microcontroller continuously acquires sensor data, filters it to reduce noise, and compares each parameter against safe threshold limits using IF–THEN decision logic. When abnormal conditions such as irregular heart rate, unsafe air quality, or fire detection are identified, the system instantly triggers alerts.

For communication, the ESP32 connects to the Blynk IoT cloud platform via Wi-Fi, enabling real-time data upload, centralized storage, and remote monitoring. Critical alerts are transmitted as push notifications to doctors and nurses through mobile applications, while dashboard updates are displayed at the nursing station. All sensor readings and alert events are timestamped and logged for future analysis. Once parameters return to normal levels, the system automatically resets alerts and resumes continuous monitoring, ensuring a seamless and reliable smart hospital management cycle.

6. CONCLUSION

The Smart Automated Digital Hospital Monitoring System presents an efficient and scalable solution to overcome the limitations of traditional healthcare monitoring methods. By integrating patient vital monitoring and environmental surveillance into a unified IoT-based framework, the system ensures continuous real-time observation, reduces dependency on

manual intervention, and minimizes the risk of human error. The use of the ESP32 microcontroller as a central gateway enables seamless sensor integration, intelligent threshold-based analysis, and automated alert generation for critical situations.

Through cloud connectivity and instant notification mechanisms, the proposed system significantly improves emergency response time and enhances decision-making for medical professionals. The centralized data storage and remote accessibility features support better record management, retrospective analysis, and overall hospital efficiency. By combining automation, real-time monitoring, and digital communication, the system contributes to the development of a smart, data-driven, and cost-effective healthcare infrastructure. Future enhancements may include advanced data analytics, AI-based predictive monitoring, and expanded sensor integration to further strengthen patient safety and hospital management capabilities.

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