

GSM Health Monitoring System

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Abstract:

The GSM Health Monitoring System is a real-time patient health monitoring solution developed to continuously observe important physiological parameters and support early risk detection. The system is built using an ESP32 microcontroller integrated with multiple sensors, including the MAX30102 sensor for measuring heart rate and blood oxygen saturation (SpO₂), a DHT11 sensor for monitoring body temperature, and an ECG sensor module for capturing basic cardiac activity signals.

The measured values are displayed locally on an OLED display and are also transmitted to a live web dashboard hosted by the ESP32, enabling remote monitoring through any device connected to the same network. The dashboard updates readings in real time and uses threshold-based logic to analyze the sensor values and classify the user's condition as Normal or Risk.

This system offers a compact, low-cost, and efficient solution for continuous health observation in home care, clinics, and patient monitoring environments, where timely alerts and early identification of abnormal health conditions are essential.

Keywords: GSM Health Monitoring System, ESP32, IoT, Heart Rate Monitoring, SpO₂ Monitoring, ECG Sensor, DHT11, OLED Display, Real-Time Monitoring, Web Dashboard, Health Risk Detection.

Introduction:

Medical Healthcare monitoring is shifting from occasional checkups to continuous observation, especially for people who are elderly, chronically ill, recovering from illness, or living in remote areas. In traditional healthcare practice, vital parameters such as heart rate, oxygen level, and temperature are usually measured only during hospital visits or at specific times. This creates a gap in monitoring, because many health conditions can change suddenly and may remain unnoticed between two checkups. Delayed detection of abnormal signs can increase the risk of complications and reduce the chances of timely medical response.

With the growth of Internet of Things (IoT) and embedded electronics, it has become possible to build compact and affordable health monitoring devices that can track multiple body parameters in real time. Modern microcontrollers like the ESP32 provide strong processing capability, wireless connectivity, and low power operation, making them highly suitable for smart healthcare applications. By integrating biomedical and environmental sensors with such controllers, a single device can continuously collect physiological data, display it locally, and also transmit it for remote observation.

This project, GSM Health Monitoring System, is designed as a real-time vital sign monitoring platform using the ESP32 microcontroller. The system combines multiple sensors to monitor important health indicators: the MAX30102 sensor is used to measure heart rate and blood oxygen saturation (SpO₂), the DHT11 sensor is used to monitor temperature, and an ECG sensor module is used to capture basic heart activity signals. These parameters provide a basic but useful overview of a person's condition and can help in identifying early signs of distress or abnormal health status.

One of the key strengths of this project is its dual-mode monitoring capability. First, the readings are shown locally on an OLED display, which allows immediate viewing without requiring any external device. This is useful in bedside use, clinics, or home care environments where quick visual access is important. Second, the ESP32 hosts a live web dashboard, allowing the same readings to be viewed remotely through a browser on a phone, tablet, or computer connected to the network. This makes the system more practical for caregivers, family members, or healthcare staff who need to observe the patient from another room or monitoring station.

The system is not limited to data display only; it also includes threshold-based logic for basic health risk assessment. The incoming sensor readings are continuously compared with predefined normal ranges. If one or more parameters cross the set thresholds, the system classifies the user's condition as "Risk"; otherwise, it remains "Normal." This simple classification helps in quick decision-making and improves usability for non-technical users. Instead of interpreting raw values manually all the time, the user gets an immediate status indication.

Literature Review:

- A. I. Siam, M. A. El-Affendi, A. Abou Elazm, G. M. El-Banby, N. A. El-Bahnasawy, F. E. Abd El-Samie, and A. A. Abd El-Latif (2023) in their paper "Portable and Real-Time IoT-Based Healthcare Monitoring System for Daily Medical Applications" (*published in IEEE Transactions on Computational Social Systems*) proposed a multifunction portable healthcare monitoring platform for daily medical use that measures multiple physiological parameters (including heart-related and oxygen-related signals) and supports real-time observation; the study highlighted strong practicality for pre-diagnostic monitoring and continuous patient tracking.

- **M. Putra and A. Arrayyan (2024)** in their paper “**A Review on the Application of Internet of Medical Things in Wearable Personal Health Monitoring: A Cloud-Edge Artificial Intelligence Approach**” (*published in IEEE Access*) reviewed IoMT-based wearable health monitoring systems and emphasized cloud-edge AI integration to improve response time, scalability, and intelligent health analytics while addressing latency and computation constraints in wearable devices.
- **T. Venkatesan, T. Thamaraimanalan, M. Ramkumar, A. Sivaramakrishnan, and M. Marimuthu (2023)** in their paper “**ECG Signal Feature Extraction and SVM Classifier Based Cardiac Arrhythmia Detection**” (*presented at the 2023 Second International Conference on Electrical, Electronics, Information and Communication Technologies (ICEEICT), IEEE*) proposed ECG feature extraction with an SVM-based arrhythmia classification approach, demonstrating that machine-learning-assisted ECG analysis can improve abnormality detection and support remote cardiac monitoring applications.
- **S. K. Singh et al. (2024)** in their paper “**HOT Watch: IoT-Based Wearable Health Monitoring System**” (*IEEE conference publication, 2024*) proposed a wearable IoT health monitoring watch integrating ECG, temperature, and oxygen-rate sensing modules, and showed that combining multiple biosignals in a compact wearable design improves continuous health visibility and user-friendly monitoring through connected applications.
- **A. Sinchai et al. (2023)** in their paper “**A Real-Time Web-Based Application of Healthcare Monitoring ...**” (*ACM conference paper, 2023; relevant to IEEE-style IoT monitoring architectures*) developed a real-time web-based healthcare monitoring and notification application for patient observation, demonstrating the practical importance of browser-based dashboards for instant visualization and alerting in remote care settings.
- **R. Saha et al. (2025)** in their paper “**An IoT-Driven Real-Time Health Monitoring System Prototype**” (*published in Results in Engineering*) implemented a WBAN-style real-time healthcare prototype using heterogeneous sensor nodes to monitor temperature, heart rate, SpO₂, and ECG, and reported that multi-sensor integration improves continuous health assessment and supports future smart-health deployments.
- **K. Arslanoğlu et al. (2025)** in their paper “**An Efficient Clinical Decision Support Framework Using IoMT ...**” (*2025*) discussed the use of AI-integrated IoMT frameworks for real-time health monitoring and clinical support, showing that combining continuous sensing with intelligent decision systems can improve reliability, speed, and preventive healthcare response.
- **A. P. Penumada (2026)** in their paper “**IoT-Enabled Wearable System for Real-Time ECG Monitoring with Machine Learning-Based Heart Disease Detection**” (*2026*) proposed a wearable ECG monitoring system integrated with machine-learning-based disease detection, indicating that real-time ECG streaming plus ML inference can significantly enhance early screening capability in portable monitoring devices.
- **Y. Y. Ghadi et al. (2025)** in their paper on the **integration of wearable technology and artificial intelligence in healthcare monitoring (2025)** analyzed how wearable sensing and AI-driven analytics improve continuous patient observation, personalization, and early intervention,

while also identifying deployment challenges such as data privacy, interoperability, and user adoption.

- **V. K. Damera et al. (2025)** in their paper “**Enhancing Remote Patient Monitoring with AI-Driven IoMT ...**” (*published in Scientific Reports, 2025; strong relevance to IoT health monitoring architecture*) proposed an AI-driven telemedicine framework combining IoMT, cloud computing, and wireless sensing for efficient healthcare monitoring, demonstrating improved responsiveness and better support for real-time disease detection workflows.

Methodology:

The proposed GSM Health Monitoring System (ESP32-based IoT health monitoring system) is designed to continuously collect, process, display, and analyze vital health parameters in real time. The methodology follows a sensor-to-processing-to-display-to-risk-classification workflow. The system integrates physiological sensors with an ESP32 microcontroller, which acts as the central processing and communication unit.

In the first stage, the user’s health parameters are sensed using connected modules. The MAX30102 sensor captures heart rate and SpO₂, the DHT11 sensor measures temperature, and the ECG sensor captures basic cardiac signal data. These sensors continuously generate raw values, which are read by the ESP32 through suitable input interfaces (I2C for MAX30102, digital pin for DHT11, and analog input for ECG).

In the second stage, the ESP32 performs data acquisition and preprocessing. The incoming sensor values are read at regular intervals and converted into meaningful values such as BPM (beats per minute), oxygen saturation percentage, and temperature in °C. The ECG signal is sampled and used for basic waveform observation or abnormal signal indication. Basic filtering / stabilization logic may be applied (such as repeated sampling and averaging) to reduce noise and improve readability of values.

In the third stage, the processed data is displayed locally on the OLED screen. This allows the user or caregiver to directly observe the latest values without needing a phone or computer. The OLED shows key parameters such as heart rate, SpO₂, temperature, ECG status/signal value, and overall health condition.

In the fourth stage, the ESP32 hosts an embedded web server and creates a live web dashboard. The measured parameters are transmitted from the ESP32 to the web page and refreshed continuously in real time using HTML, CSS, and JavaScript. Any device connected to the same network (mobile, laptop, tablet) can access the dashboard through a browser and monitor the patient remotely.

In the fifth stage, the system applies threshold-based health analysis. Each parameter is compared against predefined normal ranges. For example, if heart rate, SpO₂, or temperature crosses the safe threshold, the system marks the condition as Risk; otherwise, it remains Normal. This logic helps in quick identification of abnormal conditions and provides an early warning indication.

Steps

1. **Initialize system**
 - Power ON ESP32, sensors, and OLED.
 - Configure Wi-Fi and start embedded web server.
2. **Read sensor data**
 - Read heart rate and SpO₂ from MAX30102.

- Read temperature from DHT11.
- Read ECG signal from ECG sensor module.
- 3. **Process data**
 - Convert raw sensor values into usable health readings.
 - Apply basic stabilization/validation checks.
- 4. **Display locally**
 - Show real-time values on OLED screen.
- 5. **Update web dashboard**
 - Send sensor readings to ESP32-hosted web page.
 - Refresh dashboard values continuously.
- 6. **Apply threshold logic**
 - Compare readings with normal limits.
 - Classify status as **Normal** or **Risk**.
- 7. **Repeat continuously**
 - Run monitoring loop for real-time observation.

Block Diagram:

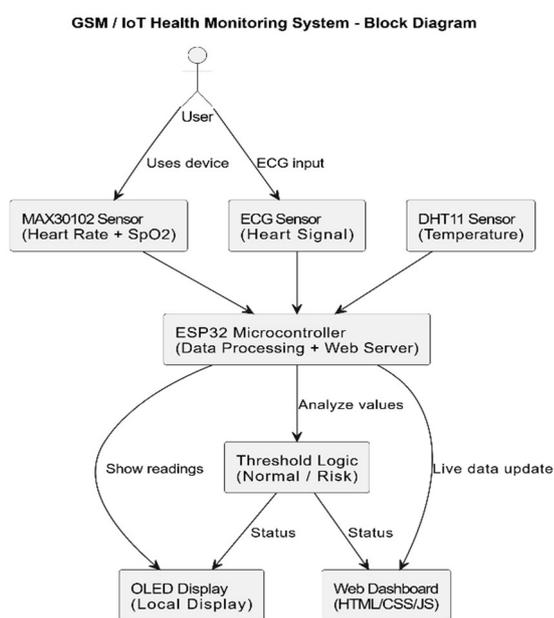


FIG 1 : BLOCK DIAGRAM

Result and Discussion:

The developed **ESP32-based Health Monitoring System** was successfully implemented and tested for real-time monitoring of vital parameters. The system was able to read and display **heart rate, SpO2, temperature, and ECG signal status** using the connected sensors. The values were shown on the **OLED display** and also updated on the **ESP32-hosted web dashboard** in real time.

During testing, the system responded correctly to normal and abnormal threshold conditions. When sensor readings remained within the predefined safe range, the system displayed **Normal** status. When any value crossed the threshold limit (for example, low SpO2 or high temperature), the system changed the status to **Risk**. This confirms that the threshold-based logic works effectively for basic early warning indication.

The overall performance of the system was found to be stable for continuous monitoring in a local network environment. The project demonstrates that a low-cost IoT device using ESP32 can provide useful real-time health observation for home care

and basic clinical support. However, sensor accuracy may vary due to motion, finger placement (MAX30102), environmental factors, and signal noise (ECG), so the system should be treated as a monitoring aid and not a replacement for professional medical devices.

Table: Performance / Evaluation Summary

Parameter / Feature	Observed Result	Status
Heart Rate (MAX30102)	Real-time BPM readings displayed correctly	Working
SpO2 (MAX30102)	Oxygen saturation values updated on OLED + dashboard	Working
Temperature (DHT11)	Body/environment temperature captured and displayed	Working
ECG Signal (ECG Module)	Basic ECG signal/status captured for monitoring	Working
OLED Display	Live values shown locally without delay	Working
Web Dashboard	Real-time monitoring accessible via browser	Working
Threshold Logic	Classified condition as Normal / Risk correctly	Working

Discussion

The test results show that the system successfully integrates multiple sensors with ESP32 and provides real-time local and remote monitoring. The dashboard and OLED display improved usability, while the threshold logic made the output easier to understand for users. The system is suitable for basic continuous monitoring and early alert support, but further improvements such as better filtering, medical-grade sensors, and cloud logging can increase reliability and practical usage. Small viva shield: if your DHT11 is measuring ambient temperature (not actual body temperature contact), mention it clearly so no one calls it “body temperature” and starts a cross-examination.

Conclusion:

The proposed ESP32-based Health Monitoring System was successfully designed and implemented for real-time monitoring of important health parameters such as heart rate, SpO2, temperature, and ECG signal status. The system integrates multiple sensors with an ESP32 microcontroller, displays readings on an OLED screen, and provides remote access through a live web dashboard.

The project demonstrates that a low-cost IoT-based setup can continuously monitor patient vitals and provide a basic early warning mechanism using threshold-based logic to classify the condition as Normal or Risk. This improves visibility of patient status and supports timely observation in home care and small clinical environments.

Overall, the system is simple, affordable, and useful for continuous health monitoring applications. Although it is not a replacement for medical-grade equipment, it works effectively as a monitoring and alert-support prototype and provides a strong foundation for future smart healthcare systems.

FUTURE SCOPE:

The current system can be further improved in many practical ways to make it more reliable, scalable, and closer to real healthcare deployment.

Future Enhancements

- **Add GSM/SMS alert module** (SIM800/SIM900) for emergency notifications
- **Cloud database integration** (Firebase/ThingSpeak/AWS) for long-term data storage
- **Mobile app integration** for doctor/caregiver **monitoring**
- **Advanced ECG signal filtering** for cleaner waveform analysis
- **AI/ML-based health prediction** instead of only threshold logic
- **Battery backup and wearable design** for portability
- **Doctor dashboard with patient history and trends**
- **Buzzer/LED emergency alerts** for local warning
- **Multi-patient monitoring support** in clinics
- **Medical-grade sensor calibration and validation** for improved accuracy

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