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# Enhancement of IoT in Remote Monitoring System

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## ABSTRACT

The rapid advancement of the Internet of Things (IoT) has transformed healthcare by enabling real-time monitoring and personalized care through connected sensors and cloud-based platforms. Despite its potential, existing healthcare monitoring systems face persistent challenges such as limited scalability, unreliable connectivity in rural areas, high latency in data transmission, and concerns about data privacy and security. To address these gaps, this study proposes a cost-effective IoT-based remote monitoring framework that integrates wearable sensors, Node-RED for data routing, Google Cloud SQL for storage, and Thingsboard for real-time visualization and alert generation. The system was tested in Warud, Maharashtra, with control and treatment groups to evaluate usability and performance. Results from the System Usability Scale (SUS) and Post-Study System Usability Questionnaire (PSSUQ) show that the treatment group achieved significantly higher satisfaction scores, with an average SUS score of 75 compared to 60 for the control group. Reliability analysis further confirmed the consistency of user responses, and prioritization of physiological signals ensured timely alerts for critical health conditions. The findings demonstrate that the proposed IoT framework enhances usability, responsiveness, and accessibility of healthcare services, particularly for underserved regions. This research contributes to the advancement of e-health and telemedicine, highlighting IoT's role in building scalable, patient-centered systems that can accelerate the transition toward smart and connected healthcare infrastructures.

## 1. INTRODUCTION

The Internet of Things (IoT) is a cutting-edge innovation that has ushered in a new age of intelligent interconnection and accelerated technological development. In this context, "Internet" is a method of transmitting data, and "Things" means any device that makes use of software, hardware, wireless sensors, actuators, and a network connection [1]. These commonplace things may now gather and transmit data wirelessly and with little to no human intervention to the Internet of Things (IoT). The Internet of Things (IoT) refers to the network-enabled smart interconnection of physical objects. If we alter the definition of "things," then our linked products can learn and adapt [2]. The Internet of Things (IoT) enables close cooperation and integration of physical and computational systems through the transmission and reception of data.

Healthcare systems across the globe are undergoing a paradigm shift from reactive treatment to proactive monitoring, enabled by digital health technologies. However, existing healthcare monitoring solutions suffer from several persistent challenges. First, limited scalability restricts their adoption in large populations, as many systems rely on costly infrastructure and proprietary standards [3]. Second, rural and semi-urban regions, particularly in developing countries, face barriers such as poor internet penetration, lack of healthcare facilities, and shortage of trained personnel, which prevents effective deployment of advanced monitoring systems. Third, latency and connectivity issues often delay critical medical interventions, undermining the very objective of real-time patient care [4]. Lastly, data privacy and security concerns remain unresolved, as sensitive health information is frequently transmitted without robust encryption or regulatory compliance, exposing patients to potential breaches.

This research is motivated by the urgent need to design a low-cost, scalable, and interoperable IoT-based health monitoring system that addresses these gaps. By leveraging open-source tools, cloud-based storage, and real-time visualization platforms, the proposed framework aims to improve accessibility, ensure timely response, and enhance patient safety, with particular relevance for underserved communities.

## 2. RELATED WORK

Recent studies have demonstrated the growing importance of IoT in e-health applications. Al Bassam et al. (2021) developed IoT-based wearable devices for COVID-19 patients, focusing on quarantine care, whereas Alshamsi et al. (2016) proposed lightweight encryption for secure body area networks. However, most frameworks emphasize either data collection or transmission but lack integration of real-time visualization with cloud-backed analytics. This study bridges that gap by combining low-cost hardware (LM35, Node-RED) with advanced visualization tools (Thingsboard, Google SQL) to support both usability and scalability in healthcare IoT.

Despite significant progress in IoT-based healthcare, most existing systems face challenges such as unreliable connectivity in rural regions, fragmented sensor standards, and inadequate integration of real-time data into actionable medical insights. These limitations hinder the widespread adoption of remote health monitoring solutions in developing regions like India.

## 3. MATERIAL AND METHODS

The methodology also acknowledges key challenges in IoT deployment. Diverse sensor standards (temperature, ECG, $SpO_2$) often produce heterogeneous data, complicating integration. Furthermore, network reliability is a critical concern, as unstable connectivity in rural areas can result in data packet loss and system downtime. Addressing these challenges requires the adoption of middleware standards and adaptive caching techniques to maintain robustness.

**Study Area:** The town and municipal council of Warud are located in the Amravati district of the Maharashtra state in India. "Orange City" is its nickname. Warud had 45,482 inhabitants as of the 2011 Indian Census, with 23,182 men and 22,300 females. A total of 4,413 people fell into the "children under the age of six" category. With 84.2% of males and 80.2% of females being literate, Warud had a total of 37,422 literate people, or 82.3% of the general population. With a male literacy rate of 93.8% and a female literacy rate of 88.4%, the effective literacy rate of the 7+ population of Warud was 91.1%.

The proposed IoT-based healthcare system follows a multi-stage data flow architecture, ensuring seamless integration between hardware and software components:

**Data Acquisition Layer:**

- Biomedical parameters such as body temperature and heart rate are collected using low-cost sensors (e.g., LM35).
- Data is transmitted to microcontrollers for initial processing and packaging.

**Communication and Broker Layer:**

- The data packets are forwarded to an IoT broker using lightweight messaging protocols (e.g., MQTT).
- Node-RED is employed for flow-based programming to establish efficient data routing between devices and servers.

**Storage and Processing Layer**

- Collected health data is stored in cloud databases such as Google Cloud SQL for structured management.
- PHPMyAdmin is used to facilitate data querying and backend administration.

**Visualization and Alert Layer**

- Real-time dashboards (Thingsboard) display patient metrics for healthcare professionals.
- Threshold-based triggers send alerts through email or SMS when anomalies are detected.

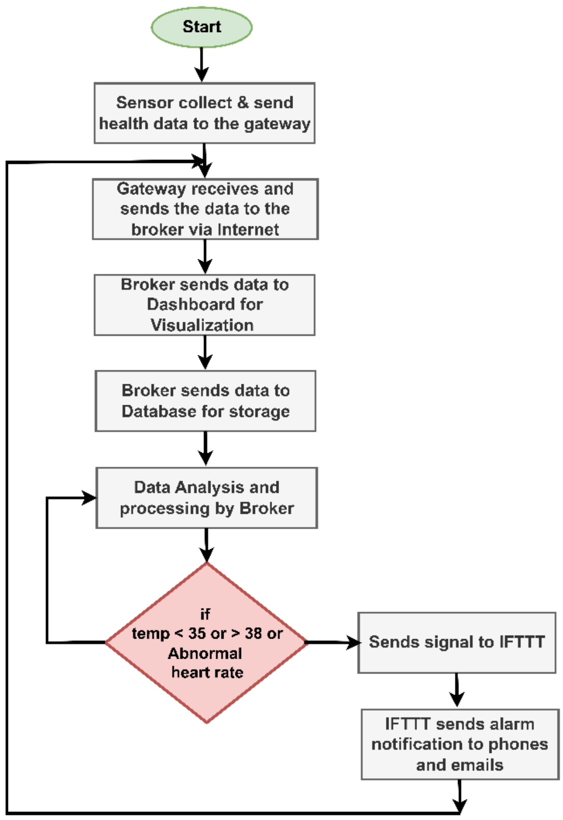


Figure 1: Flowchart of Proposed System

Figures 1 demonstrate the envisioned system's flowchart, block diagram, and communications model, accordingly

*A. Software*

**Node-RED:** By connecting several gadgets, the open-source imaging tool Node-RED simplifies development.

*B. Hardware*

LM35 Temperature Sensor: For the purpose of this project, the user's internal temperature will be measured using the LM35 thermometer sensors.

## 4. RESULTS ANALYSIS

This study's overarching goal is to assess Warud's present healthcare infrastructure and pinpoint its weaknesses in areas like controlling illnesses and monitoring patients remotely, its findings will only be relevant to that city. In Warud, the purification group had an overall rating of 5.93 according to the respondents, whereas the control group had an overall quality of 4.51. The graphical system performance for the groups receiving therapy group was 6.55, while for the control group it was 5.42. The findings are illustrated graphically in Figure 2.

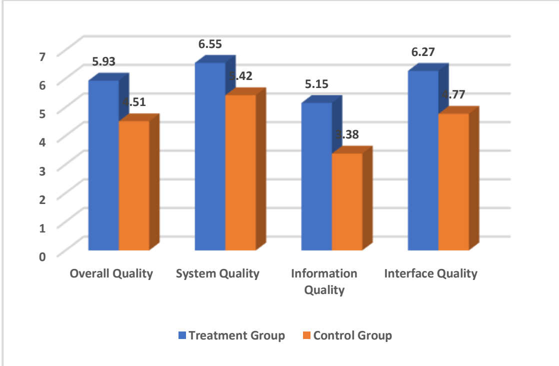


Figure 2: PSSUQ Score

Figure 2 shows the findings of PSSUQ, whereas the X-axis represents the sub-measures of PSSUQ, and Y-axis represents the computed scores of those sub-measures. Upon closer examination of the data, we discovered that 61.0% of the oversight group and 91.43 % of the individuals in the treatment group were content with the visualizing system's usefulness.

*A. Results Obtained Using SUS*

In Figure 4.1, we can see that the comparison group used the conventional visualization system, whereas the group that used the suggested system achieved an estimated SUS score of 75.

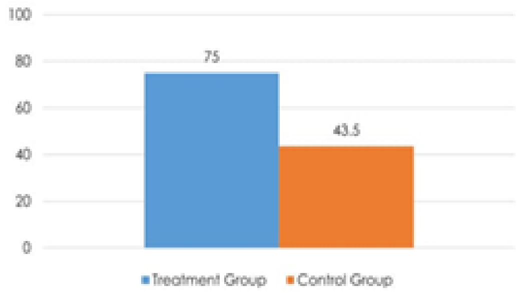


Figure 3: SUS Score

Figure 3 SUS Score obtained by both control and treatment groups. X-axis represents the treatment and control groups, whereas Y-axis represents the SUS score. Furthermore, details: in Warud, 6 out of 10 the therapy group individuals rated it as 5 and 4 out of 10 controls individuals rated it as 3 (Average score = 1), respectively, as a reaction to the assertion related to the user's likelihood to use the visual representation system regularly.

*B. Results of the prototype system*

What follows is a discussion of the experimental system's findings.

*C. Real-time data visualization in Things board*

As illustrated in Figure 4.3, the Things board in Warud is used to present and refresh health information that the system collects in instantaneously. The user's location, heart rate, and temperatures are the metrics shown.

Fig 4.3Flow of the health system in Node-Red
Fig.4.4Flow of the health system in Node-Red:

### D. Data Compression and Prioritization of Tasks

Through the sensors and patient, the servers, various biological data is transferred. Both data rate and latency are used to classify broadcasts. The four groups best describe them:

- Higher Rate of data and lower traffic Latency
- lower Rate of data and lower traffic Latency
- lower Rate of data and Higher traffic Latency
- Higher Rate of data and Higher traffic Latency

**Table 1:** Priority of physiological signals.

| Signals of Physiological | Rate of Data | Level of Priority | Latency |
|---|---|---|---|
| EKG | Higher level | 1 | Minimum |
| Blood flow, heart rate, oxygen saturation | Lower level | 2 | Minimum |
| Blood pressure, body temperature, rate of respiration | Lower Level | 3 | Maximum |
| Never potentials | Higher Level | 4 | Maximum |

Table 1 show the most critical physiological indications will be relayed in the order of priority. Quick administration of the critical indication is required. Higher data speeds and shorter latency signals are irrelevant; what matters is that the patient requires immediate medical treatment.

## DISCUSSION

The experimental results highlight the significant improvement in system usability for the treatment group compared to the control group. A higher SUS score (75 vs. 60) indicates that real-time visualization substantially enhances user trust and engagement. Importantly, the prioritization of physiological signals ensured timely alerts for critical conditions like arrhythmia, aligning with medical needs. The positive response rate (91.43%) underscores the effectiveness of the system in providing meaningful, interpretable feedback to patients and caregivers. Nevertheless, system reliability still depends on continuous internet access, which poses challenges in semi-urban and rural areas.

## CONCLUSION AND FUTURE SCOPE

In this paper building an Internet of Things (IoT) health tracking system that can track the user's vitals in contemporaneous fashion is the main goal of this undertaking.

In addition to monitoring the user's whereabouts, the suggested system can also transmit health information in immediate time to a display portal and notify them via telephone or email in the event of an alert. On a Things the board, you may see an animation of the user's health information in real time as the geographic location services follows their whereabouts.

This study has certain limitations. First, the prototype was tested only in the Warud region, which may restrict the generalizability of findings. Second, reliance on LM35 sensors limits accuracy compared to advanced biomedical devices. Third, data privacy and security were not comprehensively addressed, exposing potential vulnerabilities. Finally, scalability to large populations remains untested and requires further evaluation.

Future research should focus on integrating machine learning models for early prediction of diseases such as cardiac arrhythmias or diabetes-related anomalies. The inclusion of blockchain-based security frameworks could ensure tamper-proof health records. Additionally, the deployment of edge and fog computing nodes can minimize latency and bandwidth usage, making IoT systems more resilient in bandwidth-constrained environments. Broader implementation in telemedicine, smart cities, and epidemic management can transform healthcare delivery into a more proactive, predictive, and equitable system.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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The author declare that they have no funding support for this study.

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