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IoT-Based Smart Nursing Call System with Integrated Physiological Monitoring for Enhanced Patient Safety

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Abstract
Conventional nurse-call systems are primarily dependent on manual patient activation and often do not provide real-time information on patient physiological condition, which may delay emergency response and patient care. This study focused on the design and fabrication of an IoT-based smart nursing call device with physiological monitoring system to improve patient monitoring and enhance communication between patients and healthcare providers. The system was developed using the ESP32 microcontroller and integrated physiological sensing modules for monitoring blood oxygen saturation (SpO_2), heart rate, body temperature, and hydration level. The circuit design and simulation were carried out using Proteus software, while a 12 V rechargeable battery served as the power source for the system. The developed device combined continuous physiological monitoring with a manual nurse-call push-button and wireless IoT communication for remote monitoring. Performance evaluation showed that the system successfully acquired physiological parameters in real time, displayed readings on the LCD interface, and transmitted patient data wirelessly to a cloud-based dashboard for remote access. Validation was carried out by comparing readings obtained from the developed device with those from conventional clinical instruments, namely the Contec CMS50D fingertip pulse oximeter and Omron MC-246 digital thermometer. The results showed close agreement between both systems, with only minimal deviations observed in SpO_2 , heart-rate, and temperature measurements. The system also demonstrated effective alarm activation under abnormal physiological conditions and successful nurse-call alert notification. The study concluded that the developed IoT-based smart nursing call device with physiological monitoring system is reliable and effective for continuous patient monitoring and emergency nurse notification. The device has potential application in hospitals, clinics, elderly care facilities, and remote healthcare settings to improve patient safety, reduce response time, and support efficient healthcare delivery.

Keywords: IoT, smart nursing call system, physiological monitoring, ESP32, patient monitoring, remote healthcare.

I. Introduction

Nurses make up half of the global health workforce and serve as the frontline of patient care, monitoring, and coordination (Dall'Ora et al., 2022). A major challenge undermining their effectiveness is the low nurse-to-patient ratio; in many resource-limited hospitals, a single nurse manages 10–15 patients, far above the recommended 1:4–6 for general wards and 1:1–2 for ICUs (Aiken et al., 2014; Li et al., 2024; Shekelle, 2013). This imbalance leads to delayed responses, missed deterioration signs, and worse outcomes, including higher rates of falls, adverse events, and mortality problems most acute in emergency, ICU, and medical-surgical units.

Traditional wired call systems (bedside buzzers) suffer from restricted mobility, wiring faults, and inability to prioritize urgent requests, and typically only alert a central nurse station, causing delays when nurses are elsewhere (Chaman & Deepak, 2015; Tzeng & Yin, 2009; Unluturk, 2012). Wireless nurse call systems improved deployment ease and flexibility (Aly El-Shinnawi et al., 2018;

Aswin et al., 2011; Wan & Wang, 2018), but both wired and wireless systems remain patient-initiateduseless for unconscious, cognitively impaired, or too-weak patients. Since up to 86% of in-hospital cardiac arrests are preceded by detectable abnormal vital signs (Li et al., 2024), integrating continuous physiological monitoring (SpO_2 , heart rate, temperature) into call systems is proposed as essential to close this gap through automated threshold-based alerts.

Multiple studies link staffing levels directly to safety outcomes. Aiken et al. (2014), studying nine European countries, found better staffing and nurse education associated with lower hospital mortality. Dall'Ora et al. (2022) similarly found inadequate staffing predicts medication errors, falls, and hospital-acquired infections. Montgomery et al. (2021) showed nurse burnoutoften driven by workload predicts medication administration errors, illustrating that staffing pressures harm both nurses and patients simultaneously. These pressures are worse in developing countries and resource-limited settings, reinforcing the need for supportive technology. Sharma and Gautam (2015) described wired systems using RS-485 bus protocols for deterministic, interference-resistant delivery, but noted high installation costs, poor reconfigurability, and lack of prioritization. Tzeng and Yin (2009) linked delayed call responses to increased fall rates. Unluturk (2012) added prioritization features but remained reliant on patient activation, without automated monitoring. Wan and Wang (2018) used RF codec ICs for flexible, lower-cost multi-bed alert systems. Aly El-Shinnawi et al. (2018) and Aswin et al. (2011) demonstrated feasible wireless request systems with wider ward coverage. Calvo Salcedo et al. (2019) emphasized affordability for resource-limited settings. Wen et al. (2022) evaluated a Smart Patient Care System routing alerts to mobile phones with bed-exit detection and two-way communication, showing improved alarm handling and nurse satisfaction versus traditional systems evidence that "smart" features enhance workflow efficiency.

Mok et al.,2015 identified heart rate, temperature, respiratory rate, SpO_2 , and blood pressure as key deterioration indicators, concluding continuous monitoring outperforms intermittent checks. Shammari et al. (2022) reinforced that accurate, early vital sign detection prevents irreversible adverse events. Cardona-Morrell et al. (2016) found continuous monitoring particularly beneficial for high-risk ward patients, aided by increasingly feasible and affordable technology. Rodrigues, Postolache, and Cercas (2020) reviewed IoT-based physiological/behavioral monitoring, highlighting distributed sensor networks feeding cloud systems directly relevant to biosensor integration into nurse call devices. De Fazio et al. (2021) reviewed wearable sensors for temperature, heart rate, SpO_2 , respiration, and movement, noting their value for lightweight, low-power, continuous remote monitoring.

Jeyaraj and Samuel Nadar (2019) built an IoT patient monitoring system with intelligent automated alerts for abnormal vitals, closely paralleling the proposed system's goals. Wang et al. (2024) reviewed IoT-driven digital transformation in nursing, concluding smart systems improve safety, workflow, response speed, and accuracy. Chopade et al., 2023) surveyed healthcare sensors (physiological, motion, environmental, wearable, biosensors), evaluating them on accuracy, energy use, range, reliability, and cost informing component selection for microcontroller-based prototypes (e.g., Arduino/ESP32).

Several studies validate specific low-cost sensors: Contardi et al. (2021) confirmed MAX30102 with ESP32 gives SpO_2 readings comparable to standard oximetry. Muthmainnah et al. (2022) reported ~97% heart-rate accuracy for MAX30102. Pravin Savaridass et al. (2021) validated the LM35 temperature sensor for stable patient monitoring. Faizah et al. (2025) combined ESP32 and MAX30102 in a portable diagnostic system achieving 1–3.4% error rates while transmitting SpO_2 , BPM, and temperature to a cloud database in real time demonstrating practical multi-sensor IoT integration. Ongenae et al. (2012) developed a context-aware system prioritizing calls based on patient condition, location, urgency, and caregiver availability, improving workflow beyond simple alert buttons. Lafta et al. (2024) demonstrated low-cost Arduino-based wireless call systems, informing embedded hardware design. Nursuwars and Rahmatulloh (2018) added RFID to track nurse response times and task completion, suggesting future expansion for performance monitoring and accountability. Despite these advances, three gaps persist: (1) most nurse call systems remain patient-initiated, failing incapacitated patients; (2) physiological monitoring systems are typically separate from call systems, requiring duplicate infrastructure; (3) few integrated, low-cost platforms combine both patient-initiated calls and automated physiological monitoring for resource-limited settings. This study addresses these gaps by developing an IoT-based smart nursing call device integrating real-time monitoring of SpO_2 , heart rate, body temperature,

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and hydration with automated threshold-based alerts and traditional patient-initiated call functionality. Using the ESP32 microcontroller's built-in Wi-Fi eliminates the need for separate communication modules, reducing cost and complexity. The goal is a single affordable platform combining continuous automated surveillance and manual call capabilityenabling faster interventions, reducing preventable complications, and easing burden on overstretched nursing staff, particularly in resource-limited healthcare environments.

II. Materials and Method

This study will adopt an experimental design approach involving the development, construction, and testing of the proposed nursing call and physiological monitoring system.

2.1 Materials

The materials to be used for the proposed nursing call and physiological monitoring system is divided into hardware and software components.

2.2 Hardware Components

The hardware components of the proposed nursing call and physiological monitoring system is presented in Table 1.

Table 1: Hardware component of the proposed nursing call and physiological monitoring system.

S/N	Material	Specification	Source	Function
	Project Enclosure		Locally made	
	Push button		Locally sourced	To initiate call to the nurse.
	Battery	(12V7.2AH/20HR)	Locally sourced	To store energy and then discharges it
	Heartbeat sensor		Locally sourced	Switches DC currents to the motor windings
	SPO_2 Sensor		Locally sourced	To measure the oxygen level in the blood
	Liquid Crystal Alphanumeric Display Module	20*4 LCD	Locally sourced	To display outputs
	Arduino board	Arduino Uno	Locally sourced	To monitor process and generate result acquired from the temperature and humidity sensor.
	GSM module	SIM800L	Locally sourced	To transfer data to a distance
	Relay	12V/10A sensitive relay (1 module)	Locally sourced	To open and close circuits electromechanically
	Resistors	20Ω, 10Ω	Locally sourced	For calibration of ADC (analog to digital converter) voltage signal.
	Capacitor	1000µF/50v, 22pf	Locally sourced	For filtration of crystal and voltage ripple.
	Regulators	7805, 1A, 5VDC	Locally sourced	To reduce supply voltage to choice value
	Keypad Module	4*3	Locally sourced	For inputting data
	Transformer	220V/12V, 1000Ma	Locally sourced	For reducing the 220V to 12V that can be utilize by the discrete components.
	Body temperature sensor	DS18B20	Locally sourced	For acquiring of temperature and humidity change value.

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Transistors X4	BC547 NPN	Locally sourced	For signal amplification
Jumper wires	Male to male; Female to male	Locally sourced	For connectivity
Diode	1N4007	Locally sourced	To control signal flow in one direction.

2.3 Software Components

Arduino IDE was used for programming the Arduino IDE Arduino Uno microcontroller using the C/C++ embedded programming language. Proteus Proteus simulation software was used for designing, testing, and simulating electronic circuits before hardware implementation. A Bluetooth module was used for monitoring the state of the device. Blynk Blynk/ThingSpeakThingSpeak IoT dashboard was used to provide cloud-based monitoring, data logging, and push notifications to nurses' mobile phones.

2.4 Description of Proposed IoT-based Smart Nursing Call Device with Physiological Monitoring System

The system was powered from a mains AC supply of 220–240 V, which was stepped down by a transformer to a 12 V AC secondary output. This was then rectified and filtered using a full-wave bridge rectifier composed of four 1N4007 diodes and a smoothing capacitor of 2200 µF / 25 V to provide a stable DC output. A 7805 linear regulator was employed to generate a regulated 5 V supply rail for the Arduino, sensors, LCD, buzzer, relays, and the RS-485 communication module, with decoupling capacitors (0.33 µF at the input and 0.1 µF at the output) as well as a 1000 µF electrolytic capacitor placed near the output for stability.A dedicated 3.3 V rail was derived using an AMS1117-3.3 regulator powered from the 5 V rail to supply the ESP8266 Wi-Fi module and other 3.3 V sensors. A 10 µF electrolytic capacitor and a 0.1 µF ceramic capacitor were placed close to the output for noise suppression.

To ensure uninterrupted operation during mains power failure, a 12 V sealed lead-acid (SLA) battery or rechargeable 12 V battery pack was included as backup. It was connected through an automatic charging system and diode ORing arrangement, with a Schottky diode (e.g., 1N5819) used for reverse current protection, while a fuse was incorporated on the battery line to enhance safety

2.5 Methods

Block diagram of the Smart Nursing Call device with Physiological Monitoring System.

The block diagram of the smart nursing call system is presented in Figure 3.1.

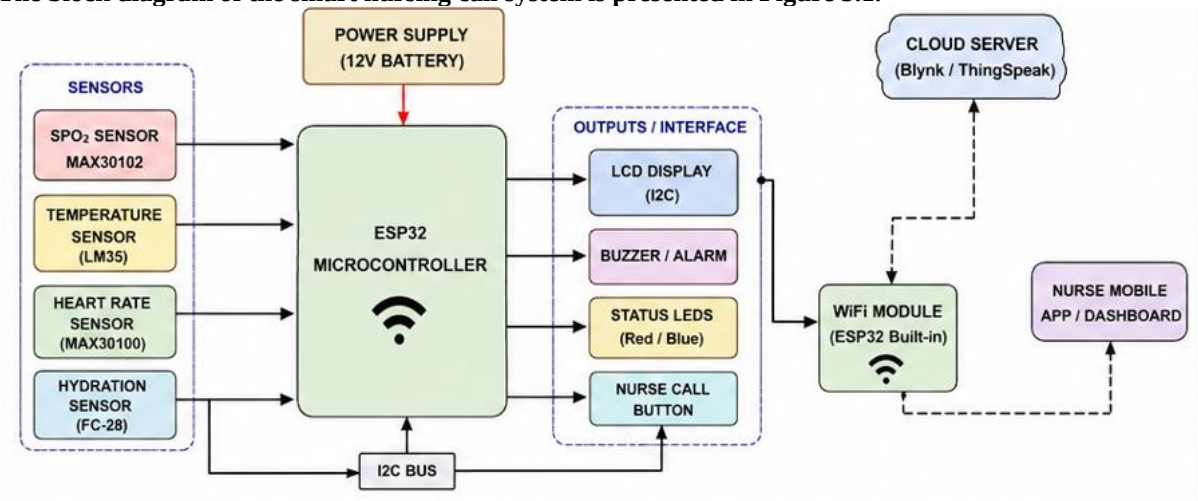

Figure 1 Block diagram of the designed nurse call system

2.6 Sensor Selection Criteria

The selection of sensors for the development of the IoT-based smart nursing call device with physiological monitoring system was guided by the functional requirements of the device, the clinical relevance of the physiological parameters to be monitored, compatibility with the ESP32 microcontroller architecture, power consumption

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characteristics, measurement reliability, and ease of integration within both the Proteus simulation environment and the physical prototype implementation.The MAX30102 sensor was selected for blood oxygen saturation monitoring due to its ability to measure peripheral oxygen saturation non-invasively through photoplethysmography principles.

The device integrates red and infrared light-emitting diodes alongside a photodetector, allowing real-time estimation of oxygen saturation based on optical absorption characteristics of oxygenated and deoxygenated blood. Its digital I²C communication interface enabled direct integration with the ESP32, while its compact size and low operating current made it suitable for continuous monitoring applications in a patient-care setting.The MAX30100 sensor was incorporated for heart rate monitoring. The choice was based on its high sensitivity to pulse waveform detection, compact architecture, and ability to provide continuous pulse rate measurements with minimal signal conditioning requirements. Its compatibility with low-voltage embedded systems and digital communication support simplified implementation and ensured reliable signal acquisition within the system. For temperature sensing, the LM35 precision analog temperature sensor was adopted due to its linear output response, high accuracy, and low power demand. The LM35 produces an output voltage directly proportional to temperature in degrees Celsius, thereby eliminating the need for extensive calibration or compensation circuitry. Its analog voltage output was directly interfaced with the analog-to-digital conversion capability of the ESP32.

2.7 Power Management Approach

The power management system of the developed device was centered on a 12 V rechargeable battery supply, which served as the primary source of power for the entire system as presented in Figure 3.2. The battery-powered architecture was selected to ensure uninterrupted operation during utility power failure and to improve portability within hospital or bedside environments.

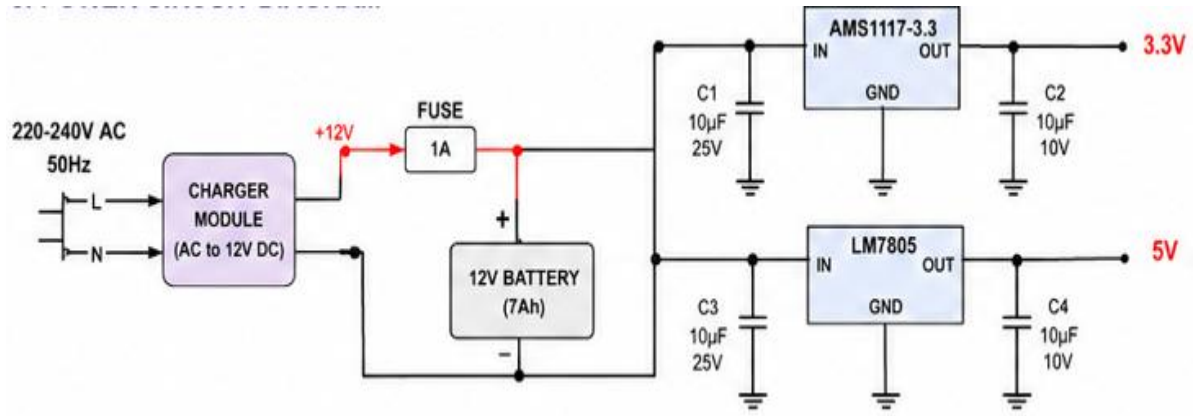

Fig 2 Power rectification of the designed nurse call system

Battery charging was achieved using an AC-to-DC charging unit connected to a 220–240 V mains supply. The charger converted the AC input into regulated 12 V DC suitable for charging the battery. Once charged, the battery supplied DC power continuously to the device. Since the various electronic subsystems operated at different voltage levels, voltage regulation stages were incorporated to derive appropriate operating voltages from the 12 V battery source. A 7805-voltage regulator was employed to generate a regulated 5 V output for powering the LCD display, buzzer, LEDs, and associated sensor modules. The 5 V rail ensured stable operation of peripheral components while protecting them from voltage fluctuations.

A dedicated 3.3 V rail was generated using the AMS1117-3.3 voltage regulator to power the ESP32 microcontroller. This was necessary because the ESP32 operates within a 3.3 V logic domain and is sensitive to overvoltage exposure. Capacitive filtering was included at the regulator input and output stages to minimize ripple, suppress electrical noise, and improve output voltage stability. This ensured reliable sensor measurements and stable wireless communication performance. The battery-backed architecture ensured that the system remained operational during mains failure while also allowing recharge through conventional AC supply when available.

International Journal of Advances in Engineering and Management (IJAEM)
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2.8 Device Operation Workflow

Upon powering the device, electrical energy from the 12 V rechargeable battery was distributed to the voltage regulation stages. The regulators generated stable 5 V and 3.3 V supply rails, energizing the ESP32 microcontroller and all connected peripherals. Following power-up, the ESP32 initialized all connected hardware modules including the MAX30102 SpO_2 sensor, MAX30100 heart rate sensor, LM35 temperature sensor, FC-28 hydration sensor, LCD display, alarm buzzer, LED indicators, and Wi-Fi communication stack. After initialization, the controller entered continuous monitoring mode. Sensor readings were sampled periodically from all connected physiological monitoring units. The acquired signals were converted where necessary and processed by the ESP32.

Processed data were displayed locally on the LCD screen to provide bedside visual feedback to both patients and medical personnel. Simultaneously, the same data were transmitted wirelessly through Wi-Fi to the IoT dashboard for remote access. The ESP32 continuously compared all measured values against predefined physiological threshold limits stored in the firmware. If any parameter exceeded the permissible threshold, the controller activated the alarm buzzer, illuminated the alert LED, and transmitted a notification to the remote nurse monitoring interface. In addition to automated threshold-based alerts, the patient could manually request assistance through the nurse-call push-button. Once activated, the ESP32 immediately triggered the alarm output and transmitted an emergency alert to the nurse dashboard. This monitoring-alert-feedback cycle continued continuously throughout operation until the device was switched off or the battery was depleted.

2.81Load and Energy Calculations

The electrical load analysis of the developed system was performed to determine total current demand, battery capacity suitability, operating duration, charging requirements, and regulator performance. The current requirement of each subsystem was estimated from manufacturer datasheets and simulation parameters. The ESP32, operating with active Wi-Fi transmission, required approximately 240 mA. The MAX30102 SpO_2 sensor required approximately 25 mA. The MAX30100 heart-rate sensor consumed approximately 25 mA. The LM35 temperature sensor required approximately 5 mA. The FC-28 hydration sensor consumed approximately 20 mA. The 16×2 I²C LCD required approximately 20 mA. The buzzer required approximately 30 mA during active alarm operation, while the status LEDs collectively consumed approximately 10 mA.

Thus: $I_{total} = 240 + 25 + 25 + 5 + 20 + 20 + 30 + 10$

$I_{total} = 375mA = 0.375A$

The battery used in the system was rated: V = 12V, C = 7Ah

Hence, the total stored battery energy was: E = V × Ah =12×7 E = 84Wh

The expected runtime of the system under full-load operation was estimated using $T = \frac{Capacity}{Current}$

$T = \frac{7}{0.375} = 18.67$ hours

Since the buzzer operates intermittently and not continuously, average current draw during normal monitoring operation was estimated at approximately 0.30 A.

Therefore $T = \frac{7}{0.3} = 23.3$hours.

This indicates that the system can operate continuously for approximately 18 to 23 hours depending on alarm frequency and wireless transmission activity. Battery charging analysis was based on the standard charging rate of 0.1C. Therefore, $I_c = 0.1 \times 7 = 0.7A$

Charging time was estimated as: $T = \frac{7}{0.7} = 10$ hours

Allowing for conversion losses and charging inefficiencies, practical charging duration was estimated between 10 and 12 hours.

The total input electrical power consumed by the system was P = V × I

$P = 12 \times 0.375 = 4.5W$

Power dissipation across the 7805 regulator was calculated as:

$P = (12 - 5) \times 0.30 = 2.1W$

Power dissipation across the AMS1117-3.3 regulator was:

$P = (12-3.3) \times 0.15 = 1.31W$

These losses were expected due to the use of linear voltage regulators, which dissipate excess voltage as heat. Thermal management through appropriate heatsinking or ventilation should therefore be considered during physical implementation.

Efficiency estimate

Useful output power: $P_{out} = 5V\ (0.135) + 3.3V\ (0.24)$

$P_{out} = 0.675 + 0.792 = 1.467W$

Efficiency $\eta = \frac{P_{out}}{P_{in}} \times 100 = \frac{1.467}{4.5} \times 100 = 32.6\%$

2.9 Algorithm Flowchart of the Smart Nursing Call device with Physiological Monitoring System.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 8, Issue 10 October. 2026, pp:74-90www.ijaem.net ISSN: 2395-5252

The flowchart of the developed smart nursing call device with physiological monitoring system is presented in Figure 4

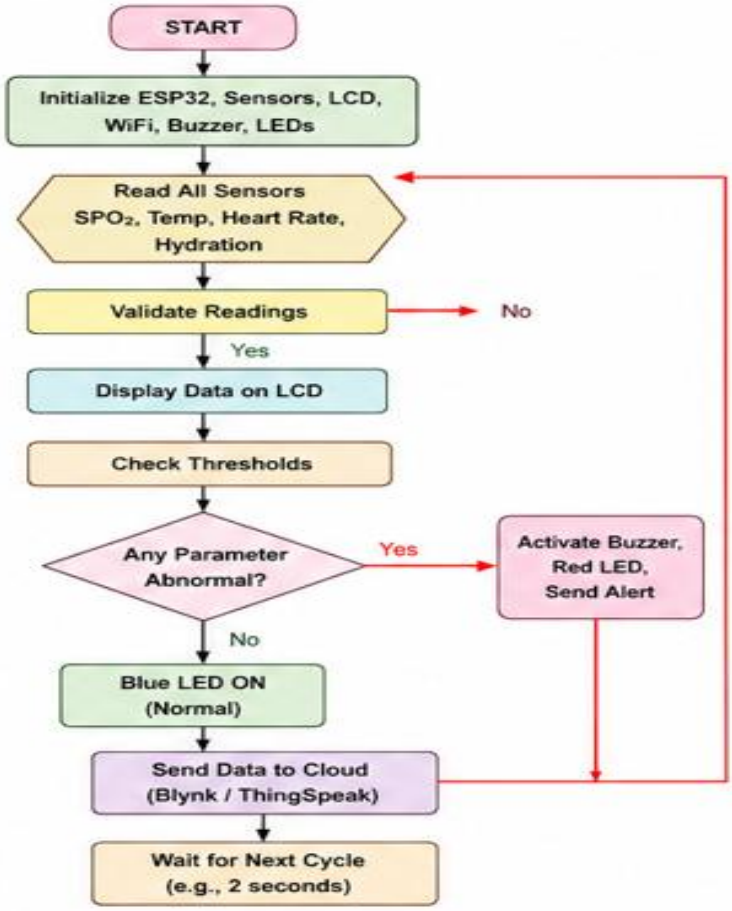

Fig 3 Algorithm flowchart of the developed nurse call system with physiological monitoring system.

Working Principle of the Proposed IoT-based Smart Nursing Call device with Physiological Monitoring System.

The IoT-based smart nursing call device with physiological monitoring system operated using the ESP32-WROOM-32 ESP32 microcontroller as the central processing unit. The ESP32 coordinated real-time acquisition, processing, display, and transmission of physiological data obtained from the integrated sensing units. These included the MAX30102 MAX30102 sensor for SpO_2 monitoring, the MAX30100 MAX30100 for heart-rate monitoring, the LM35 LM35 temperature sensor, and the FC-28 FC-28 hydration sensor. During operation, the ESP32 continuously acquired signals from the sensors at defined sampling intervals. These physiological values were processed internally and compared against pre-programmed threshold values representing safe clinical ranges. For instance, oxygen saturation values below 90% were interpreted as abnormal and indicative of possible hypoxemia. Heart-rate values below 50 beats per minute or above 120 beats per minute were identified as bradycardic or tachycardic conditions respectively, while elevated temperature readings above 38°C indicated possible fever. Hydration readings were similarly monitored against predefined reference values to detect dehydration-related conditions. Whenever any monitored parameter deviated from its safe threshold, the controller immediately initiated an alert sequence. This involved activation of the audible buzzer and visual LED indicators at the bedside to provide immediate local notification. Simultaneously, the physiological values and alert condition were displayed on the LCD interface for direct observation. In addition to automated physiological monitoring, the system incorporated a patient-operated nurse-call push-button. This enabled the patient to manually request assistance independent of sensor-triggered alerts. Once the push-button was

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pressed, the ESP32 registered the event and initiated an emergency nurse-call alert in the same manner as an abnormal physiological trigger.

Wireless communication and remote monitoring were achieved through the integrated Wi-Fi functionality of the ESP32. Processed sensor readings and alert signals were transmitted over the wireless network to cloud-based monitoring platforms such as Blynk Blynk and ThingSpeakThingSpeak. This enabled real-time monitoring of patient physiological status from mobile devices or web dashboards by nurses and caregivers. Notifications generated by the system could therefore be accessed both locally at the patient's bedside and remotely through the cloud interface. The continuous logging of sensor readings to the cloud created a record of patient physiological history over time. This provided the possibility for trend observation, remote supervision, and improved clinical response. By combining physiological sensing, manual patient-initiated alerting, local alarm output, and cloud-based remote monitoring into a single embedded platform, the developed system provided a reliable means of enhancing patient safety, improving response time, and supporting continuous bedside care.

III. Result

The system was designed to provide continuous monitoring of selected patient physiological parameters while simultaneously enabling manual nurse-call functionality. The developed device was simulated using Proteus software, after which its functional behavior was evaluated based on sensor response, alarm activation, wireless data transmission, and power performance as shown in Figure 4.

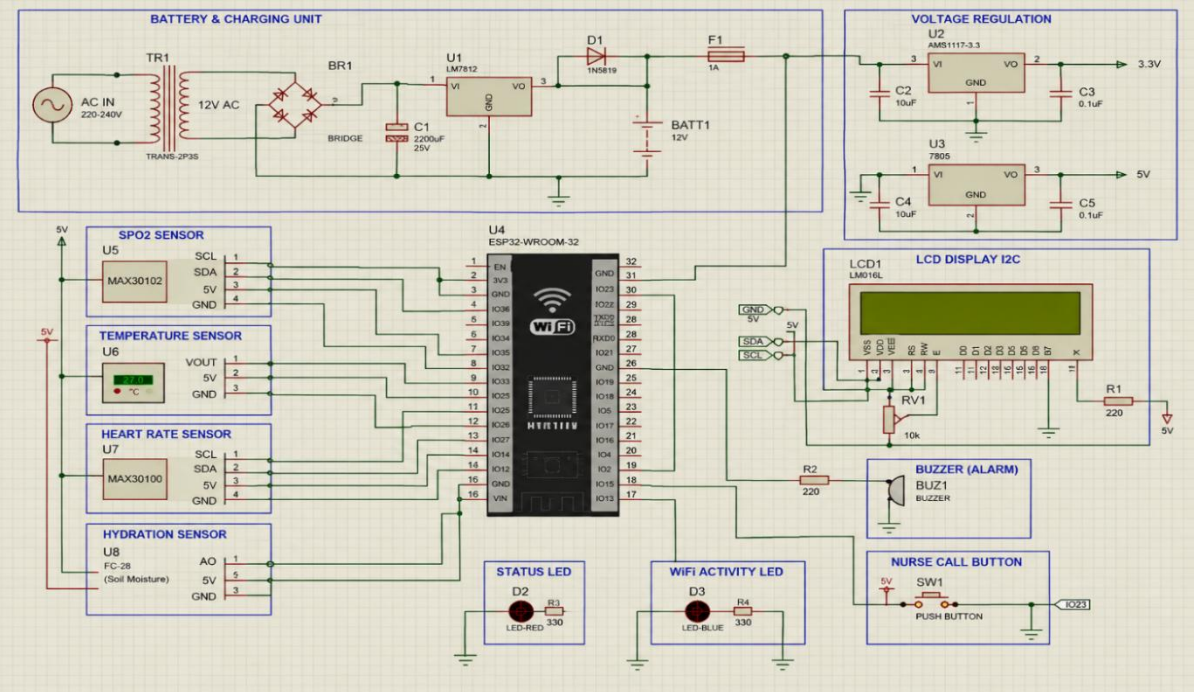

Figure 4: Proteus design and simulation of the developed nurse call system

The developed system successfully integrated four physiological monitoring sensors, SpO_2 sensor, heart-rate sensor, temperature sensor, and hydration sensor with the ESP32-WROOM-32 ESP32 microcontroller. The ESP32 served as the central processing unit responsible for sensor data acquisition, processing, threshold comparison, alarm control, LCD interfacing, and wireless transmission to the IoT monitoring platform. The coupling of the individual components is seen in Plate 1 and Plate 2.

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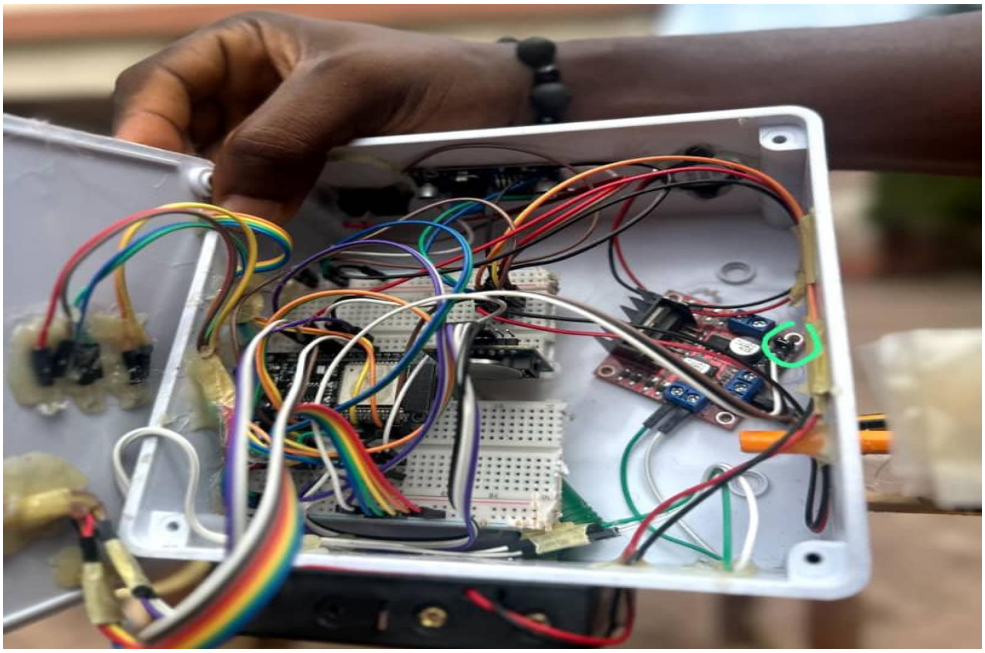

Plate 1: Assemble of component of the developed smart nurse call system

Plate2 : Image of the developed device showing physiological parameters

Simulation results showed that the system was able to continuously read sensor values, display the acquired data on google sheet, and transmit these values to the cloud dashboard in real time as seen is Figure 4.2 and 4.3. The LCD displayed the physiological readings in a clear and readable format, allowing immediate bedside observation.

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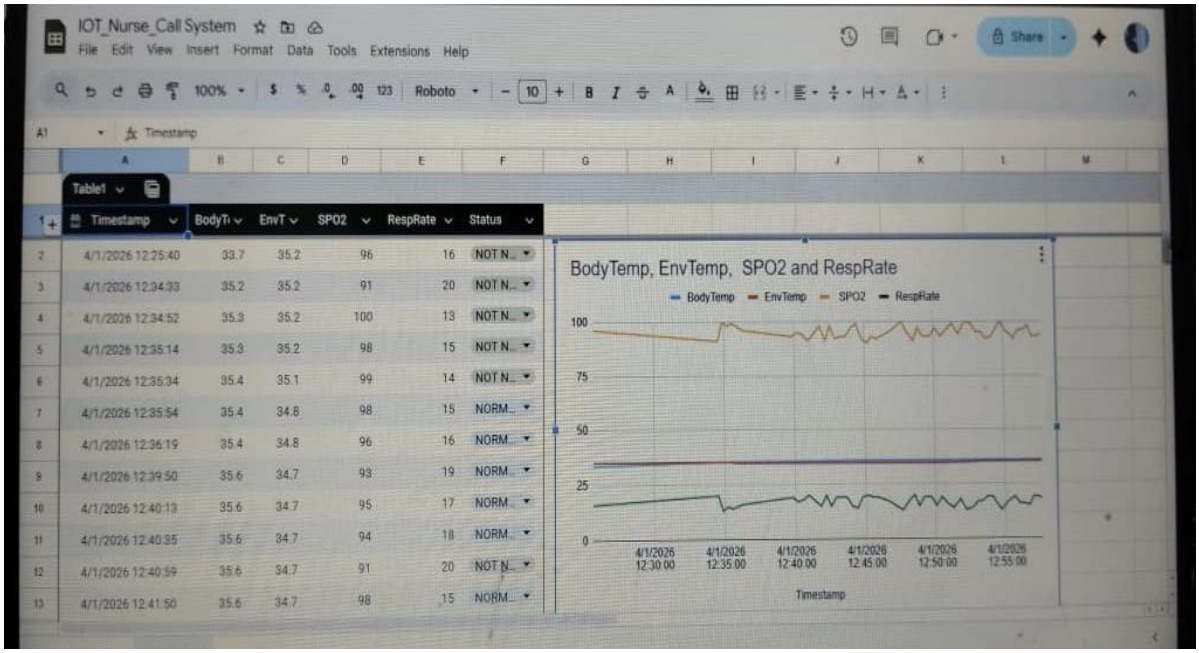

Figure 5: Real-Time Display of Physiological Parameters on the Google Sheet of the Developed System

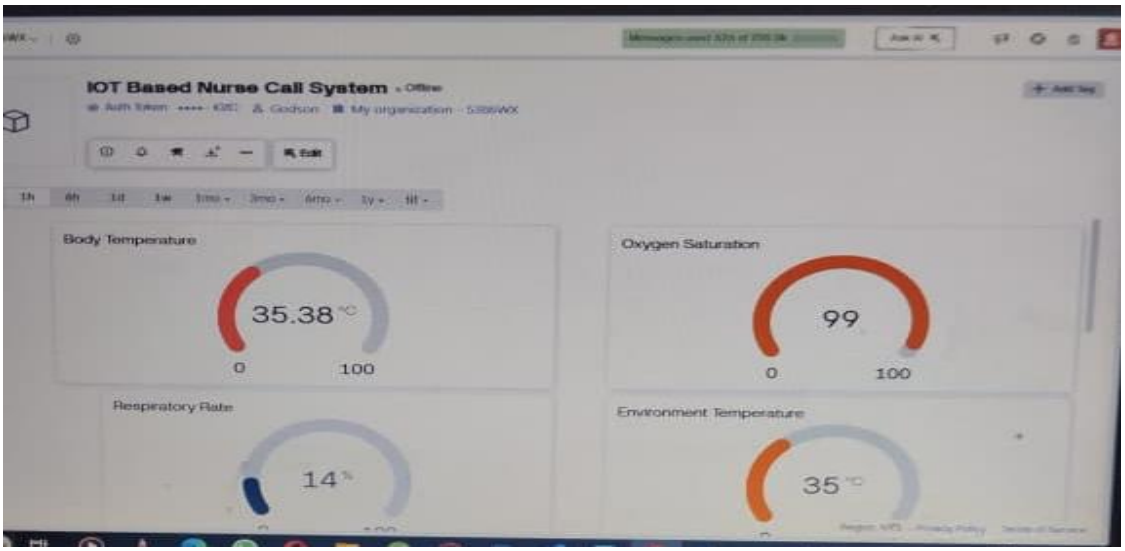

Figure 6: Real-Time Blynk Dashboard Monitoring of Physiological Parameters Transmitted from the Developed System

Under normal physiological conditions, the system maintained stable operation and displayed the measured parameters while indicating normal patient status through the visual status indicator. During simulated abnormal conditions such as reduced oxygen saturation, elevated body temperature, abnormal pulse rate, or reduced hydration level, the controller correctly identified the threshold violation and activated the alert system. The alarm response consisted of buzzer activation, visual LED indication, and wireless transmission of the alert signal to the IoT dashboard. This confirmed successful implementation of both local and remote alert notification mechanisms.

3.1 Sensor Performance Evaluation

To validate the performance of the developed IoT-based smart nursing call device with physiological monitoring system, readings obtained from the developed device were compared against measurements obtained from conventional commercially available clinical monitoring instruments as presented in Table 2, 3 and 4. For oxygen saturation and heart rate validation, the

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Volume 8, Issue 10 October. 2026, pp:74-90www.ijaem.net ISSN: 2395-5252

Contec CMS50D Contec CMS50D Fingertip Pulse Oximeter manufactured by Contec Medical Systems was used as the standard comparison instrument. The device has an SpO_2 measurement range of 70–100%, a pulse rate measurement range of 30–250 bpm, and a stated accuracy of ±2% for SpO_2 measurements and ±2 bpm for pulse rate measurement. The instrument was selected because it provides non-invasive simultaneous monitoring of both blood oxygen saturation and pulse rate and is widely used in clinical and home-care environments. For temperature validation, the Omron MC-246 Omron Digital Thermometer (Model MC-246), manufactured by Omron Healthcare, was used as the conventional temperature measurement device. The thermometer has a measurement range of 32.0–42.0 °C with a stated accuracy of ±0.1 °C. Its clinical reliability and high sensitivity made it suitable for comparison with the developed temperature sensing subsystem.

Table 2: Comparison of SpO_2 Readings Obtained from the Developed Device and the Contec CMS50D Contec CMS50D Fingertip Pulse Oximeter

Trial	Developed Device (%)	Conventional Device (%)
1	96	98
2	95	98
3	99	99
4	96	97
5	99	97
6	97	97
7	98	99
8	98	96
9	97	98
10	93	98

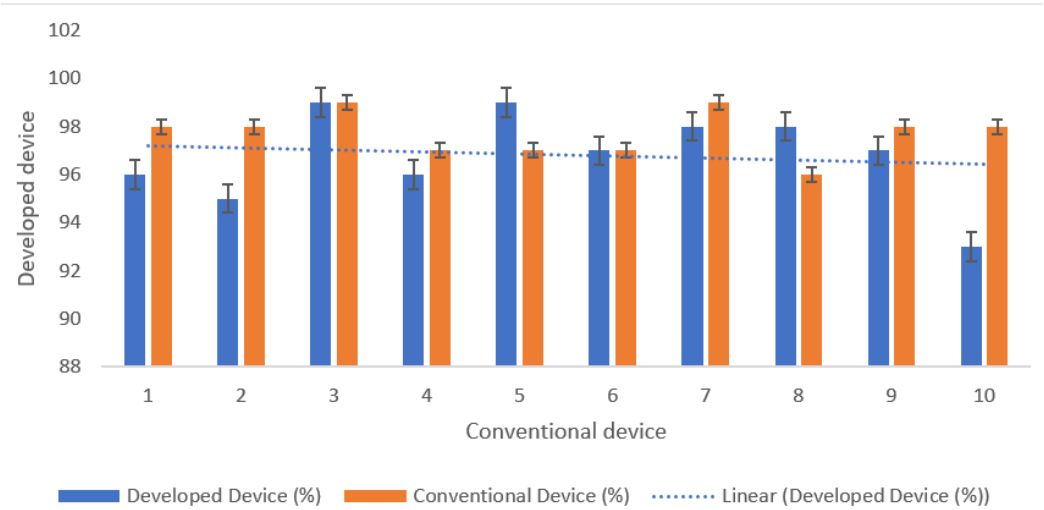

Table 2 Comparison of Heart Rate Readings Obtained from the Developed Device and the Contec CMS50D Contec CMS50D Fingertip Pulse Oximeter

Trial	Developed Device (bpm)	Conventional Device (bpm)
1	76	75
2	78	77

International Journal of Advances in Engineering and Management (IJAEM)
Volume 8, Issue 10 October. 2026, pp:74-90www.ijaem.net ISSN: 2395-5252

3	80	79
4	74	74
5	77	76
6	75	75
7	79	78
8	81	80
9	76	76
10	78	77

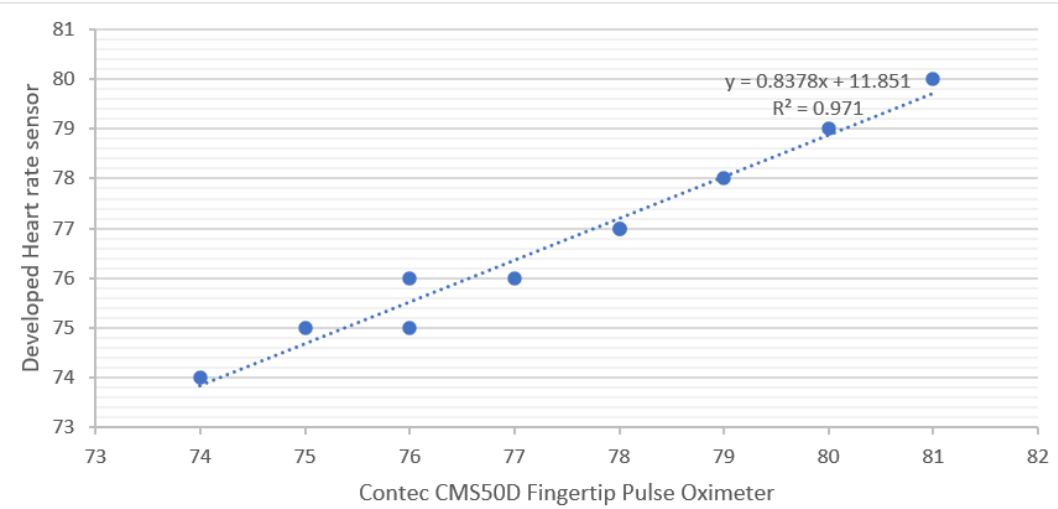

Table 3 Comparison of Body Temperature Readings Obtained from the Developed Device and the Omron MC-246 Omron Digital Thermometer (Model MC-246)

Trial	Developed Device (°C)	Conventional Device (°C)
1	36.7	36.6
2	36.8	36.8
3	36.9	36.8
4	37.0	36.9
5	36.6	36.6
6	36.8	36.7
7	36.7	36.8
8	36.9	36.9
9	36.8	36.7
10	36.7	36.6

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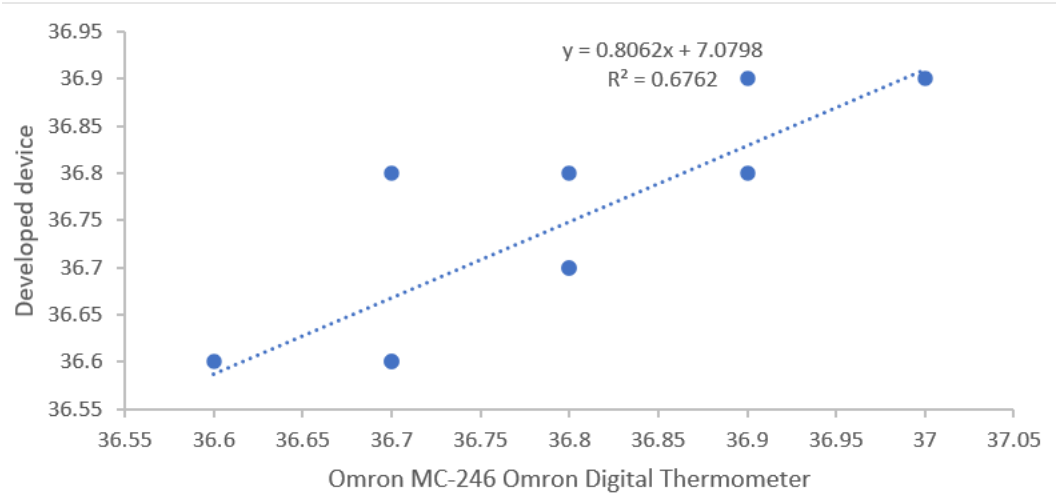

Bill of Engineering Management Evaluation (BEME) of the developed Smart Nursing Call Device with Physiological Monitoring System.
The bill of engineering management and evaluation (BEME) is presented in Table 4.4

Table 4 Bill of Engineering Management Evaluation (BEME) of the developed Smart Nursing Call Device with Physiological Monitoring System

S/N	Material	Specification	Quantity	Amount (Naira)
	Project Enclosure			20,000
	Push button		2	1,000
	Battery	NP12V7.2A (12V7.2AH/20HR)	1	25,000
	Heartbeat sensor	MAX30100/30102	2	12,000
	SPO_2 Sensor	MAX86916	1	9,000
	Liquid Crystal Alphanumeric Display Module	20*4 LCD	1	7,500
	Arduino board	Arduino Uno	1	9000
	GSM module	SIM800L	1	9000
	Relay	12V/10A sensitive relay (1 module)	2	1,000
	Resistors	20Ω, 10Ω	3	2,500
	Capacitor	1000µF/50v, 22pf	1	2,000
	Regulators	7805, 1A, 5VDC	1	8,000
	Keypad Module	4*3	1	2,000
	Transformer	220V/12V, 1000Ma	1	8,000
	Body temperature sensor	DS18B20	1	1,500
	Transistors X4	BC547 NPN		4,000
	Jumper wires	Male to male; Female to male	1	1,000

International Journal of Advances in Engineering and Management (IJAEM)
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Diode	1N4007	7,500
Cloud sync with Bluetooth module		20,000
TOTAL		150,000

IV. Discussion

The results obtained from the design and simulation of the IoT-based smart nursing call device with physiological monitoring system demonstrated successful achievement of the project objectives. The integration of physiological monitoring with nurse-call functionality provided a more responsive and intelligent patient support system compared with conventional nurse-call systems that depend solely on manual patient intervention. The use of the ESP32 significantly improved system functionality by combining processing capability and wireless communication within a single platform. This simplified circuit design, reduced hardware complexity, and enabled real-time transmission of patient data to cloud monitoring platforms (Han et al., 2023; Sardana et al., 2019). The Proteus simulation confirmed the operational feasibility of the electronic design prior to physical implementation. Functional verification of sensor acquisition, alarm activation, LCD output, and IoT communication demonstrated that the system architecture was reliable and practical.

The successful operation of both automatic alert generation and manual nurse-call triggering suggests that the developed system can reduce response time in patient emergencies while supporting continuous remote observation by nursing staff. The results obtained from the simulation and performance evaluation of the developed IoT-based smart nursing call device with physiological monitoring system demonstrated satisfactory performance across sensing, alert generation, data transmission, and power management. The successful integration of the physiological sensors with the ESP32-WROOM-32 ESP32 microcontroller enabled continuous acquisition and processing of patient physiological data, while also providing manual nurse-call functionality. The system maintained stable operation throughout simulation in Proteus Proteus, with successful visualization of sensor outputs on the LCD interface and simultaneous wireless transmission of data to the cloud dashboard.

The SpO_2 monitoring subsystem showed strong agreement with the Contec CMS50D Contec CMS50D fingertip pulse oximeter. Across the ten measurement trials, the developed device recorded SpO_2 values ranging from 93–99%, while the conventional device recorded values between 96–99%. Although slight deviations were observed in some trials, particularly in Trial 10, the values remained within acceptable measurement tolerance for low-cost optical monitoring systems. These findings are comparable with the study by Contardi et al. (2021), who reported reliable SpO_2 monitoring using a MAX30102 sensor integrated with an ESP32 webserver, with readings comparable to standard pulse oximetry devices. The authors concluded that the MAX30102 sensor is suitable for continuous low-cost patient monitoring applications.

The heart-rate monitoring subsystem also demonstrated strong correlation with the Contec CMS50D pulse oximeter. The developed system recorded values between 74 and 81 bpm, while the conventional device recorded values between 74 and 80 bpm. The observed variation between the two systems was minimal, with differences of approximately ±1 bpm in most trials. This indicates that the developed system was able to reliably detect pulse rate under test conditions. Similar findings were reported by Muthmainnah et al. (2022), who characterized the MAX30102 sensor as a heart-rate monitoring device and reported an average measurement accuracy of approximately 97% when compared with pulse oximeter readings.

The temperature sensing subsystem using the LM35 LM35 sensor also showed close agreement with the Omron MC-246 Omron MC-246 digital thermometer. Across the ten trials, the maximum observed deviation was ±0.1 °C, which falls within the expected measurement tolerance of the reference thermometer. This indicates acceptable accuracy for routine physiological temperature monitoring. Comparable observations were reported in the work of Pravin Savaridass et al. (2021), who developed an IoT-based smart health monitoring system using an LM35 temperature sensor and similarly reported stable and accurate temperature measurement suitable for patient monitoring applications. Beyond sensor performance, the developed device demonstrated effective alarm functionality. During simulated abnormal conditions including low oxygen saturation, abnormal pulse

rate, elevated temperature, and low hydration level, the controller correctly identified threshold violations and initiated buzzer alerts, LED indication, and cloud-based notifications. This confirms successful implementation of both local and remote emergency notification pathways. Similar outcomes were reported byFaizah et al. (2025), who developed an IoT-based portable diagnostic monitoring system using ESP32 and MAX30102 and reported average error rates between 1–3.4% while achieving successful real-time transmission of SpO_2 , BPM, and body temperature to a cloud database for remote access. The integration of manual nurse-call functionality alongside physiological monitoring represents a notable contribution of the present work (Aly El-Shinnawi et al., 2018; Aswin et al., 2011; Sharma & Gautam, 2015). While many IoT health monitoring studies focus primarily on sensor acquisition and remote transmission, the addition of a patient-operated nurse-call alert button improves usability within hospital ward settings by enabling both proactive physiological monitoring and reactive patient-initiated assistance requests. This dual functionality enhances patient safety and may improve response time during emergencies.

V. Conclusion

This study successfully designed and developed an IoT-based smart nursing call device with physiological monitoring system for continuous patient monitoring and emergency nurse notification. The system integrated four physiological sensing units for monitoring blood oxygen saturation (SpO_2), heart rate, body temperature, and hydration level, alongside a manual nurse-call push-button interface. These components were interfaced with the ESP32-WROOM-32 ESP32 microcontroller, which served as the central processing and communication unit of the system.Simulation of the system using Proteus confirmed the successful operation of the circuit design. The developed system was able to continuously acquire physiological data, process sensor readings, compare values against predefined thresholds, and trigger alerts whenever abnormal physiological conditions were detected. The system also successfully displayed real-time patient parameters on the LCD interface and transmitted data wirelessly to cloud-based IoT monitoring platforms for remote access by healthcare personnel.Performance validation carried out through comparison with conventional clinical monitoring instruments showed close agreement between readings obtained from the developed system and standard measurement devices. The developed device demonstrated satisfactory accuracy in SpO_2 , heart rate, and temperature monitoring, with only minimal variation observed across repeated measurement trials. This confirms the reliability of the selected sensors and the effectiveness of the embedded control architecture.The integration of both automated physiological monitoring and patient-initiated nurse-call functionality represents an improvement over conventional nurse-call systems, which depend solely on manual activation. By combining continuous vital-sign monitoring with automated alert generation and wireless notification capability, the developed system enhances patient safety, improves caregiver response time, and supports remote supervision within hospital environments.Based on the findings of this study, the following recommendations are proposed:

The developed system should be subjected to full-scale clinical testing in real healthcare environments involving multiple patients in order to further evaluate performance, durability, and reliability under practical operating conditions.

Future development may incorporate additional physiological monitoring parameters such as blood pressure, respiratory rate, and electrocardiogram (ECG) monitoring to improve the diagnostic capability of the system.

A rechargeable battery management system with intelligent charging control and battery health monitoring may be integrated in future versions to improve energy efficiency and battery lifespan.

The hydration sensing subsystem may be further refined using clinically validated hydration assessment sensors specifically designed for biomedical applications to improve accuracy.

Integration with hospital electronic medical record systems may also be considered to enable automatic storage of patient physiological history and seamless access by clinicians.

Future versions of the system may include GSM-based communication support as a backup alert channel in areas with limited Wi-Fi availability to improve communication reliability.

Miniaturization of the device through printed circuit board optimization and compact enclosure design is recommended to improve portability, patient comfort, and ease of deployment at the bedside.

Finally, the developed system may be adapted for home healthcare monitoring, elderly care, and telemedicine applications, particularly in resource-limited settings where continuous bedside monitoring systems are not readily available.

Reference

[1]. Aiken, L. H., Sloane, D. M., Bruyneel, L., Van den Heede, K., Griffiths, P., Busse, R., Diomidous, M., Kinnunen, J., Kózka, M., Lesaffre, E., McHugh, M. D., Moreno-Casbas, M. T., Rafferty, A. M., Schwendimann, R., Scott, P. A., Tishelman, C., van Achterberg, T., &Sermeus, W. (2014). Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. *The Lancet*, *383*(9931), 1824–1830. https://doi.org/10.1016/S0140-6736(13)62631-8

[2]. Aly El-Shinnawi, A., Sharawi, A., Aref, M. H., &Sharawi, A. A. (2018). Wireless Nurse Call System in Medical Institutions. *Article in American Journal of Biomedical Research*, *6*(2), 40–45. https://doi.org/10.12691/ajbr-6-2-2

[3]. Aswin, S., Gopalakrishnan, N., Jeyender, S., Gnana Prasanna, R., & Pravin Kumar, S. (2011). *DESIGN DEVELOPMENT AND IMPLEMENTATION OF WIRELESS NURSE CALL STATION*.

[4]. Burnes, B. L., Aydin, C. E., Donaldson, N., Brown, D. S., Sandhu, M., Fridman, M., & Aronow, H. U. (2007). Mandated nurse staffing ratios in California: a comparison of staffing and nursing-sensitive outcomes pre- and postregulation. *Policy, Politics & Nursing Practice*, *8*(4), 238–250. https://doi.org/10.1177/1527154407312737

[5]. Calvo Salcedo, A. F., Henao Baena, C. A., & Castillo González, A. (2019). Design of a nursing call system: an alternative. *Visión Electrónica*, *13*(1), 75–83. https://doi.org/10.14483/22484728.14403

[6]. Cardona-Morrell, M., Prgomet, M., Turner, R. M., Nicholson, M., & Hillman, K. (2016). Effectiveness of continuous or intermittent vital signs monitoring in preventing adverse events on general wards: a systematic review and meta-analysis. *International Journal of Clinical Practice*, *70*(10), 806–824. https://doi.org/10.1111/ijcp.12846

[7]. Chaman, S., & Deepak, K. G. (2015). *2015 International Conference on Green Computing and Internet of Things*. IEEE Computer Society.

[8]. Contardi, U. A., Morikawa, M., Brunelli, B., & Thomaz, D. V. (2021). MAX30102 Photometric Biosensor Coupled to ESP32-Webserver Capabilities for Continuous Point of Care Oxygen Saturation and Heartrate Monitoring. *The 2nd International Electronic Conference on Biosensors*, 9. https://doi.org/10.3390/IECB2022-11114

[9]. Dall'Ora, C., Saville, C., Rubbo, B., Turner, L., Jones, J., & Griffiths, P. (2022). Nurse staffing levels and patient outcomes: A systematic review of longitudinal studies. In *International Journal of Nursing Studies* (Vol. 134). Elsevier Ltd. https://doi.org/10.1016/j.ijnurstu.2022.104311

[10]. Faizah, Sofie, M., &Widiyana, I. (2025). RANCANG BANGUN DIAGNOSTIC POCKET UNTUK PEMANTAUAN NON-INVASIF SPO2, BPM DAN SUHU TUBUH BERBASIS IOT DENGAN SENSOR OPTIK DAN INFRAMERAH SECARA REAL-TIME. *Orbith: MajalahIlmiah Pengembangan Rekayasa Dan Sosial*, *21*(2), 106–112. https://doi.org/10.32497/orbith.v21i2.6657

[11]. Han, X., Huang, M., Wu, Z., Gao, Y., Xia, Y., Yang, P., Fan, S., Lu, X., Yang, X., Liang, L., Su, W., Wang, L., Cui, Z., Zhao, Y., Li, Z., Zhao, L., & Jiang, Z. (2023). Advances in high-performance MEMS pressure sensors: design, fabrication, and packaging. *Microsystems & Nanoengineering*, *9*(1), 156. https://doi.org/10.1038/s41378-023-00620-1

[12]. Li, L. Z., Yang, P., Singer, S. J., Pfeffer, J., Mathur, M. B., & Shanafelt, T. (2024). Nurse Burnout and Patient Safety, Satisfaction, and Quality of Care. *JAMA Network Open*, *7*(11), e2443059. https://doi.org/10.1001/jamanetworkopen.2024.43059

[13]. Montgomery, A. P., Azuero, A., Baernholdt, M., Loan, L. A., Miltner, R. S., Qu, H., Raju, D., & Patrician, P. A. (2021a). Nurse Burnout Predicts Self-Reported Medication Administration Errors in Acute Care Hospitals. *Journal for Healthcare Quality*, *43*(1), 13–23. https://doi.org/10.1097/JHQ.0000000000000274

[14]. Montgomery, A. P., Azuero, A., Baernholdt, M., Loan, L. A., Miltner, R. S., Qu, H., Raju, D., & Patrician, P. A. (2021b). Nurse Burnout Predicts Self-Reported Medication Administration Errors in Acute Care Hospitals. *Journal for Healthcare Quality*, *43*(1), 13–23. https://doi.org/10.1097/JHQ.0000000000000274

[15]. Muthmainnah, M., Deni Bako Tabriawan, & Imam Tazi. (2022). Karakterisasi Sensor MAX30102 Sebagai Alat UkurDetakJantung dan SuhuTubuhBerbasisPhotoplethysmograph. *JURNAL PENDIDIKAN MIPA*, *12*(3), 726–731. https://doi.org/10.37630/jpm.v12i3.655

[16]. Pravin Savaridass, M., Ikram, N., Deepika, R., & Aarnika, R. (2021). Development of smart health monitoring system using Internet of Things. *Materials Today: Proceedings*, *45*, 986–989. https://doi.org/10.1016/j.matpr.2020.03.046

[17]. Sardana, P., Kalra, M., & Sardana, A. (2019). Design, fabrication, and testing of an internet connected intravenous drip monitoring device. *Journal of Sensor and Actuator Networks*, *8*(1). https://doi.org/10.3390/jsan8010002

[18]. Shah, P., Pathak, A., Pathak, Y., Patil, A., Patil, K., &Talele, A. (2023). *Vishwakarma Institute of Technology, India 3 2nd year B.tech, Artificial Intelligence and Data Science, Vishwakarma Institute of Technology, India 4 2nd year B.tech, Artificial Intelligence and Data Science, Vishwakarma Institute of Technology, India 5 2nd year B.tech, Artificial Intelligence and Data Science, Vishwakarma Institute of Technology*. www.ijiird.com

[19]. Shammari, M. S., Dosari, A. M., Anizi, T. S. S., Ruwill, O. J., Qadri, A. T., Mutairi, H. Z., & Sara, M. S. (2022). The Life-Saving Importance of Accurate vital Signs in Healthcare: A Systematic Review. *International Journal of Development Research*, 59937–59940. https://doi.org/10.37118/ijdr.28700.10.2022

[20]. Sharma, C., & Gautam, D. K. (2015). Design development and implementation of wired Nurse calling system. *2015 International Conference on Green Computing and Internet of Things (ICGCIoT)*, 1258–1262. https://doi.org/10.1109/ICGCIoT.2015.7380657

[21]. Shekelle, P. G. (2013). *Nurse-Patient Ratios as a Patient Safety Strategy A Systematic Review*. www.annals.org

[22]. Tzeng, H. M., & Yin, C. Y. (2009). Relationship between call light use and response time and inpatient falls in acute care settings. *Journal of Clinical Nursing*, *18*(23), 3333–3341. https://doi.org/10.1111/j.1365-2702.2009.02916.x

[23]. Unluturk, M. S. (2012). Advanced Nurse-Patient Communication System. *Journal of Medical Systems*, *36*(4), 2529–2536. https://doi.org/10.1007/s10916-011-9725-y

[24]. Wan, J., & Wang, Y. (2018). *Design and Implementation of Medical Wireless Nursing Call System*.

[25]. Watkins, T., Whisman, L., & Booker, P. (2016). Nursing assessment of continuous vital sign surveillance to improve patient safety on the medical/surgical unit. *Journal of Clinical Nursing*, *25*(1–2), 278–281. https://doi.org/10.1111/jocn.13102

[26]. Wen, M.-H., Bai, D., Lin, S., Chu, C.-J., & Hsu, Y.-L. (2022). Implementation and experience of an innovative smart patient care system: a cross-sectional study. *BMC Health Services Research*, *22*(1), 126. https://doi.org/10.1186/s12913-022-07511-7