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Non-Invasive Vital Sign Monitoring Using Arduino-Based System

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In the current era, access to vital signs monitoring systems is limited in some areas, such as remote areas. This project is an early prototype aimed at validating a non-invasive monitoring system using an Arduino-based platform with an ESP32 Hibiscus. This early stage focuses on real-time body temperature, heart rate, oxygen saturation and blood pressure estimation. The data were obtained from female subjects aged 22 to 28 years over a period of 10 to 15 minutes and validated against standard clinical equipment. The results indicate an accuracy range of 78% to 95% for heart rate, 96%-100% for SpO2, 98% to 100% for body temperature and 79% to 99% for blood pressure estimate. The project presents a low cost and accessible solution for maternal health monitoring. It differs from existing Arduino-based systems by using a MAP-based blood pressure estimation and the particular subject validation. The findings indicate the practicality of the proposed system as a preliminary tool for remote monitoring with the possibility of future integration with IoT and clinical validation.

Keywords: vital signs; esp32 hibiscus; Arduino; temperature; heart rate; blood pressure

I. INTRODUCTION

Nowadays, vital sign monitoring is a usual procedure in general medical wards and is often performed as a "spot check" every 4 to 8 hours (Rowland *et al.*, 2025). Vital signs including body temperature, heart rate and blood pressure are also important indicators of a person's health. These parameters are useful in detecting early health issues such as fever, heart problems, and irregular blood pressure. Nevertheless, this technology is not accessible to all individuals, particularly those who reside in remote areas or wish to monitor their health status from home. Intermittent monitoring can also increase the chance of delayed medical care and potentially increase mortality (Aalberg *et al.*, 2024; Nursyifa Azizah *et al.*, 2023). For example, studies have shown a strong correlation between serious cases requiring hospital admission and decreased oxygen saturation (SpO_2) levels in COVID-19 patients (Greenhalgh *et al.* 2021).

Traditionally, healthcare professionals use specialised equipment to measure vital signs in person (Belmin Alić *et al.*, 2023; Li *et al.*, 2023). By reducing physical contact and the risk of disease transmission, these technologies address the urgent need for infection control, which is particularly critical in high-risk settings such as hospitals (Al-Nabulsi & Haddad, 2024). Women are considered a high-risk group, particularly those with advanced maternal age, obesity, hypertension, and diabetes. Besides, pregnant women are also a vulnerable group in the event of an outbreak of any infectious disease (Kahankova *et al.*, 2023). Vital sign monitoring systems can support early disease detection and continuous health monitoring (Shen & Zhou, 2021), as well as signs of abnormalities and possible complications, thus

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ensuring that the health of pregnant women and their unborn children is prioritised (Stricker *et al.*, 2025).

Most previous studies focused mainly on limited parameters such as heart rate (BPM), oxygen saturation (SpO_2) and other monitoring using standalone systems. However, fewer studies integrated multiple vital sign parameters, indirect blood pressure estimation and IoT-based remote monitoring into a single monitoring system. Therefore, a non-invasive maternal vital sign monitoring system based on an Arduino–ESP32 Hibiscus platform is proposed. The system uses the AHT10 sensor to monitor body temperature and the MAX30100 sensor to measure heart rate (BPM), oxygen saturation (SpO_2) and estimated blood pressure in real time. The results are shown on a local display and made available online. Additionally, the system aims to support continuous maternal health monitoring through a low-cost and portable platform.

II. LITERATURE REVIEW

In a related study, (Ganesh & Ruhan Bevi, 2021) developed a portable monitoring system that monitored two parameters with stable performance. The main sensor used was the MAX30100 due to its high accuracy in measuring vital signs, the data were displayed on an OLED. Therefore, this article primarily focused on measuring oxygen saturation (SpO_2) and heart rate (BPM), limiting its ability to monitor vital signs. The IoT–based Patient Monitoring System for COVID-19 was developed (Ummi Najwa Izzati Kamaludin & Nur Ilyani Ramli, 2022), which uses cloud and IoT technology for continuous monitoring and real-time transmission of crucial information. During the epidemic, the system focused on remote health care assistance that allowed medical workers to view patient data online. The research emphasised the benefits of IoT integration for remote patient monitoring.

Similarly, (Nur Adlina Jumain & Suriani, 2021) developed a respiratory monitoring system that addressed abnormal respiratory rate and body pressure index. This integrated system monitored both respiratory rate and pressure index in real time. These three parameters were measured using multiple sensors, including a DS18B20 temperature sensor, a Galvanic Skin Response sensor and a pulse sensor, to measure physiological parameters simultaneously, and the data were displayed on the LCD screen according to the individual's condition. The respiratory monitoring system in this article was proposed to measure both respiratory rate and body pressure index. However, the system experienced environmental sensitivity that affected measurement accuracy. Another study proposed an ESP32 and LoRa-based monitoring system using ESP32 to transmit data and LoRa technology that functioned as wireless communication. The MLX90614 sensor was used for body temperature measurement, and the MAX30100 sensor was used for SpO_2 and heart rate monitoring. The measured parameters were displayed on OLED and LCD interfaces. An alert mechanism was implemented to activate a buzzer and flash an LED in response to abnormal readings in vital parameters. However, this article focused on system accuracy and performance, such as Average Mean Error (MAE) and Root Mean Square Error (RMSE) but did not discuss practical problems and challenges that existed during design or reported testing (Hayder Fadhil Jawad, Ali Al-Askery & Adnan Hussein Ali, 2022).

Research by (Hartono *et al.*, 2022) emphasized in that heart rate and body temperature were critical components of vital signs that required regular monitoring, especially during the COVID-19 pandemic. This proposed system used a pulse sensor and an AD8232 sensor to obtain heart rate readings and an MLX90614 sensor to measure body temperature. The main microcontroller was a NodeMCU ESP8266, which processed the signals and the results on an LCD screen. The study developed a low-cost integrated monitoring system for body temperature and heart rate measurement, and the system was achieved 99.24% accuracy for temperature and 98.86% accuracy for pulse sensors, with stable performance in subject tests. A notable limitation was that it incorporated several sensors on the NodeMCU ESP8266, which posed technical issues such as signal interference and hardware damage, affecting performance and reducing system reliability. Apart from that, (Ihsan, 2023) developed a monitoring device using the MLX90614 for temperature measurement, while the MAX30100 sensor measured heart rate and SpO_2 levels. The system integrated an Arduino Nano and an ESP8266 NodeMCU for data processing and connectivity. One important drawback identified was the differences in accuracy between readings obtained from health monitoring devices. Although the readings were satisfactory in terms of accuracy, this gap suggested that additional calibration steps should be performed to achieve full compatibility with clinical medical equipment.

In previous articles, (Mukhtiar *et al.*, 2023) developed a control system, focusing on automated anaesthesia using an Arduino UNO microcontroller. In the study, the researchers used two sensors, which were MAX30100 for heart rate and oxygen saturation measurement, and LM35 sensors for body temperature. As a result, the data accuracy was 95-98%. However, the study lacked discussion on emergency response time and system reliability in critical conditions. Several research articles, (Protik Parvez Sheikh *et al.*, 2024) developed an Arduino-based personal health monitoring system. The system included a DHT11 sensor for temperature, a MAX30100 for heart rate and SpO2, and an Arduino Nano as a processing unit, while the readings were displayed on an LCD screen. However, limited technological capability reduced system scalability and effectiveness.

Another article for a smart heart rate and pulse monitoring system using Arduino technology to analyse human vital signs by (Buragohain *et al.*, 2024), focused on three parameters, namely heart rate, pulse and oxygen saturation levels. This system used an AD8232 ECG sensor with Arduino Mega to record heart rate and ECG signals, while a MAX30102 sensor with Arduino UNO functioned as a measure of oxygen levels, and the results were displayed on an OLED. The system demonstrated consistent SpO2 readings during testing. However, the study focused only on heart rate and oxygen saturation monitoring without integrating blood pressure and temperature measurements. Next, articles by (Shah *et al.*, 2025) also introduced the Critical Ambulatory Transport Vehicle (CATV). In this article, the system used an AD8232 ECG sensor for electrocardiogram monitoring, a MAX30100 Pulse Oximeter sensor for SpO2 and pulse rate, an HX710B pressure sensor for Non-Invasive Blood Pressure (NIBP) measurement, and a mini temperature sensor to monitor key health parameters. One limitation was that the discussion emphasised only the design and benefits of smart stretcher systems without mentioning certain limitations, such as inaccuracies under certain conditions, challenges in long-term use.

In the latest development, researchers (Mohammad *et al.*, 2025) introduced non-invasive blood glucose monitoring based on wearable optical technology. This system used Arduino Nano as its central control unit, a laser emitter module to emit red laser, and a Light Dependent Resistor (LDR) to detect the intensity of the laser light after it passed through the skin, while the results were displayed on an OLED screen. The system was tested using wearable optical technology for non-invasive glucose monitoring. A major limitation of the study was maintaining measurement accuracy under different physiological conditions. Although the system showed a better error rate than traditional systems, it was still not completely successful.

Most previous studies focused on embedded and IoT-based health monitoring systems for physiological parameter monitoring. However, many studies only focused on limited vital sign parameters and lacked integration between multiple physiological measurements and IoT-based remote monitoring. In addition, limited discussion on sensor limitations, environmental effects, calibration and system reliability was reported in several previous studies.

III. METHODOLOGY

This system is developed for non-invasive vital signs monitoring on an Arduino-based platform, specifically for maternal use. In the initial stage, validation was done on non-pregnant volunteers to improve the system before establishing an IoT application for the next stage, with a focus on maternal. The selection of sensors is very important for the measurement of the four parameters that are focused on as the main objective. In terms of design, emphasis is placed on low-cost real-time monitoring, offering a basic yet effective solution for personal health tracking.

A. System Architecture and Design

In this system, the ESP32 Hibiscus processed data from two sensors to measure four vital sign parameters, which were displayed on the OLED. This early-stage design facilitated future improvements without the need for expensive hardware, thereby reducing the costs. The MAX30100 sensor was selected because it could measure heart rate (BPM), oxygen saturation (SpO2) and blood pressure estimation, such as systolic and diastolic. The sensor supported non-invasive and low-cost monitoring applications suitable for continuous health monitoring systems. Another sensor used to measure temperature was the AHT10. The AHT10 sensor was selected because of its compact size, digital output and suitability for real-time body temperature monitoring. For preliminary validation purposes, the obtained readings were compared with standard clinical monitoring devices. The complete system architecture of the proposed monitoring system is illustrated in Figure 1.

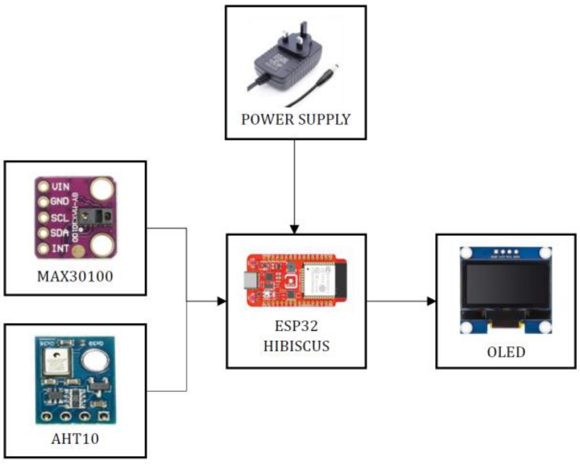


Figure 1. System block diagram of the ESP32-based vital sign monitoring setup

B. Software (Arduino)

In this monitoring system, Arduino (IDE) was used to receive vital signs readings from the main microcontroller, ESP32 Hibiscus. The forehead sensor was used to take body temperature, while the fingertip sensor collected data on heart rate, oxygen saturation and estimated blood pressure which produces systolic and diastolic readings. The sensor readings were taken by placing the subject in the correct position for approximately 10 minutes, depending on the subject's situation. Therefore, the ESP32 Hibiscus microcontroller collected real-time data from all the connected sensors and sent it to the Serial Monitor.

In this project, the stability of the measured parameters was monitored during the data collection phase. If the unstable results were detected, the subject needed to repeat the measurement at least 3 times for improved consistency. Photoplethysmography (PPG) signals from the MAX30100 sensor were used to infer blood pressure readings instead of measuring directly and the estimation was obtained from MAP calculation techniques, which estimated systolic and diastolic values using pulse waveform parameters. This technique assumed stable physiological conditions and consistent sensor deployment. Other factors such as subject movement, finger position and interference from surrounding light could also affect the estimation, so the readings obtained were considered preliminary estimates rather than precise clinical measurements.

The study focused on maternal health, female participants within the age range of 22 to 28 years were recruited. At this phase, non-pregnant people were used to validate the system under controlled conditions before testing on pregnant subjects. All subjects provided informed consent before data collection was carried out. The readings were displayed on the OLED screen if the data was stable. To encourage real-time monitoring without the use of invasive tools, the system was intended to be cost-effective, user-friendly and simple. This system was designed for home-based remote environments. The complete system operation is illustrated in Figure 2.

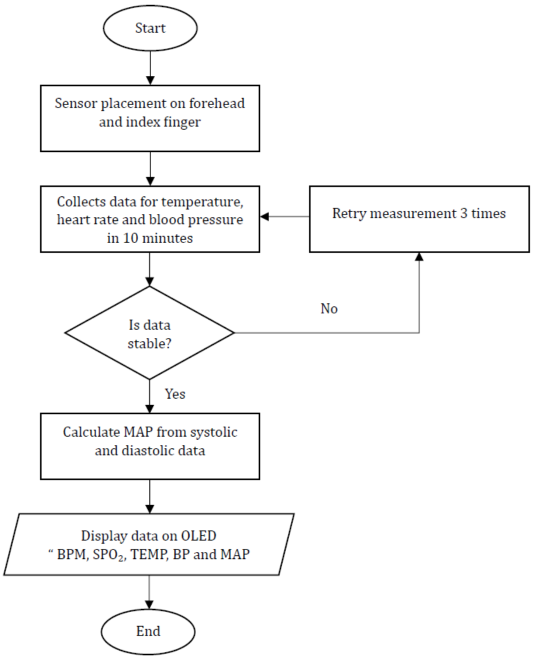


Figure 2. Flowchart of the system operation for maternal vital sign monitoring

IV. RESULTS AND DISCUSSION

Before comparing the prototype with clinical equipment, the developed system was first tested to ensure that all components and software were functioning properly. As shown in Figure 3, the prototype consisted of an ESP32 Hibiscus microcontroller connected to an AHT10 temperature sensor and a MAX30100 module for vital sign acquisition and processing. Figure 4 shows an OLED display that continuously presented real-time readings of heart rate, oxygen saturation, body temperature and estimated of blood pressure.

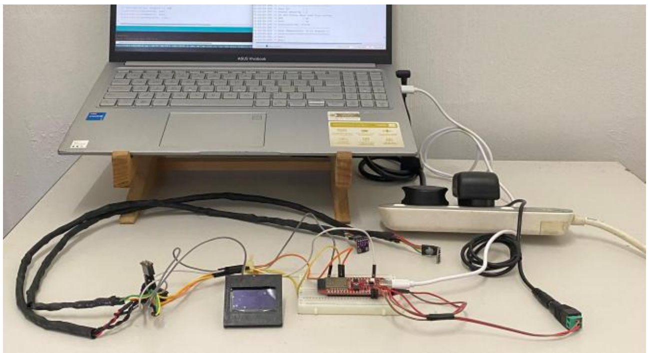


Figure 3. System prototype of the ESP32 Hibiscus microcontroller connected to the AHT10 and MAX30100 module

Figure 4. Real-time vital sign display on the OLED

During the test, subjects were asked to place the sensors correctly on their forehead and index finger. When readings were taken, the Mean Arterial Pressure (MAP) value was successfully generated using a formula, as shown in equation 1, and displayed alongside other vital signs. At the same time, the Mean Arterial Pressure (MAP) result was used for comparison against values from standard clinical devices to assess accuracy. Mean Arterial Pressure (MAP) is used to represent the time-averaged pressure in the peripheral arteries over the cardiac cycle and is usually obtained through invasive arterial (Chemla *et al.*, 2025).

The system produces repeatable outputs. Therefore, readings need to be visually monitored to ensure data stability even in non-clinical environments. In these situations, where inconsistent readings are observed during testing, subjects are instructed to repeat the measurement manually. This prototype serves to verify the repeatability of a real-life system where maternal users may need to monitor their vitals multiple times for verification. The recorded data was analysed and compared between sensor and equipment readings. Each vital sign parameter showed a different level of accuracy and was evaluated using the percentage error (Chen *et al.*, 2024) as shown in equations 2 and 3.

$$MAP \;= \frac{(2DP+SP)}{3} \qquad (1)$$

$$Accuracy, \% = 100\% \;- Error(\%) \qquad (2)$$

$$Error, \% = \frac{|Measured\ Value - True\ Value|}{|True\ Value|} \times 100 \qquad (3)$$

A. BPM and SpO2

This experiment involved collecting heart rate (BPM) and (SpO2) data with the MAX30100 sensor, and comparing with measurements from a fingertip oximeter to assess the accuracy and consistency of the system. This was important in the measurement aspect to achieve prototype performance for non-invasive monitoring applications.

The line graph in Figure 5 shows the trend of heart rate (BPM) readings obtained from 10 subjects by comparing the output of the MAX30100 sensor with that of a clinical oximeter.

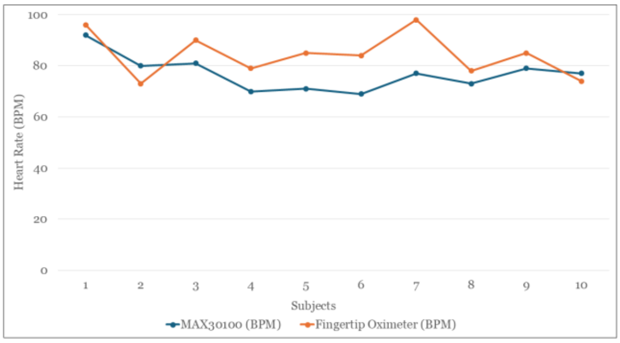


Figure 5. Trend of heart rate (BPM) readings across subjects using sensor-based and clinical measurements

In the subject situation, the MAX30100 sensor produced values close to those of a standard fingertip oximeter with an average accuracy of 90% or higher as in Subject 1 to Subject 3, followed by Subject 8 to Subject 10. Meanwhile, the accuracy of subjects such as Subject 4 to Subject 7, showed values below 90%. This accuracy value may be due to several factors such as sensor placement or indirect subject movement. Variations in blood circulation and inconsistent finger placement may also contribute to fluctuations in the sensor readings. To evaluate the prototype results, different levels of accuracy and percentage error were calculated from the sensor and the readings of the device. The visualisation supports the data presented in Table 1.

Table 1. Comparison of heart rate (BPM) readings

Subj.	Sensor (BPM)	Oximeter (BPM)	Error (%)	Accuracy (%)
1	92	96	4.16	95.84
2	80	73	9.58	90.42
3	81	90	10	90
4	70	79	11.39	88.61
5	71	85	16.47	83.53
6	69	84	17.85	82.15
7	77	98	21.43	78.57
8	73	78	6.41	93.59
9	79	85	7.05	92.95
10	77	74	4.05	95.95

In this project, the average accuracy obtained for heart rate monitoring using the MAX30100 sensor was 89.16%. Oxygen saturation (SpO2) was also measured using the MAX30100 sensor and compared with a standard fingertip oximeter, as this parameter was important for assessing respiratory efficiency and detecting early signs during the initial stage of this project, as shown in Figure 6, where the sensor readings were almost stable compared with the clinical devices. Based on the line graph in Figure 6, most of the subjects' values were in the range of 95% and above. This data also showed that the MAX30100 sensor produced consistent output, with a slight deviation of 1 to 3% within a given subject, especially for Subjects 1 to 5, and followed by Subjects 7 to 10. Subject 6 produced a sensor reading that was the same as the reading from the standard fingertip oximeter, where both readings recorded 99%. This resulted in a reading error of 0% and an accuracy of 100%, demonstrating the high reliability and consistency in measuring oxygen saturation for this subject under proper placement according to the planned procedure, especially for routine monitoring outside the hospital setting.

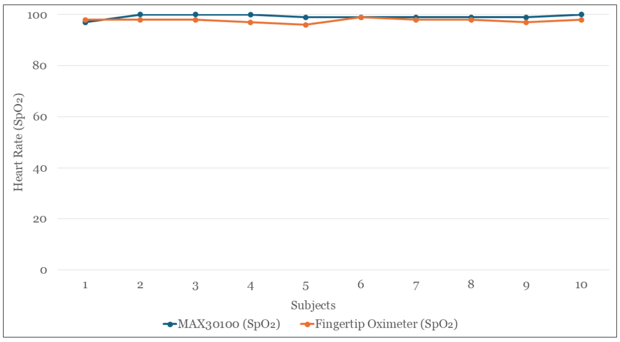


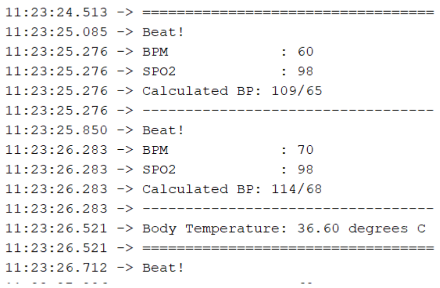
Figure 6. Trend of oxygen saturation (SpO2) readings across subjects using sensor-based and clinical measurements

Normal readings for a healthy individual are values (SpO2) in the range of 95% to 99% and a normal resting heart rate in the range of 60 to 100 BPM. However, higher resting heart rates may be associated with poor clinical outcomes (Sobieraj, Siński & Lewandowski, 2021). By reducing repeated measurements, better reliability can be ensured during practical testing with proper sensor placement, as shown in Table 2.

Table 2. Comparison of oxygen saturation (SpO2) readings

Subj.	Sensor (BPM)	Oximeter (BPM)	Error (%)	Accuracy (%)
1	97	98	1.02	98.98
2	100	98	2.04	97.96
3	100	98	2.04	97.96
4	100	97	3.09	96.91
5	99	96	3.13	96.87
6	99	99	0	100
7	99	98	1.02	98.98
8	99	98	1.02	98.98
9	99	97	2.06	97.94
10	100	98	2.04	97.96

The average accuracy of the oxygen saturation (SpO2) monitoring readings obtained was 98.25%. On the other hand, a value that remains consistently below 90% indicates hypoxemia or low blood oxygen saturation from impaired lung function, low oxygen concentration (Shapiro *et al.*, 2023). The MAX30100 sensor provided real-time heart rate readings through an Arduino-based monitoring system and showed little difference compared to clinical oximeters, as shown in Figure 7 and Figure 8.



```
11:23:24.513 -> ==================================
11:23:25.085 -> Beat!
11:23:25.276 -> BPM             : 60
11:23:25.276 -> SPO2            : 98
11:23:25.276 -> Calculated BP: 109/65
11:23:25.276 -> ----------------------------------
11:23:25.850 -> Beat!
11:23:26.283 -> BPM             : 70
11:23:26.283 -> SPO2            : 98
11:23:26.283 -> Calculated BP: 114/68
11:23:26.283 -> ----------------------------------
11:23:26.521 -> Body Temperature: 36.60 degrees C
11:23:26.521 -> ==================================
11:23:26.712 -> Beat!
```

Figure 7. Serial monitor displaying real-time data from the vital sign monitoring system

Figure 8. Volunteer subject using the oximeter on fingertip

B. Body Temperature

The AHT10 sensor was used to measure body temperature from the skin surface. One study stated that normal human body temperature ranged between 36.5°C and 37°C (Lee *et al.*, 2023). Therefore, these readings were commonly used in clinical procedures as a benchmark for assessing a person's health status. The sensor readings were compared with those obtained from a standard clinical thermometer, which served as the reference device.

The visual representation below showed that the sensor readings followed the clinical thermometer readings, indicating that the AHT10 sensor could accurately track temperature trends according to the subject's situation. Body temperature readings were also collected from 10 subjects using the AHT10 sensor and the clinical thermometer readings. As shown in Figure 9, only slight differences were observed between the AHT10 sensor and the thermometer readings, indicating stable temperature measurements.

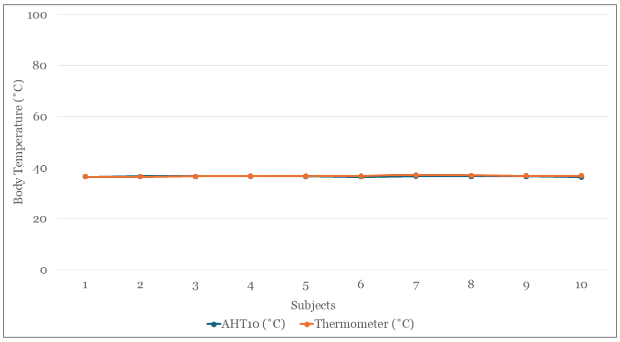


Figure 9. Trend of temperature (˚C) readings across subjects using sensor-based and clinical measurements

Based on the table below, most of the subjects recorded small differences between 0.03% to 1.19% error, while all accuracy values remained above 98%. Meanwhile, Subject 1 produced the same reading with both devices, which was 36.5°C, and achieving 0% error and 100% accuracy. From this analysis, the reliability of the AHT10 sensor when used correctly, especially in consistent environmental conditions and correct sensor placement, as shown in Table 3.

Table 3. Comparison of temperature (°C) readings

Subj.	**Sensor (°C)**	**Oximeter (°C)**	**Error (%)**	**Accuracy (%)**
1	36.50	36.5	0	100
2	36.60	36.5	0.27	99.73
3	36.61	36.6	0.03	99.7
4	36.75	36.7	0.14	99.86
5	36.61	36.8	0.52	99.48
6	36.59	36.8	0.57	99.43
7	36.76	37.2	1.10	98.9
8	36.60	37.0	1.08	98.92
9	36.61	36.9	0.79	99.21
10	36.46	36.9	1.19	98.81

From the average accuracy results obtained from Subjects 1 to 10 was 99.40%. This indicated that most of the readings were close, with slight variations due to differences in skin surface temperature and situational factors, as shown in Table 3. This test system compared the readings from the temperature sensor with those from a clinical thermometer commonly used on the forehead, as shown in Figure 10 and Figure 11.

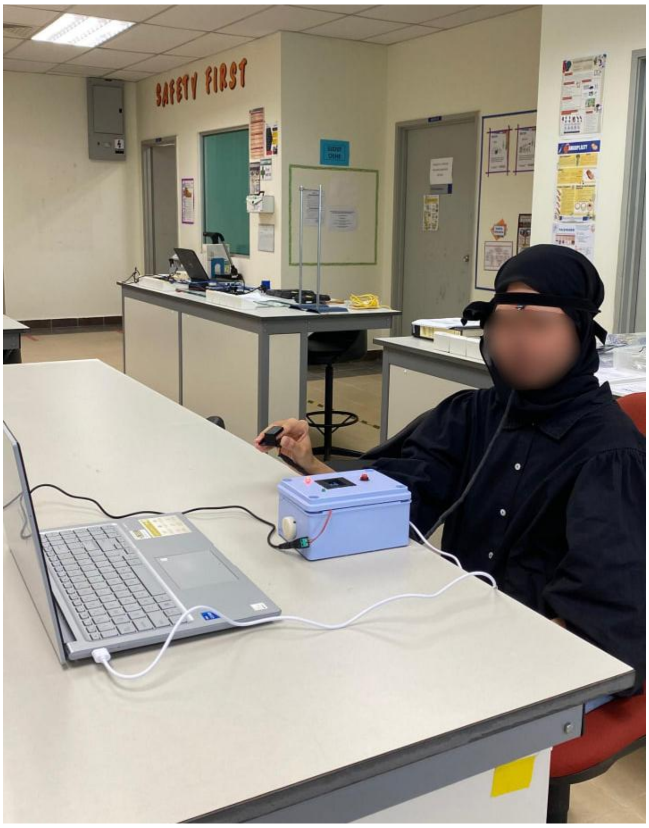


Figure 10. Volunteer using the monitoring system

Figure 11. Forehead temperature measurement with thermometer

C. Blood Pressure

In this system, blood pressure was estimated indirectly using the pulse wave pattern from the MAX30100 sensor. In clinical practice, a systolic reading of 90 to 120 mmHg or a diastolic reading of 60 to 80 mmHg was optimal as 'normal' (Giuseppe Mancia *et al.*, 2023).

The line graph below showed a comparison of MAP values from the MAX30100 sensor and a standard digital monitor for 10 subjects. The graph was used because it clearly showed the results with a consistent pattern despite slight variations. This indicated that the sensor could provide a reliable estimation of MAP when used correctly, as in Figure 12.

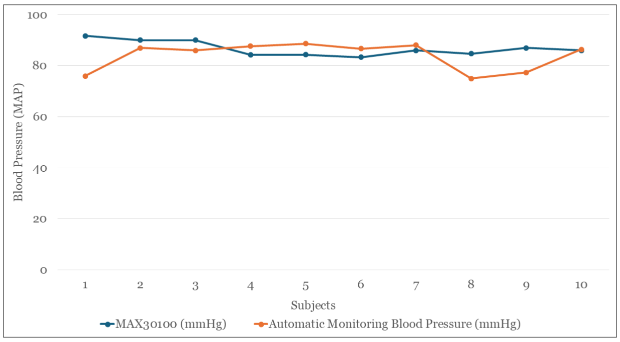


Figure 12. Trend of estimated blood pressure (mmHg) readings across subjects using sensor-based and clinical measurements

The MAP calculation and percentage error for each subject were calculated to evaluate the accuracy of each subject's measurement. Some error rates exceed 12% such as Subjects 1, 8 and 9, which exceeding 12%. This indicates a lower accuracy value for these subjects. Most of the results showed acceptable accuracy exceeding 90%. Meanwhile, Subject 10 produced an almost accurate reading, with an error of 0.38% and an accuracy of 99.62%. The MAX30100 sensor does not immediately provide systolic and diastolic readings. Thus, the mean arterial pressure (MAP) derived from it was validated using manual measurements from a digital blood pressure monitor, as showed in Table 4. In addition, indirect blood pressure estimation using PPG signals may have been affected by physiological variability between subjects, including blood circulation, finger size and sensor positioning consistency.

Table 4. Comparison of estimated blood pressure (mmHg) readings

Subj.	**Sensor (Sys/Dia)**	**Blood Pressure Monitor (Sys/Dia)**	**Error (%)**	**Accuracy (%)**
1	125/75	102/63	20.6	79.4
2	120/72	109/76	3.44	96.56
3	120/72	100/79	4.65	95.35
4	115/69	103/80	3.79	96.21
5	115/69	110/78	4.88	95.12
6	114/68	114/73	3.84	96.16
7	118/70	118/73	2.27	97.73
8	116/69	93/66	12.88	87.12
9	119/71	94/69	12.50	87.5
10	118/70	107/76	0.38	99.62

Additionally, the average accuracy obtained for MAP estimation was 93.08%. This method allows the prototype to be evaluated not only from a technical perspective but also from a usability perspective. Automated blood pressure measurements were also used for comparison to assess accuracy and percentage error to the collected data, as shown in Figure 13.

Figure 13. Blood pressure measurement using an automatic digital monitor on a volunteer

Without this stage, it would have been difficult to move from prototype testing to a larger implementation. This also makes it easier to plan design improvements before the system was tested on a larger number of subjects in a more focused and practical manner. This method also provided additional insight into the reliability of the estimated blood pressure values when compare with actual clinical readings, because it did not just focus on range accuracy, but also highlighted whether the system responded in a consistent and predictable manner under different subject conditions.

V. CONCLUSION

In conclusion, this project successfully developed a non-invasive health monitoring system at an early stage using Arduino with ESP32 Hibiscus. This system records vital signs such as temperature, heart rate (BPM), oxygen saturation (SpO2), and estimated blood pressure from two low-cost sensors, and then the readings are displayed. Initial tests were conducted over 10 to 15 minutes, depending on the subject's condition, to ensure measurement accuracy. Quantitative analysis of this project showed that the MAX30100 sensor achieved an average accuracy of 90% to 96% for heart rate (BPM) and 97% to 100% for oxygen saturation (SpO2), while the AHT10 sensor used showed an accuracy of over 98% for body temperature compared to clinical equipment, namely thermometers. For blood pressure estimation based on MAP calculations, the accuracy readings were mostly above 90%, although some subjects recorded lower values (79% to 87%) due to interference in the signal, positioning, and situational conditions.

Although the results are helpful, there are still several limitations. Blood pressure measurements are estimated using pulse wave analysis and MAP calculation techniques rather than direct clinical measurements, which may introduce inaccuracies due to subject variation and signal interference. However, this project offers an affordable and accessible solution for maternal health monitoring at home, particularly for pregnant women in rural areas. Its simple design and usability make it suitable for individuals with limited access to healthcare facilities. The system will be further developed with IoT based connectivity for real time data transmit and remote monitoring by the healthcare professionals. Furthermore, additional clinical validation with pregnant subjects in a healthcare setting reliability and usefulness of the system. These enhancements will contribute to the creation of a more robust and useful maternal health monitoring system.

VI. ACKNOWLEDGEMENT

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