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MOBILE APPLICATION INTEGRATED WEARABLE VITAL SIGN MONITORING SYSTEM

BY

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SUPERVISED BY

Dr I.V. DIWE

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INTRODUCTION



Fig 1: Premvitals device

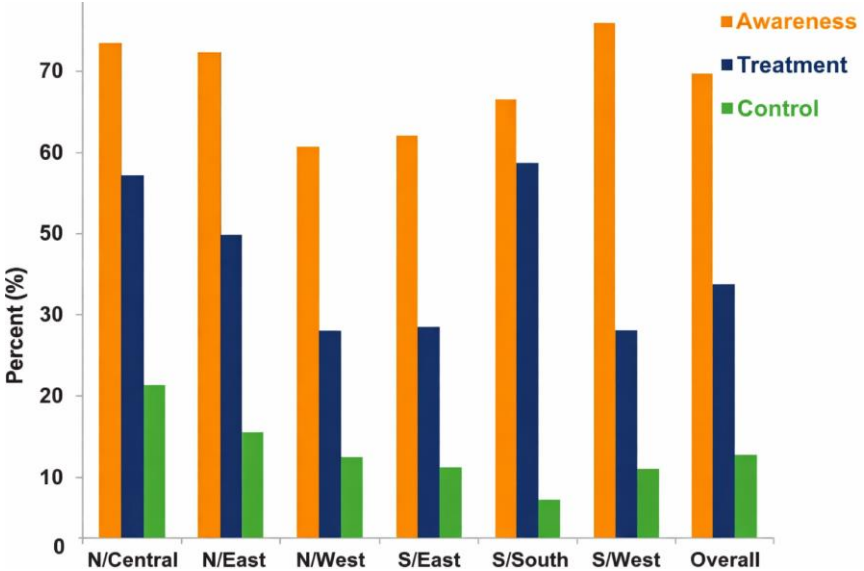


Figure 2: Hypertension prevalence by region in Nigeria

image source: https://pubmed.ncbi.nlm.nih.gov/32923341

Background of Study

- Hypertension prevalence in Nigeria: 28–38% (Adeloye et al., 2022).
- Lagos prevalence: 35.8% (Odukoya et al., 2021).
- High sodium intake exceeds WHO 5 g/day recommendation (Oyebode et al., 2023).

Abbreviations

Abbreviation	Full Form
BLE	Bluetooth low Energy
ECG	Electrocardiogram
ESP32	Espressif Systems 32-bit Microcontroller
OLED	Organic light emitting diode
PPG	Photophetomography
PTT	Pulse Transit Time
SpO_2	Blood Oxygen Saturation

Problem Statement

- Cuffed devices are intermittent and uncomfortable.
- Existing wearable health monitors are often expensive
- They are not well suited for resource-constrained environments



Figure 3: Traditional cuff being used on patient

image source:
http://www.frankshospitalworkshop.com/equipment/sphygmomanometer_equipment.html

Aim of Study

To develop a low-cost, cuffless wrist-worn device for continuous non-invasive vital sign monitoring.

Objectives of Study

1. To design an ESP32-based wrist wearable prototype integrating PPG, ECG, motion, and temperature sensors for real-time vital sign monitoring.
2. To implement cuffless blood pressure estimation using the Pulse Transit Time (PTT) method, with calibration against a standard blood pressure monitor, and a practical PPG-based fallback when ECG signals are unavailable.
3. To develop a BLE-enabled Flutter mobile application for real-time data visualization, logging, trend analysis, and dietary sodium intake tracking.
4. To integrate a solar-assisted charging system to support extended device operation in environments with unstable power supply.

Scope / De-Limitations

The scope of this study focuses on developing a low-cost wearable prototype that can monitor vital signs such as blood pressure, heart rate, SpO_2, and skin temperature.



Figure 4: A doctor observing a patient's vital signs

image source: https://agurgentcare.com/what-are-normal-vital-signs/

De-Limitations of Study

- Limited clinical validation
- BP estimation is research-grade, not clinical-grade
- ECG electrodes are inconvenient for continuous wearable use
- Solar charging works best under direct sunlight

Significance of the Study

- Improves affordable vital signs monitoring
- Promotes preventive self-care
- Supports sustainable healthcare innovation in underserved Nigerian communities.

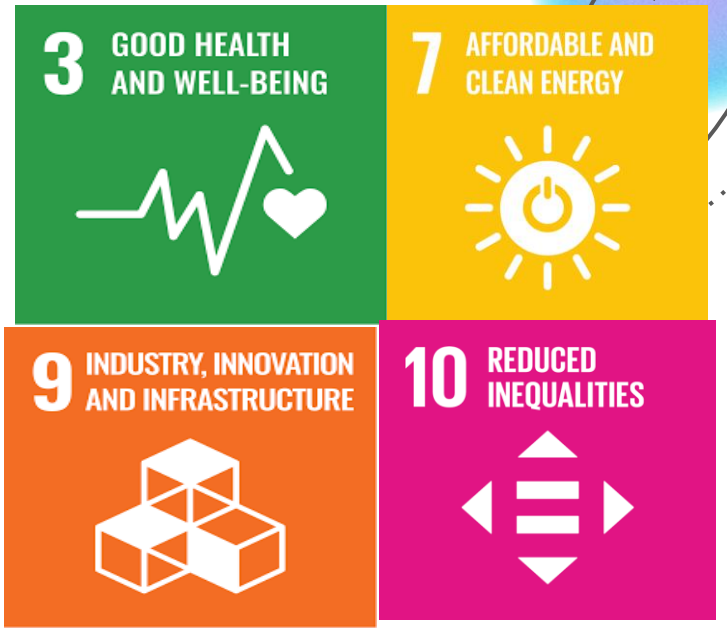


Figure 5: United nations sustainable development goals this study aligns with

image source: https://sdgs.un.org/goals

LITERATURE REVIEW

S/N	AUTHOR	DESCRIPTION	GAPS IDENTIFIED
1.	Oyebode et al., (2023)	High sodium from processed foods exceeds WHO limits; associated with poor BP control.	• No wearable-linked sodium tracking • No real-time monitoring integration
2.	Adeloye et al., (2022)	28–38% adult prevalence; low awareness (~30%); poor BP control rates.	• Focus on clinic-based data • Limited continuous/home monitoring discussion

LITERATURE REVIEW

S/N	AUTHOR	DESCRIPTION	GAPS IDENTIFIED
3.	Odukoya et al., (2021)	35.8% prevalence; higher in males and middle-aged groups; urban stress and high-salt diets key drivers	• One-time measurements • No dietary logging integration • No real-time wearable monitoring
.			

Literature Gaps Summary

Current studies focus on hypertension prevalence rather than continuous monitoring, with limited wearable solutions, real-time tracking, and integration of lifestyle factors for effective management.

METHODOLOGY

Our wearable vitals monitor consists of two main parts: the hardware device and mobile application.

Research Methodology

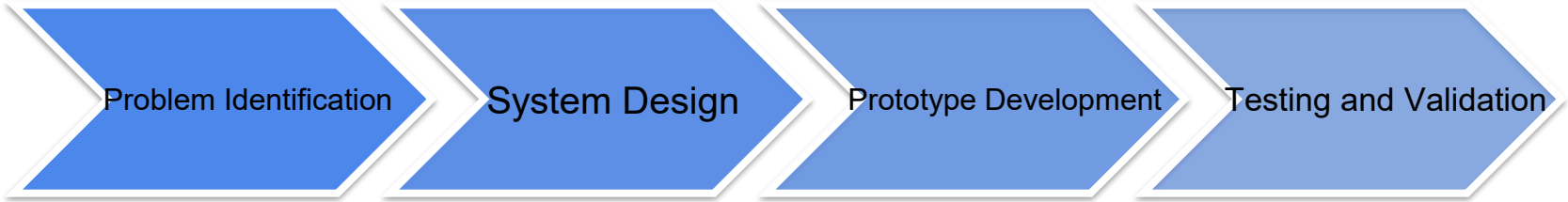


Figure 6: A flowchart showing our research process

System Architecture

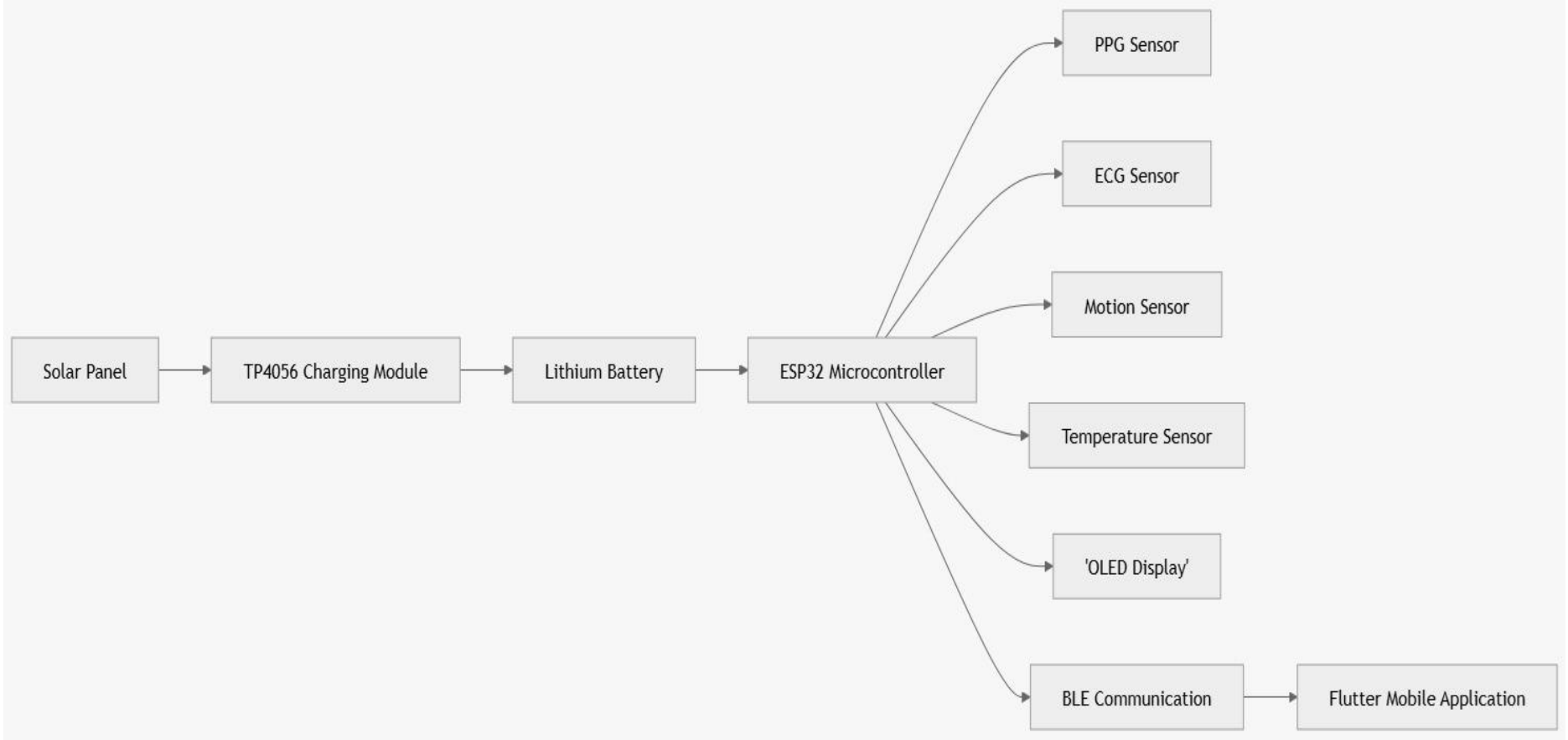


Figure 7: Block diagram of the cuffless wrist-worn wearable system.

Firmware Architecture

The firmware was developed using the Arduino IDE and programmed onto the ESP32 microcontroller. The firmware is responsible for:

- Initializing all sensors
- Acquiring physiological signals (PPG, ECG, temperature, and motion data)
- Filtering noise and detecting key signal points such as the ECG R-peak and PPG pulse arrival

Firmware Architecture

- Calculating Pulse Transit Time (PTT)
- Estimating blood pressure using the PTT and PPG -based model
- Displaying real-time readings on the OLED screen
- Transmitting data to the mobile application through Bluetooth Low Energy (BLE)

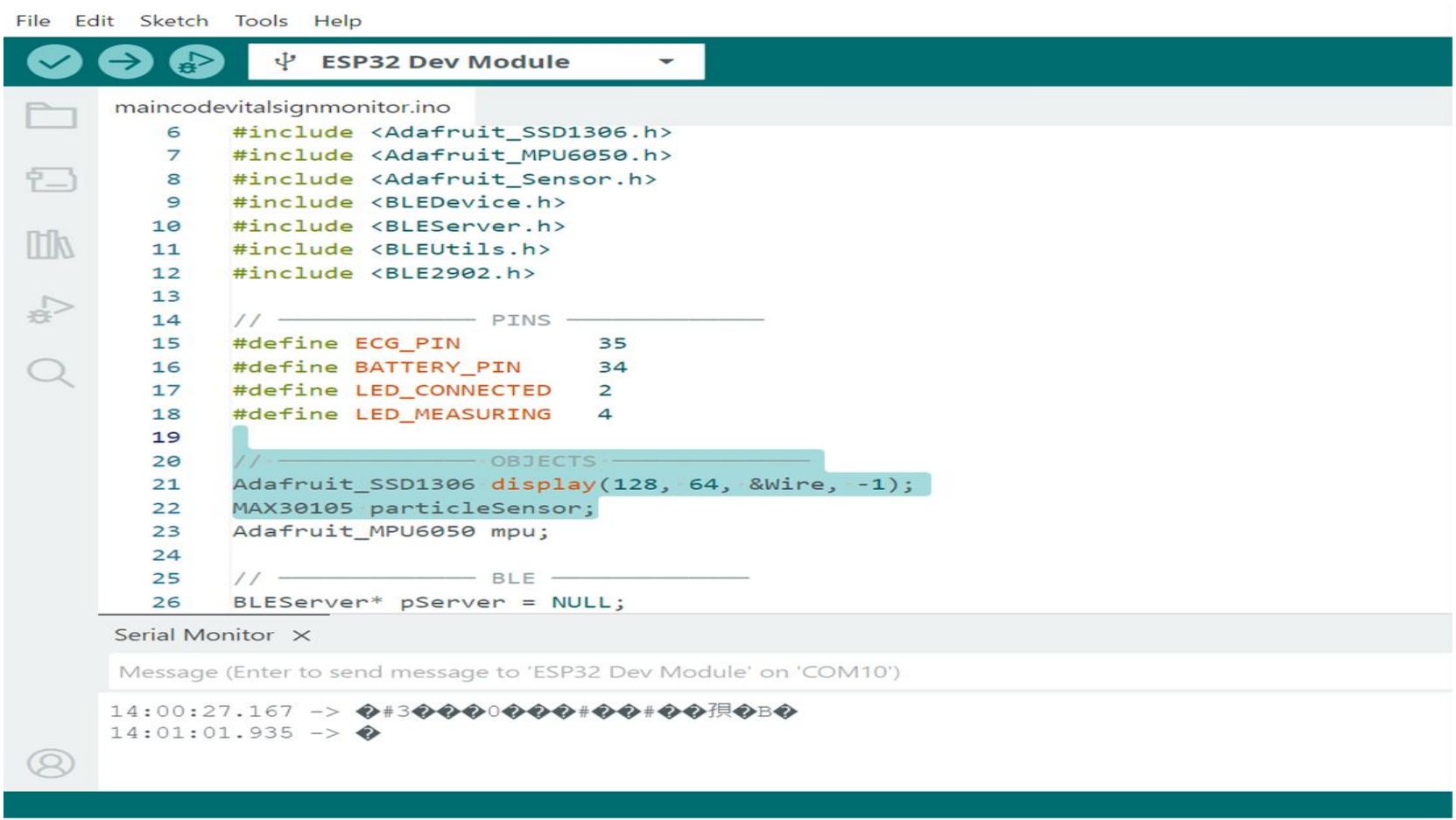


Figure 8: Arduino IDE interface

Software Architecture — Flutter Mobile Application

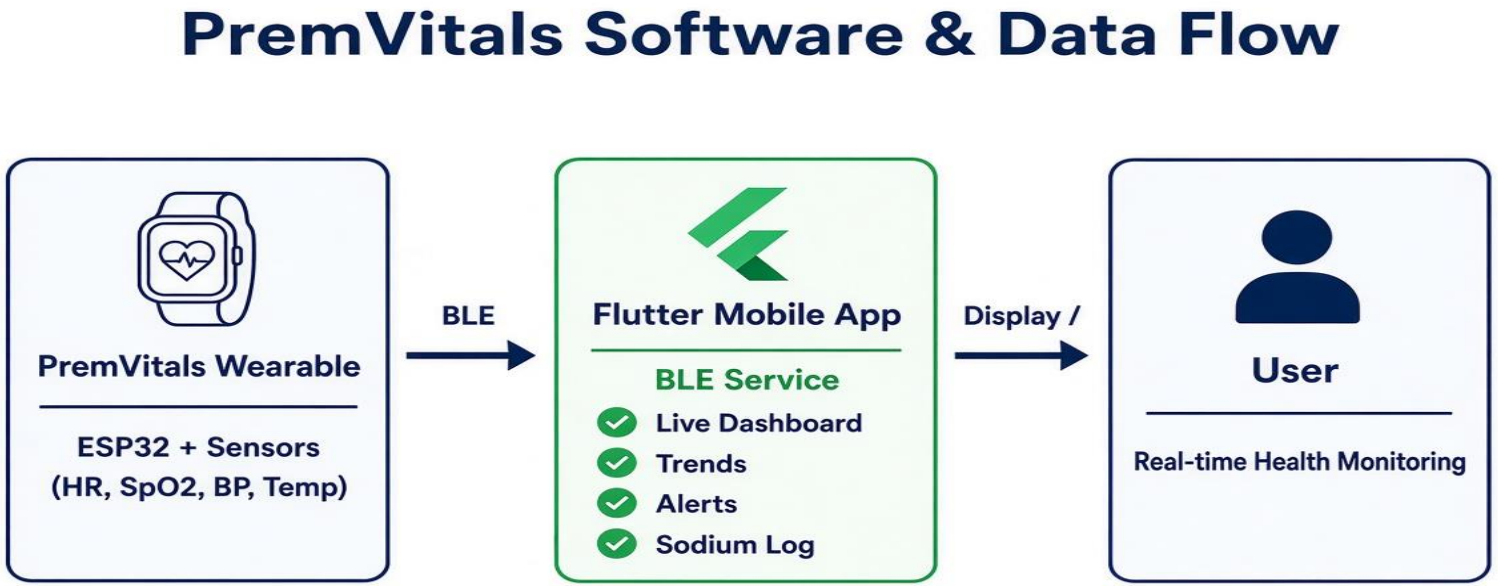


Fig 9: Mobile App data flow

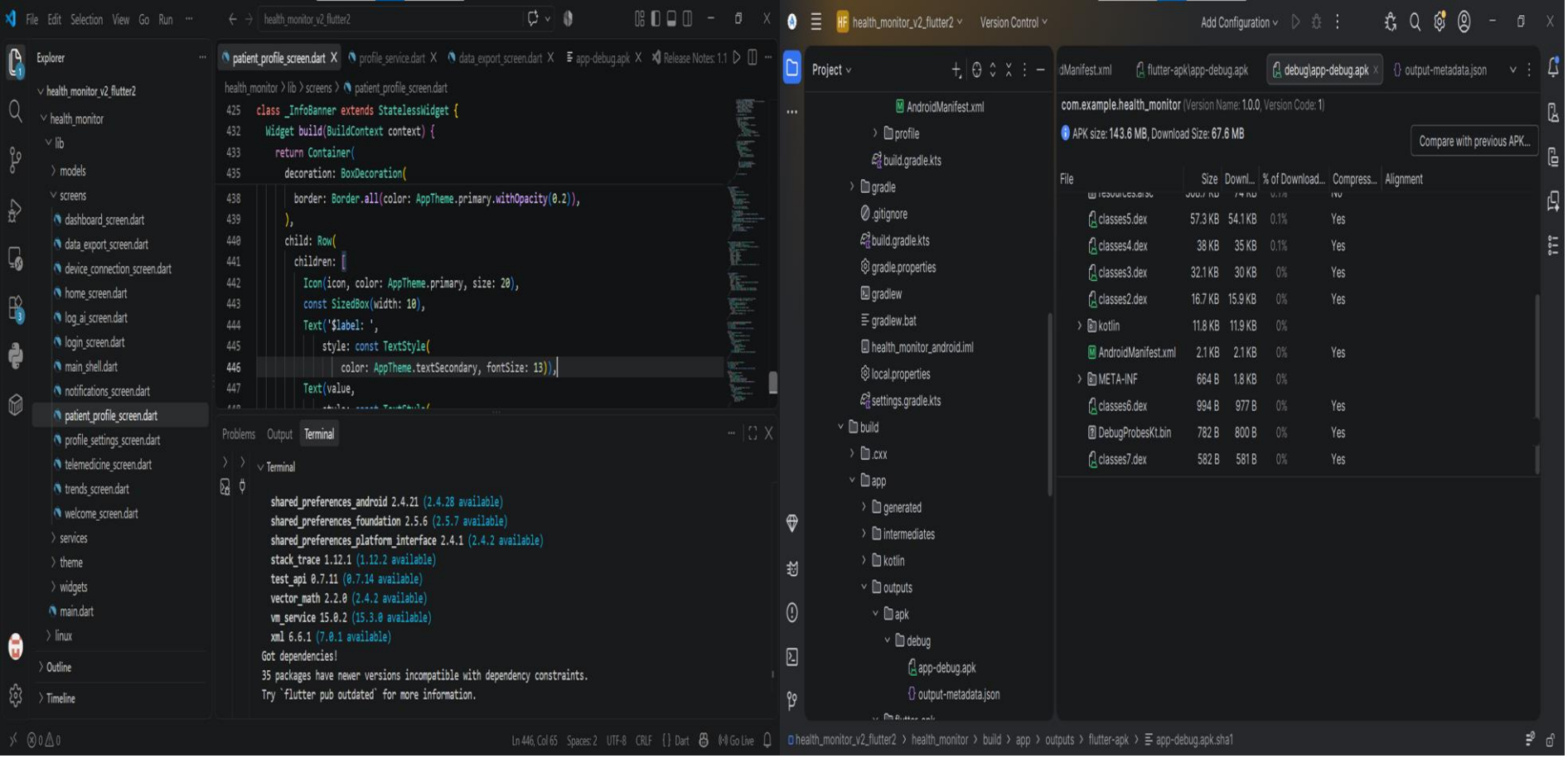


Fig 10: VS code and Android Studio workstation

Methodology—Electronic Design

Key Electronic Components:

- ESP32-WROOM-32
- MAX30105
- AD8232
- MAX30205
- MPU6050
- 0.96" OLED Display
- TP4056 Charging Module
- 3.7V LiPo Battery
- Solar Panel (5V–6V)
- 1N4007 Diode

Circuit Diagram

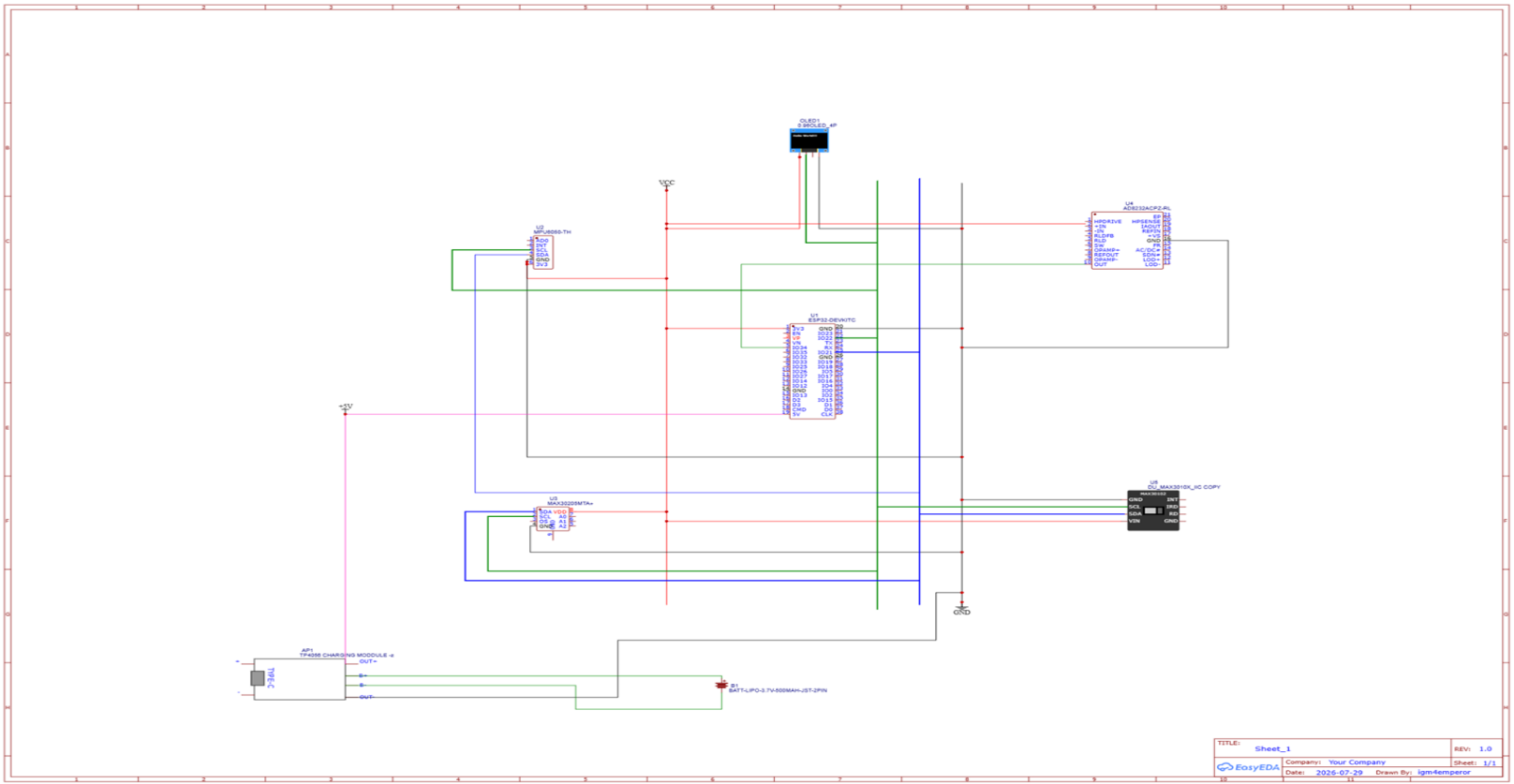


Figure 11: A detailed electrical schematic of the prototype

Circuit Diagram

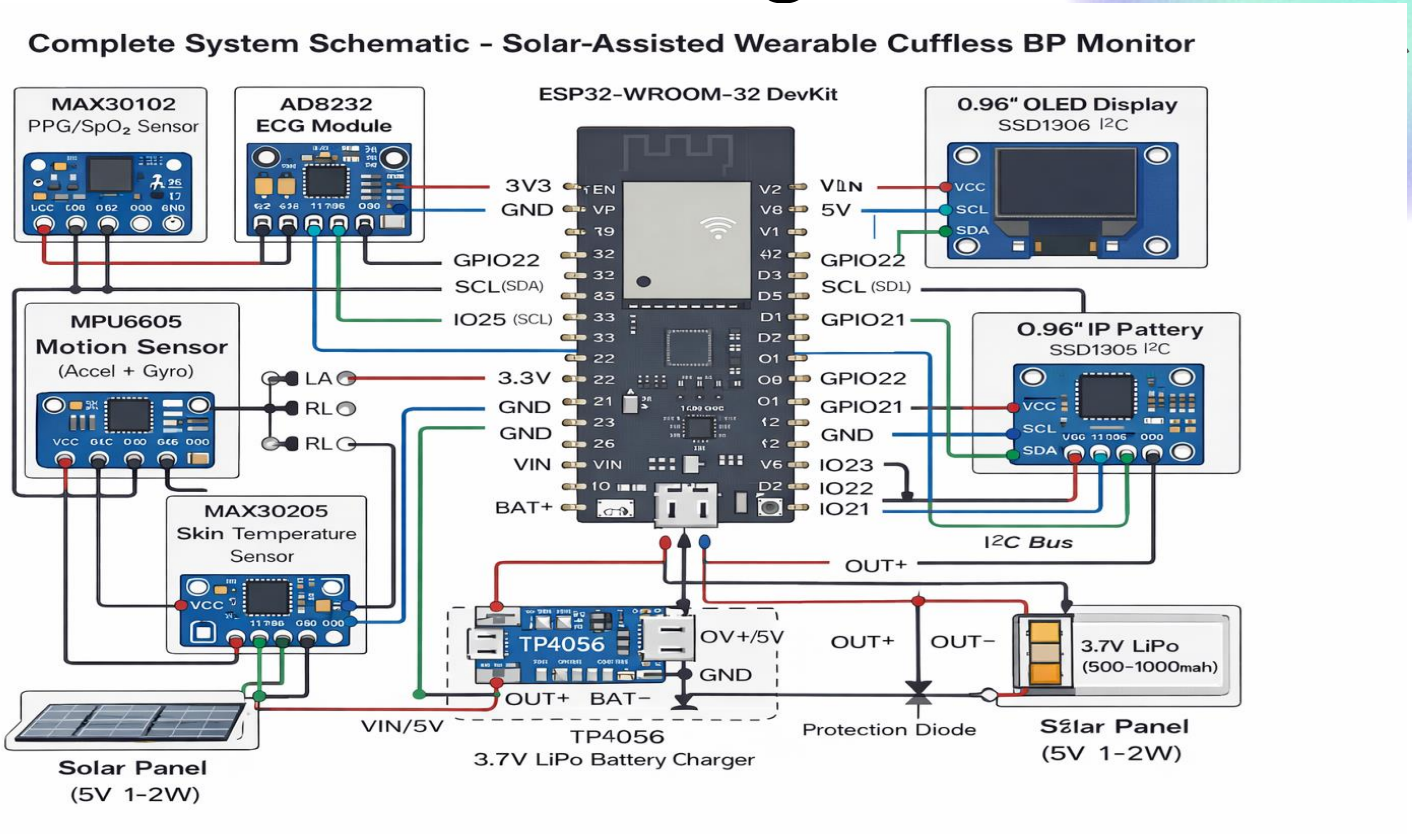
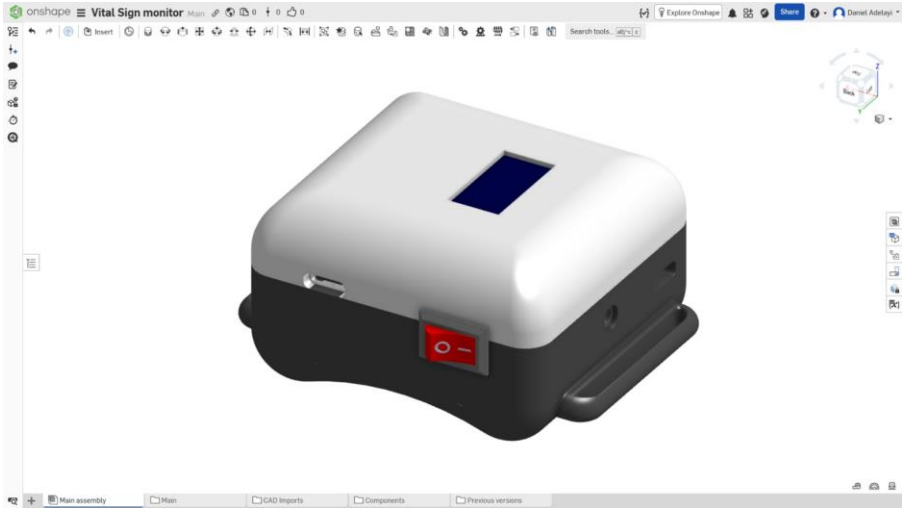


Figure 12: A generated visual representation of the electrical circuit

Methodology—Hardware Design



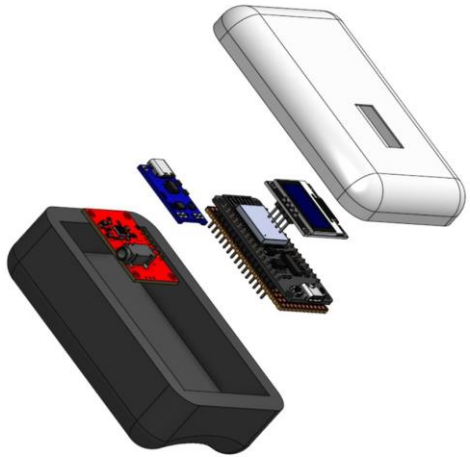


Figure 13: 3D hardware design

Hardware Components

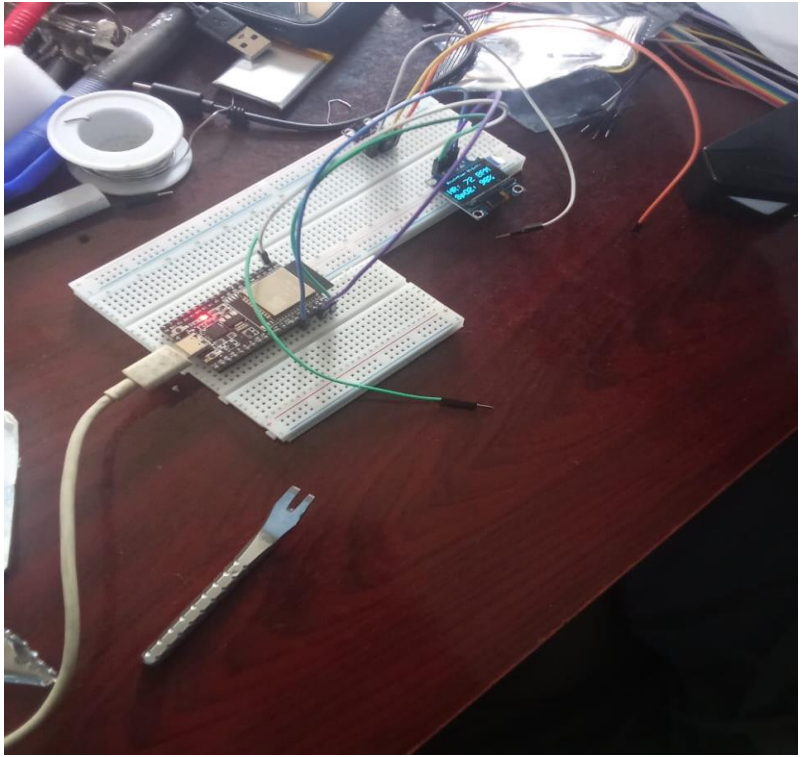


Figure 14: Testing ESP32 and OLED screen on breadboard



Figure 15: Testing sensors

Hardware Components

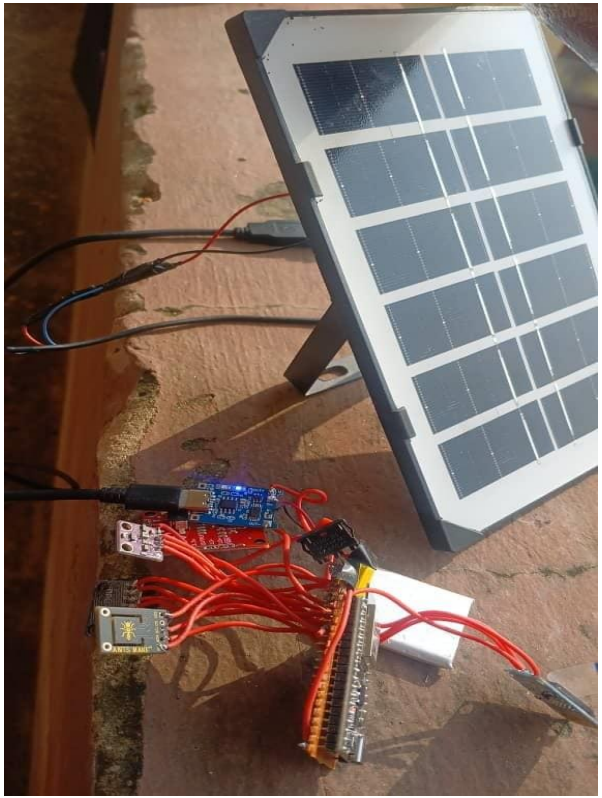


Figure 16: Charging prototype with solar module.



Figure 17: OLED screen displaying vitals

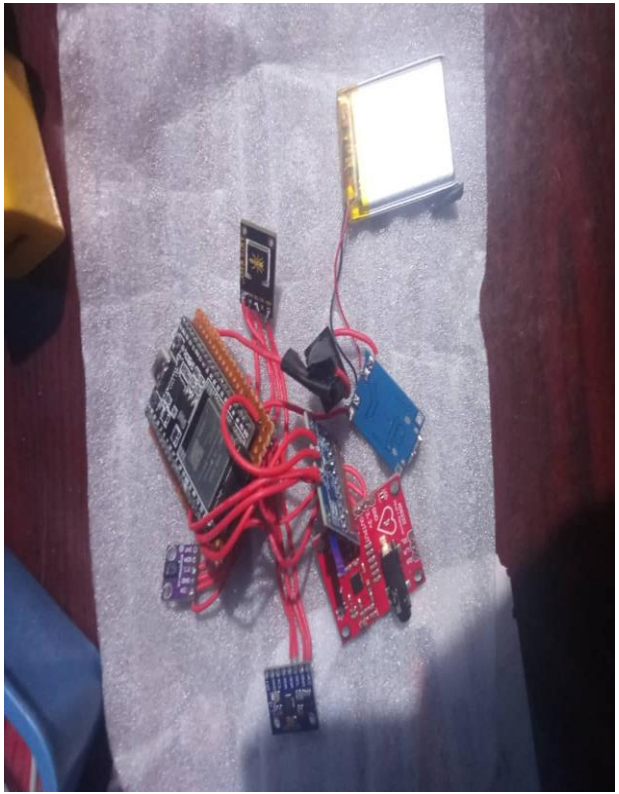


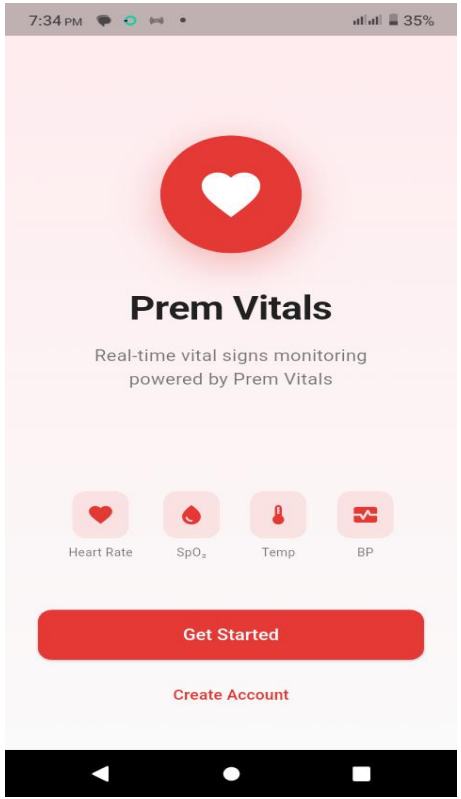
Figure 18: Components soldered to Vero Board

RESULTS



Fig 14: Prototype calibration at Gbagada general hospital

App Interface



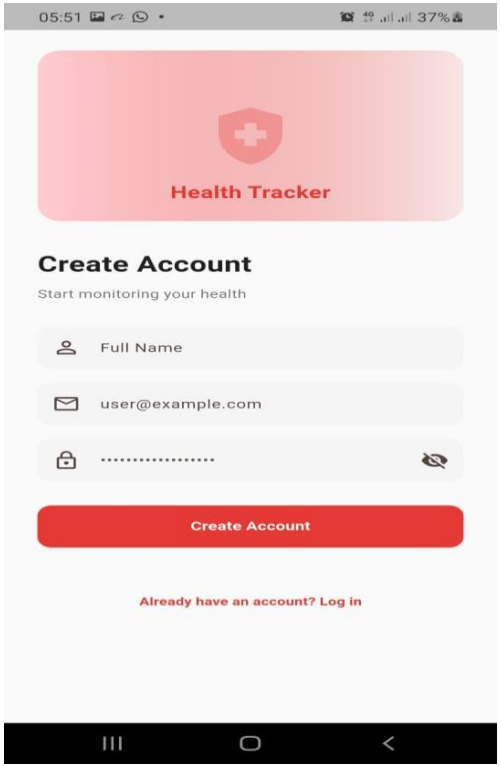
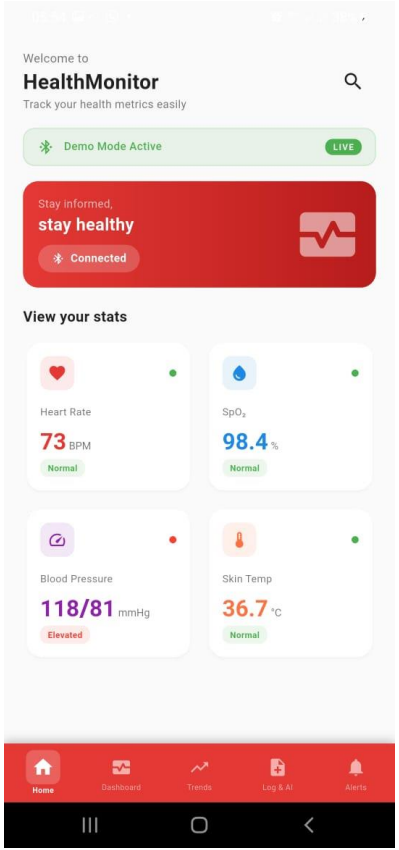


Figure 15: Sign-in screen

App Interface



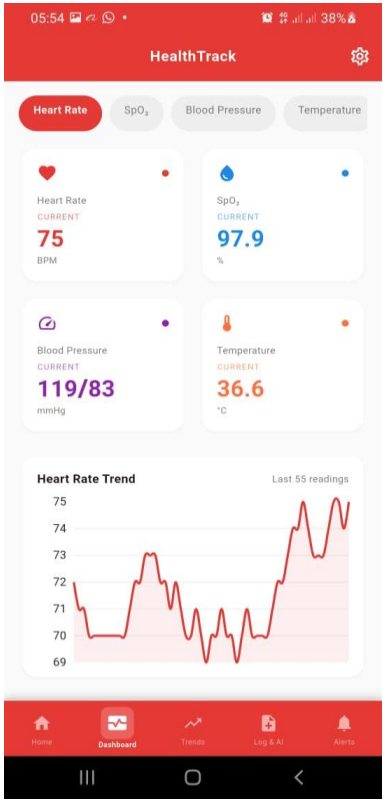
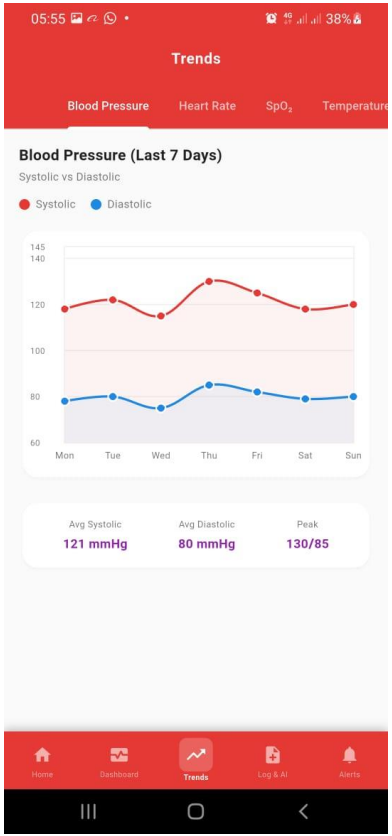


Figure 16: Dashboard and vitals monitoring screen

App Interface



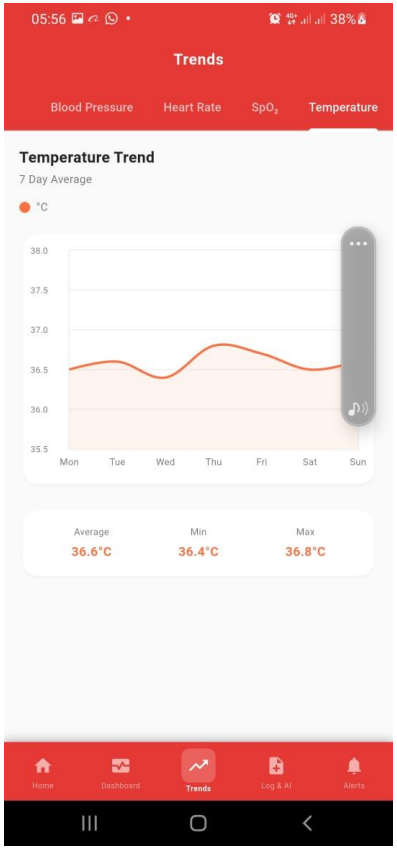
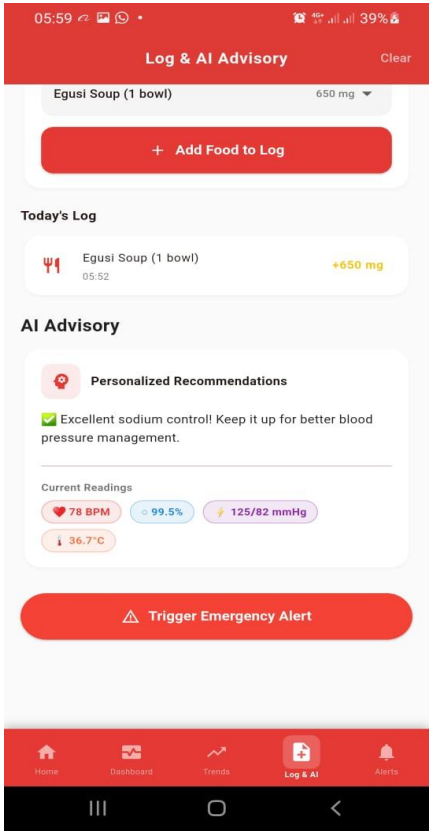


Figure 17: Vitals trend graph screen

App Interface



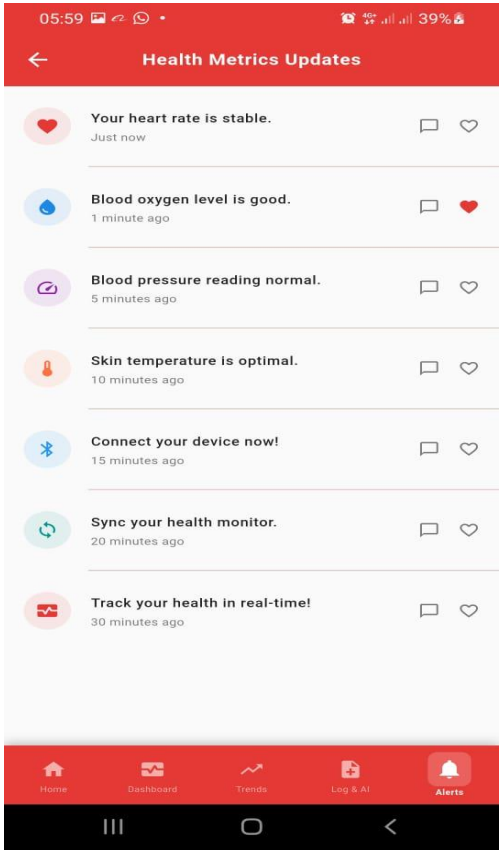


Figure 18: Sodium intake/diet log and health metrics update screen

Heart Rate & SpO_2

- Wrist PPG readings stable under rest
- HR within about ±5 BPM of reference
- SpO_2 usually equal or within ~1%



Fig 19: Heart rate and SpO_2 values comparison

Temperature

Wrist skin temperature from the PremVitals prototype was compared with a reference thermometer. The readings were close, with a difference of less than 1°C in the observed test.

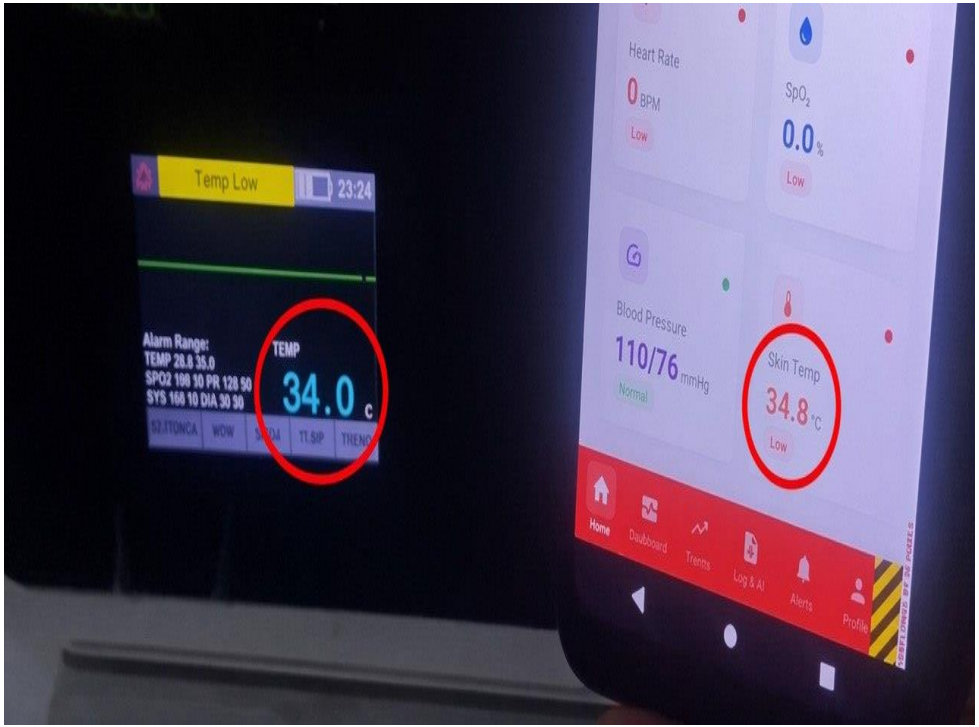


Fig 20: Comparison of Temprature values

Blood Pressure

- Compared with Omron digital monitor
- Systolic MAE ≈ **3.0 mmHg**
- Diastolic MAE ≈ **7.5 mmHg**

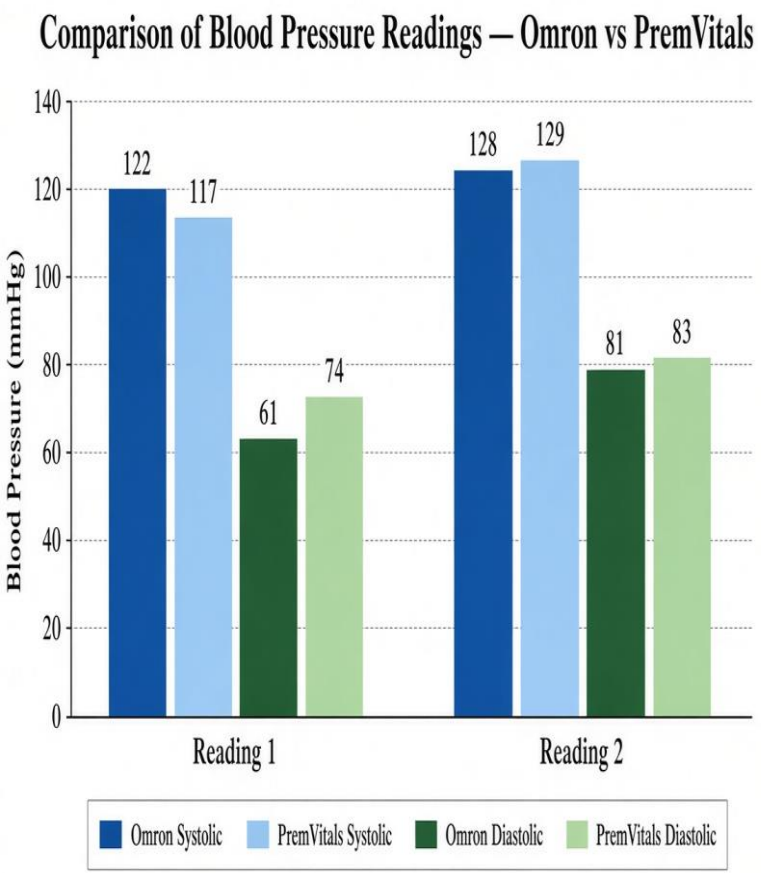


Fig 21 : Comparison of blood pressure readings



Fig 22: Images taken during calibration

BLE Communication

- Device discovery ≈ 2.4 s
- Connection ≈ 1.8 s
- Stable real-time data transfer to app

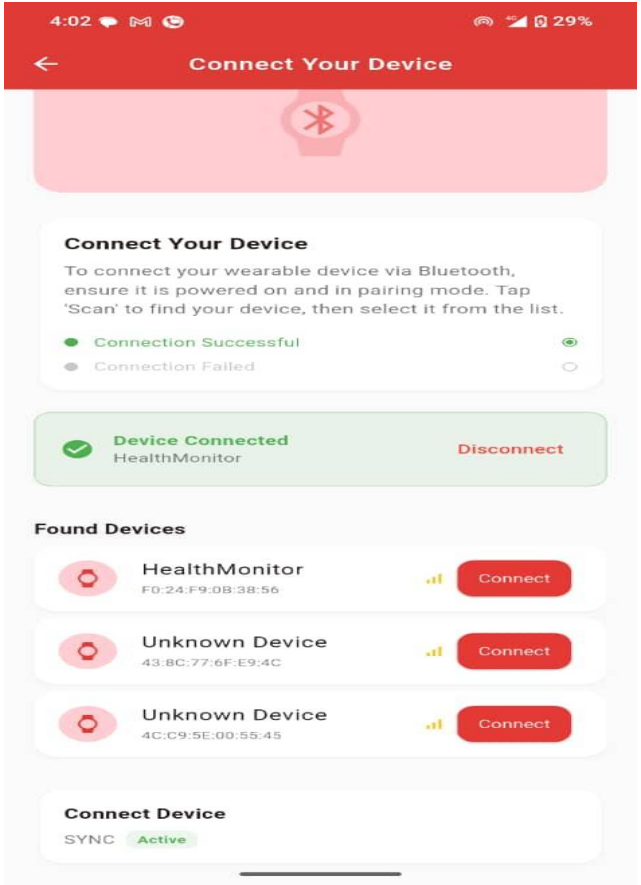


Fig 23: App bluetooth connection page

Mobile Application

- Live vital signs display working
- Trends, alerts, and sodium logging functional
- User vitals record sharing

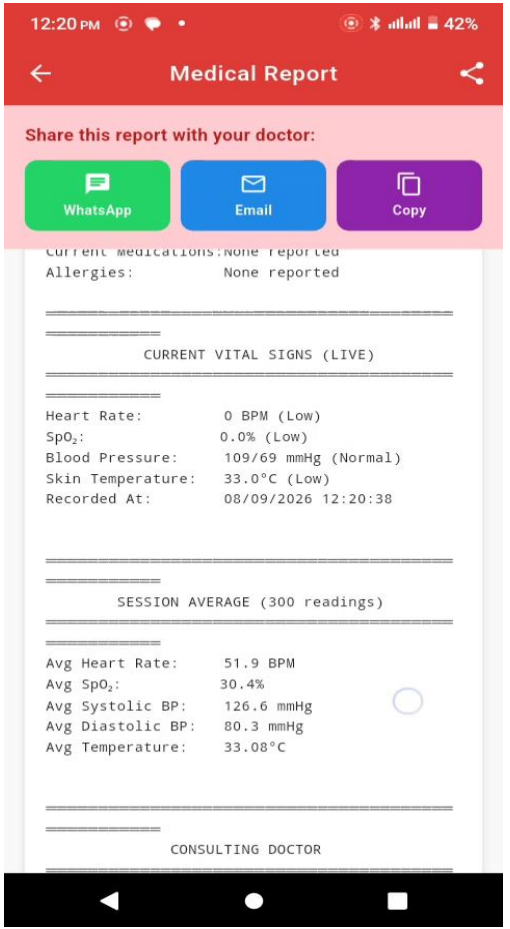


Fig 24: Vitals record sharing page

Solar Charging

- About **40%** run-time extension under outdoor sunlight
- The PremVitals prototype successfully demonstrated multi-parameter monitoring, BLE connectivity, and practical cuffless BP estimation at low cost.

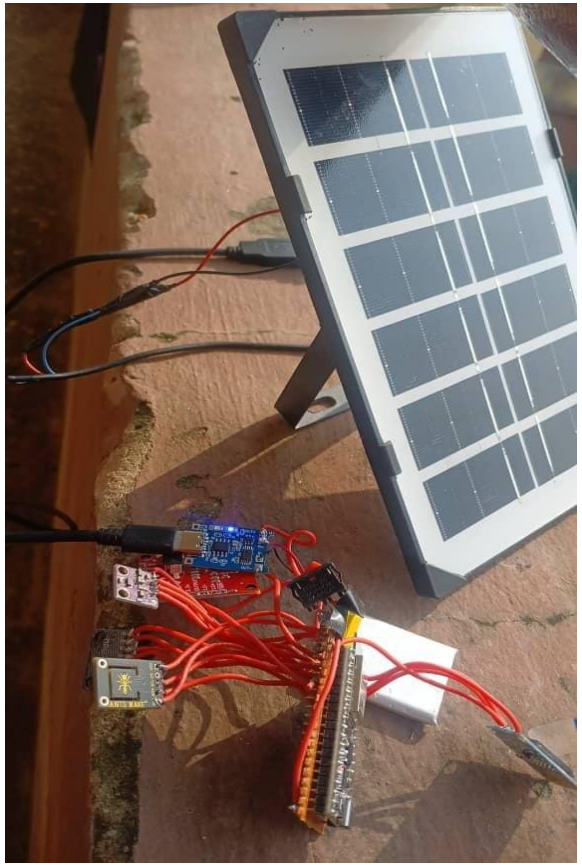


Fig 25: Charging prototype with solar module

CONCLUSION

- Low-cost wearable vitals monitoring system developed.
- Real-time BP, HR, SpO_2, and temperature monitoring.
- Solar-assisted charging extends battery life.
- Supports everyday health tracking.
- Offline operation for resource-limited areas.
- Health records can be shared with doctors.
- Hybrid method used: PTT when ECG is available, PPG fallback when not

RECOMMENDATIONS

- Add additional physiological sensors for expanded health assessment (e.g., non-invasive glucose monitoring)
- Conduct larger clinical trials to further validate accuracy
- Expand offline data-sharing features
- Promote use in low-resource areas
- Provide user training for better adoption

Bill of Engineering Measurement and Evaluation — Prototype Component Costs

S/N	Item	Qty	Unit Price (₦)	Total (₦)
1	ESP32-WROOM-32 DevKit Microcontroller	1	15,000	15,000
2	MAX30102 PPG/SpO_2 Sensor Module	1	4,000	4,000
3	AD8232 ECG Module with 3-electrode cable	1	15,000	15,000
4	MPU6050 Motion Sensor (3-axis accel + gyro)	1	12,000	12,000
5	MAX30205 Skin Temperature Sensor Module	1	12,000	12,000
6	SSD1306 0.96" OLED Display (I^2C)	1	8,000	8,000
7	LiPo Battery 3.7V 500–1000 mAh with JST	1	7,000	7,000
8	TP4056 Battery Charger Module (with protection)	1	2,000	2,000
9	Solar Panel 5V 1–2W Mini	1	13,000	13,000
10	Vero Board / Stripboard 10×15 cm	1	1,500	1,500
11	Jumper Wires and Connectors	1 set	3,200	3,200
12	Breadboard (830-point)	1	2,500	2,500
13	Soldering Iron, Solder Wire, Flux, Miscellaneous	1 set	3,500	3,500
			GRAND TOTAL	₦98,700

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http://www.frankshospitalworkshop.com/equipment/sphygmomanometer_equipment.html

https://agurgentcare.com/what-are-normal-vital-signs/

THANK YOU FOR LISTENING.

Video Link

https://drive.google.com/file/d/15XMWmFLhnivtu1mw-jg1NuCGIPE7ut4C/view?usp=drivesdk

