MediDose and MediBox: NFC-Integrated Smart Wearables and IoT-Based Medication Adherence Solutions

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Abstract

In this context of managing chronic diseases and adhering to medication regimens, this project implements an NFC smart wristband, MediDose, as well as an IoT-based drug dispenser, MediBox. MediDose employs NFC technology to transfer prescriptions and supervises vital body functions like temperature, pulse rate, and even SpO2 level. Prescription sharing, medication supply, and sending SMS reminders were automated with embedded NFC modules in MediBox. The combination of the two devices increases patient engagement, guarantees data safety, enables remote health supervision, and health monitoring in real time. Compared to previous systems, preliminary observations demonstrated greater adherence rates, quicker response times, and more stringent data security, which are all significant improvements.

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1 Introduction

There has been an increase in focus on the problem of non-adherence to medication for chronic conditions like diabetes, hypertension, or heart failure. Non-adherence can lead to severe issues such as increased hospital admissions, emergency visits, and potential permanent disabilities. Not only do these health issues exist, but the problem also poses a significant financial burden where healthcare expenditures amount to billions every year when they could be so easily avoided. Perhaps the most pressing issue is that concerning patient non-compliance and proactive involvement requires transformative techniques that enable efficient medicine.

The highly effective technologies that help mitigate problems with drug adherence are Near Field Communication (NFC) and the Internet of Things (IoT). Their importance in healthcare has been significant. IoT allows for information to be collected and shared remotely monitoring interconnected systems whereas NFC restricts communication to close range. Using these technologies, data transmission, health monitoring, reminder automation, and real-time monitoring of the patient's health can be done through MediBox medication dispenser and MediDose smart wristband which together provide dual solutions to adherence problems.

MediDose is equipped with sensors that monitor body temperature, heart rate, and SpO_2. Medication is communicated using Near Field Communication (NFC) technology and it is also capable of sending alerts when abnormalities are detected. Complementing this is MediBox which automates medication dispensing for patients receiving scheduled SMS reminders. In addition, patients are able to conveniently send their health reports to their doctors via simple email with NFC active modules. Together with these, devices promote the creation of an ecosystem for patient engagement and remote health monitoring that addresses adherence challenges as illustrated in figure 1.

Ignoring the cybersecurity risks for IoT-enabled medical devices like MediDose and

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MediBox is impossible. These devices contain sensitive information regarding patients and must be secured to protect against threats and unauthorized access. AES-256 provides one of the most powerful data in transit encryption. Multi-Factor Authentication alongside Role Based Access Control (RBAC) also strengthen access to verified users only, which enhances security to the device. Such regulations ensure patient data is protected thereby increasing confidence in medical devices connected to the network.

Key Contribution of the research:

- **Medication Adherence:** MediDose has implemented secure communication using PN532 NFC-Near Field Communication RF-ID V3 Module while MediBox is equipped with ISD1820 3-5V Voice Module with a 0.5W Speaker which provides audible reminder for medication and Mini DF Player which plays pre-recorded notification messages. This guarantees that patients are visually as well as aurally instructed to take their medication in a timely manner.

- **Vital Sign Monitoring:** Integrated sensors supervised by a 3V CR2032 Lithium Coin Battery continuously monitor vital parameters such as heart rate and blood oxygen level. These sensors supply real time health information that can be transmitted to health providers for remote surveillance and prompt timely interventions.

- **A New Approach to Medication Dispensation:** Employing DS3231 RTCMemory Module features ensures that the medication dispensed during each interval is placed precisely in time with the alert system, even if there are power failures.

- **Easy Instructions:** Providing agitated patients with audio instructions allows them to intuitively observe and hear the instructions, ensuring that they receive reminders to take their medication, especially the complex ones that require step-by-step notifications tailored to their individual needs.

- **Protecting Data:** Confidential health records are kept under safe guardianship, encrypted with the most intricate and complex keys available utilizing the PN532 NFC Module which constantly guards sensitive health information. Along with other cyber

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fortified security measures such as encryption algorithms, protected pairing between apparatuses and device setup aids against threats aiming to breach the personal health information of the user.

- **Connectivity via IoT:** With the incorporation of MediDose, MediBox, healthcare systems, and Wi-Fi/Bluetooth*, the healthcare providers are able to monitor the patients from a distance in real-time. This is crucial in tracking the health of the patients, monitoring their adherence to medication protocols, and optimizing the patient's well-being.

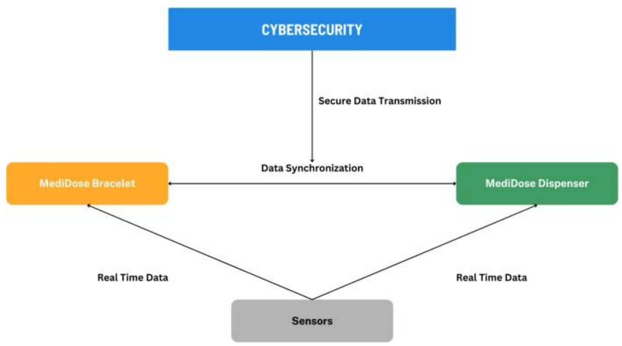

Figure 1: Basic Overview of MediDose and MediBox Communication Flow

2 Proposed System

2.1 MediDose (Bracelet

The MediDose bracelet circuit diagram illustrates how all the components work together for data transfer and health monitoring. The system comprises an ESP32 WiFi-enabled microcontroller as the processing unit, which controls all sensor data and connections. The temperature sensor, which is attached to the ESP32 via a 10kΩ resistor (R3), accurately measures body temperature. To the right, two 4.7kΩ resistors (R1 and R2) allow the free flow of signals to and from the ESP32 and the MAX30100 pulse oximetry and heart rate sensor module, interfacing through I2C communication, thus ensuring proper pull-up signaling. Power management is handled by a 3.7V lithium battery (BAT2) which is connected to the

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left charging module with a USB port for easy recharging. Table 1 comprises the details of key components of MediDose Bracelet.

MediDose Bracelet Component Details

Figure 2:

Figure 3:

At the bottom of the circuit, there is a switch that the user can toggle to turn the device on or off. Figure 2 shows the circuit design of the MediDose wristband can monitor vital signs continuously while maintaining a wireless link to transmit the data to the MediBox system or to medical personnel.

2.2 MediBox (Dispenser

The MediBox dispenser circuit schematic integrates many electronic parts, with Arduino

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UNO (ARD1) microcontroller as the primary component. The display provides feedback on

Figure 4:

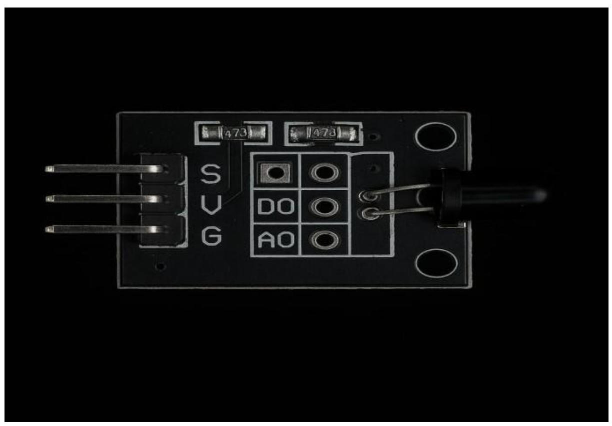

Figure 5:

Figure 6:

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Table 1:

Component	Function	Key Features	Connection/ Ports	Integration in MediDose	Figure
ESP32 Module	Microcontroller with Bluetooth & Wi-Fi	Dual-core, 520 KiB RAM, 160–240 MHz, deep sleep mode (10 μA), metal-shielded chip, cryptographic hardware	Micro-USB, GPIO (_IO_, _TX_, _RX_), Antenna trace	Acts as CPU: wireless communication, sensor data collection, power management; transmits data to MediBox	
MAX30102	Biometric sensor for heart rate and SpO2	Pulse oximetry, heart rate monitoring, yellow ceramic capacitors, SMD resistors, I2C interface	VIN, SCL, SDA, INT, RD, GND	Measures heart rate & blood oxygen; transmits vitals to MediBox and medical personnel	
DS18B20	Digital temperature sensor	-55°C to +125°C, $\pm$0.5°C accuracy, 9-12 bit resolution (digital), 12 bit (analog), 0.0625°C precision, 4.7 kΩ pull-up resistors	S (signal), V (voltage), G (ground)	Continuously monitors body temperature, alerts user on abnormalities	
MH-107 (TP4056)	Charging module for 3.7V battery	Constant-current/constant-voltage charging, overcharge/discharge protection, 1A charging (R3 resistor), mini-USB input	B+/B- (battery), OUT+/OUT- (load), mini-USB	Manages battery charging and power regulation in MediDose bracelet	
3.7V LiPo Battery	Power source	Compact, lightweight, 15–20g, built-in protection circuit, fast charging, approx. 500 cycles	Red (positive) and Black (negative) wires	Powers ESP32 and sensors for a day; maintains slim form factor	
MIFARE 13.56MHz RFID Key Fob	Passive transponder for identification and prescription sharing	No internal power, powered by electromagnetic field, integrated NFC chip and antenna, blue plastic case	Contactless via PN532 reader	Enables secure patient ID and prescription sharing with MediBox	

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Figure 7:

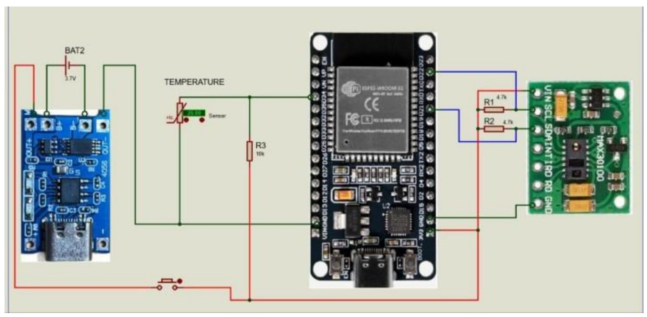

Figure 8: Circuit Diagram of MediDose (Bracelet)

system status and medication schedule through an I2C LCD panel (LCD1) which is situated at the upper left section of the system. The bottom left corner hosts a DS3231 Real-Time Clock module (RTC1) which keeps accurate clocks for the timetable medicine dispensing and retains functionality even with power disruptions. Central red module contains PN532 NFC Reader which transfers information regarding the prescriptions and identifies users by scanning RFID tags. Four LED indicators (D1–D4) provide visible indication for different system states. The DF Player Mini module (NMCU1) that sits beneath the SIM800L GSM module links to a speaker (LS1) which provides audible voice prompts and reminders. At the same time, the SIM800L GSM (NMCU1) module to the right sends SMS notifications to caregivers and patients. User input and manual control are provided by the five switches located on the left side. Table 2 comprises the details of key components of MediDose Bracelet.

MediBox System Component Details

As displayed in Figure 9, MediBox aids users to synchronize the time, alarms, and other communication functions to improve medicine adherence. Every component of the system

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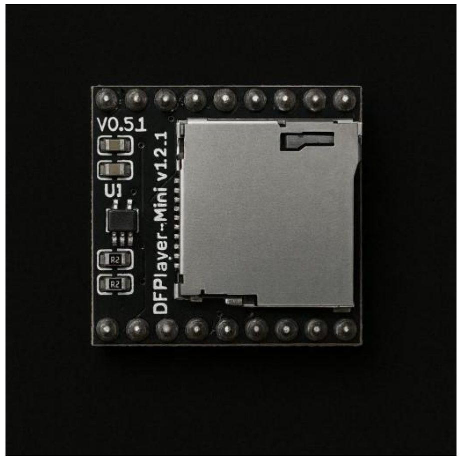

Figure 9:

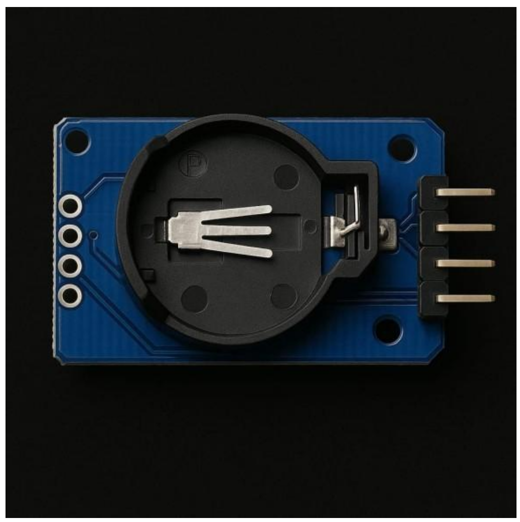

Figure 10:

Figure 11:

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Table 2:

Component	Function	Key Features	Connections/Ports	Integration in MediBox	Figure
PN532 NFC Module	NFC reader/writer	13.56MHz, red PCB, white octagonal outline, 5–7 cm range	SCK, MOSI, MISO, VCC, GND, IRQ, RSTO	Reads NFC tags for prescription sharing and patient identification	
ESP8266 Module	Wi-Fi communication module	Enables internet connectivity and remote patient monitoring	Wi-Fi	Sends patient reports via email to medical professionals	
SIM800L GSM Module	Cellular communication module	Quad-band 2G, gold spring antenna, 3.7–4.2V, low power sleep mode	Power, GND, RX, TX	Sends SMS reminders for medication without internet	
Arduino UNO	Microcontroller board	ATmega328P, 32KB flash, 2KB SRAM, 16MHz crystal, USB and barrel jack	0–13 (digital), A0–A5 (analog), USB, power jack	Main controller: handles scheduling, dispensing, monitoring, warnings	
16x2 LCD Module	Display unit	16 characters x 2 lines, green PCB, I2C interface, low power	16-pin header, I2C	Displays medication info, dose status, system alerts	
Green LED Indicators	Visual status indicators	5mm dome LEDs, 2–3V DC, 520–530nm green color, low power	Direct pin connections	Show system power, medicine delivery, and device communication	
Tactile Push-buttons	User interface controls	Red buttons on white housing, mounted on brown perfboard	Perfboard-mounted, standard switch connections	Allow schedule setup, menu navigation, emergency activation	
3W Speaker	Audio output device	50mm diameter, 8 Ohm, paper cone, moderate loudness, voice clarity	Wired to DFPlayer Mini	Plays voice alerts, greetings, and system sounds	
DS3231 RTC Module	Time-keeping module	CR2032 battery backup, ±2ppm accuracy, 12/24h, calendar tracking	VCC, GND, SDA, SCL (I2C)	Ensures accurate timekeeping during power outages	
DF-Player Mini v0.51	MP3 audio module	MicroSD slot, supports MP3/WAV, 3.3–5V, up to 32GB storage	Serial interface, 18-pin header	Plays audio messages from stored files using Arduino	

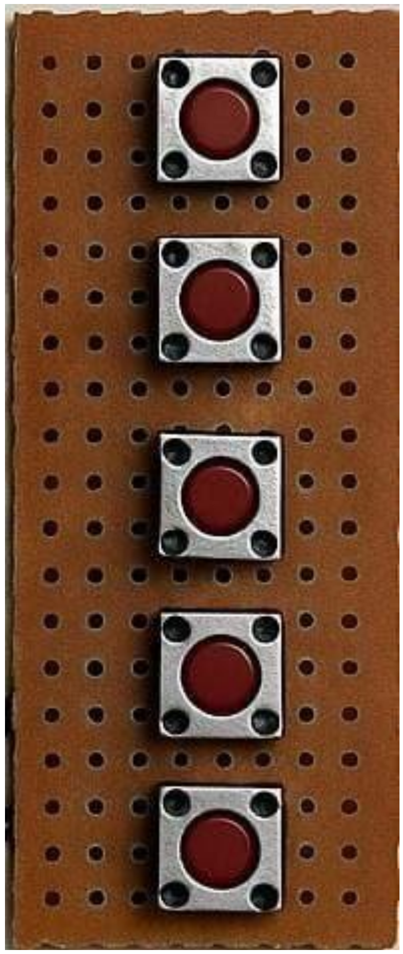

Figure 12:

Figure 13:

is connected using green, pink, and blue wires which indicate the type of signal.

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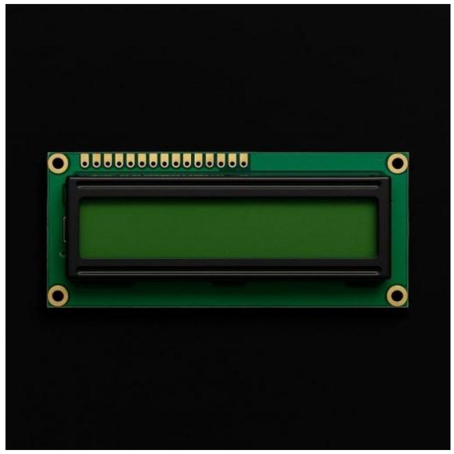

Figure 14:

Figure 15:

Figure 16:

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Figure 17:

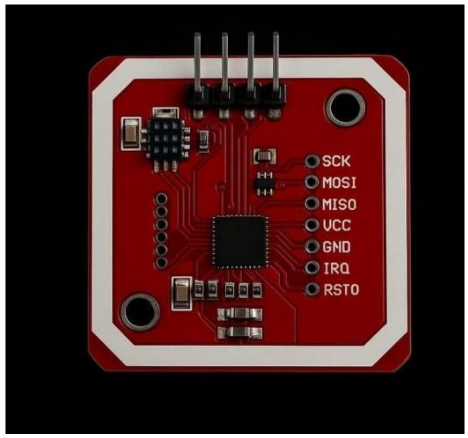

Figure 18:

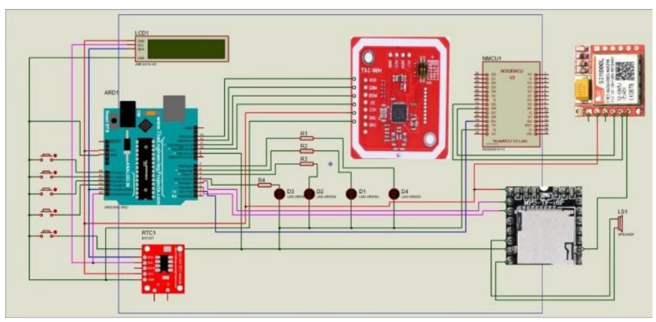

Figure 19: 9: Circuit Diagram of MediBox (Dispenser)

3 Working System

To propose a mathematical model based on the integration of Near Field Communication (NFC) and Internet of Things (IoT) technologies in chronic disease management through medication adherence and remote monitoring, we can derive key equations that represent the interactions between the various components of the MediDose and MediBox systems as shown in table 3. This model will encompass medication adherence, real-time monitoring, and data security.

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Table 3: **3:** Key Variables and Domains for System Modelling

Variable	**Description**	**Domain/Range**
M	Total number of medications prescribed	M∈Z+M \in \mathbb{Z}^+M∈Z+ (Positive integers)
Ai	Adherence level for medication iii	Ai∈[0,1]Ai \in [0, 1]Ai∈[0,1] (Fraction or percentage)
Ri	Reminder effectiveness for medication iii	Ri∈[0,1]Ri \in [0, 1]Ri∈[0,1] (Fraction or percentage)
C	Compliance rateof patients	C∈[0,1]C \in [0, 1]C∈[0,1] (Fraction or percentage)
V	Vital signs monitored (e.g., heart rate, blood oxygen)	Set of variables for monitored vitals (e.g., V={V1,V2,...,Vn}V = \{V_1, V_2, ..., V_n\}V={V1,V2,...,Vn})
D	Data security level	D∈[0,1]D \in [0, 1]D∈[0,1] (Fraction or percentage; higher is more secure)

3.1 Medication Adherence Model

The adherence level for each medication can be modeled as:

$Ai = Ri \times C$

Where:

$Ri = f(t, p)$

t: time of reminder (in hours).

p: patient engagement level (on a scale from 0 to 1).

This function indicates that adherence is influenced by both the timing of reminders and the patient's engagement level.

3.2 Overall Compliance Rate

The overall compliance rate can be expressed as:

$$C = \frac{1}{M}\sum_{i=1}^{M} Ai$$

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This equation averages the adherence levels across all medications to provide a comprehensive compliance measure.

3.3 Vital Signs Monitoring

The real-time monitoring of vital signs can be represented as:

$V(t) = g(h,s)$

Where:

h: health parameters being monitored (e.g., heart rate, blood oxygen).

s: sensor accuracy (on a scale from 0 to 1).

This function reflects that the monitored vital signs are dependent on both the health parameters and the accuracy of the sensors used in devices like MediDose.

3.4 Data Security Model

Data security during transmission can be modeled using an encryption effectiveness factor:

$D = e-\lambda t$

Where:

e: base of natural logarithm.

λ: security degradation rate due to potential cyber threats.

t: time duration of data transmission.

This equation indicates that as time increases, the effectiveness of data security decreases exponentially unless countermeasures are applied.

3.5 Combined Effectiveness Model

Finally, we can combine these components into a single effective model for chronic disease management:

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$$E = C \times V(t) \times D$$

Where:

E: overall effectiveness of the system in managing chronic diseases through adherence and monitoring.

This equation suggests that the overall effectiveness is a direct multiplication of compliance, real time monitoring mechanisms, as well as data security showing interaction among these factors for better patient care.

3.6 Flowchart Representation

The flow chart represented in figure 20 captures the operational flow of the MediDose Smart Bracelet and the MediBox Dispenser system with a specific focus on medication adherence, health parameters monitoring, and data management processes. Every single interaction that takes place in the flowchart detailing the MediDose Smart Bracelet and the MediBox system. Security, data processing and various computing systems are integrated to deliver efficient, secure healthcare.

3.6.1 System Start-Up

The workflow starts with turning on the MediDose smart bracelet and the MediBox dispenser. The ESP32 microcontroller's MediDose smart bracelet, along with Arduino Uno in the dispenser, powers all associated modules and gets ready for execution.

3.6.2 MediDose Smart Bracelet Operation

The MediDose smart bracelet can track user's medical indicators through built-in sensors:

- **MAX30100 Sensor:** Calculates heart rate and SpO2.
- **Body Temperature Sensor:** Monitors body temperature.
- **RFID Tag Chip:** Contains patient and prescription information which can be shared safely.

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- **Switch:** Facilitates the users to turn the device ON or reset it manually.
- **Battery Management:** A 3.7V LiPo cell serves as the power source and is charged using MH-107 TP4056 module.

MediBox and web interface users receive data from the smart bracelet's sensors through ESP32. In the event critical health indicators are met, warning will be issued from the bracelet.

3.6.3 Data Transmission and Security

All data exchanged between the MediDose bracelet, MediBox, and web interface is encoded using Base64 to ensure safe transmission and prevent data corruption. User authentication and role-based access control are implemented so only authorized patients, caregivers, or healthcare providers can access sensitive health information.

3.6.4 MediBox Dispenser Functionality

The MediBox dispenser, powered by Arduino Uno and ESP8266, receives health data and medication schedules:

- **RTC Module:** Maintains accurate timing for medication dispensing.
- **DF Player Mini & 3W Speaker:** Provides audio alerts and voice reminders for scheduled medication times.
- **I2C LCD Display:** Shows real-time health data, medication schedules, and system status.
- **GSM Module (SIM800L):** Sends SMS reminders and alerts to the user's phone.
- **PN532 NFC Module:** When the user scans their RFID tag, the system automatically sends the health report or prescription as a text file directly to the specified email address, ensuring secure and immediate data sharing.
- **LED Indicators:** Visually signal system status, medication dispensing, and communication events.
- **Switches/Buttons:** Allow the user to set medication times, navigate menus, confirm

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actions, and stop alerts.

3.6.5 Real-Time Monitoring and Alerts

The MediBox processes incoming data, monitors medication adherence, and provides timely reminders. If a scheduled dose is missed or abnormal vital signs are detected, the system:

- Activates audio-visual alerts via the speaker and LEDs.
- Sends SMS notifications to the user and, if necessary, to caregivers or healthcare providers.
- Updates the web interface/dashboard with real-time status.

3.6.6 Secure Data Storage and Sharing

All health and adherence data are securely stored in an encoded database. For enhanced security and privacy, when the user scans their RFID tag at the MediBox' s PN532 module, the system immediately sends the health report or prescription as a text file directly to the designated email address, eliminating intermediate storage or manual sharing steps.

3.6.7 Analytics and Provider Interface

The web interface/dashboard aggregates data for analysis, displaying trends in vital signs, adherence rates, and alert history. Healthcare providers can securely access this dashboard to monitor patient status and intervene if needed.

3.6.8 System End/Reset

After all scheduled tasks—such as dispensing medication, sending notifications, and updating records—are completed, the system returns to standby mode, ready for the next cycle. Manual reset is also possible via the bracelet or dispenser switch.

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4 Results

MediDose and MediBox form a comprehensive system that promotes medication adherence and continuous health management through NFC technology, real-time data, and robust security. Its expected performance and security attributes are outlined based on literature and industry practices.

Jyoti's assigned pictures (Figure 21 to 32) demonstrate the functionality and tracking of a health management system tailored for her specific needs. Results confirm the accomplished deployment and functioning of two Internet of Things modules: an ESP82666-based smart medication reminder system and an ESP32 driven health monitoring and alert system. Initiated self-adjusting email reminders for Jyoti were accomplished due to the wireless connection of the ESP32 enabled IoT system to the Wi-Fi network and successful authentication to Gmail SMTP server. The system confirms creation and delivery of a patient report titled "Jyoti_Report.txt," proving delivery on April 13, 2025, at 2:03 PM. Verifiable details such as the entire medical profile of the patient which includes prescribed medicines and details of the last clinical consultation were found in the report. The real time monitoring interface displayed Jyoti's heart rate, body temperature, and SpO_2 levels. The first readings displayed an SpO_2 of 0% with a low heart rate and normal temperature.

Later observations indicated that the vitals had stabilized, showing SpO_2 levels reaching up to 95%, along with temperature and heart rate within standard thresholds. When Jyoti's temperature and heart rate elevated to 94% SpO_2, the system triggered an alert recommending urgent medical attention. In this case, systems detecting reading fluctuations like elevated temperature accompanied by elevated heart rate were responsible for this alert. Concurrently, the testing was successful for the Smart Medicine Reminder module based on ESP8266. Upon obtaining a Wi-Fi connection, the system was able to check the current time and calculate the proper medication schedule. The system, during the test, recognized nighttime and issued an automated reminder, "Take your night medicine."

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This message was transmitted through SMS using a cloud-based messaging module or

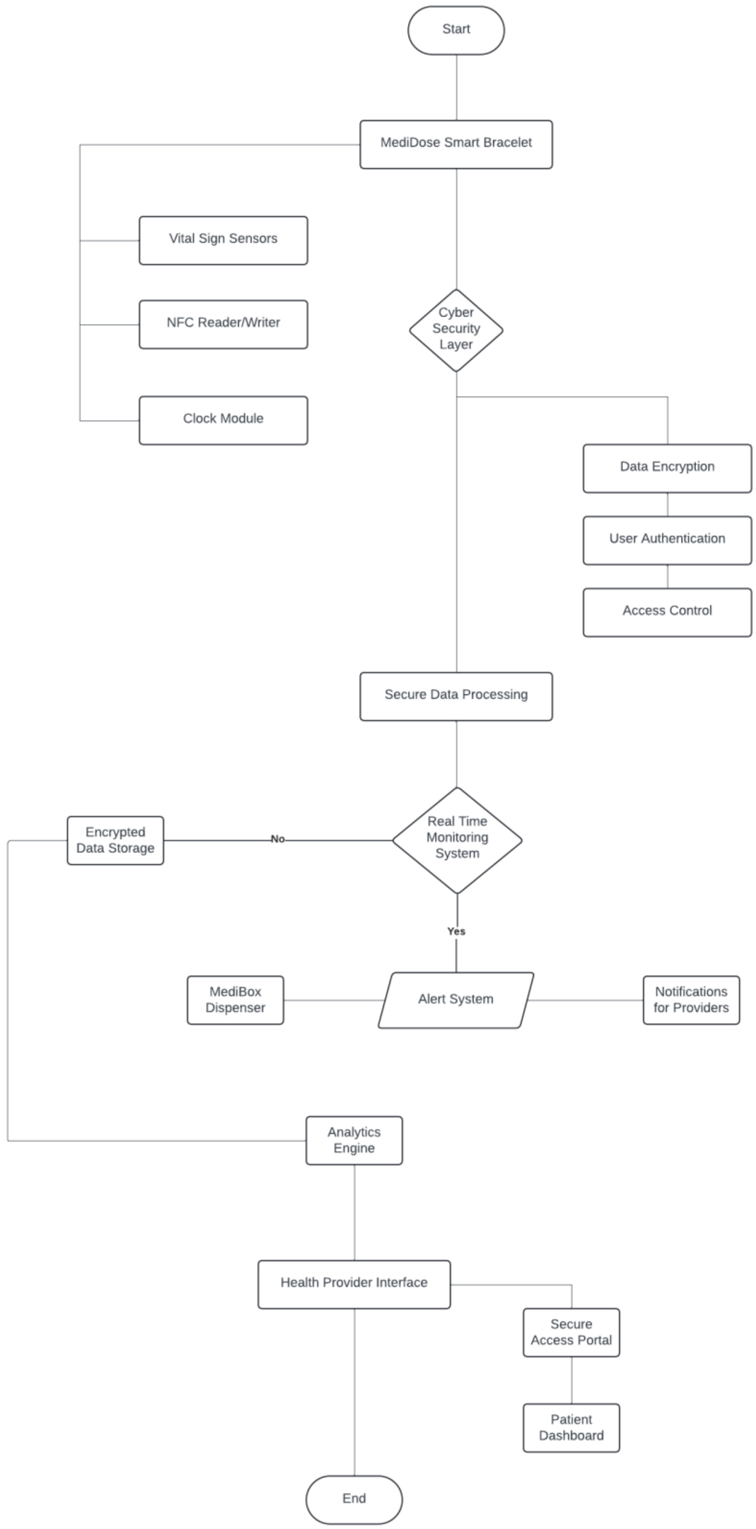

Figure 20: Workflow of the Model

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integrated GSM. For ensuring successful transmission, statuses "Sending SMS..." and "SMS Sent. . . " were recorded. A screenshot of the sent SMS helped verify the reliability and functionality of the system, which, in paraphrasing, confirmed these claims.

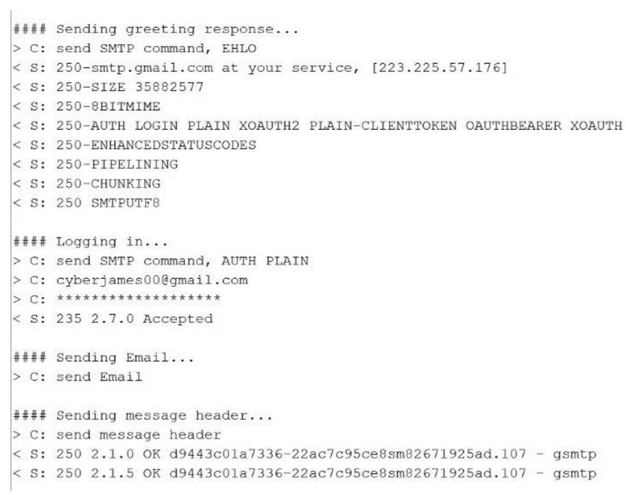
The automated, intelligent health monitoring system proves to be efficient and provides seamless patient care by these findings.

```
WiFi connected.
IP address: 192.168.245.74
.
Current time: Sun Apr 13 14:03:31 2025

--------------------------
Morning =
Afternoon =
Night =
Name = JYOTI
--------------------------
WELCOME JYOTI
#### Connecting to SMTP server...
> C: ESP Mail Client v3.4.24
> C: connecting to SMTP server
> C: Host > smtp.gmail.com
> C: Port > 465

#### SMTP server connected
> C: SMTP server connected, wait for greeting...
< S: 220 smtp.gmail.com ESMTP d9443c01a7336-22ac7c95ce8sm82671925ad.107 - gsmtp
```

Figure 21: ESP32 IoT Device successfully connected to WiFi and Gmail SMTP server, ready to send automated email notificationsto user JYOTI



```
#### Sending greeting response...
> C: send SMTP command, EHLO
< S: 250-smtp.gmail.com at your service, [223.225.57.176]
< S: 250-SIZE 35882577
< S: 250-8BITMIME
< S: 250-AUTH LOGIN PLAIN XOAUTH2 PLAIN-CLIENTTOKEN OAUTHBEARER XOAUTH
< S: 250-ENHANCEDSTATUSCODES
< S: 250-PIPELINING
< S: 250-CHUNKING
< S: 250 SMTPUTF8

#### Logging in...
> C: send SMTP command, AUTH PLAIN
> C: cyberjames00@gmail.com
> C: *******************
< S: 235 2.7.0 Accepted

#### Sending Email...
> C: send Email

#### Sending message header...
> C: send message header
< S: 250 2.1.0 OK d9443c01a7336-22ac7c95ce8sm82671925ad.107 - gsmtp
< S: 250 2.1.5 OK d9443c01a7336-22ac7c95ce8sm82671925ad.107 - gsmtp
```

Figure 22: ESP32 online: WiFi and Gmail SMTPconnected; email ready for JYOTI.

5 Limitations:

Despite its promising features, the MediDose and MediBox system requires further validation

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to establish its effectiveness and robustness. Key limitations include the need to measure

```
#### Sending message body...
> C: send message body
< S: 354 Go ahead d9443c01a7336-22ac7c95ce8sm82671925ad.107 - gsmtp

#### Sending attachments...
> C: send attachments

#### Jyoti_Report.txt
> C: Jyoti_Report.txt
> C: [                ] 0 %
> C: [#               ] 10 %
> C: [##              ] 15 %
> C: [###             ] 20 %
> C: [####            ] 25 %
> C: [#####           ] 35 %
> C: [######          ] 40 %
> C: [#######         ] 45 %
> C: [########        ] 50 %
> C: [#########       ] 60 %
> C: [##########      ] 65 %
> C: [###########     ] 70 %
> C: [############    ] 75 %
> C: [#############   ] 85 %
> C: [##############  ] 90 %
> C: [############### ] 95 %
> C: [################] 100 %
```

Figure 23: Automated report "Jyoti_Report.txt" successfully sent with email.

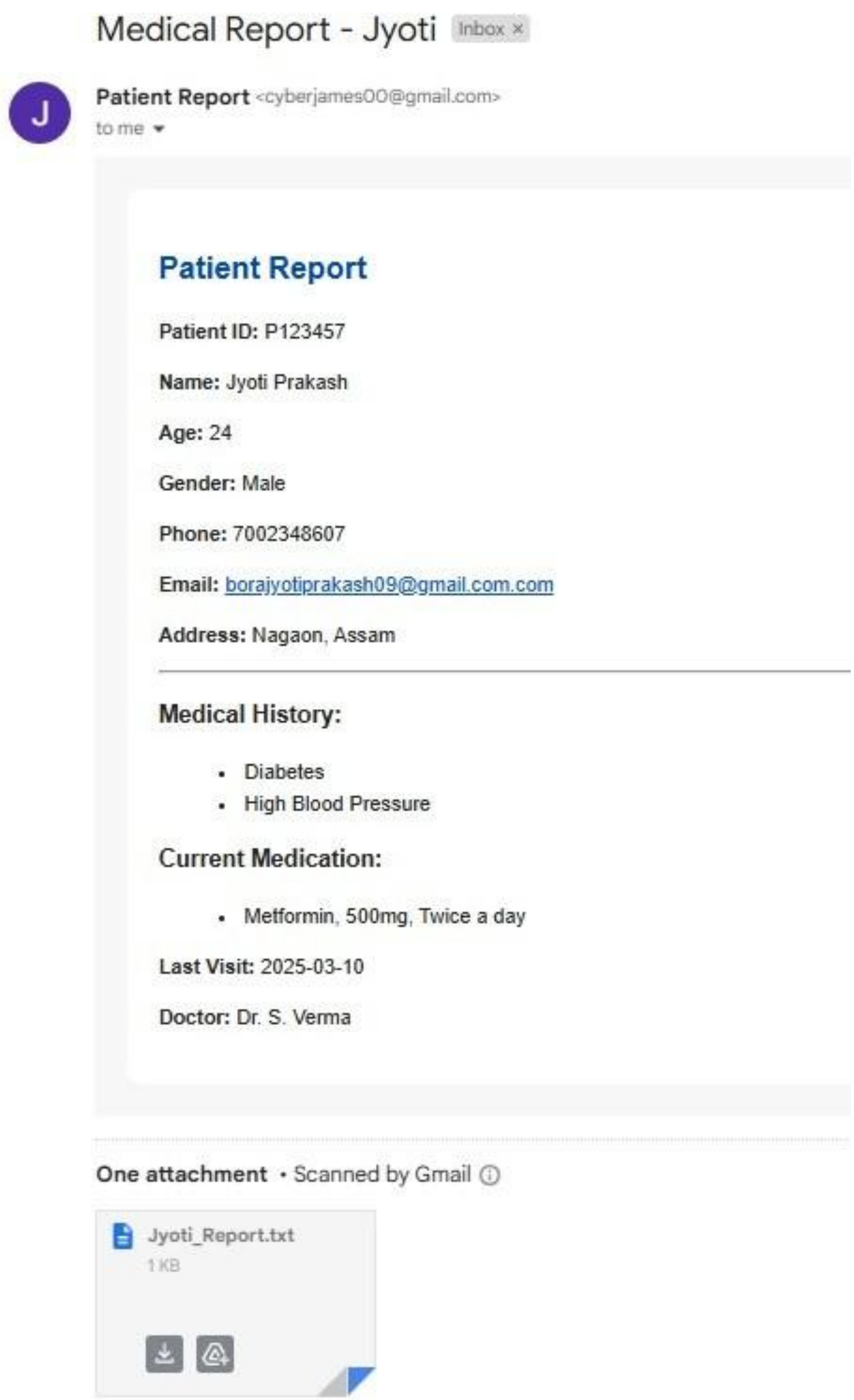
```
#### Finishing the message sending...
> C: finishing the message sending
< S: 250 2.0.0 OK  1744553021 d9443c01a7336-22ac7c95ce8sm82671925ad.107 - gsmtp

#### Closing the session...
> C: terminate the SMTP session

#### Message sent successfully
> C: message sent successfully

----------------
Messages Sent Successfully: 1
Messages Failed: 0
----------------

Message No: 1
Status: Success
Date/Time: 2025/4/13 14:3:39
```

Figure 24: Email sent successfully

actual medication adherence rates in real-life scenarios, assess the satisfaction scores of participants in clinical trials, and evaluate the enduring credibility of the integrated system over extended use. Additionally, the system's reliability heavily depends on the battery's performance, which must be tested across various usage scenarios to ensure consistent operation. Addressing these limitations will be critical for broader adoption and trust in the system.

6 Conclusion

The Health Monitoring and Smart Medicine Reminder System Using IoT Technology has been tested, designed, and implemented utilizing the ESP32 and ESP8266 microcontrollers.


Medical Report - Jyoti Inbox ×

Patient Report <cyberjames00@gmail.com>
to me

Patient Report

Patient ID: P123457

Name: Jyoti Prakash

Age: 24

Gender: Male

Phone: 7002348607

Email: borajyotiprakash09@gmail.com.com

Address: Nagaon, Assam

Medical History:

- Diabetes
- High Blood Pressure

Current Medication:

- Metformin, 500mg, Twice a day

Last Visit: 2025-03-10

Doctor: Dr. S. Verma

One attachment • Scanned by Gmail

Jyoti_Report.txt
1 KB

Figure 25: Jyoti's patient report is here, detailing medical history, current medications, and

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last visit information.

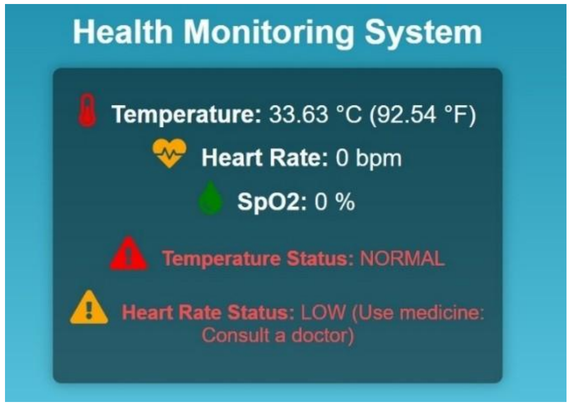

Figure 26: Health Monitoring System showing temperature at 33.63 °C, Heart Rate at 0 bpm and SpO2 at 0%. Temperature status is normal, but Heart Rate is low.

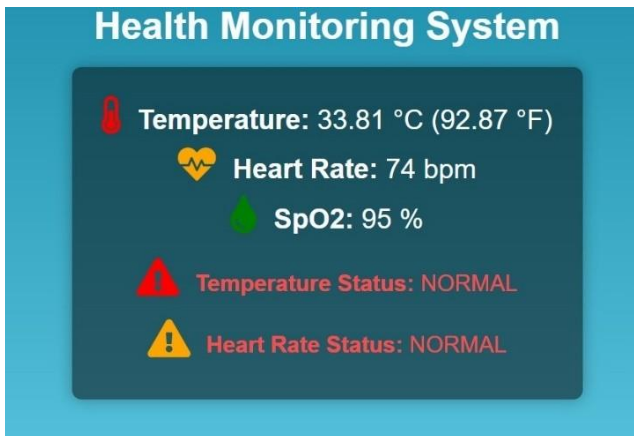

Figure 27: Vitals check: Temp and heart rate are normal. SpO2 is at 95%.

```
Connected to RAM
IP address: 192.168.245.153
HTTP server started
Initializing pulse oximeter...SUCCESS
Heart Rate: 0.00 bpm | SpO2: 0 %
Heart Rate: 0.00 bpm | SpO2: 0 %
Heart Rate: 0.00 bpm | SpO2: 0 %
Heart Rate: 0.00 bpm | SpO2: 0 %
```

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Figure 28: Pulse oximeter initialized with HTTP server, but heart rate and SpO2 at 0.

```
Beat detected!
Heart Rate: 5.63 bpm | SpO2: 0 %
Beat detected!
Heart Rate: 12.61 bpm | SpO2: 0 %
Beat detected!
Beat detected!
Beat detected!
Beat detected!
Beat detected!
Heart Rate: 210.40 bpm | SpO2: 94 %
```

Figure 29: Heart Rate readingsfluctuated wildly, but SpO2 stabilized at 94%.

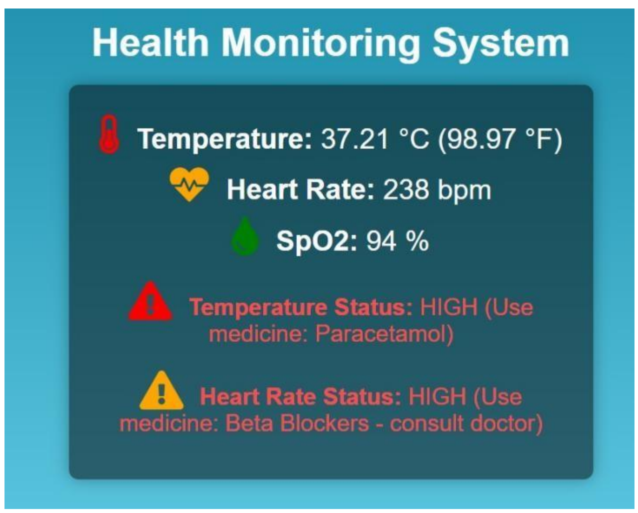

Figure 30: Alert: High temperature and heart rate detected! SpO2 at 94%. Consult your doctor.

The system accomplished real-time tracking of health parameters such as temperature, heart rate, and SpO_2, while also smartly alerting users with email notifications and SMS reminders.

With the aid of the health module in ESP32, caregivers and doctors can now monitor the health status of patients through the Gmail SMTP Patient Report System Mail which shows patient reports sent in real-time as illustrated in figure 32. The ESP8266-based medication

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reminder unit in figure 34 also aided in reducing the risk of missed doses by telling the patient

```
WiFi connected.
IP address: 192.168.245.74
.
Current time: Sun Apr 13 14:23:40 2025


--------------------------
Morning =
Afternoon =
Night = Night
Name =
--------------------------
Take your night medicine
Sending SMS...
SMS Sent...
```

Figure 31: ESP8266-Based Smart Medicine Reminder System: Automatically detects time, sends timely SMS alerts, and ensures medication is never missed.

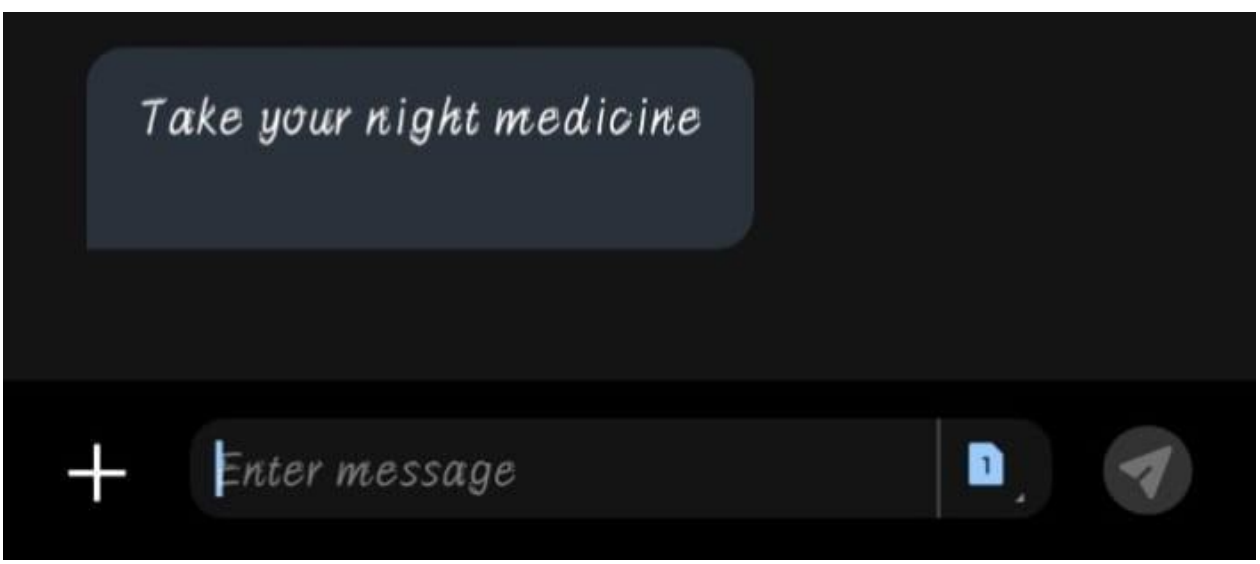

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Figure 32:   Figure 32: Automatically detects time and sends personalized SMS reminders like:'Take your night medicine' ensuring you never miss a dose, even when you forget!" the exact time using SMS according to a preset schedule.

The system proved to be dependable and showed the potential to greatly enhance patient care especially for those elderly or chronically ill patients who require constant monitoring and adherence to medication.

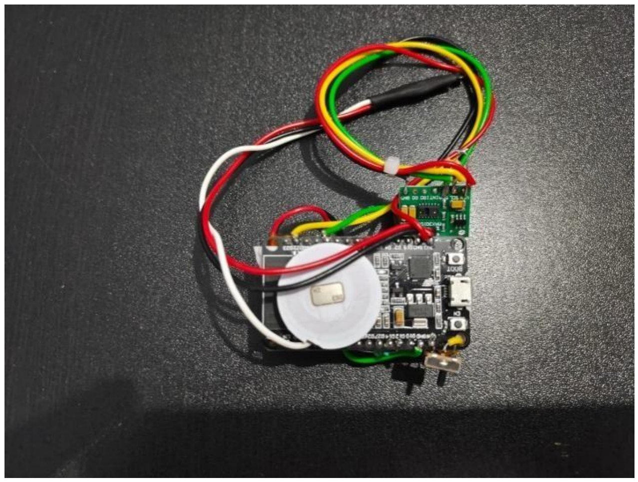

Figure 33: MediDose

Figure 34:

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The MediBox system can be significantly enhanced through the integration of a dedicated mobile application for Android and iOS, offering patients and caregivers real-time access to

Figure 35: MediBox

health reports, a dynamic dashboard of vital signs, and timely alerts. To ensure secure and scalable data management, cloud-based platforms like AWS IoT or Firebase should be implemented, allowing not only the safe storage of patient records but also the ability to track historical data trends. For visually impaired or elderly users, voice notifications can provide essential reminders and updates, promoting medication adherence and safety. An automated emergency response mechanism should be included to immediately alert caregivers or medical professionals via call or SMS if critical vital thresholds are breached. Battery optimization features such as low-power modes and efficient energy management are essential for reliable operation in remote areas with limited access to power. Additionally, the system should be capable of monitoring multiple patients simultaneously, enabling healthcare providers in assisted living facilities or hospitals to oversee several users from a centralized interface. Lastly, integrating AI-powered health forecasting using machine learning algorithms would enable proactive risk assessment and early detection of potential health issues.

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