

# Medi-Sense: Smart Medication Management with Health and Emotion Monitoring

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**Abstract**—The Medi-Sense system combines a smartwatch and mobile app to support elderly and chronically ill patients through smart medication reminders, real-time health tracking, and emotional monitoring. Using an ESP32 microcontroller, the smartwatch collects data from GSR, heart rate, oxygen, and vibration sensors. Data is sent to Firebase for live analysis, with alerts triggered for abnormal vitals or stress. The app visualizes live data, alerts caregivers, and provides mental health tips. Personalized medicine reminders are sent to the watch, which responds with a vibration and OLED display prompt. This low-cost, user-friendly system improves medication adherence, health insights, and caregiver communication.

**Index Terms**—Smart Health Monitoring, Wearable Devices, Medication Adherence, Emotion Monitoring, GSR Sensor, Heart Rate Variability, IoT-based Healthcare, Firebase Realtime Database, ESP32 Microcontroller, Android Health Application, Stress Detection, Elderly Care Technology, Real-time Notifications, Mental Health Tracking, Vibration Alert System

## I. INTRODUCTION

The rise in chronic illnesses and aging populations has emphasized the need for personalized, real-time healthcare solutions. Conventional healthcare systems often fail to provide timely interventions, especially in cases of irregular medication intake or undetected health fluctuations.

Medi-Sense addresses these issues through an integrated system combining a smartwatch prototype and a mobile application. Powered by an ESP32 microcontroller, it gathers data from sensors including a GSR sensor (for stress detection), pulse oximeter (for heart rate and oxygen), and a vibration sensor. This data is transmitted to Firebase cloud storage for real-time analysis.

The mobile app visualizes health metrics through live graphs and issues personalized medication reminders based on medical history, missed doses, and stress levels. If abnormalities are detected, alerts are sent to caregivers, enabling prompt action. In addition to physical health, Medi-Sense supports mental well-being by offering stress-reduction tips and emotional health insights.

With its modular design, cloud integration, and dual focus on physical and emotional monitoring, Medi-Sense offers a scalable, affordable, and user-friendly approach to enhancing patient care and supporting independent living.

## II. SYSTEM ARCHITECTURE

The proposed system, Medi-Sense, is a smart wearable-based solution that integrates real-time health monitoring, emotional state detection, and medication management for elderly and chronically ill patients. It consists of a four-layer architecture: the sensing layer collects heart rate, SpO<sub>2</sub>, and stress levels using biomedical sensors; the processing layer, powered by an ESP32 microcontroller, analyzes data and triggers alerts via an OLED display and vibration motor; the communication layer ensures secure data transmission to the Firebase cloud using Wi-Fi; and the application layer, built with Flutter, displays health metrics, manages medication schedules, and notifies caregivers of anomalies. Designed to be modular, energy-efficient, and user-friendly, Medi-Sense enhances patient safety, supports timely interventions, and improves treatment adherence through personalized, cloud-connected monitoring. Additionally, the system incorporates threshold-based alert mechanisms to promptly notify caregivers and healthcare providers of any abnormal readings. Its modular design allows for easy integration of additional sensors or features based on

individual patient needs. By combining wearable technology with cloud analytics, Medi-Sense offers a scalable and proactive approach to remote healthcare monitoring.

The architecture consists of five main layers:

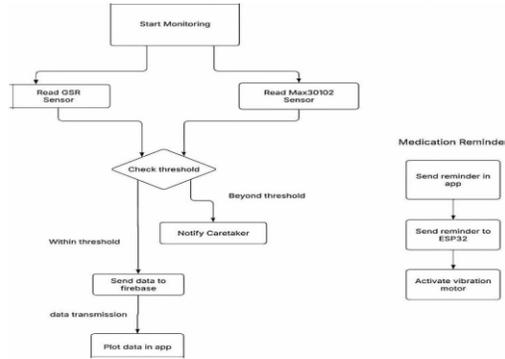


Figure 1: System Architecture

1. Sensing Layer: The sensing layer of the Medi-Sense system features biomedical sensors integrated into a wearable smartwatch to enable continuous monitoring of vital signs and emotional well-being. These sensors gather real-time physiological and behavioral data, which form the foundation for health tracking, emotional assessment, and early detection of medical issues. By capturing critical metrics directly from the body, the sensing layer ensures timely and accurate data acquisition, which supports the system’s overall goal of proactive healthcare management and intervention. The sensors used in this system include:

- MAX30102: Monitors heart rate and SpO<sub>2</sub> using photoplethysmography (PPG), providing insight into cardiovascular and respiratory health
- GSR Sensor: Measures electrodermal activity to detect emotional stress or anxiety, offering valuable data on the user's mental state.
- Vibration Sensor: Detects movement related to pillbox usage (optional), helping to monitor medication adherence patterns.

2. Processing Layer: The processing layer of the Medi-Sense system is managed by the ESP32 microcontroller embedded within the smartwatch. This layer is responsible for acquiring, analyzing, and responding to sensor data in real time. It ensures efficient local processing to reduce latency, enhances reliability during network disruptions, and provides immediate feedback to the user through visual and haptic alerts. Additionally, this layer manages power

consumption by activating components only when necessary, contributing to the device's overall energy efficiency. The ESP32’s dual-core capability also allows parallel execution of multiple tasks, ensuring smooth system performance without delays or data loss. which performs the following:

- Acquires real-time data from biomedical sensors for continuous monitoring of physiological and behavioral signals.
- Processes raw data, including noise filtering, smoothing, and detection of abnormal health metrics based on predefined thresholds.
- Displays health status and medication alerts on a compact OLED screen, making the system accessible and easy to use for elderly patients.
- Triggers haptic feedback using a vibration motor to alert users to emergencies or scheduled medication times, improving adherence and timely response.
- Manages energy efficiency by controlling sensor activity and display usage, ensuring longer battery life during continuous use.

3. Communication Layer: The communication layer is a vital component of the Medi-Sense system, enabling seamless and reliable data exchange between the wearable device, the cloud (Firebase), and the user’s mobile application. Managed by the ESP32 microcontroller, this layer supports both online and offline modes to maintain uninterrupted monitoring and data integrity. Through Wi-Fi and optional Bluetooth connectivity, the system ensures that real-time health data is continuously transmitted and synchronized, allowing caregivers and medical professionals to access up-to-date information regardless of the patient’s location. This capability enhances remote healthcare delivery, facilitates timely medical interventions, and supports long-term data analysis for improved treatment planning. The key features of this layer include:

- Wi-Fi Communication: Enables continuous uploading of sensor data to the Firebase Realtime Database for real-time cloud storage and monitoring.
- HTTP Protocols: Facilitates RESTful communication between the hardware and Firebase, supporting secure, structured, and scalable data exchange.
- Bi-directional Data Flow: Allows not only data upload but also reception of alerts, configuration settings, and reminders from the cloud or app.

- **Secure Communication:** Supports encrypted data transmission to protect user privacy and ensure the integrity of medical information

4. **Application & Cloud Layer:** The Application & Cloud Layer forms the user-facing and backend interface of the Medi-Sense system, enabling users and caregivers to interact with real-time health data and system features. At the front end, a Flutter-based Android application provides a responsive and user-friendly interface that supports seamless communication with the wearable device and the Firebase cloud. It ensures easy onboarding through Firebase Authentication, allowing secure access to personalized dashboards. The app visually represents health data through interactive charts and graphs, enhancing user awareness and enabling easy tracking of heart rate, SpO<sub>2</sub> levels, and stress trends over time.

- **Flutter-based Android Application:**
  - Authenticates users securely using Firebase Authentication.
  - Displays live graphs for HR, SpO<sub>2</sub>, and stress using MPAndroidChart, helping visualize trends and spot irregularities.
  - Issues real-time alerts for abnormal physiological readings and missed medications.
  - Sends medication reminders to the smartwatch based on predefined schedules or real-time health data conditions.
- **Firebase Cloud Backend:**
  - Stores and updates user vitals, medication history, and sensor logs in a secure and scalable environment.
  - Syncs medication reminders and system settings with the smartwatch for consistent functioning.
  - Manages notification triggers for caregivers or healthcare providers when abnormal thresholds are crossed.

5. **Alert & Feedback Layer:** The Alert & Feedback Layer is essential for closing the loop between data monitoring and user action. It provides immediate, multi-modal feedback through on-device alerts and caregiver notifications, ensuring both the user and their support network are informed in critical moments. The wearable device features an OLED display and a vibration motor, which serve as visual and haptic cues, respectively. These cues notify the user of events such as high heart rate, low SpO<sub>2</sub>, emotional stress, or medication times, even without checking the app. This is particularly beneficial for elderly

users or those with limited mobility or vision.

- **On-device Vibration & OLED Display:**
  - Acts as immediate haptic and visual feedback for users in case of critical alerts or scheduled medication.
  - Ensures non-intrusive yet effective communication, especially for users with hearing or cognitive challenges.
- **Push Notifications to Caregivers:**
  - Triggered when:
    - Medication is missed, reminding both users and caregivers for follow-up.
    - Heart rate or SpO<sub>2</sub> exceeds safe thresholds, prompting early intervention.
    - Emotional stress levels are abnormally high, signaling possible anxiety or panic attacks.
  - Enables remote monitoring and enhances communication between the patient and support network.

### III SENSOR OVERVIEW

1. **MAX30102:** The MAX30102 is a Photoplethysmography (PPG) sensor used to measure heart rate and blood oxygen level (SpO<sub>2</sub>). It works by using infrared and red LEDs to detect blood flow under the skin and is useful for tracking cardiovascular health and detecting conditions



Figure 1: MAX30102

2. **GSR Sensor:** The GSR Sensor (Galvanic Skin Response) is an electrodermal activity sensor that detects stress and emotional arousal by measuring skin conductance, which varies with sweat gland activity during emotional stress—providing insights into mental/emotional well-being.



Figure 2: GSR Sensor

3. Oximeter: The Oximeter integrated with MAX30102, measures blood oxygen saturation (SpO<sub>2</sub>) by analyzing light absorption in the blood and is useful for detecting breathing or respiratory issues, which is critical for elderly care.



Figure 3: Oximeter Sensors

4. OLED: The OLED Display (SSD1306 OLED, 128×64 resolution) is used to display real-time values like heart rate, SpO<sub>2</sub>, stress level, and alerts, helping users visually monitor their health on the device. Its high contrast and sharp resolution make it easy to read even in low-light conditions, which is especially beneficial for elderly users. The display provides instant feedback without needing to open the mobile app, making the device more user-friendly and accessible.



Figure 4: OLED Display

5. Vibration Motor: The Vibration Motor provides haptic alerts for medication reminders and warnings, ensuring that alerts are felt even if visual or auditory cues are missed—especially useful for elderly users.



Figure 5: Vibration motor

6. Microcontroller: These sensors are all connected to the ESP32 microcontroller, which acts as the central processing unit of the Medi-Sense system. It reads, processes, and analyzes real-time sensor data such as heart rate, SpO<sub>2</sub>, and GSR (stress level), and securely transmits this information to the Firebase cloud. The data is then synchronized with the Medi-Sense mobile application, allowing users and caregivers to view live health metrics, receive alerts, and track historical health trends. The ESP32 also controls the OLED display, showing on-device sensor readings, and activates the vibration motor for timely medication reminders or health alerts.

The advantages of using the ESP32 microcontroller include its built-in Wi-Fi and Bluetooth, which enable reliable wireless communication with cloud services and mobile devices. It supports multitasking, allowing simultaneous sensor reading, data processing, and user notification. Additionally, the ESP32 is cost-effective, energy-efficient, and compact—making it ideal for wearable health monitoring systems. Its high processing power and wide community support also contribute to faster development and easier integration of advanced features.



Figure 6: Microcontroller

7. Rechargeable battery: Rechargeable battery (e.g., Lithium-polymer), charging circuit, and power management IC. Powers the device, ensures optimal energy management, and promotes battery longevity. The system includes a safe recharging mechanism.



Figure 7: Lithium-polymer

#### IV IMPLEMENTATION

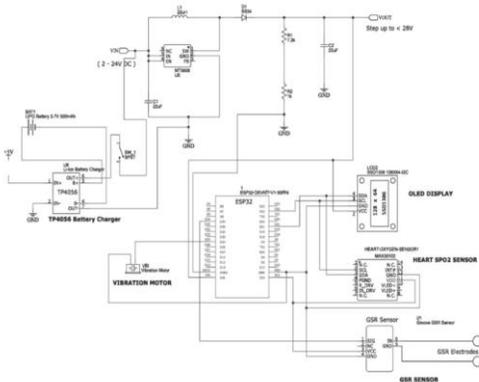


Figure 8: Circuit diagram

The Medi-Sense system is implemented using an ESP32 microcontroller which acts as the core processing and communication unit. The ESP32 is selected for its integrated Wi-Fi capabilities, low power consumption, and ability to interface with multiple health sensors. The hardware is designed as a wearable prototype that includes a MAX30102 sensor for real-time heart rate and blood oxygen (SpO<sub>2</sub>)

measurement, and a GSR (Galvanic Skin Response) sensor for monitoring stress levels based on skin conductance. The sensors are connected via I<sup>2</sup>C and analog pins on the ESP32, and data from these sensors is processed to determine the user's physiological and emotional state.

For user interaction and feedback, the system incorporates an SSD1306 OLED display and a miniature vibration motor. The OLED display, with a resolution of 128×64 pixels, provides clear visual output of health metrics and medication notifications, allowing the user to stay informed without accessing the mobile app. The vibration motor acts as a tactile alert mechanism, particularly helpful for users with hearing impairments or those in environments where audible alarms are impractical. The wearable device is powered by a rechargeable 3.7V 500mAh Li-Po battery. To manage charging and power conversion, a TP4056 charging module and MT3608 boost converter are integrated. The TP4056 ensures safe and efficient charging with overcharge and discharge protection, while the MT3608 boosts the battery voltage to the required levels for operating the ESP32 and peripheral sensors. This compact power management system supports continuous operation for several hours on a single charge, enhancing the usability and portability of the device.

Sensor data is locally processed by the ESP32. The firmware is programmed to read sensor values at regular intervals, compare them against predefined thresholds, and initiate appropriate actions. If a user's heart rate exceeds safe limits, SpO<sub>2</sub> levels drop below normal, or elevated stress is detected through GSR readings, the ESP32 triggers a local vibration alert and updates the OLED with a health warning. Simultaneously, the processed data is transmitted to the Firebase Realtime Database over Wi-Fi. Firebase serves as the cloud backend, storing health parameters, alert history, and medication logs. This real-time cloud integration allows seamless synchronization between the wearable device and the Android-based mobile application. The ESP32 also listens for medication reminder signals from the mobile app, enabling two-way communication. Upon receiving a reminder, the device activates the vibration motor and displays the medicine name, dosage, and timing, ensuring the user receives a clear and immediate prompt to take their

medication.

The mobile application, developed using Kotlin in Android Studio, retrieves health data and medication logs from Firebase and presents it to users and caregivers through an intuitive graphical interface. Live graphs for heart rate, SpO<sub>2</sub> levels, and stress indicators are rendered using the MPAndroidChart library, offering a real-time view of the user's health trends. Users can configure medication schedules, view historical health data, and receive personalized insights. The app also sends custom alerts to caregivers in case of abnormal readings or missed doses. These notifications are crucial for timely intervention, especially in the case of elderly patients or those under remote supervision. By allowing caregivers to monitor patient vitals remotely, the system bridges the gap between home care and clinical support. Furthermore, the app's integration with Firebase ensures that data is always up-to-date, even across multiple devices, enhancing reliability and accessibility.

The integration of hardware and software components in Medi-Sense is carefully optimized to ensure smooth and uninterrupted data flow across the system. The ESP32's multitasking capabilities allow simultaneous sensor polling, display updates, Wi-Fi communication, and vibration alerts without affecting system responsiveness. The firmware employs non-blocking code and interrupt-driven designs to minimize latency and reduce power consumption. On the cloud side, Firebase ensures high-speed data transactions, secure authentication, and real-time syncing, which is essential for health-critical applications. The modular structure of the codebase allows future extensions such as AI-based anomaly detection, integration with voice assistants for accessibility, and offline data caching during Wi-Fi unavailability. The compact design, lightweight build, and ease of use make the system practical for long-term daily use by elderly individuals or those with cognitive limitations.

Overall, the Medi-Sense implementation achieves a robust, scalable, and user-centered design that addresses both the physical and emotional health monitoring needs of modern healthcare. The Medi-Sense system demonstrates a successful integration of wearable hardware, real-time health monitoring, personalized medication management, and cloud-based data synchronization. By leveraging the

capabilities of the ESP32 microcontroller, biomedical sensors, OLED display, and vibration alerts, the system provides continuous tracking of vital signs and emotional states. Combined with a Firebase-connected mobile application, Medi-Sense enables users and caregivers to monitor health conditions proactively and receive timely alerts, ensuring safety, adherence, and improved well-being. The compact, energy-efficient design and scalable software architecture make Medi-Sense a practical and intelligent solution for modern healthcare challenges.

## V RESULT



Figure 9: Final prototype

The final prototype of Medi-Sense is a compact, wearable device that effectively combines health monitoring sensors, a display, and vibration alerts into a fully functional smart medication assistant.

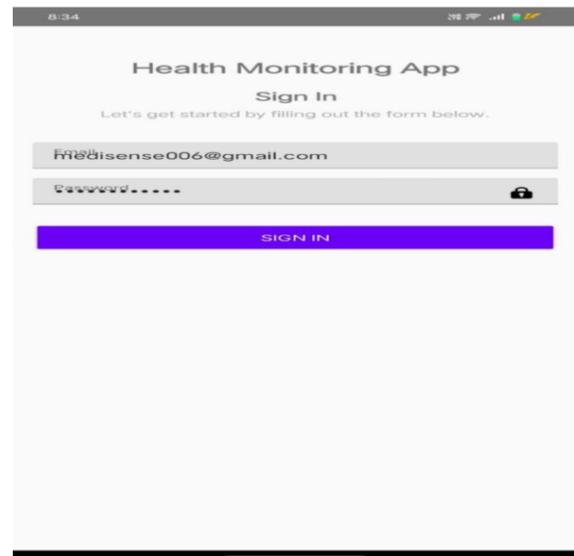


Figure 10: User Login Page

The Health Monitoring App User login interface was

successfully implemented, allowing users to authenticate using their credentials. As shown in Figure 10, the sign-in screen includes an email input field, a password field with a visibility toggle option, and a clearly visible Sign In button. This ensures a user-friendly experience for secure access to the application. The interface follows a minimalist design approach, with a clean and simple layout that enhances usability. The color scheme is designed to provide clear contrast, ensuring readability and ease of navigation.

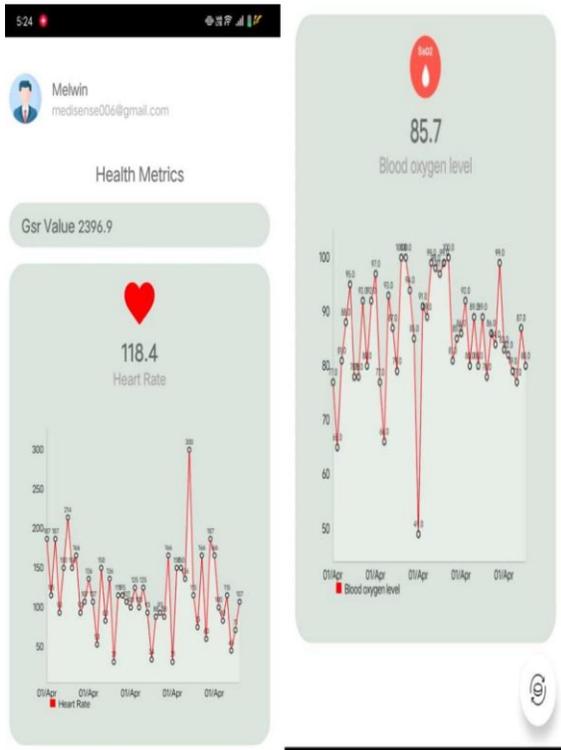


Figure 11: GSR,Heart Rate&Blood Oxygen Level

Figures 11 illustrate the GSR, heart rate, and SpO<sub>2</sub> levels, offering a clear picture of the user’s physiological and emotional health. A GSR value of 2396.9 indicates moderate emotional arousal, while a heart rate of 118.4 bpm exceeds the normal range, suggesting stress or physical strain. The SpO<sub>2</sub> level of 85.7% is critically low, pointing to possible respiratory issues. Fluctuations in these parameters highlight periods of stress, exertion, or recovery, emphasizing the importance of continuous monitoring for early detection of health risks and timely intervention.

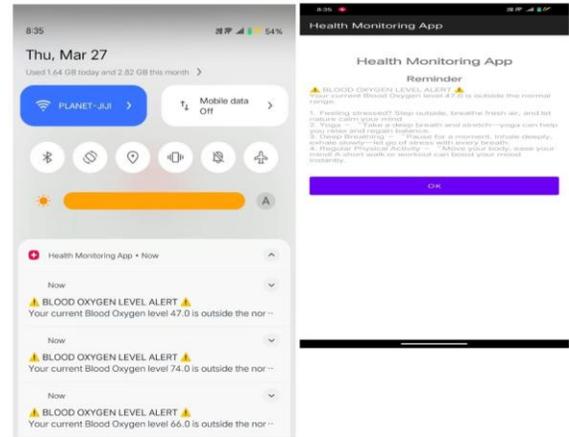


Figure 12: Notifications Figure & Recommendations

Figures 12 demonstrate the system’s real-time health alert and recommendation capabilities. When abnormal values in SpO<sub>2</sub>, heart rate, or GSR are detected, the system generates immediate alerts to ensure early intervention, reducing the risk of medical emergencies. Alongside these alerts, the system provides personalized recommendations—such as breathing exercises or going outdoors—to help users manage their condition effectively. This dual functionality enhances continuous health monitoring, promotes proactive care, and supports better outcomes for users, especially those under remote or chronic care.

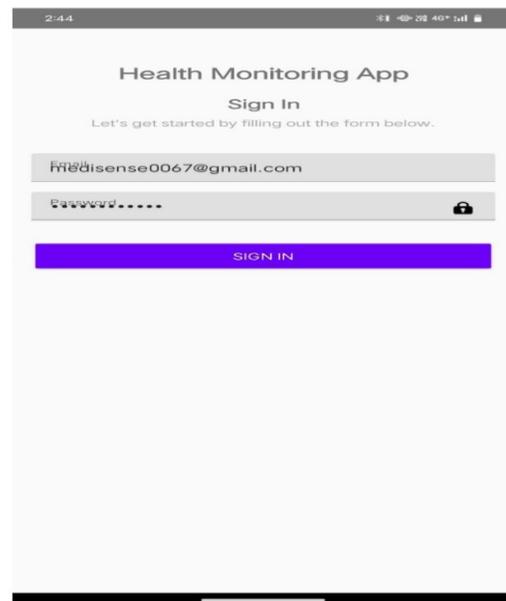


Figure 13: Care Taker Login page  
The Health Monitoring App Care Taker login interface

was successfully implemented, allowing users to authenticate using their credentials securely and efficiently. As shown in Figure 13, the sign-in screen includes essential elements such as an email input field, a password field with a visibility toggle option, and a prominently displayed Sign In button, ensuring a user-friendly and intuitive experience. The interface follows a minimalist design approach with a clean and structured layout that enhances usability, particularly for users with limited technical expertise. The color scheme provides strong visual contrast, ensuring optimal readability and ease of navigation across devices. The responsive design ensures compatibility with various screen sizes, offering a consistent user experience on smartphones and tablets. Error handling features, such as invalid input warnings and password mismatch prompts, further improve reliability and guide the user through smooth login operations. This secure and accessible interface serves as the entry point for caregivers to access patient data, monitor real-time health metrics, and receive critical alerts.

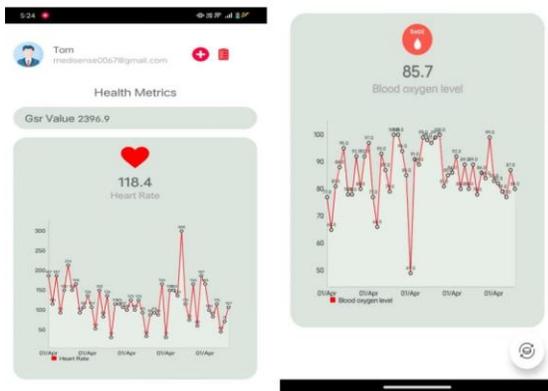


Figure 14: Care Taker Dashboard

Figures 14 illustrate the user’s physiological and emotional states through GSR, heart rate, and SpO<sub>2</sub> data. The GSR values fall within the expected threshold, indicating normal stress or relaxation responses over time. However, the heart rate reading of 118.4 bpm exceeds the normal range, with visible fluctuations suggesting periods of physical activity, stress, or potential cardiovascular strain. The SpO<sub>2</sub> level, recorded at a critically low 85.7%, points to possible oxygen deficiency, which may result from irregular breathing patterns or stress. These variations highlight the importance of continuous monitoring for early detection and timely intervention.

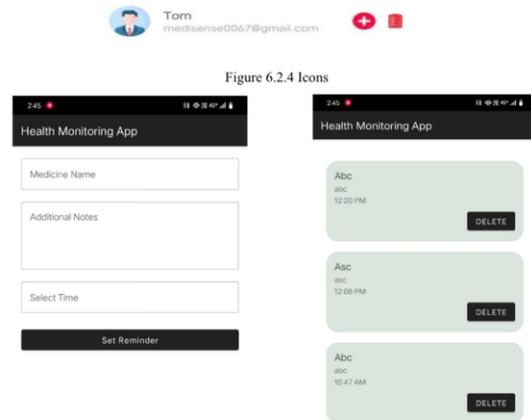


Figure 15: Medicine Reminder Setting & Medicine Lists

Figure 15 presents the Medicine Reminder Interface, allowing Care Takers to schedule and manage medication alerts. Users can input the medicine name, add dosage notes, set a reminder time, and confirm with the “Set Reminder” button. A list of active reminders is also displayed, showing relevant details with an option to delete entries. This feature ensures timely medication intake and supports effective prescription management, especially for patients with chronic conditions.

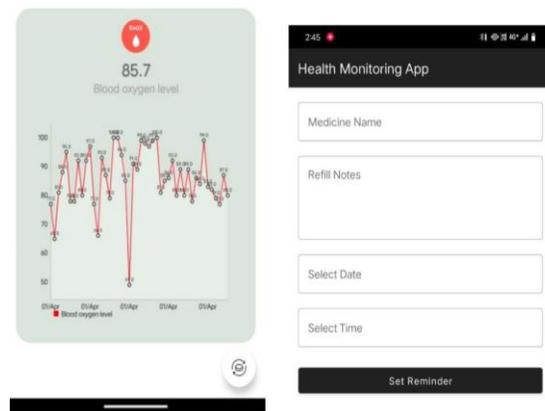


Figure 16: Refill Icon & Refill Settings

Figure 16 displays the Care Taker interface of the Health Monitoring App used to set medication refill reminders. The layout is simple and well-organized, with clear input fields and a confirmation button for ease of use. At the top, the title “Health Monitoring App” signifies its health-focused purpose. Below it,

the “Medicine Name” field allows users to enter the name of the medication requiring a refill, followed by a “Refill Notes” section for additional details like dosage instructions or pharmacy information. The “Select Date” and “Select Time” fields enable precise scheduling of the reminder. At the bottom, a prominently placed “Set Reminder” button confirms the entry and activates the alert. This interface is designed to ensure timely medication refills, promoting better prescription adherence and reducing the risk of missed doses.

## VI CONCLUSION

The Medi-Sense system presents a comprehensive and innovative solution for elderly individuals and chronically ill patients by integrating health monitoring and emotional well-being tracking into a single wearable device. By incorporating real-time tracking of vital health metrics such as heart rate, blood oxygen levels (SpO<sub>2</sub>), and skin conductivity (GSR), the system ensures that both patients and caregivers have continuous access to critical health data. Beyond physical health, Medi-Sense goes a step further by offering personalized medication reminders, significantly improving medication adherence and reducing the risks associated with missed doses.

Additionally, by monitoring stress and anxiety levels, the system provides valuable insights into the user's mental and emotional health, allowing caregivers and healthcare providers to intervene promptly if irregularities are detected. The system's adaptive alert mechanism, which responds dynamically to stress and anxiety fluctuations, introduces a holistic approach to patient care, ensuring not just physical well-being but also mental health stability.

This proactive healthcare solution helps in reducing hospital visits, enabling remote monitoring, and providing real-time insights, ultimately enhancing quality of life for patients while easing the burden on caregivers and healthcare facilities. With the increasing demand for remote healthcare solutions and AI-driven monitoring, the Medi-Sense system stands out as a reliable, user-friendly, and technologically advanced approach to modern healthcare management. Its potential for future enhancements,

such as AI-driven diagnostics, hospital integrations, and insurance-based healthcare support, makes it a versatile and scalable system poised to revolutionize patient care worldwide.

## VII ACKNOWLEDGMENT

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We also appreciate the contributions of our team members for their dedication and collaboration in designing and implementing the wearable health monitoring system and mobile application. Additionally, we acknowledge the efforts of researchers and developers whose work in wearable technology, IoT-based healthcare systems, and emotional monitoring inspired and informed our approach.

Finally, we extend our thanks to the institutions and organizations that provided resources, support, and encouragement for this project. Their support has been instrumental in developing an intelligent, real-time health monitoring solution that aims to enhance medication adherence and overall well-being, especially for elderly and chronically ill patients.

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