Journal of IoT in Social, Mobile, Analytics, and Cloud (ISSN: 2582-1369)
www.irojournals.com/iroismac/

A Smart Pill Reminder with Configurable Alerts, Multi-Modal Notifications, and Integrated Health Monitoring for Medical Adherence

Chandana Mohanty[1], **Saranya S.**[2], **Carolina Jennifer S.**[3], **Remya Raj**[4]

Department of Biomedical Engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai, India.

E-mail: [1]cm3796@srmist.edu.in, [2]ss1068@srmist.edu.in, [3]cs7673@srmist.edu.in, [4]remyar2@srmist.edu.in

Abstract

Patients must frequently follow medication regimens that call for both large dosages and extended durations of time until the recommended course is finished in order to recover from hospitalization and the diagnosis. Medication adherence is the ability of the patient to adapt to changes in medication as the disease progresses, as well as the patient's dedication to taking their medications on time and finishing the entire course of treatment. In particular, elderly patients with complex conditions like Alzheimer's, dementia, diabetes, and liver diseases require continuous and long-term medication adherence, making it difficult to maintain strict adherence to prescribed treatments and the medication list provided by healthcare professionals. Disease progression, higher healthcare expenses, and higher death rates can result from non-adherence. Disease progression, higher healthcare expenses, and higher death rates can result from non-adherence. 53% of medication errors happened during administration, and 17% were related to prescription errors, according to a study done at a tertiary care hospital in South India. Forgetting, not being aware, and having trouble handling

DOI: https://doi.org/10.36548/jismac.2025.2.002
Received: 22.04.2025, received in revised form: 19.05.2025, accepted: 06.06.2025, published: 17.06.2025

complicated prescriptions are all contributing factors.We suggest a smart pill reminder system as a creative and portable way to help patients stick to a regular medication schedule in order to overcome these difficulties. This system's main goal is to improve adherence by sending out timely reminders, which will cut down on missed doses and guarantee appropriate medication intake. The reminder system provides a workable way to enhance patient outcomes and the overall effectiveness of healthcare by instituting a methodical approach to medication management. Patients or caregivers can personalize medication names and dosage schedules via a dedicated webpage. Along with providing real-time data on environmental variables like temperature and humidity, as well as vital signs like heart rate and SpO2 levels, this platform also makes it possible to track a patient's history of medication intake.

Keywords: Medicine Box, Medical Adherence, Dementia, Medication Scheduling, Webpage Integration, IR Sensors.

1. Introduction

Keeping track of medication schedules is crucial, especially for the elderly, people with chronic illnesses, and those with cognitive impairments. Medication errors or missed doses can worsen pre-existing conditions, particularly in patients with diabetes, hypertension, cardiovascular disease, Parkinson's disease, and Alzheimer's. The intricacy of daily medication schedules is one of the main obstacles to medication adherence. It can be challenging to remember to take each dose of the numerous medications that many elderly people are prescribed at different times of the day. Elderly medication adherence in India is a serious issue; depending on the situation, adherence rates can range from 40% to 75%. A Karnataka study found that 42.3% of senior patients had low adherence and 47.1% had medium adherence, indicating a general problem with following prescribed medication schedules. Patients with memory-related disorders face additional challenges because they may forget to take their medication or take multiple doses in error, thinking they have missed their previous doses. This issue is also greatly exacerbated by psychological and economic barriers. Due to adverse effects like fatigue, nausea, or dizziness, many patients stop taking their prescribed drugs without consulting a doctor. According to research, a significant number of medication administration errors occur, and a significant number of prescriptions result in adverse drug reactions. Furthermore, poor storage conditions in hot or humid climates, especially in rural areas, can reduce the efficacy of pharmaceuticals.

Given these widespread issues, a medication tracker provides a useful and efficient remedy. In order to improve medication adherence and safety, this device offers a portable and intuitive platform that combines automated alerts, health tracking, and environmental monitoring. It guarantees that patients take the right medication at the right time by providing timely notifications via sound, LED indicators, and mobile alerts. Real-time monitoring is made easier by integrated health tracking features, which include metrics like pulse rate and SpO_2 levels. This helps to avert possible medical emergencies. Additionally, environmental sensors can identify variations in humidity and temperature, guaranteeing that pharmaceuticals are kept in the best possible conditions. For people who depend on long-term treatment, a smart pill reminder system that is well-designed can help close the gap between patients and successful medication adherence, greatly lowering errors, improving health outcomes, and raising overall quality of life.

1.1 Objectives

This model's main goal is to solve the aforementioned issues by creating an intuitive tool that makes it possible for people to easily track their medication intake without the need for specialized training or intricate operational knowledge. This intelligent pill reminder tool was created especially to reduce medication errors in nursing homes and hospitals where many patients need to take multiple medications every day. Giving this device to every patient will greatly lower the possibility of mistakes and improve the effectiveness and speed of care that nurses and other caregivers provide. By handling pill administration, the device will free up time that would otherwise be needed for this task. This website will make it easier to record the times for the three daily pill reminders that are scheduled in tandem with wellness checks. The possible negative effects linked to the large number of prescription drugs given to the elderly are becoming more widely recognized.

2. Related Work

The growing need for medication adherence, particularly among chronic disease patients and older adults, has led to the development of smart drug reminder technologies. In addition to reminding patients via mobile phone calls, Paul et al. [1] suggested a smart medicine reminder kit that includes basic health monitoring features tailored for senior citizens. This approach aims to address forgetfulness, a common issue among senior citizens. Expanding on the broader background, Sahu et al. [2] provided a summary of various smart drug systems, emphasizing that success depends on user-friendly interfaces and real-time feedback mechanisms.

For patients with complex medication regimens, Sharmin et al. [3] have even proposed an automated and online medication dispenser that delivers the right dosage at the right time. Additionally, Jagadeeshwaran et al. [4] created a smart pill reminder system with an emphasis on ease of use and minimal hardware integration. Ahmad et al.'s [5] IoT-based reminder and monitoring system, which can track drug intake and notify caregivers or physicians of any deviations, is another noteworthy contribution.

In order to offer more individualized and scalable healthcare support, Dayananda and Upadhya [6] suggested a smart pill expert system built on IoT infrastructure. These developments are in line with the broader healthcare concerns that have been brought to light by studies like those conducted by Mathuranath et al. [9], who documented the rising incidence of Alzheimer's disease in India and the necessity of mechanisms to assist patients with memory impairments. Furthermore, the statistical analysis of medication errors in Indian medical settings by Agrawal et al. [10] and Ramesh et al. [11] highlights how important these reminder systems are to reducing patient harm and human error. Together, these pieces show that although there are a number of models and prototypes for smart medication adherence technologies, ranging from mobile-based alerts to autonomous dispensers, further development and integration of IoT, AI, and user-centric design are essential to their advancement.

3. Existing System

From basic reminder devices to sophisticated IoT-based healthcare systems, a range of systems have been created to help patients follow their prescription schedules. Simple pill reminder systems, like mobile apps or alarms, send out timely notifications to users to remind them to take their prescriptions. Despite their accessibility and convenience, these solutions don't have any way to confirm that the drug has been consumed. By delivering the right dosage at predetermined intervals and frequently featuring optional audio or visual alerts, automated pill dispensers improve accuracy. They do not, however, permit remote access and hardly ever monitor ambient conditions or patient vitals. Similar to this, mobile health apps provide features like personalized scheduling and medication reminders, but they also need human intervention, which makes them prone to mistakes and less appropriate for elderly or less tech-savvy users.

More sophisticated solutions, like IoT-enabled health monitoring systems and smart wearables, offer constant real-time monitoring of physiological parameters like temperature, heart rate, and oxygen saturation. These gadgets improve health monitoring, but because they can't dispense drugs or check pill intake, they are less useful for managing medications. Additionally, wearables can be difficult to use continuously, especially for older people. By identifying open compartments and reminding patients of missed doses, sensor-based pillboxes provide a certain amount of automation. However, the lack of environmental sensing or health monitoring features in many of these devices reduces their overall efficacy. Despite developments in this area, these systems frequently function independently and don't offer a complete solution that combines environmental feedback, health monitoring, and real-time reminders into a user-friendly and integrated system.

4. Proposed Work

A pillbox with LEDs, a buzzer, and a sensory unit is depicted in the block diagram in Figure 1. According to the patient's prescription, it is divided into three sections that serve as reminders for taking medications in the morning, afternoon, and evening. The Arduino IDE software is used to program commands that are executed by the ESP32 microcontroller. An NTP server guarantees real-time synchronization, and a web interface is used to configure the reminder schedule.

Visual and auditory alerts are activated by the LEDs and buzzer, respectively, when the designated time coincides with the current time. To improve usability and personalization, a speaker also plays a message that has been pre-recorded by the family member/caretaker. Medication reminders and daily wellness checks are shown on the LCD screen. The sensory unit includes an Arduino Nano that manages a DHT11 sensor for tracking the environment in real time and a MAX30102 sensor for monitoring heart rate and SpO2.

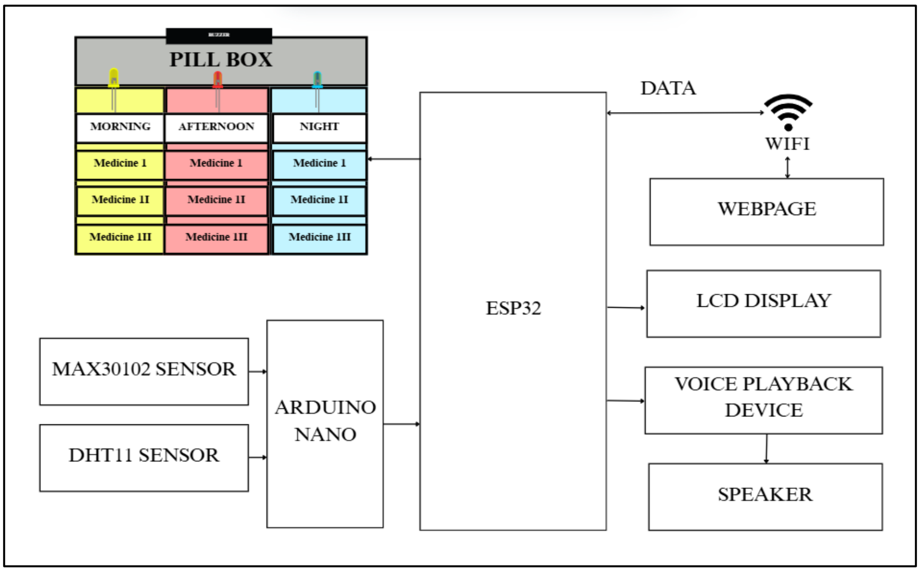

Figure 1. Block Diagram of the Proposed System

4.1 Materials Used

ELECTRONIC COMPONENTS	Qty
ESP 32	1
Arduino Nano	1
ISD 1820 Module	1
ISD Module Speaker	1
LCD Display	1
I2C Module	1
MAX30102 Sensor	1
DHT 11 Sensor	1
LEDs	3
Buzzer	1
Jumper wires	As required
Adapter	1
7805 Voltage regulator	3
GP Board	5
Berg Stick	10

Figure 2. List of the Materials Used

Figure 2 provides a comprehensive overview of all the materials utilized in our project.

ESP32 Module: The ESP32 is the main microcontroller and is the key element required for system management. A dual-core 32-bit LX6 microprocessor running at 160 or 240 MHz powers this 2.4 GHz Wi-Fi and Bluetooth combo chip. UART, SPI, I2C, and PWM are among the interfaces that the module supports.

Arduino Nano: Our system's sensory components, such as the DHT11 sensor (which measures temperature and humidity) and the MAX30102 (which measures SpO2 and heart rate), are controlled by the Arduino Nano. The Arduino Nano features a PCB size of 18 x 45 mm and weighs 7 grams. It is equipped with 22 digital I/O pins, six of which support PWM. The device operates at 5 volts and accepts an input voltage range of 7 to 12 volts.

DHT11 Sensor: The DHT11 sensor measures temperature and humidity. It operates with a voltage range of 3.5V to 5.5V and a current draw of 0.3mA during measurement and 60µA in standby mode. The sensor has a temperature measurement range of 0°C to 50°C and a humidity range of 20% to 90%, with an accuracy of ±1°C and ±1%.

ISD1820 Voice/Audio and Playback Module: Messages from a family member or well-wisher are recorded using the ISD1820 voice recording and playback module to serve as medication adherence reminders. The specifications of this module are as follows: Operating voltage: DC 3V-5V; loudspeaker impedance: 8Ω, 0.5W; recording duration: 8-20 seconds; primary chip type: ISD1820; Non-volatile memory: Holds recordings while retaining messages at zero power; microphone: built-in microphone; Connector: A connector provides access to every ISD1820 pin; Playback features include single-pass, jog, and looping playback.

I2C LCD 16x2: An I2C module-equipped 16x2 or 20x4 character LCD display offers a streamlined interface for smooth microcontroller communication. Usually set up with addresses 0x27 or 0x3F, it uses the Inter-Integrated Circuit (I2C) protocol to function. It has an LED backlight with ON/OFF control and adjustable contrast via a potentiometer on the I2C module, and it is made to run at 5V (some models can run at 3.3V). Compared to parallel-interface LCDs, it drastically lowers wiring complexity with just four connection pins (VCC, GND, SDA, and SCL). It is a dependable option for a range of embedded system applications due to its low power consumption, wide-angle visibility, and operating temperature range of -20°C to +70°C.

Buzzer: With an operating voltage range of 4–7V, the buzzer used in this application is a small electronic sound device that runs on a 5V DC power source. When a voltage is applied, it produces sound using piezoelectric or electromagnetic mechanisms. It is made of sturdy black plastic, weighs 8g, and operates in a temperature range of -20°C to +85°C, making it appropriate for a variety of environmental settings.

4.2 Circuit Diagram

Using "Cirkit Designer" software, a schematic circuit diagram of the suggested medication management system has been created, as shown in Figure 3. Users can plan their medication schedules on the website according to their doctor's prescriptions. As shown in Figure 4, users must log in with their email address and password. After successfully logging in and entering an authenticated password on a secure local WiFi network, the pill box can be controlled according to the morning, afternoon, and evening schedules entered, as illustrated in Figure 5. The smart pill reminder system incorporates multiple components to ensure precise medication reminders and real-time health monitoring. The Arduino Nano collects vital signs utilizing the MAX30102 pulse oximeter (for heart rate and oxygen saturation) and the DHT11 sensor (for temperature and humidity). These sensors communicate with the Nano via I2C and digital pins, with the MAX30102 connected to pins A4 (SDA) and A5 (SCL) and the DHT11 connected to pin D7. The collected data is subsequently transmitted to the ESP32 using UART communication, with the Nano's TX connected to the ESP32's RX and vice versa, sharing a common ground. The ESP32 processes this data and transmits it to the cloud via WiFi. A 16x2 LCD, connected through I2C (SDA to GPIO 21, SCL to GPIO 22), displays real-time health parameters and reminders. LED indicators (connected to GPIO 25, 26, and 27) provide visual alerts to the user, while a buzzer (GPIO 32) and speaker (GPIO 15) deliver auditory reminders.

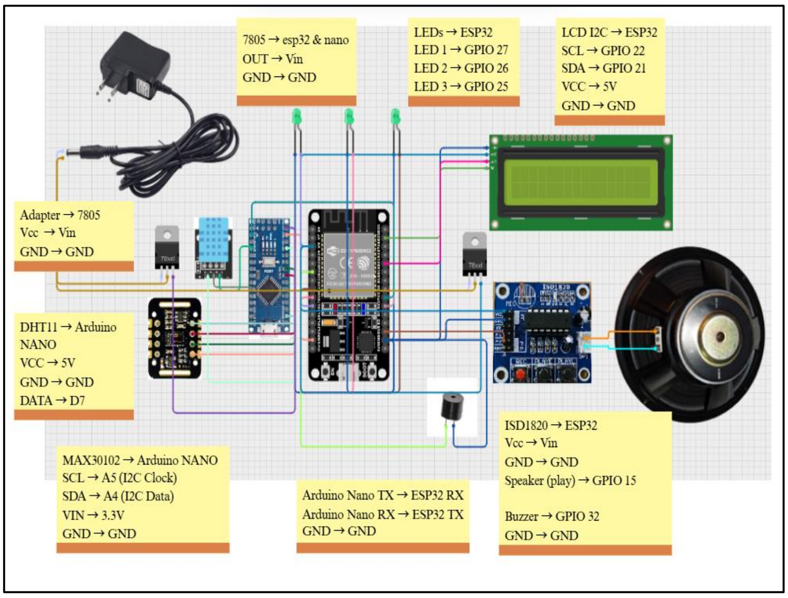

Figure 3. Circuit Diagram of Medication Reminder System.

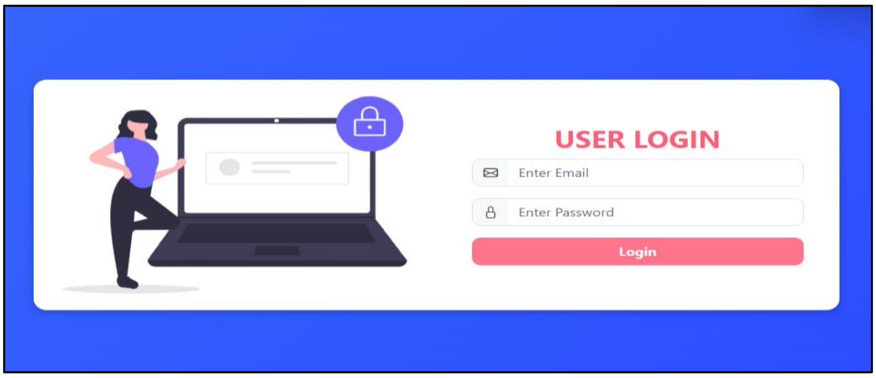

Figure 4. The User Interface.

Figure 5. Set Time for Medicine Intake

4.3 Flowchart

The entire operating process of the proposed system has been depicted in the flowchart, Figure 6. The smart pill dispensing system's overall operation and process flow are depicted in the flowchart shown in Figure 6. When the box is powered by an adapter that offers a steady and dependable power source, the system comes on. After activation, the user enters their login information, such as their password and email address, to access the web interface. The user can enter, modify, and set the appropriate timings for medicine administration after successfully logging in.

Three programmable time slots are supported by the system: morning, afternoon, and night. The system initiates both visual and auditory reminders at these specified times. To remind the user to take their medication on time, a buzzer sounds and LEDs light up. In order to help with medication adherence, the system also has an LCD screen that shows wellness check messages like "Good Morning," "Good Afternoon," "Good Night," and "Time to take medicine." The ESP32 microcontroller, which controls communication between the web interface, LEDs, and buzzer, coordinates these tasks via UART data transmission. The system's sensor module, which consists of the DHT11 sensor that measures ambient temperature and humidity and the MAX30102 sensor that measures heart rate and SpO_2 (oxygen saturation) by absorbing infrared light when the user places a finger on the sensor, is controlled by a secondary microcontroller, the Arduino Nano.

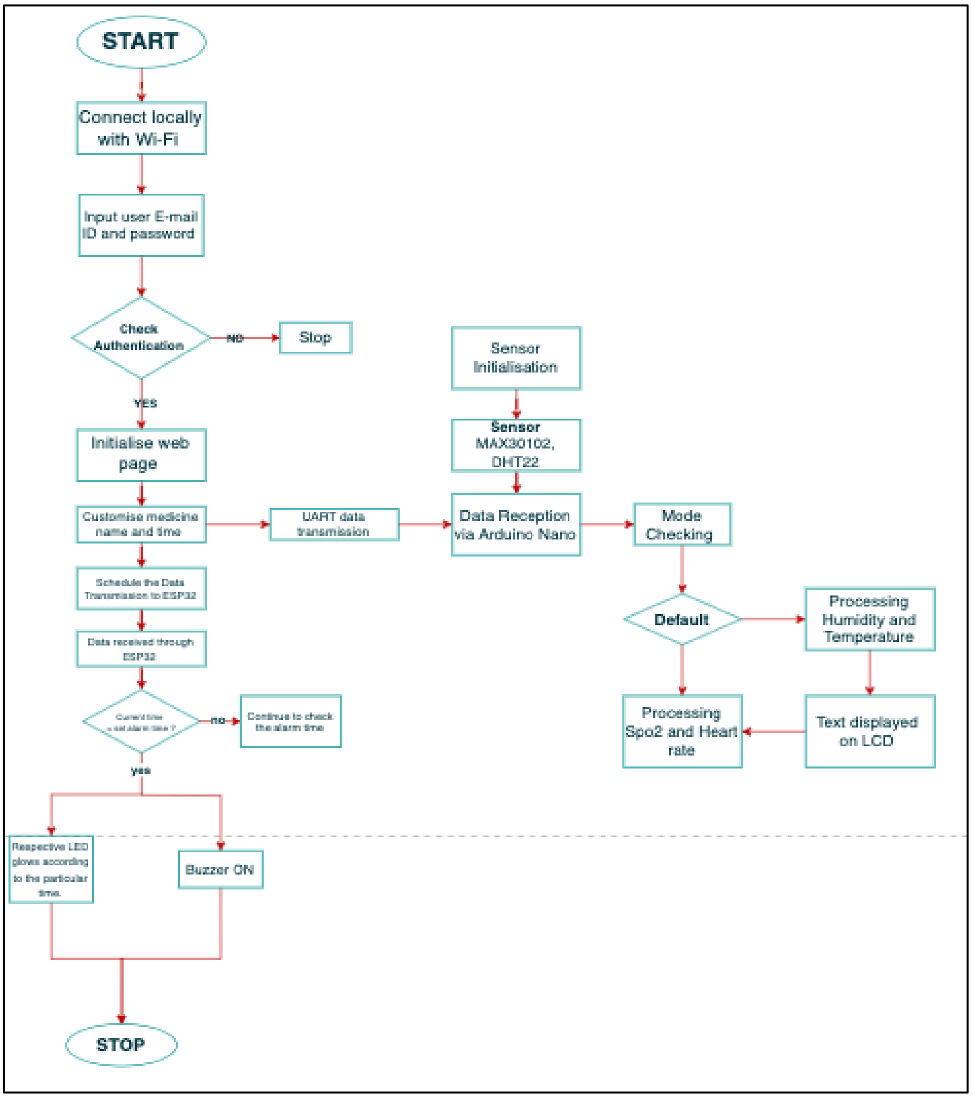

Figure 6. Flowchart of the Proposed System

When combined, these elements guarantee that the system offers basic health monitoring in addition to reminding users to take their medications. The entire procedure mentioned above is clearly depicted in the flowchart.

4.4 Pictures of the Prototype

Figure 7. Morning LED & Buzzer on

Figure 8. Afternoon LED & Buzzer

Figure 9. Night LED & Buzzer on

Figure 10. Morning Medicine Reminder

Figure 11. Afternoon Medicine Reminder

Figure 12. Night Medicine Reminder

Figure 13. Heart Rate, Spo2, Temperature, and Humidity Monitoring

Figure 14. Top View Showing MAX30102 and DHT11 Sensors

Figure 15. Picture of the Final Prototype

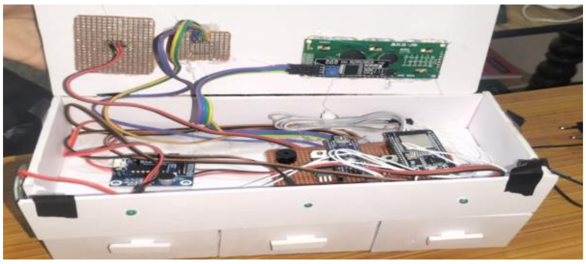

Figure 16. Connections Between Components

5. Experimental Result and Analysis

We recruited test users who were 50 years of age or older to use our suggested model for a week in order to conduct an experimental analysis of the system. We then held a feedback session to get their opinions about the product and enable them to point out the system's benefits and drawbacks. The survey's findings are described in detail below.

Survey: Ten people 50 years of age and older participated in our survey. A number of questions about our application's features which include voice alerts, basic reminders, health monitoring, temperature and humidity tracking, real-time clock synchronization, multimodal feedback, and system modularity were included in this survey.

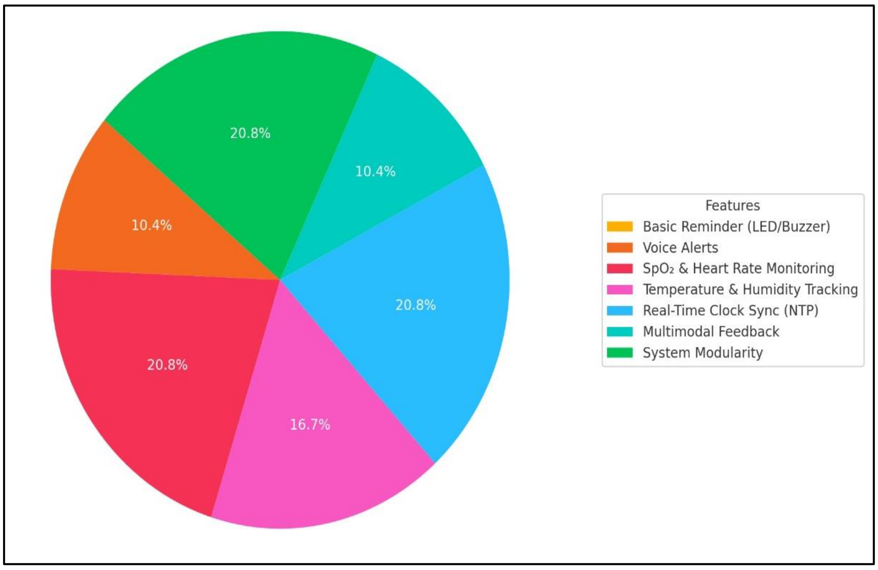

Figure 17. The Pie Chart Shows the Favourability Percentage of Each Feature

We have produced a pie chart figure 17 shows the favorability percentage of each feature based on the responses. Observation: In compliance with our survey, we observed ten distinct patients. Along with the buzzer beeps and voice module that provided audio alerts, we concentrated on when they should take their medications as illustrated in figure 18.

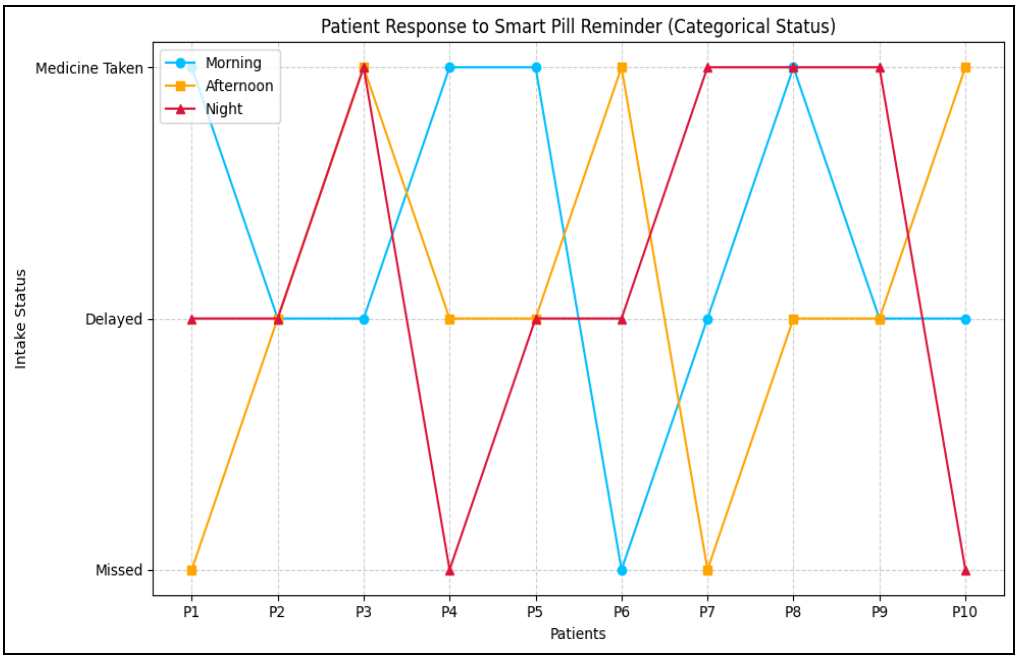

Figure 18. The Line Graph Shows the Patient Response to the Alerts and Intake Status of 10 Patients.

6. Future Prospects

The system's ability to support multiple users at once will allow each user to create a customized profile and medication schedule. Both pill and liquid medication dispensing will be supported by the system to improve usability. To increase flexibility, the updated scheduling feature will offer three daily timings: morning, afternoon, and evening, spanning the entire week. A GSM module will improve connectivity and lessen patient isolation by enabling real-time communication between patients and their doctors or caregivers. The system will automatically update patient records with information about medication adherence by integrating with Electronic Health Records (EHR). Additionally, using real-time patient health data obtained from the EHR, medical professionals will be able to remotely modify medication schedules.

Drug dispensing schedules will be modified by the system using artificial intelligence and machine learning in accordance with the medical conditions and habits of each patient. Certain medications, like injectable vaccines and topical treatments that need to be refrigerated, can be stored. The system will effectively handle several medications with different schedules and dosages, guaranteeing precise adherence. By producing thorough reports and analytics on each user's medication dispensing habits, it will also monitor adherence over time. The outer structure of the device will be 3D printed, offering a cost-effective and flexible design.

7. Conclusion

In conclusion, simplifying the patient's medication intake schedule is one of the best ways to improve medication adherence. As was previously mentioned, people with chronic conditions that require regular medication intake, such as diabetes and cardiovascular and pulmonary diseases, have a particularly high rate of non-adherence. This noncompliance frequently causes new symptoms to appear and makes general health issues worse. The main way that our suggested solution helps users is by sending out timely reminders to take their medications on time. The system also has an integrated sensor that records the patient's heart rate and SpO2 levels, keeping an extensive log of the information. Additionally, it keeps an eye on environmental variables like humidity and temperature. Keeping aside the technical aspects, our system's main benefits are its affordability, low carbon footprint, semi-portability, and user-friendly design. In addition to being urged to take their medications as prescribed, users will also get personalized reminders via a voice module that plays recordings of their loved ones at the appropriate times. As a result, our medication reminder system is a simple and efficient way to increase patient adherence.

References

[1] Paul, Liton Chandra, Sayed Shifat Ahmed, Tithi Rani, Md Ashraful Haque, Tushar Kanti Roy, Md Najmul Hossain, and Md Azad Hossain. "A smart medicine reminder kit with mobile phone calls and some health monitoring features for senior citizens." Heliyon 10, no. 4 (2024).

[2] Sahu, Mahendra Kumar, Riju Bhattacharya, Naina Dhamecha, R. Jagannath Rao, Rashmi Patle, and Prajjawal Gupta. "Smart Medication System: A review." Mathematical Statistician and Engineering Applications 72, no. 1 (2023): 443-450.

[3] Sharmin, Shayla, Md Ibrahim Khulil Ullah Ratan, and Ashraful Haque Piash. "An Automated and Online-Based Medicine Reminder and Dispenser." In Proceedings of the International Conference on Big Data, IoT, and Machine Learning: BIM 2021, Springer Singapore, 2022, 513-524.

[4] Jagadeeshwaran, A., H. Shree Kumar, Saiyed Salim Sayeed, and Chockalingam Aravind Vaithilingam. "Smart pill reminder." In 2021 First International Conference on Advances in Computing and Future Communication Technologies (ICACFCT), IEEE, 2021, 174-178.

[5] Ahmad, Sultan, Mahamudul Hasan, M. Shahabuddin, Tasnia Tabassum, and Mustafa Wasif Allvi. "IoT based pill reminder and monitoring system." International Journal of Computer Science and Network Security 20, no. 7 (2020): 152-158.

[6] Dayananda, P., and Amrutha G. Upadhya. "Development of Smart Pill Expert System Based on IoT." Journal of The Institution of Engineers (India): Series B 105, no. 3 (2024): 457-467.

[7] Paul, Liton Chandra, Sayed Shifat Ahmed, Tithi Rani, Md Ashraful Haque, Tushar Kanti Roy, Md Najmul Hossain, and Md Azad Hossain. "A smart medicine reminder kit with mobile phone calls and some health monitoring features for senior citizens." Heliyon 10, no. 4 (2024).

[8] Paul, Liton Chandra, Sayed Shifat Ahmed, Tithi Rani, Md Ashraful Haque, Tushar Kanti Roy, Md Najmul Hossain, and Md Azad Hossain. "A smart medicine reminder kit with

mobile phone calls and some health monitoring features for senior citizens." Heliyon 10, no. 4 (2024).

[9] Mathuranath, P. S., Annamma George, Neelima Ranjith, Sunita Justus, M. S. Kumar, Ramsekhar Menon, P. S. Sarma, and Joe Verghese. "Incidence of Alzheimer′ s disease in India: A 10 years follow-up study." Neurology India 60, no. 6 (2012): 625-630.

[10] Agrawal, Pankaj, Ajay Sachan, Rajeev K. Singla, and Pankaj Jain. "Statistical analysis of medication errors in Delhi, India." Indo Global Journal of Pharmaceutical Sciences 2, no. 1 (2012): 88-97.

[11] Ramesh, Ganpisetti, Challa Anitha, Sravya Malika, K. Rani Samyuktha, Sk Sharmila, and P. Srinivasa Babu. "Incidence of Medication Errors in a Tertiary Care Hospital in South-India." Indian Journal of Pharmacy Practice 12, no. 2 (2019).