IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 1, September 2023

Smart Pill Box with Voice Announcement and Wrist Band Accessory

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Abstract: *A project has been developed to address the challenges faced by individuals in managing complex medication regimens independently. The solution incorporates various components, including the NodeMCU ESP32 Wroom, RTC module, GSM module, Smart Pill Box dispenser, and a wristband. The NodeMCU ESP32 Wroom module enables seamless communication and synchronization between the Smart Pill Box Dispenser and the wristband accessory. By leveraging its Wi-Fi capabilities, the NodeMCU ESP32 Wroom ensures that the dispenser and wristband stay connected, facilitating real-time notifications related to medication schedules and reminders. To ensure accurate timekeeping and synchronization, an RTC (Real-Time Clock) module is integrated into the system. The GSM module is utilized for the SMS alert functionality of the system. In the event that a patient neglects to take their medication, the GSM module sends an alert message to a designated person, notifying them of the situation. A wristband accessory is a piece of equipment that the patient wears constantly. It includes LCD display, MAX30102 sensor, body temperature sensor, and vibrator, among other things. The MAX30102 sensor measures the patient's heart rate, SpO2, and temperature, while the temperature sensor measures the patient's body temperature. These values are all shown on an LCD screen. By leveraging IoT technology, the solution enhances medication adherence, improves safety, and reduces the need for constant medical supervision, thereby promoting the well-being and independence of the users.*

Keywords: NodeMCU ESP32 Wroom (Wifi Module), RTC Module, GSM Module, Smart Pill Box , Wrist Band

I. INTRODUCTION

The rise in chronic diseases has led to a significant concern regarding medication non-adherence, posing a substantial public health challenge. The use of medication dispensers is frequently advised in order to improve patient adherence. By giving patients their medications according to predetermined schedules, medication dispensers are useful tools for enhancing medication adherence. Nonetheless, there is potential for enhancing the current state of medication dispensers. The majority of current medication dispensers are primarily developed to accommodate a single user and lack scalability to a significant extent. There would be an increase in operational costs as a result of giving each patient their own medication dispenser.

For the modern medication dispensers to minimise inconveniences and potential errors brought on by manual user input, accurate medication schedules and system configurations must be pre-programmed. However, users must manage independently because current medication dispensers lack remote device management capabilities. In the event of dispenser mistakes, these restrictions may have fatal results. Therefore, thorough investigations are required to address these problems, especially in light of the fact that many people who use medication dispensers are elderly or suffer from chronic illnesses.

This research paper presents a novel concept of a smart medication dispenser that offers exceptional scalability and remote manageability. The proposed device allows multiple users to utilize a single dispenser, ensuring scalability while promoting cost efficiency and safe operation. Instead of end users, medical staff and system administrators are responsible for managing the medication dispensers, enhancing overall device management. Medications are stored in individual cartridges placed within the dispenser tray, allowing for easy customization for each patient. The medication

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schedule and system configurations are remotely updated by medical staff, while system administrators handle remote management of embedded programs, system settings, and operational issues.

In addition, the smart medication dispenser rectifies any discrepancies in a patient's medication status and transmits the corrected data to a medication-monitoring server. In cases where an abnormal state is detected, the dispenser and server engage in a series of management messages. Consequently, it can be inferred that the smart medication dispenser requires more frequent message transmission compared to existing dispensers, posing a significant challenge for limited bandwidth networks. To overcome this limitation, the open mobile alliance device management protocol is implemented. This protocol, widely recognized as an international standard for mobile device management, offers a suitable solution for medication dispenser management due to its original design catering to limited bandwidth networks.

This paper introduces a novel smart medication dispenser as its main contribution.. Efficiency is greater if only one person uses the proposed model. In order to enhance remote manageability and minimize management costs and efforts, the paper proposes and implements remote management methods. These methods enable seamless updates of the medication schedule configured in the smart dispenser.

A small literature survey was done and the summary is as follows. Many elderly people live alone, and some of them have disabilities that make it more difficult for them to take care of themselves. Any missed doses or even taking their medication at the wrong time could result in health problems. This paper introduces the Smart Medicine Box (SMB) design. In order to monitor and guarantee that the proper dosage of each medicine is taken at the appropriate time, the proposed SMB can be used by patients as well as nurses or other carers. When a specific medication needs to be taken or refilled, the SMB notifies the user visually and audibly[1]. A smart medicine box that will remind hospital patients or elderly patients to take the right dosage of their medications at the right time, as per the doctor's instructions is proposed in [2]. To store the medication, the device has twenty-one airtight compartments. A patient's carer or nurse can create a weekly schedule for medicine leftovers by keeping medication in twenty-one compartments for three doses per day. The attendant can manually set the time for taking medications or load a text file containing the times for each compartment's medications onto an SD card. The time can be read from the device's real-time clock. The device plays a sound in the speaker to share the information about the quantity of medicine and blinks the LED of the particular compartment where medicine is kept for that time when the time matches the set time. The device also tells the patient whether to take the medication before or after eating. The device can guarantee medication safety, proper medication dosage, and the avoidance of elderly drug abuse. Along with an email that will assist the patient in taking the medication, the suggested medicine box aids the patient in taking the proper medication at the appropriate time. A laptop is used as a server to store detailed information about the patient, the doctor, and the date of the appointment. Both the patient and the doctor have an ID and password to access the server. Additionally, for the convenience of the doctor, the server stores the patient's temperature and medication information. If necessary, the doctor may alter the patient's prescription; this will also be communicated via email. In addition, the doctor is able to act quickly in an emergency. Because of their poor memories and use of various drugs, the author claims that elderly people frequently forget to take their medications or take them accidentally[3]. The paper uses an intelligent medicine box control system to remind the elderly to take their medications on time. The sensor that detects the approach of the human body, the motor that rotates the medicine box, the LCD display screen, and the buzzer that helps users take their medications are all controlled by the STM32 series single-chip microcomputer in the intelligent medicine box controller. In order to make it simpler for users to configure the information on the medicine box, create an application that makes use of a user-friendly human-computer interface[4]. In another article the author discusses how the majority of elderly people take medications to maintain a stable state of health despite having multiple chronic illnesses[5]. The chemists association urged families to pay closer attention to their elderly loved ones medication safety. In this paper, an intelligent pillbox and its back-end monitoring system are designed. The implemented pill box can notify the families remotely when the elders take the medication and can remind the elders to take their medications on time. This pill box's safety features can stop people from abusing drugs. The elders' medication times can be easily scheduled by the carers.

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Overall, these papers and articles provide insight into the current state of research and development of smart smart pill box systems with patient health monitoring capabilities. The rest of the paper details the proposed model, implementation, outcomes, restrictions, and potential future applications.

II. PROPOSED METHOD

The project is designed for senior citizens who have rigorous and demanding medication regimes. People occasionally forget to take their drugs, take the wrong medication, or overdose due to the age-related issue and the multiple medications that must be taken, all of which can have detrimental health repercussions. These problems are addressed by the proposed model. The model is divided into two parts: Pill Dispenser and Wristband Accessory.

2.1 Working:

The entire architecture of the Smart Pill Dispenser and Wristband Accessory for Dementia People is shown in Fig. 1 which shows a block diagram. The Smart Pill Dispenser is made up of electronic parts like the LCD display, RTC module, speaker, push buttons, servo motors, and GSM module. The vibrator, DS18B20 temperature sensor, MAX30102 heart rate sensor, and SpO2 sensor are all parts of the wristband accessory. The ESP32 Microcontroller, which is coupled to all components, serves as both units' primary component. The entire assembly is powered by a computer or an external power source.

Smart Pill Dispenser:

Pill Dispenser:

The pill dispenser is programmed to dispense medication three times per day: in the morning, in the afternoon, and in the evening. The program is then dumped into ESP32 Microcontroller. The Fig. 1 shows the block diagram of Smart Pill Box Dispenser. The proposed model is designed to distribute only one pill at a time. This limitation can be removed by using advanced design techniques. Only four pills may be stored in the suggested device, and for each pill dispenser, a push button is dedicated which, when pressed, dispenses the appropriate drug.

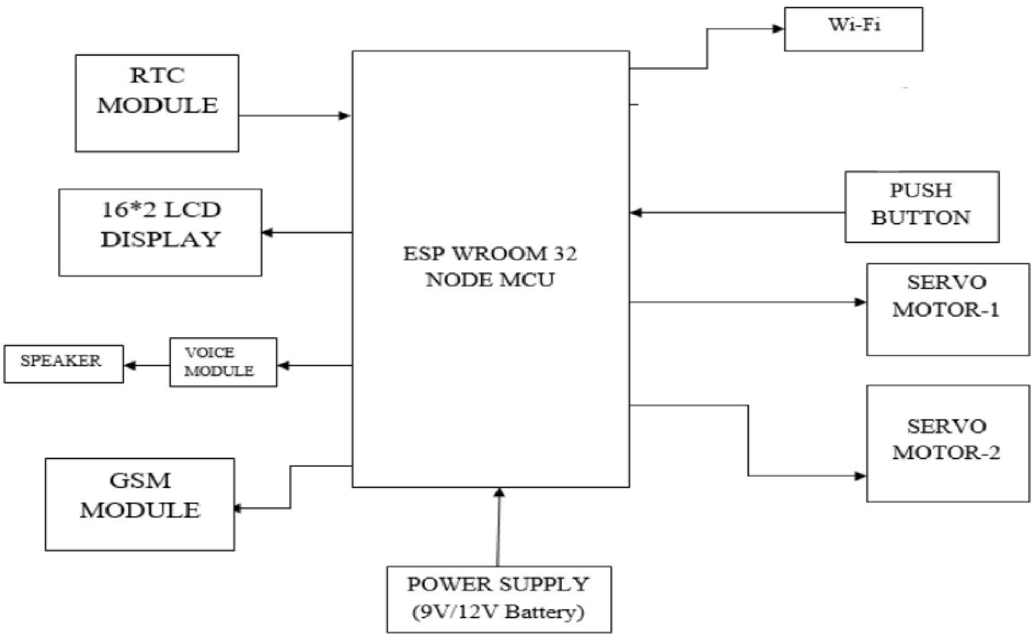

Fig 1. Block Diagram of Smart Pill Box Dispenser

The working of block diagram Fig. 1 is discussed further, with the use of a speaker and speech playback module, a voice announcement is produced at the prescribed times for "Medicines in the morning," "Medicines in the afternoon," and "Medicines in the evening". The speech announcements are made via the speaker at a volume that the patient can hear, and the voice playback module is utilised to save the voice lines that are used when delivering announcements.

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Elderly people will use this as a reminder to take their pills on time. When the voice announcement is simultaneously made, the wristband's vibrator will begin to shake. If an elderly person is unable to hear the voice announcement, this function is set up so that vibrations will act as a backup notification.

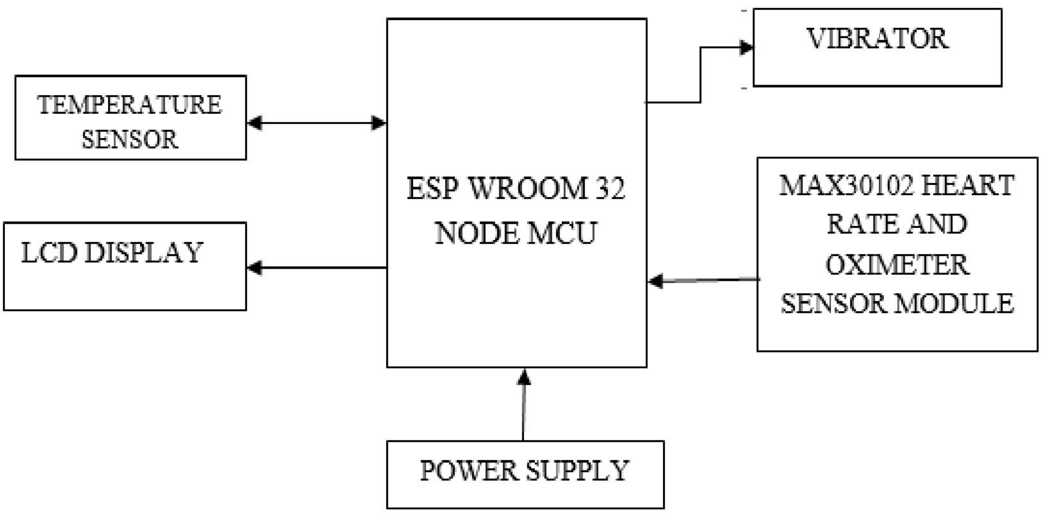
The dispensing method is implemented using servo motors coupled to CDs (Compact Disc) with calculated-position holes. The patient goes to the pill dispenser and presses the buttons when they are told it is time to take their pills. Push buttons operate servo motors, rotate the attached CD when they are activated. The pill will be released when the CDs and tubes' holes are lined up.

The elderly must visit the pill dispenser after being informed that it is time to take their medication and must press the push buttons before a pill is dispensed. With the aid of a GSM (Global System for Mobile communication) module, an SMS (short message service) message is sent to the appropriate person after the pill has been administered. A text message stating "first medicine is dispensed" is sent to the person in question, for instance, if the patient pushes the first push button and takes the corresponding pill.

A Real-Time Clock (RTC) module is a piece of technology that provides precise timekeeping and date information to a microcontroller or other electronic device. A clock crystal, a battery backup, and an integrated circuit or microcontroller that manages timekeeping operations are often included. It has a few benefits, including precision, flexible interface options, and low power consumption. The suggested model uses the RTC module to track both planned and real-time data. As soon as the appointed time arrives, the voice announcement will begin thanks to the RTC module.

A 16x2 LCD display is interfaced in the smart pill box dispenser. This will display the date, time and day.

Wristband Accessory:



Figs 3. Block Diagram of Wristband Accessory

An essential component of the suggested model is the wristband. The primary function of this device is patient health monitoring. A dedicated ESP32 microcontroller, equipped with a 16x2 LCD display, vibrator, temperature sensor, and MAX30102 sensor, is used to run the embedded C program. The patient's body temperature, oxygen saturation level, and heart rate will all be displayed on the LCD screen continuously. The Smart Pill Dispenser's verbal announcement of the time to take your medication is accompanied by a vibration alert from the wristband's vibrator motor. If the patient doesn't reply to voice announcements, this will act as a backup form of notification for them.

The prototype of the proposed model which includes both smart pill dispenser and wristband accessory is given in Fig 2.

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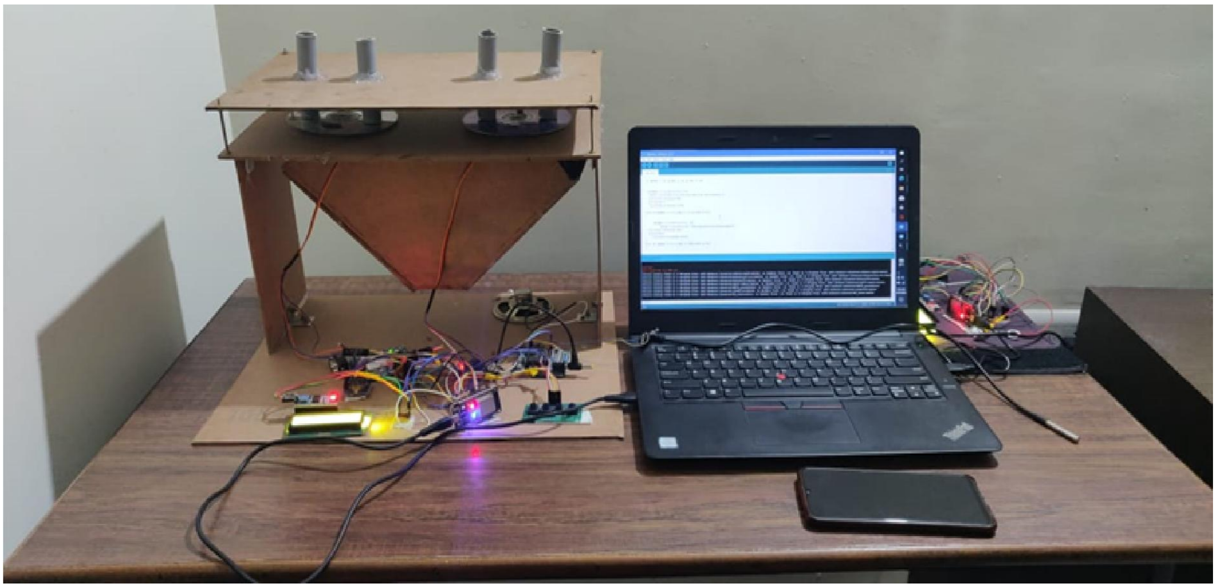

Fig 2. The Prototype of the Proposed Model

Cardboard is used to assemble the proposed model's outer body. It is cut to size as needed and assembled with a glue gun. Four partitions made of PVC pipes are used to store the pills. Pills can be dispensed from one end while being inserted into the partitions from the other. Two CDs (compact discs) are used to hold the pills in place and have holes drilled into them at strategic locations to prevent the pills from falling from the pipes. The servo motors attached to the CDs will rotate when the predetermined time has passed, turning the CD. The hole on the CD and the end of the pipe where the pills exit are matched when the CD rotates. So, pills are administered.

The entire wristband's component parts are put together on velcro-equipped cloth. This helps secure the cloth around the wrist. The wristband and Smart Pill Box can both be powered by a laptop or power bank.

The Table 1 lists the components used in Smart Pill Box Dispenser and its specifications.

Components	Specification	Quantity
Speaker	0.5 W, 8 ohm	1
ESP32 Microcontroller	2.4 GHz dual-mode Wifi, 512 KB SRAM, 4MB flash memory, 21 pins, 240 Hz clock frequency, 3.3V,	1
Servo Motor SG90	5V	4
Voice Playback Module	3V, 340 ~ 680 sec voice recording length	1
16x2 LCD Display	5V	1
RTC Module	3V	1
GSM Module	3.3V	1
Cardboard	2mm thickness	As per requirement

Table1 Shows the components, its specifications and quantity used in Smart Pill Dispenser

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The Table 2 lists the components used in wristband accessory and its specifications.

Components	Specification	Quantity
DS18B20 Temperature sensor	3.5V - 5V	1
Vibrator Motor	1.8V	1
16x2 LCD Display	5V	1
MAX30102	1.8V	1
Cloth	0.3m	1

Table 2 Shows the components, its specifications and quantity used in Wristband accessory

III. RESULTS AND DISCUSSION

One of the co-authors conducted a test of the suggested model in their living room. The experiment involved programming the device to dispense tablets three times, with a 2-minute interval between each dispensing, for the purpose of testing. Specifically, medication for fever and headache was scheduled to be administered at 12:55 PM and 12:57 PM, respectively. At 12:55 PM, a voice announcement was delivered with the assistance of a speaker. Additionally, to ensure the patient's awareness, both a wristband attachment and a vibrator motor were utilized, providing simultaneous alerts.

To administer the medication, the patient is required to approach the automated pill dispenser and select the corresponding button for the specific medication. Once the medication is dispensed, a notification in the form of an SMS (short message service) is sent to the caregiver, informing them that the patient has taken the medication. The SMS received by the caregiver is illustrated in Figure 3.

Fig. 3 Screenshot of SMS alert received by the caretaker

The model underwent further testing at various intervals of 2 minutes, just like in the previous experiments. However, this time, the testing involved three different types of pills. Once the pills were dispensed, an SMS alert was automatically sent to the caretaker, notifying them that the patient had taken their medication. As described in the methodology, the pill storage is divided into four partitions labeled as P1, P2, P3, and P4. Each partition contains medication for cough, bodily discomfort, headaches, and fever, respectively.

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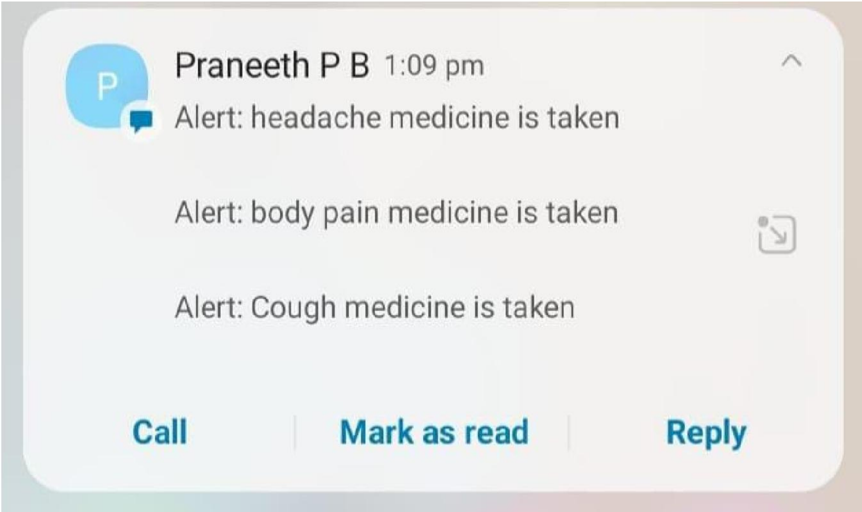

Fig. 4 Carer receives an SMS message indicating that the patient has taken medicine for their headache, body pain, and cough.

The RTC module, responsible for displaying the time, day, and date on the smart pill box, remains constantly active. This feature is incorporated into the design to provide a visual means of monitoring the current time, day, and date. This can be seen in Figure 5.

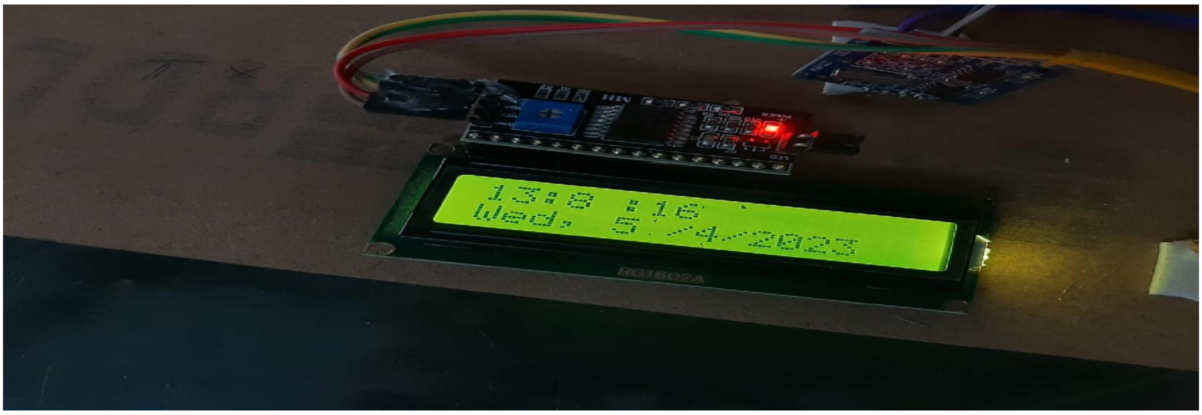

Fig. 5 Image of LCD Display showing time, day and date

The RTC module, responsible for the continuous display of time, day, and date on the smart pill box, remains active at all times. This feature is inherent in the design to allow users to conveniently monitor the current time, day, and date visually. The corresponding illustration can be found in Figure 5. This is shown in the Fig. 6.

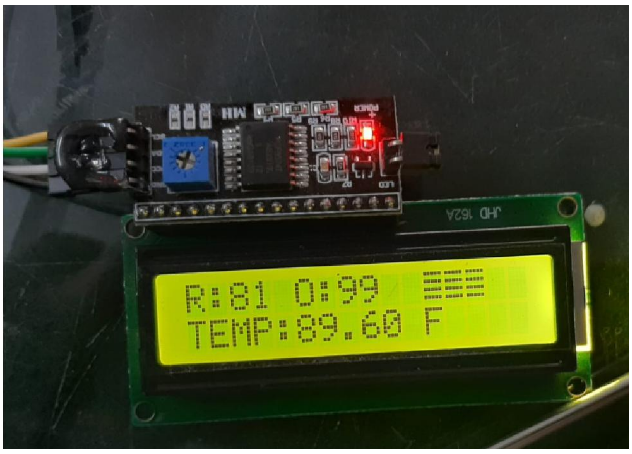

Fig 6. Image of MAX30102 sensor displaying patient's body temperature, heart rate & SpO2

The entire procedure of notifying the patient through speakers, delivering a vibration alert via a wristband attachment, dispensing the medication, and sending an SMS alert to the caregiver is completed within a timeframe of 12 to 15 seconds. This streamlined process significantly speeds up the medication intake process, facilitating efficient drug administration. The model was tested for different dimensions of pills ranging from 0.2cm to 0.5cm. This is shown in the Table 3.

Tablet Name	Dimensions
Dolo 650mg	0.5 cm
Montek FX 10mg	0.3 cm
Zincovit	0.4 cm
Pan 40mg	0.2 cm

Table3 Pills of different dimensions that were tested on the proposed model

IV. CONCLUSION

The use of a smart pill dispenser with a wristband accessory that also serves as a patient health monitoring system can be beneficial for patients who take many medications or have complicated regimens. By employing this paradigm, pharmaceutical errors, missed doses, and medication confusion can all be avoided. People can be reminded to take their prescriptions on time and in the recommended amount with the use of a GSM module and voice announcement feature, which lowers the likelihood of missed doses and boosts medication adherence. Few disadvantages of the proposed model are smart pill boxes rely on technology to work, the user could not get a prescription reminder if the gadget breaks down or the battery runs out. To reduce the chance of technological breakdowns, the system must be constantly tested and maintained. For those who take numerous prescriptions or significant amounts, smart pill boxes may only offer a small amount of storage space. In future AI and machine learning can be utilised to deliver tailored medication management and remote drug adherence monitoring, enabling health care workers to act quickly.

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