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DESIGN AND IMPLEMENTATION OF MEDICINE TIME REMINDER SYSTEM USING SOUND AND VIBRATION INDICATORS

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Abstract: This project was to design and implement a Medicine Time Reminder System, aimed at helping patients remember to take their medications on time. The system was designed with a microcontroller as the central processing unit, which regulated and controlled all the system's activities. The microcontroller receives input from a Real-Time Clock module, then compared to the pre-set alarm time stored in its memory, The alarm is triggered when the two times align, causing the system to vibrate and initiate calls to the designated phone numbers. In the implementation process, a 3-by-4 keypad was connected to the microcontroller, allowing patients to set the alarm time and phone numbers. The OLED display was connected to the microcontroller via an I2C protocol and displayed system status, time, date, and other data. A GSM module was connected to the microcontroller via a serial communication protocol, allowing the system to make calls. A buzzer and vibrator were connected to the microcontroller through a BC547 transistor, providing sound and vibration notifications. The system was tested with 110 patients aged 17 years and above. The assessment results showed that the system was highly effective in ensuring the patients took their medications on time. Eighty-four percent of patients reported that the system effectively reminded them to take their medication at the right time. The medicine time reminder system utilizing sound, vibrators, and a GSM module offers a comprehensive solution for medication adherence. By combining auditory and tactile cues and incorporating Phone calls, this system improves the chances of timely medication intake and helps individuals stay on track with their prescribed dosage schedules.

Keywords: Microcontroller ATmege328p, Buzzer, GSM module, Real Time Clock, Vibrator, LCD, Keypad

I. INTRODUCTION

Most people today require medicines that were not available a few years ago, and the reason for this is that diseases are becoming more prevalent. Some diseases are only temporary, while others are chronic and life-threatening, integrating with the human body in such a way that they cannot leave the body and multiply rapidly. Many people miss their medication, with more than 80% of patients occasionally forgetting to take a dose, leading to consequences down the road. Almost 25% of heart fatalities can be avoided by taking medicine as directed [9]. Work-related obligations, forgetfulness, or confusion can lead to patients or their loved ones failing to take prescribed medication. For instance, administering medication can take around 2 minutes, but people may forget the dosage or the medication's name. The COVID vaccination provides a recent example where some individuals failed to receive the second dosage of the vaccine at the scheduled time [7]. The COVID pandemic has also led to hospitals being busy treating patients, which could result in other patients using the wrong medications. Hospital care itself can be dangerous, with nearly ten percent of patients experiencing an injury and 1.4 million people worldwide contracting illnesses from hospitals. The prevalence of diseases and the consequences of not taking medication have led to a decrease in human life expectancy. To overcome this, medicine must be taken on a regular and large scale, and patients must seek the advice of a doctor for instructions on how to take the medication and how to remember the new schedule of medicine when the prescription changes. To address this issue, our project aims to build a phone call-based smart medicine box with a real-time clock. The system will make loud noises and vibrate until the patient takes their pills from the box at the appropriate time, ensuring that they do not forget to take their medication.

STATEMENT OF PROBLEM

The current state of SMS-based medication reminder systems presents certain limitations, including high costs for patients, the possibility of missing alerts, and limitations for those with physical disabilities who may not hear the phone's

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alert. The objective of this work is to address these limitations by proposing a phone call-based medication reminder system that is cost-effective, more likely to be effective, and includes vibration and sound as an alternative notification methods for individuals with physical disabilities. The goal is to improve medication adherence and to provide a more comprehensive solution to the current limitations of SMS-based systems.

II. RELATED WORKS

Recent studies have investigated various approaches to improving medication adherence. [6] looked at the effectiveness of mobile technology in the form of customized Short Messaging Service (SMS) reminders. The study was conducted in resource-poor areas in Pakistan and involved a sample of 200 participants. The results showed that the intervention group, who received personalized medication reminders and health information SMS, had a higher mean medication score and a lower mean diastolic blood pressure compared to the control group who only received usual care. [1] also conducted a systematic review to assess the impact of text messaging on adherence to treatment for patients with established arterial occlusive events. The study included seven trials with 1310 participants but found insufficient evidence to draw conclusions on the effectiveness of text messaging interventions for medication adherence. The authors noted that the evidence was of very low quality and recommended the need for high-quality, randomized trials, particularly in low- and middle-income countries.

In a study conducted by [3], the effects of low-cost medication reminder devices on medication adherence were compared. The study involved 53,480 participants who were taking 1 to 3 oral medications for long-term use and who were suboptimally adherent to their prescribed therapies. The participants were divided into two groups: those taking medications for cardiovascular or other non-depression chronic conditions, and those taking antidepressants. Participants were randomly assigned to receive either a pill bottle strip with toggles, digital timer cap, or standard pillbox, or to receive neither notification nor a device (control group).

A formative study conducted by [4] aimed to investigate the use of Wisepill evriMED Medication Event Reminder Monitor (MERM) among outpatients with drug susceptible pulmonary tuberculosis in Thanh Hoa, a rural province in northern Viet Nam. The study enrolled 20 patients in a randomized controlled trial, where half of the participants received daily alerts and scheduled dosing history reviews while the other half received the device without an alert. The study was conducted through in-depth interviews with the participants.

In a study by [8], the importance of the rapid growth of mobile phone usage in low and middle-income countries was acknowledged as a valuable tool for public health programs to access patients. The researchers aimed to evaluate the impact of a two-way SMS reminder system called Zindagi SMS on the treatment success of patients with drug-sensitive tuberculosis. The study was conducted as a randomized controlled trial in Karachi, Pakistan, with 2,207 participants being randomly assigned to either the Zindagi SMS group or the control group. The primary outcome measured was the clinically recorded treatment success.

In a study by [5], the feasibility of a smartphone-based medication self-management system (SMSS) was investigated. The aim of the study was to design, develop and demonstrate the feasibility of the SMSS with real-time medication monitoring to help patients manage their medication regimen. The study was based on the results of interviews with 116 patients and the SMSS was designed and developed to offer two main functions to patients through their smartphones: (1) storage and provision of accurate medication history and medication-taking records; and (2) provision of reminders to take medication when patients forget. Despite its effectiveness, the SMS-based medication time reminder system still requires some improvements. One of the key challenges is the cost associated with sending multiple SMS reminders every day. A patient who requires reminders three times a day could incur a significant monthly cost from the network provider. Additionally, if the credit on the device is depleted, the patient may miss notifications. Another issue with the SMS-based approach is that the patient may not be aware of the alert if they are not with their phone at the time of delivery.

In light of these limitations, this project proposes the use of phone calls instead of SMS as a medication reminder system. This is an improvement upon the work done by [10] and it is expected to be more cost-effective as well as more effective, as the ringing period is usually longer than the message alert notification period.
The system will allow the user to specify the contact number of their dedicated medical staff, who will be notified in case the patient fails to respond to the device's notification. This builds upon the work done by [2] in integrating prescription schedules into the medication time reminder system. Additionally, the proposed system will be equipped with a vibrator, in addition to an audio notification, to serve as an alternative notification medium for physically challenged patients who may not be able to hear voice notifications.

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III. METHODOLOGY

block diagram of the various subsections that made up the Medicine Time Reminder System. The microcontroller is the most important component. It serves as the system's central processing unit (CPU). It connects all subsequent pieces and subdivisions. An O-LED display module is used to display system status, time, date, and other data.

The system communicates with the end user via the GSM module. The clock module is used to assist the microcontroller in keeping track of the current time. A buzzer and a vibrator are used for sound and vibration notification. Finally, a keypad is used to program the alarm, phone number to call, time, and date.

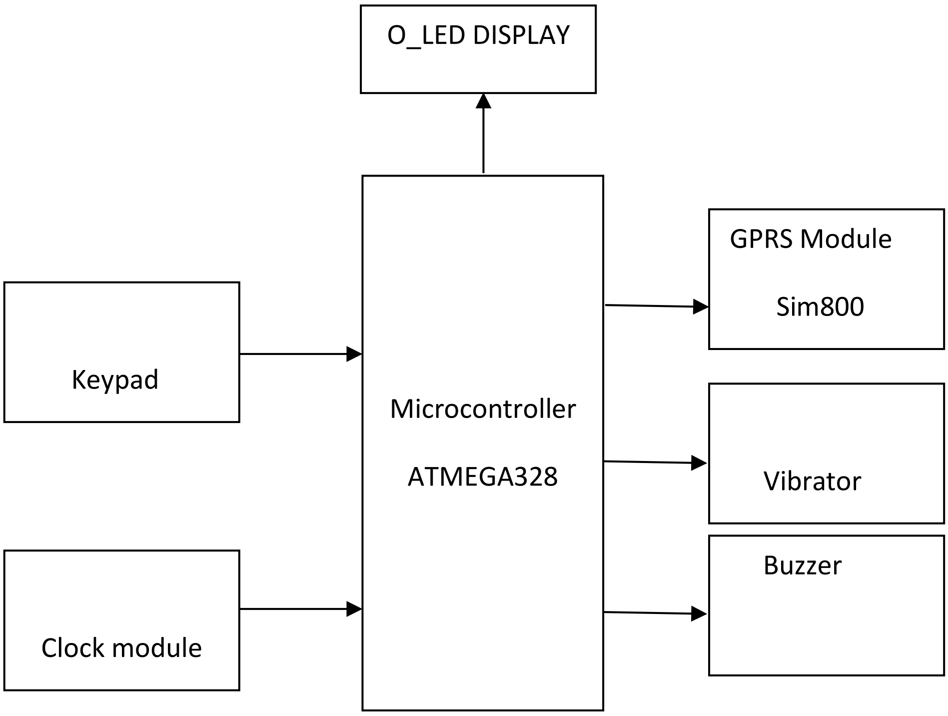

Figure 1 Generalized block diagram of a Medicine Time Reminder System

3.1.1 GSM module connection

The SIM800L module is a GSM/GPRS module that allows the Automatic Medication Time Reminder System to communicate with the end-user through their mobile phone network. It operates on EGSM900MHz, DCS1800MHz, and PCS1900MHz frequencies, making it compatible with most mobile phone networks.

3.1.2 Power Supply Circuit

Power for this unit will be sourced from the battery. The regulator down-convert the battery DC voltage to a lower DC voltage of the same polarity. It is also possible to generate multiple voltages using linear power supplies. In multi output power supply, a single voltage must be converted into the required system voltages (for example, +5V, +12V, -12V) with very high power conversion efficiency. A linear IC voltage regulator, 7805, is used to regulate the 12VDC obtained from the battery to 5V DC required for the operation of this design as shown in Figure 2.

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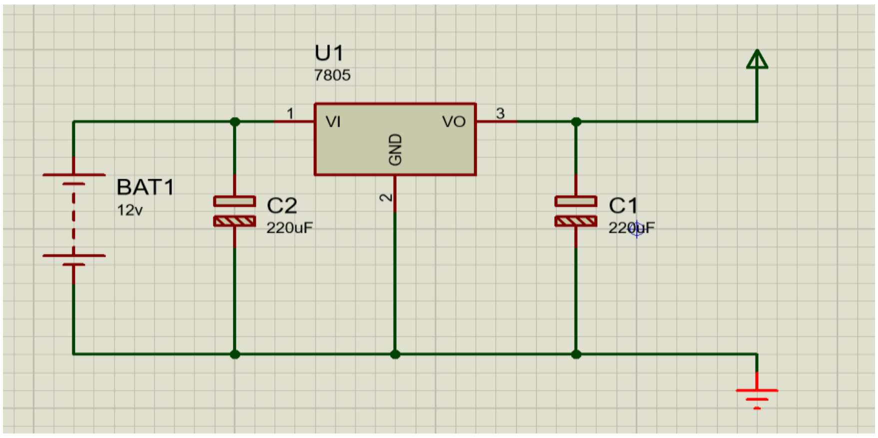

Figure 2 Power supply unit

3.1.3 Keypad connection

The 4 by 3 keypad is an essential component of the Automatic Medication Time Reminder System, as it allows the end-user to program the system's alarm, phone number to call, time, and date. The keypad contains twelve buttons, four rows, and three columns, and each button represents a unique combination of a row and column. When a button is pressed, the microcontroller detects which row and column the button is in and translates that information into a specific command or value.

3.1.4 RTC module

The clock module, specifically the DS1307 Serial Real-Time Clock, plays a critical role in the Medicine Time Reminder System. It provides the system with accurate timekeeping capabilities, which are essential for ensuring that medication reminders are delivered at the correct times.

3.1.5 Display module connection

The OLED display in the Medicine Time Reminder System is used to display important information such as system status, time, date, and other relevant data to the user. The display is only around 1" diagonal, but due to its strong contrast, it is exceptionally readable. Additionally, no backlight is necessary because the display generates its own light, which lowers the power needed to operate the OLED, accounting for its outstanding contrast and sharpness.

3.1.6 Microcontroller Specification

The microcontroller chosen for the Medicine Time Reminder System is the ATMEGA328P. The selection was based on several criteria, including the quantity of analog and digital inputs, program memory storage, clock frequency, interrupts, and timer circuits required.

The ATMEGA328P is a member of the Microchip AVR 8-bit microcontroller family and is commonly used in Arduino Uno. The microcontroller has a large memory, enough input/output ports, and analog/digital channels, making it suitable for a project that relies heavily on memory and computations.

The ATMEGA328P is available in a 28-pin DIP package that fits into available IC sockets, making it easy to use and program. It also has enough TTL compatible I/O pins and FLASH memory for easy and fast reprogramming.

The ATMEGA328P contains 32kb of FLASH memory for program storage, 2kb of RAM memory, and 1kb of EEPROM memory. It also has two 8-bit and one 16-bit timer/counters, which can count internal clock cycles or external events and generate an interrupt when reaching a specified count value. The microcontroller also has 6 channels of 10-bit analog-to-digital converter (ADC) and a serial communications port that can be used to communicate with the COM port of a computer. Additionally, it has an I2C interface port for communication with other I2C-compatible ICs.

In the Medicine Time Reminder System, the ATMEGA328P is the central processing unit that connects all the other components. It is programmed to control the OLED display module, GSM module, clock module, buzzer, vibrator, and keypad, ensuring timely reminders to users about their medication schedule. The microcontroller uses the clock module to keep track of the current time and sends notifications to the user via the GSM module, buzzer, and vibrator when it is time to take their medication. Overall, the ATMEGA328P is an essential component of the system that ensures its smooth operation and reliability.

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Figure 3 Connection of the modules

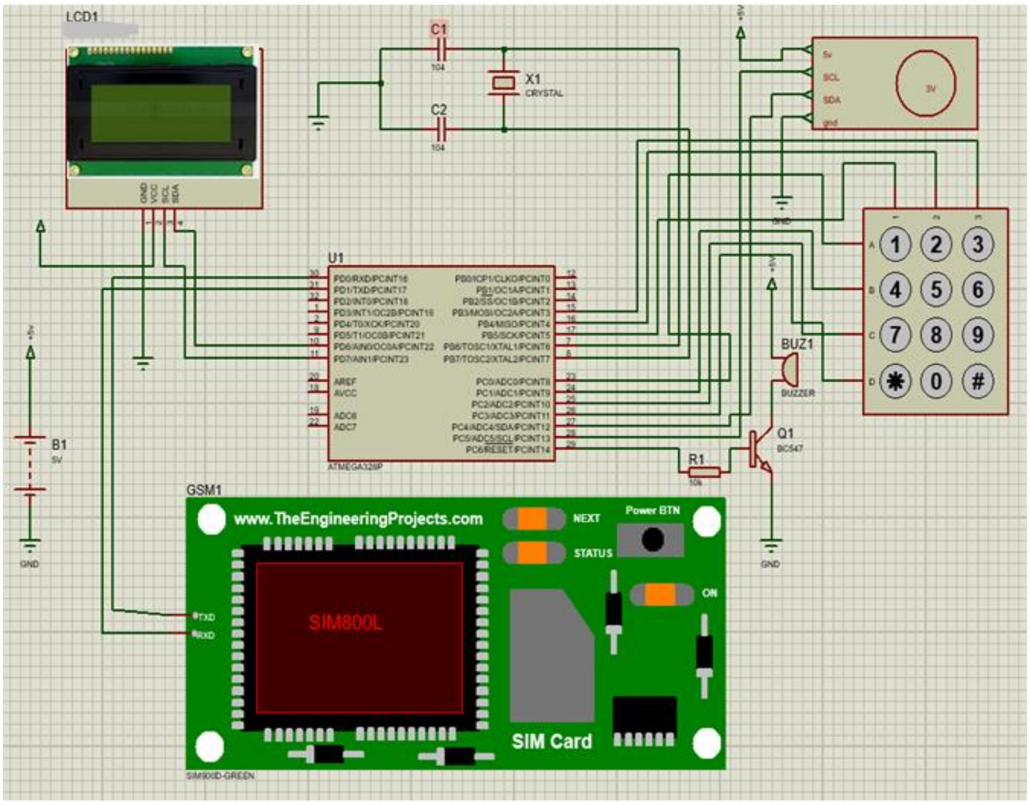

Figure 4 A complete circuit diagram of a Medicine Time Reminder System

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3.4 Principle of operation

The microcontroller regulates and controls the system's activities. The keypad will be used to set the alarm time and phone numbers. The predefined values will be saved in the microcontroller's memory. Every microsecond, the microcontroller will receive input from the Real Time Clock module (RTC) and compare it to the predefined alarm time stored in the microcontroller memory. This microcontroller will send information from the RTC to the O-LED for display. When the time received by the microcontroller matches the time saved as an alarm time on the microcontroller, the alarm is activated, starts vibrating, and calls to predefined phone numbers are made. Unless the action is acknowledged by pressing a button on the system, the system remains in this state for 5 minutes. If the button is not pressed after several minutes, the system will dial the number of the medical practitioner in charge of the patient to figure out what is wrong.

3.5 Performance Evaluation of the System

This research would employ a survey research via a TAM questionnaire as a data collection approach which combined with a linear regression model as a data analysis approach to test hypotheses about relations among primary variables of the Technology Acceptance Model (TAM).

In terms of data collection, a total of 110 survey self-administered questionnaires related to the measurement of factors were distributed to end-users of the Medicine Time Reminder System. The first section of a questionnaire related to demographic questions includes age, gender and profession. The second was a close-end question with a 7-Point Likert scale related to perceived usefulness, perceived ease of use, attitude toward and behavioural intention.

After that, a descriptive analysis was used as a data analysis approach to the demographic information of the respondents in the first place. Then, Reliability testing was conducted to measure the internal validity and consistency of items used for each construct. Later, correlation analysis was performed in order to measure the convergent of the items of TAM questionnaire. Lastly, in order to test the five Hypotheses, linear regression models was conducted by using the SPSS 26 analysis software.

IV. RESULT AND DISCUSSIONS

This questionnaire was administered to 110 respondents, giving a response rate of about 95%. Respondents consisted of 57% Male and 43% Female. Age in the range of 17-25 years (16%), 26-30 years (29%) and 35 and above (45%). Occupation of Medical practitioner (20%) Computer Expert (38%) and others (42%). User experience on the use of a Medicine Time Reminder System of 0-2 years (45%), 3-5 years (32%) and Over 5 years (33%)

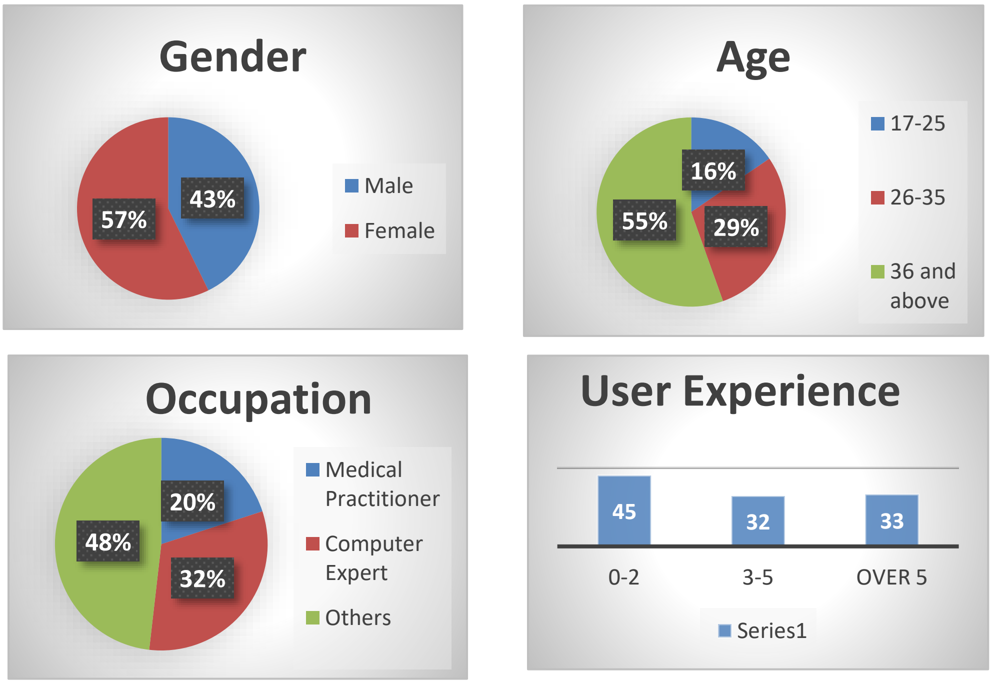

Figure 5: Demographic details

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Hardware Design Reliability

The reliability analysis was conducted in order to check the internal validity and consistency of the items used for each factors by using SPSS 26 as the analysis tool. The results of the Reliability analysis are presented in Table 1. Questionnaires for the various factors of a Medicine Time Reminder System were judged to be well reliable device with the Cronbach's alpha scores were all above 0.8.

Table 1: Reliability

Scale: ALL VARIABLES
Reliability Statistics

Cronbach's Alpha	N of items
0.839	22

Correlation Analysis
After conducting the Reliability Analysis, we inspected the correlation coefficients to discover the relationships between four factors and investigate the hypotheses of the research model. The analysis tool is also SPSS.

Table 2: Correlation

	Factor	**PEOU**	**PU**	**AT**	**BI**
PEOU	Pearson Correlation	1	0.721	0.857	0.723
PU	Pearson Correlation	0.621	1	0.855	0.827
AT	Pearson Correlation	0.729	0.922	1	0.792
BI	Pearson Correlation	0.811	0.854	0.772	1
** Correlation is significant at the 0.01 level (2-tailed).					

The table above shows that the correlations between the PEOU, PU, AT and BI are positive and significant.

1.2 Hypotheses Testing

To further enhance this findings, a regression analysis was conducted to test the H1 and H2. Table 4 summarises the result of regression.

Table 3: Predictors: PU & PEOU – Dependent Variable: AT

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.922[a]	0.850	0821	0.72

a. Predictors: (Constant), PU, PEOU

Coefficient[a]

Model	Unstandardized Coefficients		Standardized Coefficients		Sig.
	B	Std. Error	Beta	t	
1 (Constant)	0.316	0.299		1.519	.120
PEOU	0.342	0.117	0.523	6.721	.000
PU	0.623	0.145	0.741	10.462	.000

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a. Dependent Variable: AT

As we can see from Table 3, the value of R square indicates that the two predictors (PU), PEOU) explained 85% of the variation in Attitudes to use. The standard coefficient (β) shows that Perceived Usefulness (β=0.741) has a larger impact than Perceived Ease of Use (β=0.523). Also, the Sig. indicates that both of the predictors had a significant and positive impact on AT scores at the 0.001 level.
Subsequently, a linear regression model was also used to test H3 and H5 which are the impact of Perceived Usefulness and Attitude on user's behavioural intention toward a Medicine Time Reminder System.

Table 4: Predictors: PU & AT – Dependent Variable: BI

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.923[a]	0.852	0.727	0.337

a. Predictors: (Constant), AT, PU

Coefficient[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	.413	.210		1.867	.093
PU	.667	.123	.492	9.821	.000
AT	.312	.101	.322	5.642	.000

a. Dependent Variable: BI

As appears in Coefficient[a], it confirmed the H3 that Perceived Usefulness (PU) had a significant effect on Behavioural Intention (BI) with β=0.492, Sig = 0. While Attitude Toward (AT) had a positive influence on the dependent variable BI, with β=0.322, Sig=0

Finally, another linear regression model was determined to investigate the influence of Perceived Ease of Use (PEOU) on Perceived Usefulness (PU).

Table 5: Predictors: PEOU – Dependent Variable: PU

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.712[a]	0.507	0.329	0.412

a. Predictors: (Constant), AT, PU

Coefficient[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	1.892	.523		10.821	.000
PEOU	.543	.417	.529	9.338	.000

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a. Dependent Variable: PU

As seen, the R Square value (0.507) is low, thus indicating that PEOU explained only 49% of the variation in PU. Based on the Standardized coefficient value (β=0.529), Perceived Ease of Use (PEOU) had a significant impact on Perceived Usefulness (PU).

Table 6: Summary of hypothesis testing

Hypothesis	Specification	Results
H1	Perceived Ease of Use (PEOU) will positively influence users' attitudes towards the Medicine Time Reminder System	Supported ((β=0.523 p<0.001)
H2	Perceived Usefulness (PU) will positively influence users' attitudes towards the Medicine Time Reminder System	Supported ((β=0.741, p<0.001)
H3	Perceived Usefulness (PU) will positively influence users' Behavioural Intention to use the Medicine Time Reminder System	Supported ((β=0.492, p<0.001)
H4	Perceived Ease of Use (PEOU) will positively influence the Perceived Usefulness (PU) of the Medicine Time Reminder System	Supported ((β=0.529, p<0.001)
H5	attitude towards a Medicine Time Reminder System will positively influence Users' Behavioural Intention to use the Medicine Time Reminder System	Supported ((β=0.322, p<0.001)

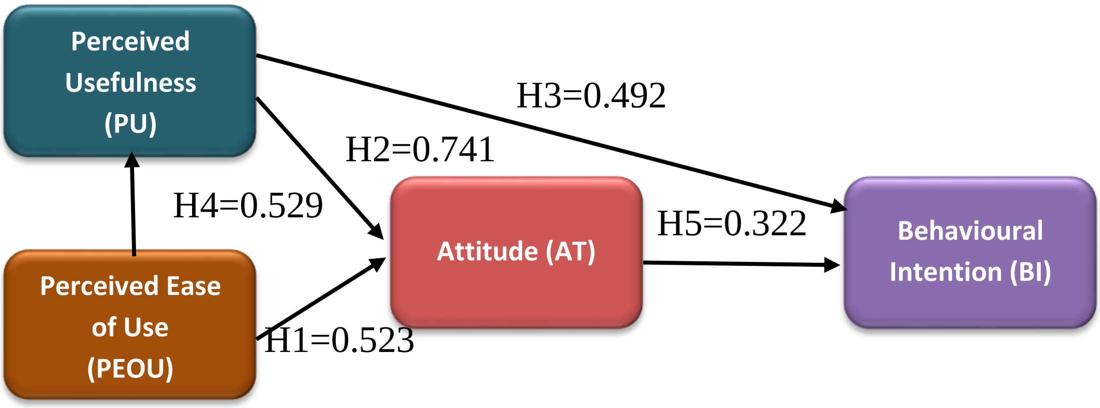

Figure 6 Linear Regression Model result

In summary, the results of linear regression analysis confirmed the five hypotheses. Perceived Ease of Use (PEOU) had the strongest impact on Attitude towards (AT), followed by the influence of Perceived Usefulness (PU) on Behavioural Intention and Attitude Toward (AT) using the Medicine Time Reminder System. Perceived Ease of Use (PEOU) had positive impact on the Perceived Usefulness of the Medicine Time Reminder System. Finally, Attitude Toward (AT) had a small influence on Behavoural Intention (BI).

Figure 7: Clock and time after 24 hours of turning the device off.

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Testing the calling functionality of the system:
One of the critical features of the Medicine Time Reminder System is the ability to call predefined phone numbers if the patient does not respond to the alarm. Therefore, it was essential to test this functionality to ensure that it worked correctly and reliably. The system was tested by setting a call to a predefined number and observing how the system responded when the call was initiated. The results showed that the calling functionality of the system was effective and reliable, making it a valuable feature of the system.

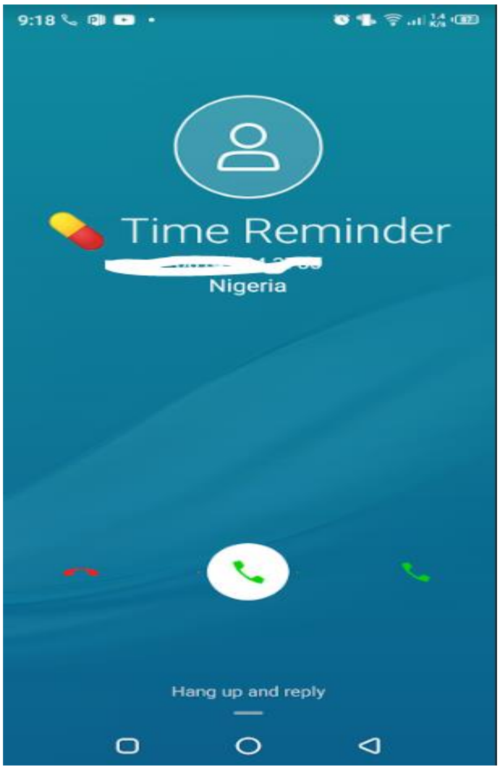
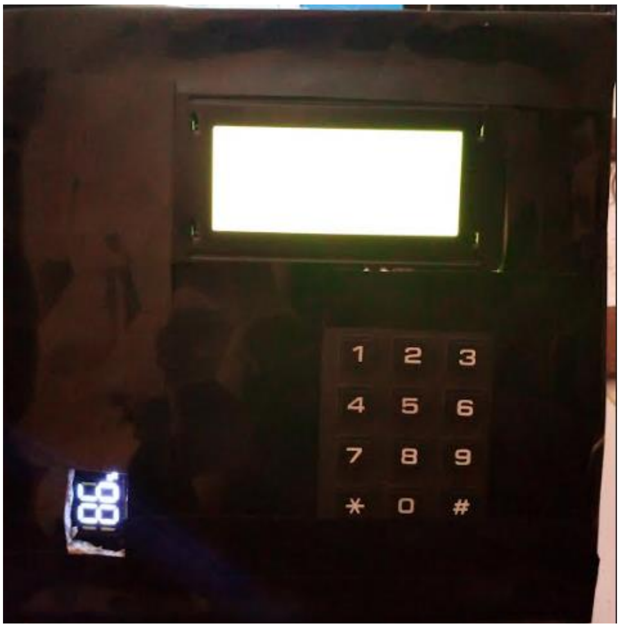


Figure 8: The screenshot of the received called.



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V CONCLUSION

A medicine time reminder system utilizing sound and vibration can be a highly effective and valuable tool for individuals who need to adhere to medication schedules. The medicine time reminder system increases the chances of timely medication intake. This system offers several advantages, including its simplicity, versatility, and accessibility to a wide range of users.

The simplicity of the medicine time reminder system using sound and vibration makes it user-friendly and accessible to a wide range of individuals. The device can be easily programmed and customized, allowing users to set up personalized medication schedules and reminders. Also the operation is dependent on how well soldering is done, and the positioning of the components on the printed circuit board. If poor soldering lead is used the circuit might form dry joint early and in that case, the project might fail.

The Medicine Time Reminder System is a well-designed and highly effective solution for ensuring that patients take their medications on time. The results of the user assessment showed that the system was highly effective in ensuring that the patients took their medications on time, with 85% of patients reporting that the system effectively reminded them to take their medication at the right time.

However, like every aspect of engineering, there is still room for improvement and further research on the project as suggested in the recommendations written out in the section that follows in the paragraph below.

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