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Smart Heart Band; The Development of Effective Emergency Band

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Abstract: Heart disease is quite common and statistics show that the risk of heart disease increases greatly as they age. Besides that, based on research findings, it has been proven that older people are also novice users of smart technologies and thus leading them to be underutilizing it especially during emergencies. This study provides a simple smart solution that integrates Internet of Things (IoT) named Smart Heart Band (SHB) for the targeted people of old age with high risk of heart disease and their caretakers that can be of any age. This smart band aims to assist the elderly in notifying their close ones during emergencies and to reduce risk of sudden unattended attacks. The study uses the Input Process Output (IPO) method in the development of this device with hardware such as NodeMCU, pulse sensor, buzzer and button. Alongside it, software like Blynk were used to connect the devices and notifying the emergency contact. Survey shows that the targeted users find the SHB to be a useful device they need in times of emergency. After testing from the developer's perspective, the effectiveness of the SHB is proven to be sufficient and able to provide all features that are necessary such as automatic notification and siren to alert people, while still being cheap and easy to understand. In conclusion, it is proven that the SHB is able to provide an easy automatic method of contacting emergency contacts during cases of emergences that medical attention as soon as possible. In future, the SHB can be connected with medical personnel so user can be attended immediately and have accurate diagnosis.

Keywords: Internet of Things (IoT), Pulse Sensor, Heart Attack, Arduino IDE, Blynk

1. Introduction

Cardiovascular Disease (CVD) is a broad term that refers to illnesses that affect the heart and blood vessels (vascular system). Ischemic heart disease is the usual cause of heart attacks and even the worst outcome, death [1][2]. Based on the World Health Organization statistics, the disease that is responsible for the most deaths in the world is crowned by ischemic heart disease with 16% of the world's total number of death [3]. Through a study in 2013 on statistics of deaths caused by ischemic heart disease in the world, it was proven that there is significant proof that age is a huge factor [2][3].

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Creating a simple, easy-to-use Smart Heart Band will be useful as other technology devices that detect abnormal heart rates are very complex and confusing. Unfortunately, it has been proven that people of older age do not necessarily understand how to use such technology [4][5].Therefore, this study aims to develop a Smart Heart Band using the Internet of Things (IoT) concept and in achieving this, the study will analyses the importance of this device for heart attack identification, use several hardware like NodeMCU, pulse sensor, buzzer and button, and software's like Blynk and Arduino IDE and finally, evaluate the effectiveness and possible future improvements for the product.

In the next session, the background of this study such as the factors and reasons as to why the SHB needs to be developed will be discussed and elaborated. The following section will explain the methodology used to develop this project and the Section Four will show the process of development. Next, Section Five will analyse the project testing and the final section will conclude the whole study.

2. Literature Review

Heart attacks are caused by a problem with the heart's blood vessels. When the blood flow to a portion of the heart muscle is significantly decreased or cut off, a heart attack ensues. This occurs when an impediment, such as blood clots form on plaque due to atherosclerosis, and blocks one of the coronary arteries. Typically, heart attacks begin with chest discomfort, shortness of breath and an increase in pulse rate resulting from the increased pressure in the heart [1][6]. Following that, poor blood circulation and lack of oxygen will produce dizziness and light-headedness, as well as cold sweating, which can cause the heart rate to drop dangerously low and even cause nausea [6].

Patients who are experiencing signs of a heart attack should seek immediate medical attention at a hospital that offers 24-hour emergency cardiac care as the damage to the heart is substantially decreased when heart attack victims receive prompt treatment [7][8]. However, as mentioned before, people of older age are those who are the most easily affected and they belong to the group of people with the least knowledge and ability to use technology [4][5][9]. When an emergency occurs, they are unable to contact anyone and due to these unfortunate circumstances, can lead to death.

Most technology designed for communication relies on the ability to see, hear and read, meaning due to health conditions, a significant chunk of society is missing out on communication opportunities [4][5][9]. Devices like the Holter Monitor, iBeat Heart Watch and Apple Watch provide the functionality of detecting the heart rate of users [10][11][12]. The Holter Monitor does not have the feature of notifying emergency contact like the other two devices, and the Apple Watch has an ECG app and even a Fall Detection Sensor while the iBeat Heart Watch has a temperature sensor. Pros and cons can be seen in **Table 1**.

Table 1: Pros and Cons of Similar Devices

Device	Pros	Cons
iBeat Heart Watch	Many sensors, automatic emergency notification when heart rate abnormal	Expensive, no siren to alert people
Apple Watch	Many sensors, automatic emergency notification when heart rate abnormal	Expensive, complicated due to too many features, no siren to alert people
Holter Monitor	Measuring, recording and printing heart electrical activity	Only used medically, no automatic notification and no siren to alert people

Although having so many features is good, which is why they are so expensive, the device becomes hard to understand for the older people who use the device and even lack the feature of alerting nearby people with a siren noise [10][11][12]. Thus, the Smart Heart Band is designed while ensuring that it is easily understandable, easy to use, and cheap, while still providing the necessary features which are the abnormal heart rate detection, automatic emergency contact notification, emergency button and a siren

to alert people. This will allow the targeted user group to use the device easily, effectively without difficulty of understanding as it is mostly automatic and has limited features while being cheap.

3. Methodology

The methodology used in this study is Input Process Output (IPO) Methodology which consists of three stages: input, process and output [13]. This method was chosen so that clearly defined stages can be used as guidance to complete the device and also have a set end goal as the main objective to reach. The stages are divided into six phases which are brainstorming and planning, analysis and specification, system and band design, development, implementation and end phase. A simple process figure of the methodology can be seen in **Figure 1** where it shows each phase and sub-phase of the IPO Methodology used to develop the Smart Heart Band**.**

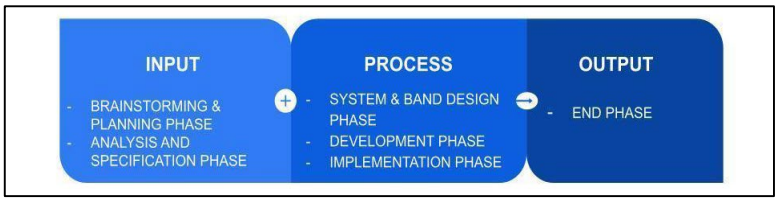


Figure 1: Input Process Output Methodology [14]

3.1 Input

Brainstorming and planning phase is a phase that defines the issue and complexity of the existing system [15]. The study checks the project's feasibility and planned the time and effort required to complete it in order to create a timeline. Limitations, threats, and device connections were all evaluated at this phase. The study analysed consumer requirements through a survey and defined the importance of having a smart heart band. An online survey through Google Forms consisting of a set of questions based on the study was created and distributed through social media platforms. The targeted respondents were those with higher risks of heart attack which are people above the age of 55, and the caretakers of this group which can be of any age, so there are many different kinds of background knowledge and history of heart disease. As for this survey conducted as a pre-test, out of the 50 respondents, only 18% were people above the age of 55, while the rest are below 55 of age (20% below 25, 10% ages 25 to 35, 22% ages 35 to 45 and 30% ages 45 to 55). The questions on awareness that were answered proved that most of the respondents did not have adequate knowledge on the topic of heart disease. Majority of respondents, at 46%, did not know that a victim could be completely unaware of their current health condition and experience a sudden heart attack.

As seen in **Figure 2**, out of all respondents, a whopping 62% agreed that a simple and cheap automatic notifier is needed in case something relating to the heart happens. According to the outcome of this survey, the majority of people today are ignorant of the dangers that surround heart patients and their consequences, which are often catastrophic. This highlights how important it is to have a smart heart band that can save people's lives.

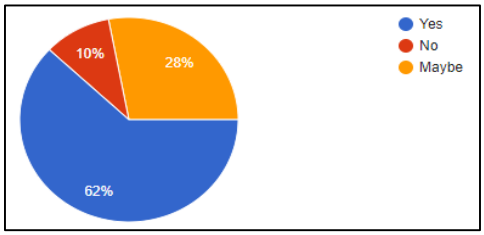


Figure 2: Survey results of whether respondents think device is needed in daily life

Meanwhile, the analysis and specification phases are where all the necessary requirements of the project were determined based on the data collected. Significant qualitative and quantitative data that was analysed was used to determine the project specifications and prototype. Based on the data, ability to detect abnormal heart rate, notifying loved ones immediately during emergency situations and alerting people surrounding the victim for immediate aid were highlighted as the project requirements.

3.2 Process

In the system and band design phase, it provides responses to "how" you can build the right solution [15]. In this design phase, first the design of the SHB was determined and a rough diagram of the band was drawn as a reference. **Figure 3** shows the diagram of the rough drawing of Smart Heart Band that was used as the design of the project where the hand of the user is drawn with a band for easy access wear while the hardware are placed on top of the band, and the pulse sensor is placed on the user's pulse to detect the heart rate. The diagram was used as a reference to prepare the necessary hardware and software needed to create the Smart Heart Band.

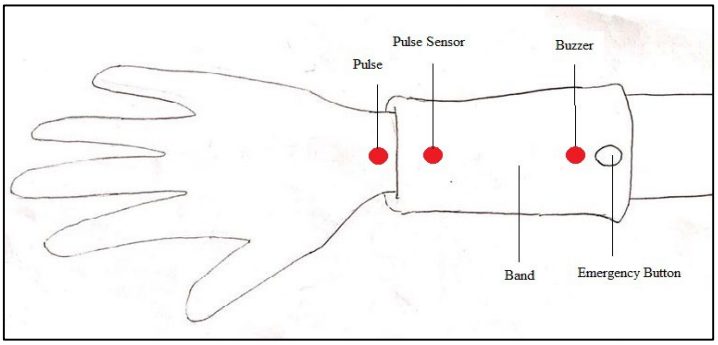


Figure 3: Rough Drawing of Smart Heart Band

A Circuit diagram containing the connections of electrical components was also created based on the design and the requirements of the band stated previously. **Figure 4** shows the circuit diagram of Smart Heart Band, with all components like buzzer, button and pulse sensor, resistor and jump wires being connected to the breadboard (the grey rectangle on the right) and NodeMCU (the blue rectangle on the left) in order to allow the Smart Heart Band to function all the specified features.

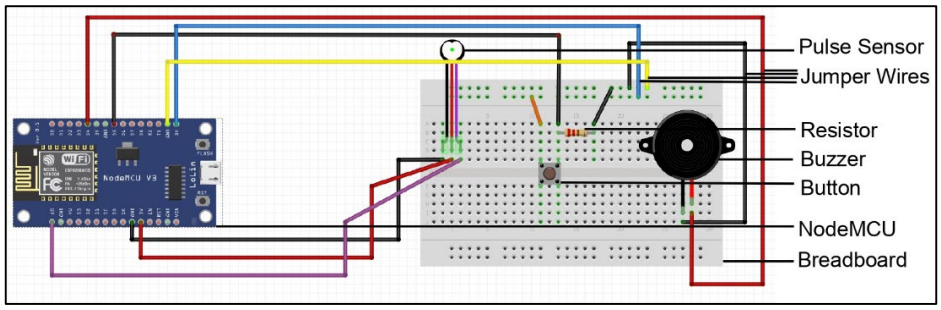


Figure 4: Circuit Diagram of Smart Heart Band

The development phase is where the designers and developers began working on turning the prototyped system and design into a workable project during the development phase. In this phase all of the previously prepared hardware and software, including the Arduino IDE, the Blynk Application, the Arduino Board, and various electrical components were used to develop the project.

Implementation phase is where the construction of the actual result of the project takes place. All necessary electrical components were wired and fixed accordingly and the coding's were checked and

tested with the fixed components. The project's performance is evaluated based on its list of requirements as well as its design.

3.3 Output

In the end phase the performance of the project is tested from the developer's perspective. The output from the testing was analysed based on the defined requirements.

The next section will explain the process of developing the Smart Hear Band using all the hardware and software mentioned in this section.

4. Project Development

Smart Heart Band was completed by wiring all the electrical components, creating a prototype wrist band, and generating the code for the entire project. Electrical components and software like IDE and Blynk to connect the device are used to complete the Smart Heart Band prototype.

4.1 Hardware

The hardware used on Smart Heart Band are breadboard, jumper wire, buzzer, micro button, resistor, NodeMCU, pulse sensor. The unit testing is done to test the functionalities of each component. Unit testing allows the integration of the components to be smooth and angle to run accurately. **Table 2** shows the functionalities of the hardware used in Smart Heart Band. The results of the unit testing prove that the components function perfectly. Each component may have different testing methods (using an LED or buzzer) to ensure components can function accordingly.

Table 2: Hardware used on Save Heart Band

Component	Functions
NodeMCU	To execute code from Arduino IDE and connect WiFi to required components
Breadboard	To connect components together on one platform
Pulse Sensor	To detect heart rate from the pulse of the user that is too high, too low, and the rate that is nearing the abnormal heart rate.
Resistor	To restrict current flow
Jumper Wire	To connect components together
Micro Button	To act as an emergency button for the user to alert people nearby and emergency contact in case heart rate is normal but user experiences other symptoms
Buzzer	To release noise for alerting people nearby

By connecting all of the components and producing a prototype of the band model, the Smart Heart Band was completed. **Figure 5** below displays the hardware used in Smart Heart Band which are the jumper wires, button, buzzer, resistor, and NodeMCU all on top of the breadboard (white rectangle thin box) and charged by the laptop using the thick blue USB on the right.

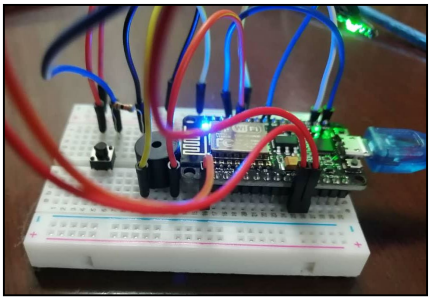


Figure 5: Hardware used on Smart Heart Band

4.2 Software

The software used to upload the code is Arduino Integrated Development Environment (IDE). The code is written and uploaded to Arduino IDE via a USB cable. There are lots of libraries that were included in this project such as PulseSensorPlayground, SPI, ESP8266WiFi and BankSimple Esp8266. **Figure 6** shows the script code for the project in the Arduino IDE that sends notifications to the emergency contact through Blynk when the user's heart rate is too high (100bpm) or too low (60 bpm), when the user's heart rate is nearing the abnormally high and the abnormally low range.

```
if (buttonState==0)
{
digitalWrite(buzzer, LOW);
delay(200);
}
 // put your main code here, to run repeatedly:;
 Blynk.run();
 // Initiates Blynk
 timer.run();
 // Initiates SimpleTimer
 if(myBPM <= 60 || myBPM >= 100) {
   Blynk.notify("The chances of getting heart attack is really high");
 }
 else if(myBPM > 69 && myBPM < 76) {
    Blynk.notify("Heart rate is almost low");
 }
 else if(myBPM > 89 && myBPM < 96) {
    Blynk.notify("Heart rate is almost high");
 }
}
```

Figure 6: Script code notifications of Smart Heart Band in Arduino IDE.

Smart Heart Band uses an IoT platform called Blynk to send notifications to smart phones. The author utilized the NodeMCU in this project which is linked to the Blynk application. Within the Blynk Application, the author built a project called Smart Heart Notification. As a result, when the user experiences sudden cardiac arrest or when the emergency button is pressed, a notification is sent to an emergency contact asking for assistance via the Blynk application. These Blynk notifications that pop up in the smartphone when the Smart Heart Band detects abnormal heart rate or when the emergency button is pressed can be seen in the post-testing from the developer's perspective in section 5 below.

4.3 Smart Heart Band Model

The Smart Heart Band prototype is made out of a thick wrist band and hardware that illustrates how the band performs. By connecting to the breadboard and NodeMCU, the device detects and reads the heart rate of the user. The laptop's battery is used to power the Save Heart Band.

Smart Heart Band was completed by wiring all the electrical components, creating a prototype wrist band, and generating the code for the entire project. The electrical component includes breadboard, jumper wire, buzzer, micro button, resistor, NodeMCU, pulse sensor. The platform used within Smart Heart Band is Blynk. Once developed, we started the developer perspective testing.

Figure 7 shows the picture of the Smart Heart Band model where all labelled hardware components are connected to the band, charged by the laptop battery and with the pulse sensor positioned at the pulse of the user to detect the heart rate. This is the prototype of the band that will be worn by the user.

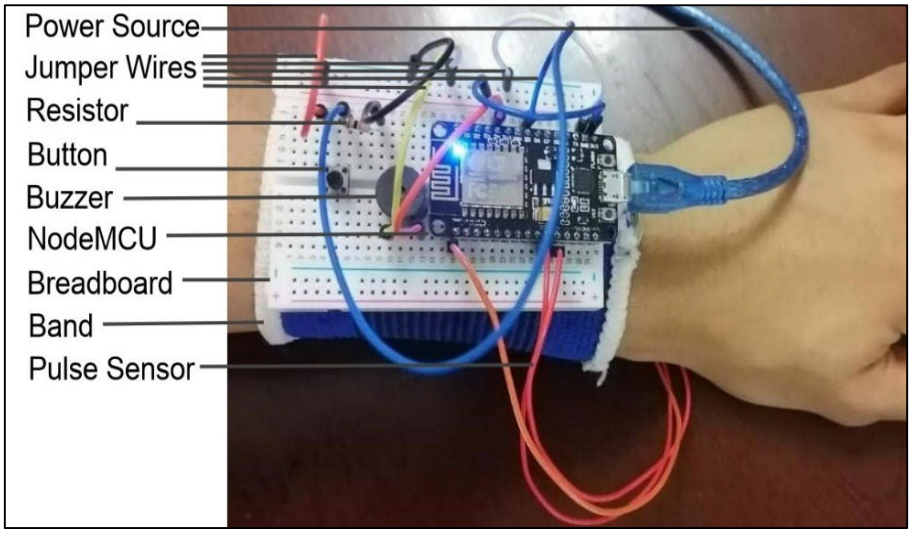


Figure 7: Smart Heart Band Model.

The next section will provide results of the prototype testing from the developer's perspective and the effectiveness of each feature provided in the Smart Heart Band.

5. Result and Discussion

This section will briefly discuss the testing results of the heart detector prototype. This testing is done after the development of the prototype and this post-testing was conducted from the developer's perspective. After testing, the results and analysis will be discussed.

Once the Smart Heart Band was developed, we started the developer perspective testing. This test will test every function of the device using suitable methods as seen in **Table 3,** from the perspective of the developer as there is a Movement Order Control upon the country. We tested the ability for the device to detect abnormal heart rate (too high and too low), detecting heart rate that is nearing the abnormal range, function of the button as an emergency button and the buzzer to notify people nearby.

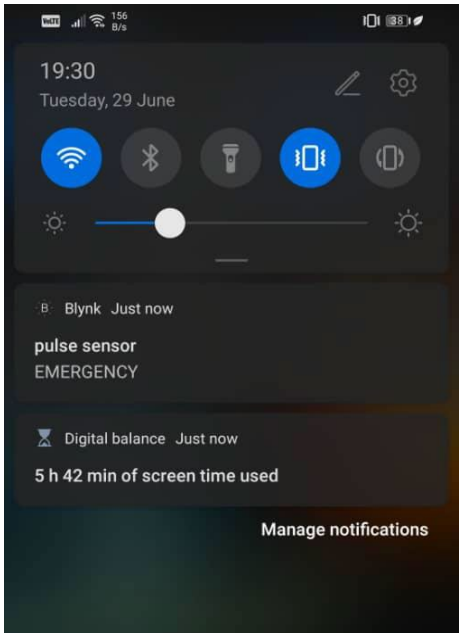
Table 3: Developer Perspective Testing

Device Function	Testing Method	Testing Results
Automatic abnormal heart rate detection notification Automatic nearing abnormal heart rate detection notifier	Developer stays at home and jog to increases heart rate while brother drives away to test if the notification still sends through distance	Emergency contact receives notification through Blynk
Manual notification through pressing emergency button	Developer presses button	Emergency contact receives notification through Blynk
Buzzer alerting nearby people by pressing emergency button	Developer presses button	People nearby hears the buzzer and is alerted

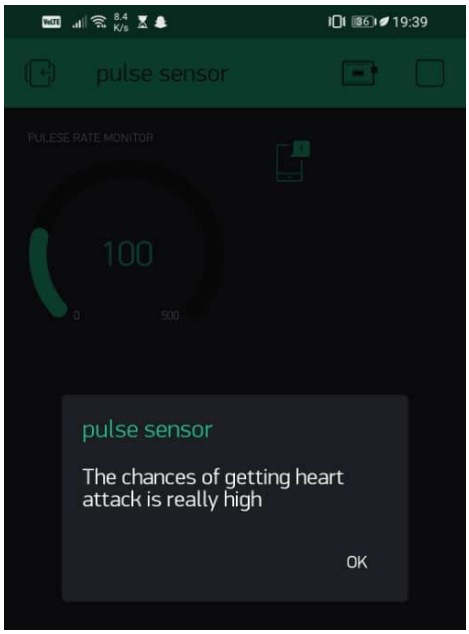
From **Table 3**, the testing method and results are displayed. For the features of automatic abnormal heart rate and nearing abnormal heart rate detection notification, the test was conducted by increasing the user's heart rate and monitoring the Blynk notification from the emergency contact's phone. For the feature of manually sending a Blynk notification to the emergency contact, the testing is done by pressing the emergency button. Through these tests, results were seen from the Blynk app notification and the alerting siren coming from the Smart Heart Band for when the button is pressed.

Results of the 4 different kinds of Blynk notifications can be seen in **Figure 8**. **Figure 8 (a)** is the notification received when the emergency button is pressed, while **Figure 8 (b)** is the automatic

notification when heart rate is too high or too low (above 100 bpm or below 60 bpm). **Figure 8 (c)** is the notification received when the heart rate is nearing the abnormally high range (95 to 99 bpm) and **Figure 8 (d)** is the notification when the heart rate is nearing abnormally low range (66 to 61 bpm).



(a)



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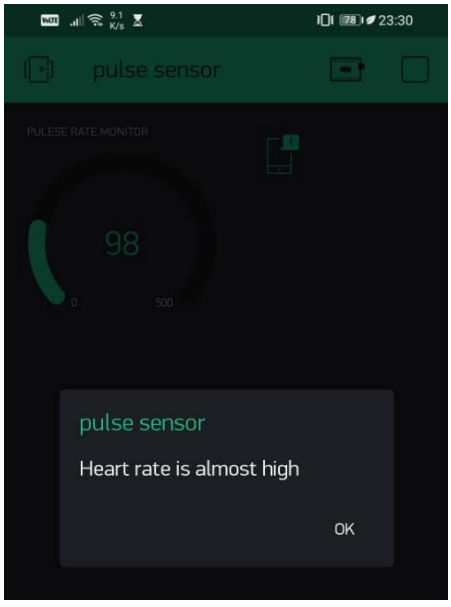
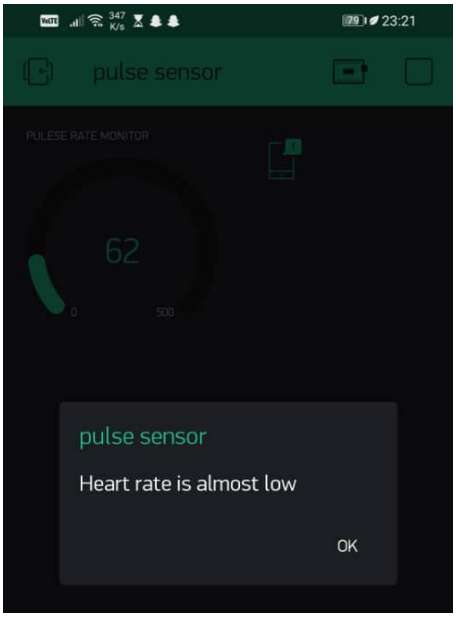


(c)



(d)

Figure 8 : Smart Heart Band Blynk Notification of (a) When user presses emergency button (b) When user heart rate has reached abnormal range (c) When user heart rate is nearing abnormally high heart rate (d) When user heart rate is nearing abnormally low heart rate

From this testing, it is proven that this Smart Heart Band is useful and efficient to be used by anyone, especially the intended targeted group (older age group) as most of its functionalities are automatic and have an easy to understand button for emergencies This efficiency provides a safer environment for patients who are at risk of heart attack any time of the day and allows easy notification of the emergency contact of choice, and siren to alert neighbours too.

6. Conclusion

In conclusion, the objective to develop a lifesaving product using the IoT concept that detects heart rate is achieved by using hardware components like NodeMCU, pulse sensor, buzzer and button and software like Blynk and Arduino IDE. Through the post-testing in the developer's perspective, the effectiveness was proven to reach expectations, as it was both easy to use and easy to understand. For future improvement, a few notable suggestions are adding a battery, creating a database to keep track of the heart rate history, calling the ambulance on the spot and adding speakers to the neighbour's house so that the sound will be alerting them straight in their house in case of emergency.

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