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# Development of Covid-19 Health Monitoring System for Hajj and Umrah Management

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**Abstract:** Hajj and Umrah are acts of worship that Muslims should conduct once in a lifetime if they can afford it. This is because the journey serves as a marker and confirmation of each servant's commitment to his Creator. When Muslims conduct Hajj and Umrah on a regular basis, they are considered circumcised. When the Islamic Year changes in the month of Dzulhijjah, Hajj is undertaken. The number of pilgrims visiting Mecca grows every year, although not at the same rate as Covid-19. To avoid the spread of the Covid-19 virus outbreak in the Holy Land, Makkah was closed to visitors from all around the world in 2020. The Saudi Arabian government, however, reopened Makkah in 2021 for those who choose to conduct the Hajj, but only for a restricted number of pilgrims. The increases number of pilgrims each year is an issues to the Mutawwif as they need to always monitor the pilgrims' health condition so that they are not infected with Covid-19 viruses. Based on this situation, a measurable device created for pilgrims to self-check their health if they are having any symptoms. This approach will ease the Mutawwif to isolate pilgrims that infected so that the other pilgrims are not infected because Mutawwif will also receive a notification of the pilgrims if there are any changes to their body parameter. It can control the numbers of pilgrims that having Covid-19 viruses from spread to everyone.

**Keywords:** Body temperature, Oxygen saturation, Heart rate, Health monitoring, Covid-19

## 1.0 INTRODUCTION

When the world has discovered the vaccines, the Ministry of Health has established a number of standards that travelers must meet in order to get an Entry Visa for Hajj and Umrah in the Kingdom of Saudi Arabia for the 1434 H Hajj season. Saudi Arabia's Ministry of Health has set a restriction on the number of pilgrims allowed to enter the country in order to reduce social distance [4]. The early detection of the person is infected with the Covid-19 virus are their level of oxygen saturation (SpO2) in their blood decrease below 95% and their body temperature increases over 37.5°.

So, in order to detect if the pilgrims are really infected, the Mutawwif can monitor from their level of oxygen saturation in blood. The number of pilgrims increases can be an issues to the Mutawwif as they need to always monitor and make sure all the pilgrims are in a good health condition especially do not infected with Covid-19. From the case above, this inspires to develop a measurable device that can nefficiently monitor each pilgrim's health state. These analyses, research, and development goals for wearable health monitoring devices are designed to address and overcome the obstacles that pilgrims and health care providers experience during the Hajj and Umrah rituals by develop a hardware and software implementation for pilgrims in monitoring health condition during Hajj and Umrah. The detection of the measurement parameter which is body temperature, oxygen saturation in blood (SpO2), and heart rate types of sensors of the pilgrims are used in this measurable device. But for Covid-19 early symptoms detection, body temperature cannot be the only factor to be measured as the weather during performing Hajj also affect the body temperature increases. When the levels of oxygen saturation in blood decreases, it can be a factor of Covid-19 infection.

## 2.0 LITERATURE REVIEW

### *2.1 Body Temperature*

The body temperature can be measured by using an instrument called as thermometer. The words thermometer can be defined from the terms thermo and meter that

represent "heat" and "measuring" respectively [7]. The ability of human's body to produce and remove heat is measured by its temperature. When the person too hot, the skin blood vessels dilate to allow the extra heat to escape to the surface. The temperature of a person's body changes depending on the age, activity level, and time of day. Thermometers that employ infrared radiation to measure a body's temperature have also been invented, and they may be used to obtain the temperature without having to touch it. The body and surfaces infrared thermometer need to be hold when using it which has dual mode and not contact measurement within 5cm to 15cm distance. The forehead measurement indicates if the person is having a fever or not.

*2.2 Oxygen Saturation*

SpO2, or percent saturation of oxygen in the blood, is a measure of blood oxygen levels. The percentage of oxygen-saturated hemoglobin molecules in arterial blood is determined by a blood-oxygen saturation measurement. The oxygen saturation level is normally estimated using a pulse oximeter device. Two main tests can be used to determine the blood oxygen level. The doctor will take blood from an artery instead of a vein to assess for ABG. Unlike veins, arteries do have detectable pulse. The measurement of oxygen saturation levels can be obtaining by using the pulse oximeter. There are few blood oxygen levels based on table below:

***Table 1**: Blood oxygen levels*

| Oxygen levels percentage | Condition |
|---|---|
| 95% - 100% | Normal blood oxygen levels |
| 91% - 95% | "Under supervision" blood oxygen levels |
| $\leq$ 90% | Low blood oxygen levels |
| 80% - 85% | Low oxygen saturation that affect brain function |
| 67% | Cyanosis |

Other than that, low blood oxygen levels will lead to hypoxemia. Hypoxemia can happen when the blood oxygen levels goes below 92% or lower. When someone's having this symptoms, they are required to seek for a medical treatment as soon as possible or else can lead to cyanosis. Cyanosis happen when the low blood oxygen levels continue on the person's.

*2.3 Heart Rate*

In the medical field, heart rate can easily be defined as the frequency of heartbeat measured by the number in a certain amount of time, generally a minute. The left ventricle of the heart beats to deliver oxygenated, clean blood to the body's blood arteries via the aorta. The wrist, side of the neck, back of the knees, top of the foot, groin, and other areas in the body where an artery is near to the skin might also sense the heartbeat. Adults' regular heart rates range around 60 and 100 beats per minute (BPM), depending on age and gender. In studies shows that normally women's heart rate average will exceed more 2 to 7 beats per minutes than men's. Not every categories age will have the same range of the heart rate. According to researches, individuals with low heart rates are more active and receive more exercise than those with higher heart rates [2]. If an individual has a high resting heart rate that is not even caused by a medical condition, regular exercise is a fantastic strategy to reduce it over time. Active people have lower resting heart rates than those who do not. During exercise, people are advisable to check their heart rate pulse every 5 minutes or during the exercise, made it a point to maintain the heart rate up.

## 3.0 METHODOLOGY

*3.1 Block Diagram*

The project development has a block diagram that begins of input which is two measurement sensor for body temperature, DS18B20 and integrate of oxygen saturation and heart rate sensor, MAX30100. The microcontroller used is ESP32 Node MCU and the output goes to the smartphone through Blynk Apps and IoT platform. The result displayed in numerical based on parameters. The body temperature will display the measurement in degree Celcius (°C), oxygen saturation will display the percentage (%) and heart rate in BPM (beat per minute). Blynk application as an output will display the measurement to ease the user to interpret the measurement data and it will give notification when the measurement exceeding the desired limit.

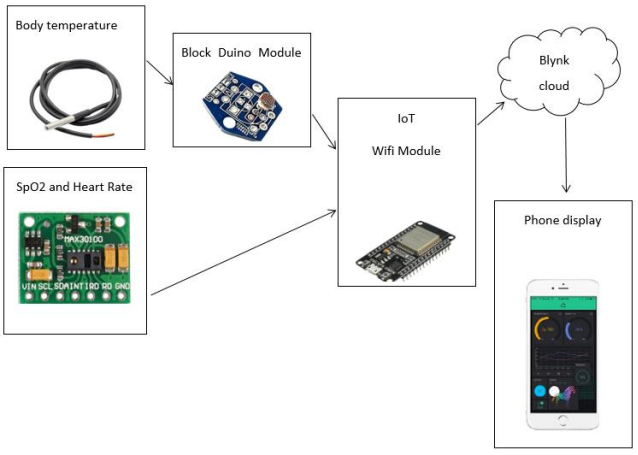


***Fig.1**: Block Diagram*

*3.2 Flowchart*

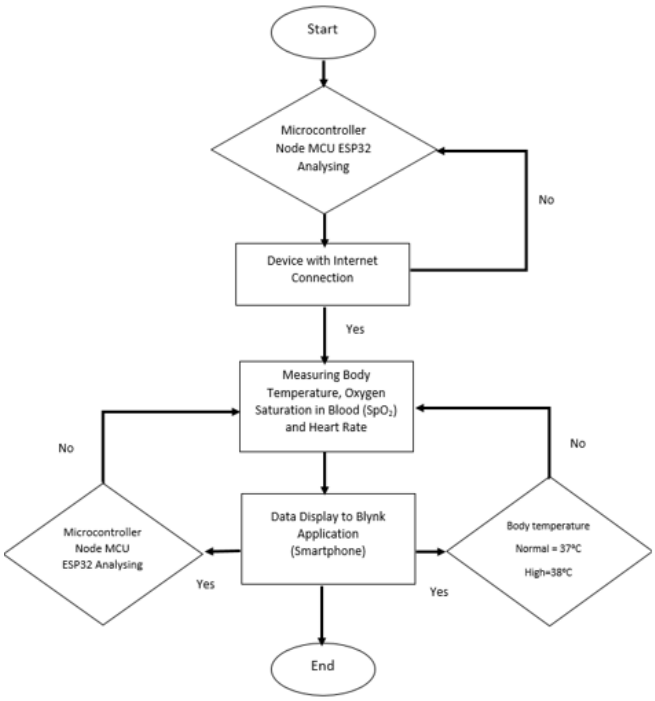


***Fig.2**: Operational Flowchart of Project Development*

According to the flowchart in Figure 2, by providing power to the microcontroller unit ESP32 Node MCU, the processor begins to examine the connections to connect to the device with an internet connection in order to display a result on the Blynk Application. For the body temperature parameter, the program will measure the body temperature and show the result in degree Celcius (°C). If the sensors cannot detect any sense of handgrip for body temperature, the data will display the temperature of surrounding. For oxygen saturation and heart rate, the measurement of both will display in percentage (%) and BPM. The program is set to give a notification when the body temperature high, 39°C and oxygen saturation level below 95%. Both input sensors will continuously be measuring the parameter and all measurement data will be in real-time in Blynk Applications.

*3.3 Development of Measurement Circuit*

The circuit construction for project development shown in Figure 3. The connection of ESp32 Node MCU pins and component was tabulate in Table 2.

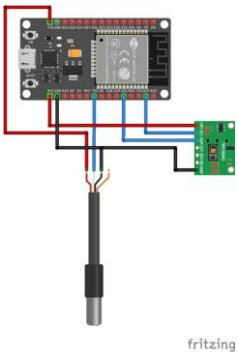


***Fig.3**:Circuit diagram*

***Table 2**: Pins Connection Details*

| No. | ESP32 Node MCU | Sensor Pin |
|---|---|---|
| 1. | Vin | VCC MAX30100 |
| 2. | 3V3 | Vin Max30100 |
| 3. | GND | GND MAX30100 & DSL8B20 |
| 4. | TX2 | Data MAX30100 |
| 5. | D21 | SDA MAX30100 |
| 6. | D22 | SCL MAX30100 |

*3.4 Development of Blynk Application*

Blynk is a framework for creating smartphone apps that can operate with a variety of microcontrollers. This application does not necessitate any mobile programming on our part. This software feature will focus more on functionality, and the greatest thing is that it is completely free of charge. Blynk, an open-source IoT platform with white label mobile apps, private clouds, device administration, data analytics, and machine learning, is a hardware-agnostic platform. It simplifies the development of complicated program while requiring less maintenance.

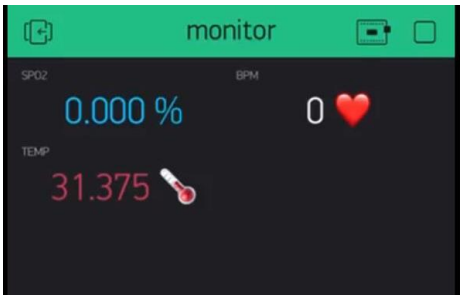


***Fig.4**: Development of Blynk Application*

## 4.0 RESULT AND DISCUSSION

***Table 3**: Data Collection of Testing Over Average*

| Condition during testing | Body temperature(°C) | | SpO2 | | Heart rate | |
|---|---|---|---|---|---|---|
| | Theory | Testing | Theory | Testing | Theory | Testing |
| Normal | 36-37 | 36.2 | 100% | 96% | 60-100bpm | 82.1 |
| After exercise | 37.5 | 36.8 | 95% | 95% | >100bpm | 135.9 |

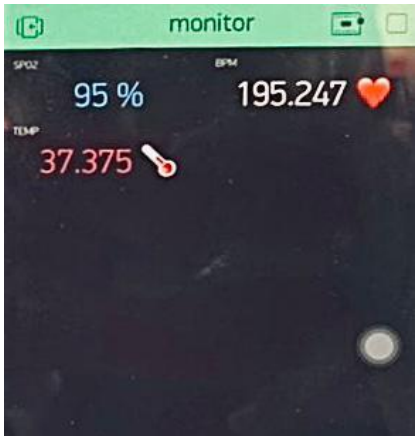


***Fig.5**: One of the testing from after exercising condition*

*4.1 Body Temperature Measurement*

***Table 4**: Data collection of body temperature in different condition with 5 minutes' laps for 10 testing*

| Condition during testing | Body Temperature/°C | | | | |
|---|---|---|---|---|---|
| | 5min | 10min | 15min | 20min | 25min |
| Normal | 36 | 36.12 | 36.12 | 36.18 | 36.25 |
| After exercise | 37 | 37 | 37 | 36.7 | 36.87 |
| | 30min | 35min | 40min | 45min | 50min |
| Normal | 36.18 | 36.25 | 36.12 | 36.12 | 36.12 |
| After exercise | 37.37 | 36.56 | 37.0 | 37.0 | 36.56 |

The data collection of body temperature measurement was taken in two different conditions. The normal condition was taken as a comparison with after exercise condition. As the data collected at outdoor in the afternoon with sunlight, the reading of body temperature will be increase. The testing was taken for 10 times with 5 minutes' laps. The mean for normal body temperature is 36.15°C and the mean for body temperature after exercise is 36.79°C.

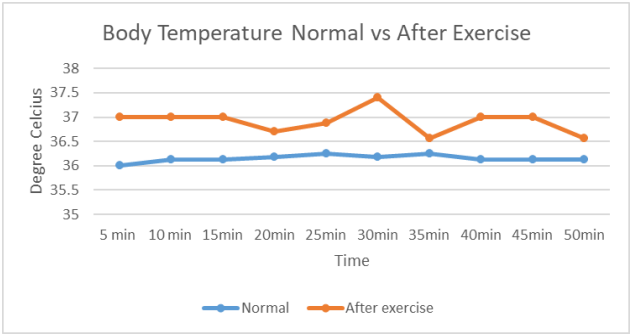


***Fig.6**: Graph trend for body temperature measurement*

Figure 6 shows the graph trend for body temperature measurement. Body temperature increase after exercise because as the muscles generate energy, heat is produced. This is due to the fact that only about 20% of the energy produced by contracting muscles is utilized for muscular contraction; the other 80% is converted to heat energy, resulting in a rise in muscle temperature during exercise. The circulation distributes the heat throughout the body, raising body temperatures.

*4.2 Oxygen Saturation Measurement*

***Table 5**: Data collection of oxygen saturation in different condition with 5 minutes' laps for 10 testing*

| Condition during testing | Oxygen saturation/% | | | | |
|---|---|---|---|---|---|
| | 5min | 10min | 15min | 20min | 25min |
| Normal | 96% | 96% | 96% | 96% | 96% |
| After exercise | 95% | 95% | 95% | 95% | 95% |
| | 30min | 35min | 40min | 45min | 50min |
| Normal | 96% | 96% | 96% | 96% | 96% |
| After exercise | 95% | 95% | 95% | 95% | 95% |

The sensor used for measuring oxygen saturation is an integrated sensor that also measures heart rate. The pulse oximetry test will measure how much oxygen your blood's hemoglobin transports. This is known as oxygen saturation and is expressed as a percentage (scored out of 100). Simply lay your finger on the sensor and wait for the reading to appear on the Blynk. Table 5 shows the data collection of oxygen saturation in different condition with 5 minutes' laps for 10 testing. there is slightly changes between the pulse oximetry for both condition during testing neither normal condition or after exercise. The normal range for oxygen levels is 95-100 percent, although

it drops following an exercise since the body demands more oxygen afterward. The mean for normal oxygen saturation is 96% and the mean for oxygen saturation after exercise is 95%.

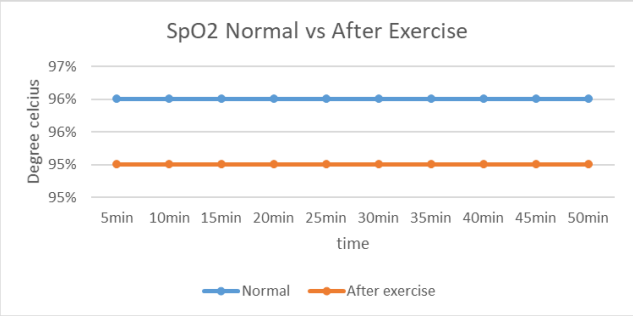


***Fig.7**: Graph trend for oxygen saturation measurement*

The graph compares two different types of testing conditions: normal and after exercise. Because exercise causes people to struggle to breathe and requires a lot of oxygen, the percentage drops after activity. If people's breathing does not continue to bring in enough oxygen to meet the body's current demands, they may experience a 2 to 3 percent drop in blood oxygen levels with greater strenuous activity. When people stop exercising, their levels will return to normal. The better their condition, the sooner these levels will return to their normal range. Because venous blood has already lost its oxygen, venous readings are always lower than arterial measurements.

*4.3 Heart Rate Measurement*

***Table 6**: Data collection of heart rate in different condition with 5 minutes' laps for 10 testing*

| **Condition during testing** | **Heart Rate/bpm** | | | | |
|---|---|---|---|---|---|
| | **5min** | **10min** | **15min** | **20min** | **25min** |
| **Normal** | 82.30 | 91.43 | 80.89 | 76.11 | 84.34 |
| **After exercise** | 107.16 | 104.51 | 103.87 | 130.92 | 156.40 |
| | **30min** | **35min** | **40min** | **45min** | **50min** |
| **Normal** | 91.63 | 78.57 | 67.064 | 96.21 | 72.61 |
| **After exercise** | 195.25 | 130.20 | 135.53 | 158.21 | 136.98 |

The more IR radiation that is absorbed, the redder the blood becomes (the greater the hemoglobin). As blood is pumped through the finger with each heartbeat, the amount of reflected light varies, resulting in a shifting waveform at the photodetector's output. A heart-beat (HR) pulse reading is acquired quickly while the light continues to shine and collect photodetector signals. The heart rate will rise from 90 to 126 for 2 hours and 30 minutes during exercise, however for strenuous activity, a heart rate of 126-153bpm is desirable. The mean for normal heart rate is 82.12bpm and the mean for heart rate after exercise is 135.92bpm.

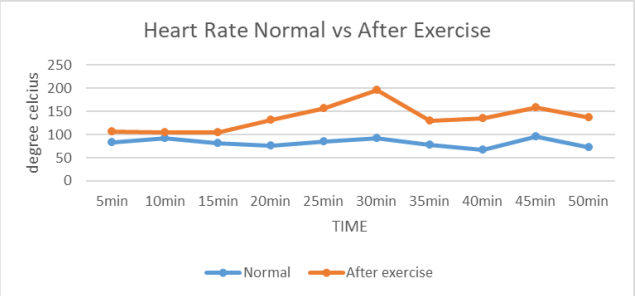


***Fig.8**: Graph trend for heart rate measurement*

Based on the graph trend for heart rate measurement above, it shows that after exercise the graph increases than normal. This is because the muscles need to provide enough newly oxygenated blood to keep body operating properly at high level.

## 5.0 CONCLUSION

This research report discusses the creation of a pilgrim's health monitoring system for Hajj and Umrah, as well as the possibility of employing IoT-based healthcare via smartphones to aid pilgrims during Hajj. Existing health and behavior monitoring options based on measurable IoT technology are presented in this development project. This technological device provides for real-time monitoring of pilgrims performing the Hajj and Umrah, as well as other users, and allows for cloud access to human critical parameter data. While performing Hajj and Umrah, pilgrim's guardian should not be worried when they are far away as the sensory data can be acquired and monitor from time to time.

The improvement can be done in both experimental hardware and software. For hardware part, the size of device is the most important to improve because this product development is not truly meet the standards of health monitoring device which can change the device size to smaller size and make it as wearable device. The wearable device should be smaller and lighter to be use on human's hand to make it comfort to use even in long term. Therefore, pilgrims can always wear them while performing Hajj and Umrah. As the body temperature sensors used are already the waterproof type, the recommendation can be done is to use a smaller waterproof sensor for body temperature so that it can be wear for taking ablution without remove the wearable device when it comes in contact with water.

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