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Human Blood Grup and Rhesus Detection Tool Prototype Design Based on IoT

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ABSTRACT

Currently, medical practitioners carry out blood type and rhesus examinations by directly observing the agglutination reaction and depending on the examiner's eye. Meanwhile, the effects of eye fatigue and saturation will cause inaccurate data. Therefore, a detection device was made which aims to display information about reading human blood type and rhesus on a digital display which can also store the data in a database. The ABO and rhesus systems were used in this study. This research was made using a real-time method based on the internet of things (IoT). sending data in real-time using WiFi Module ESP-01 and other components such as LCD microcontroller, LDR, LED, battery and Arduino Uno. based on the results of tool testing, the percentage of success values is 91.67%.

Keywords: Blood group, ABO system, rhesus system, ESP-01, Internet of Things

INTRODUCTION

The internet is now an important part of our lives and has enabled many of the machines and devices that we use in our daily lives to be remotely monitored and controlled through the Internet of Things (IoT) technology. Smart health applications have become a very fast-growing sector [1]. Smart objects are the final building blocks in the creation of cyber-physical smart ubiquitous frameworks thanks to the Internet of Things (IoT). The Internet of Things has a wide range of applications, including health care. With exciting technological, economic, and social implications, the Internet of Things revolution is reshaping current health [2]. Blood is a complex fluid that is very vital for humans. Based on antigens in the blood, blood is grouped into A, B, O, and AB blood groups. Based on the Rhesus factor in the blood, blood is grouped into Rh-positive (rh+) and Rh-negative (rh-) blood groups. Blood grouping is important for the blood donor process [3].

Manual testing of human blood and rhesus is still done by obtaining 5-10 mL of blood. Because data retrieval is done by medical personnel, the correctness of the data is still dependent on the examiner's eyes and takes a long time. The results will be available in 3 hours [4]. The Slide test is one of the ways to manually check blood types. Placing 1 drop of anti-A, anti-B, and anti-D on a clean, dry glass object separately is the technique for using a slide test. Pour one drop of blood into each reagent. Using a stirring stick, mix reagents and blood samples in a 20 mm × 40 mm area. For 2 minutes, tilt the slide from side to side. Read the results of the tests and the reactions [5]. As a result, system automation is critical for streamlining and speeding up the blood detection process, making it more effective and efficient. The identification of blood groups is shown in Table 1.

Table 1. Blood Type Identification [6]

Anti-A	Anti-B	Blood Group
No clumping	No clumping	O
No clumping	clumping	B
clumping	No clumping	A
clumping	clumping	AB

Blood includes agglutinins in addition to antigens. Antibodies against antigens are known as agglutinins. People with A antigen cannot accept blood donors who have B antigen because blood with A antigen creates B agglutinins. This is due to antibodies in the blood that reject the B antigen [7]. Tests and observations of agglutinating or non-agglutinating reactions of red blood cells given antisera must be performed by experienced persons, as the correctness of the data acquired is still dependent on the examiner's sight. Because factors like saturation and weariness impact the eyes, this approach is not suitable for assessing huge amounts of blood samples. Errors in reading this sort of blood type might pose major complications for a person, such as during blood transfusion or offspring identification [6].

Windhu Muhamad Ridha designed an Arduino-based blood type detector with the ABO system without detecting rhesus with the method plate test to react blood samples whose results will be displayed on the LCD [6]. Previous research on the detection of blood type electronically as a substitute for the human eye has also been carried out. The ABO blood group detector without rhesus was invented by Fahmi Rizal Julianto using a microcontroller-based technique plate test with output voice and SMS transmitted from the detector to a mobile phone [8]. At PMI Majalengka Regency, Dede Abdurahman produced a prototype blood type test kit using the ABO system without rhesus, which was evaluated using the method tube test in responding blood samples with the output readings presented on the LCD [9]. A similar study was conducted by Hummam Ghasan Ghiffari, namely the TensorFlow-based human blood type detector using the esp-32 cam. This study uses the OV2640 OV2640 camera to capture the image, which is processed using the Tensorflow Object Detection API so that the measurement distance greatly affects the level of data accuracy [10][11].

Based on previous research, a technology has been developed that can identify the type of blood sample electronically instead of using the human eye to provide information about the type of blood and the rhesus of the blood sample being examined. Considering that fatigue can affect the human eye, the advantage of the research conducted is that the test data can be stored in a database and can be viewed on web pages via the internet. therefore the author will develop a tool to assist blood type testing with the title "Prototype Design of IoT-Based Human and Rhesus Blood Type Detection Devices".

METHODS

The system design and workflow of the tool to be made are represented by the tool block diagram. The following tool block diagram design may be observed in figure 1.

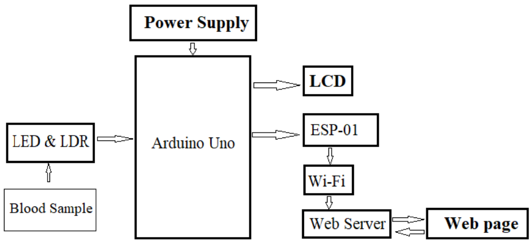

Figure 1. System Block Diagram

The value of the LDR reading on the blood sample that has been irradiated by the LED is the tool's input, and the reading's results will be processed as a blood type determinant. The processed data is shown on the LCD and delivered to the web server via the ESP-01 module, which is already linked to the internet network, as the tool's output. The information can also be accessed on the web page. The power supply in this tool is a 9-volt battery that serves as the main power source for the complete tool, including the input and output components.

The sample measurement method used is by adapting from research conducted by Windhu, namely by using LDR as a blood sample reader whose data will be processed by Arduino Uno to determine blood types A, B, AB, and O. The following illustration is in Figure 2.

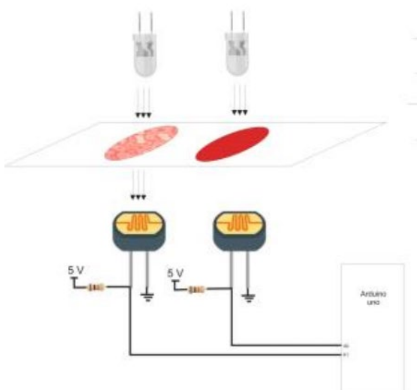

Figure 2. sample measurement illustration [6]

The difference with this research is that the results of the sample reading will be displayed on the LCD screen and sent to the database and then displayed on the website page so that the data can be used by certain agencies. In addition, the data storage memory capacity is larger when compared to a microSD card. The method used is the tool that will check whether the sample has agglutination or not. The trick is to calculate the amount of light that enters from the LED to the LDR through the sample. the more light that enters the volts of the LDR will increase. The tool will check the presence of samples that have agglutination or not. The trick is to calculate how much light that enters from the LED to the LDR passes through the sample. the more light that enters, the volts from the LDR will increase, therefore what determines the presence or absence of agglutination is the increase in the LDR voltage. the accurate value for the increase in voltage is shown in table 3. For the type of data used, namely; 1) if using pVolt, when the pVolt value is more than 1.85 then agglutination is detected; 2) if using pinRead, when the pVolt value is more than 1.85 then the pinRead value will be 1 and detected agglutination. The following figure below is the source code using pinRead data (value 1 occurs agglutination and value 0 does not occur agglutination).

```
if (pinRead1 == 1 && pinRead2 == 0){
  goldar = "B";
  lcd_goldar = "B";
}else if(pinRead1 == 0 && pinRead2 == 1){
 goldar = "A";
 lcd_goldar = "A";
}else if(pinRead1 == 0 && pinRead2 == 0){
 goldar = "AB";
 lcd_goldar = "AB";
}else if(pinRead1 == 1 && pinRead2 == 1){
 goldar = "O";
 lcd_goldar = "O";
}
```

Figure 3. Source Code

CIRCUIT DESIGN

Making the circuit begins with the creation of a circuit design for the components to be used. Fritzing software was used to create this circuit. Fritzing is free software or software that is used to design various electronic equipment by designers, artists, and electronics hobbyists. The Fritzing interface has been designed to be as interactive and simple as possible so that it can be used by persons with only a basic understanding of electronic device symbols. There is already a ready-to-use scheme of numerous Arduino microcontrollers and their shields inside the fritzing. This program was created with the goal of creating and documenting creative items that incorporate the Arduino microcontroller [10]. Starting with the Arduino, LED, LDR, 16x2 I2C LCD, ESP8266 ESP-01, push button, and battery, all of the components are combined into one whole in Figure 4.

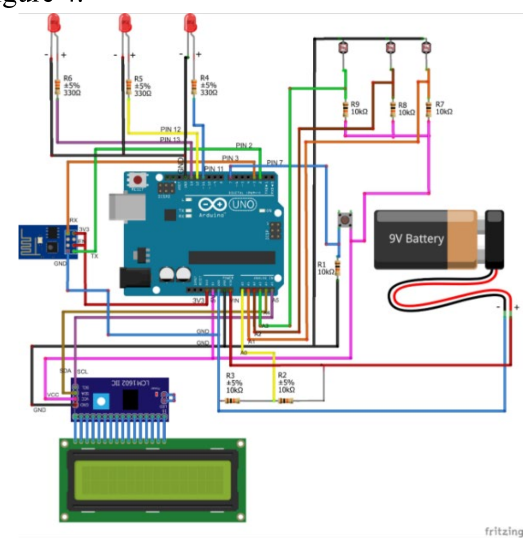

Figure 4. Whole Circuit Design

SOFTWARE DESIGN

The drawing, planning, sketching, or organization of multiple different pieces into a coherent whole and functioning can be classified as software design. In terms of software development, Arduino employs its software, dubbed Arduino IDE, which is available on the official Arduino website. C/C++ is the programming language used in software development. The flowchart of the programming design for the blood type and rhesus detection device, as seen in Figure 5, is shown below.

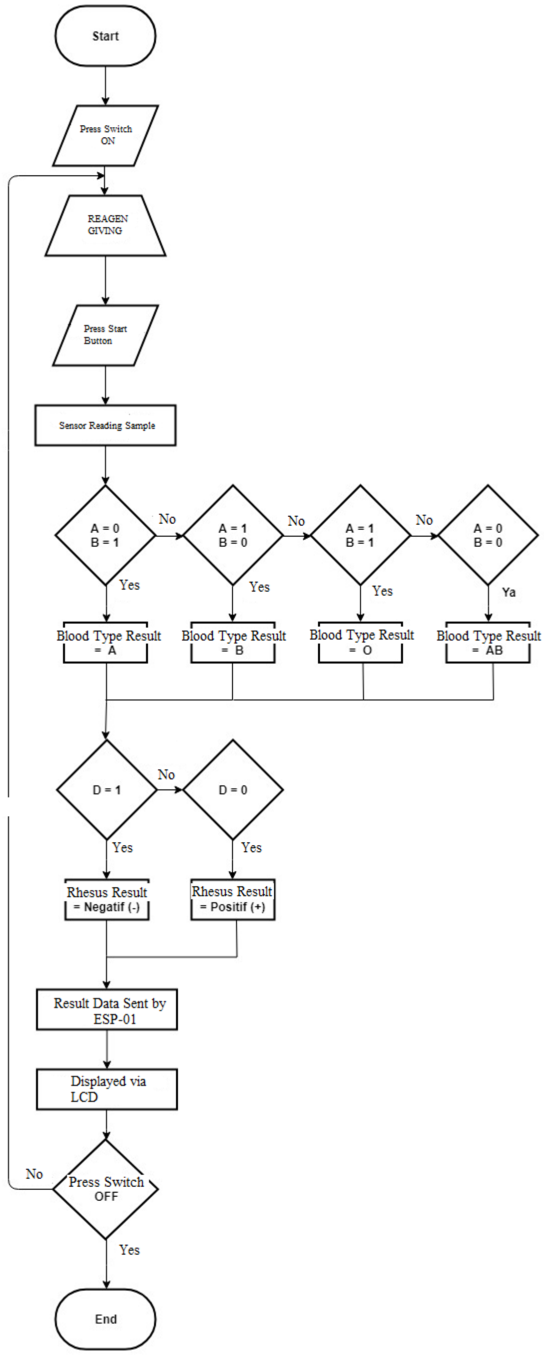

Figure 5. *flowchart* Programming design

According to Figure 5, the first step is to insert a blood sample on the given slide, and then mix it with antisera (A, Bantisera, and D) on each slide. When you turn on the tool, it provides a voltage source to the complete circuit. Before beginning to run the sample reading program, the microcontroller will launch the first, which will be displayed on the LCD. Following commencement, the microcontroller issues the command seen on the LCD, which is to click the start button. When the start button is pressed, the microcontroller sends an instruction to the sensor to begin reading it. The microcontroller will process the sensor data to determine the first blood type, followed by determining the rhesus in the sample. The digital logic between 1 and 0 that has been established in the program is used to determine whether the agglutination process occurs or not. The microcontroller will send the result data to the ESP-01 module, which will pass it to the web server through a Wi-Fi connection, and the result data will also be displayed on the display LCD, after the blood group and rhesus results are known. The microcontroller will return to the command to press the start button after reading.

DESIGN WEB INTERFACE

Design Web interface is the design of the user's interaction with a computer or laptop. The web display is used to fill in the identity of the owner of the blood group that has been checked so that it can see the data that has been stored starting from the old data to the latest data. The login page is designed to ensure that only registered users have access to the website and its contents. Figure 6 illustrates the login page section.

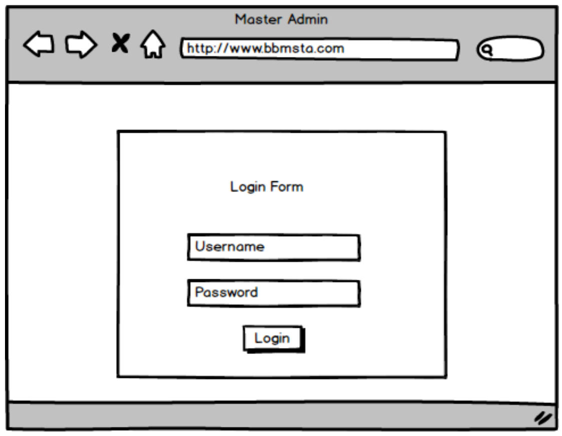

Figure 6. Login Page Display

The next screen design is an identity and data page that displays the results of sending blood type and rhesus type data from device readings, illustrated in Figure 7.

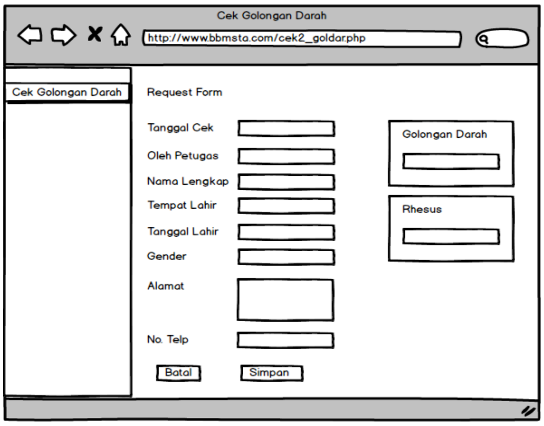

Figure 7. Page of Tool Reading Results

A table of blood type checking data has been developed on the Blood Type Check Table page. Figure 8 illustrates this.

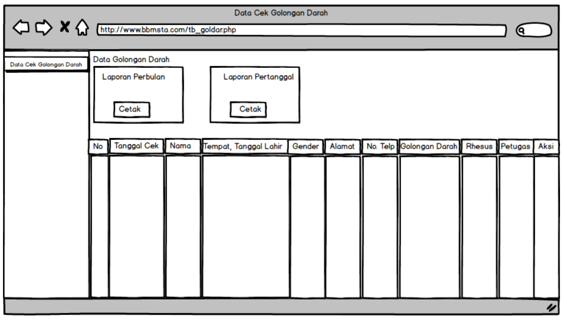

Figure 8. The Blood Type Check Table page

The kind of blood group and the identity of the card owner are printed on a blood type card for patients. Figure 9 illustrates this.

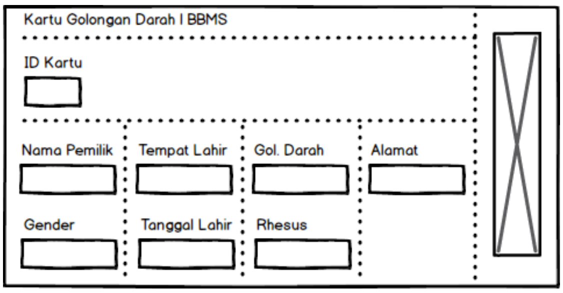

Figure 9. Blood Type Card Design

RESULT AND DISCUSSION

By integrating the previously specified hardware components, namely the ESP-01, Arduino Uno, LED, 16x2 I2C LCD, battery, push-button, LDR sensor, and object-glass as a sample location, the outcomes of the design of this tool are in the shape of a physical form of a blood type identification device.

Figure 10. Hardware Prototype (front and inside)

The detector's components are separated into two sections: the top and bottom. The LCD and push buttons are at the top of Figure 8, while the sample storage area is at the bottom. The LCD is used to display the sample test results, and the push-button is used to begin the sample reading. On the right side of the front, there is a switch and battery hole that serves to recharge the battery and on the left side of the front, there is a type B USB port which is useful as a communication medium between the computer and Arduino.

The overall circuit of the blood type detecting device is shown in Figure 9, with an Arduino Uno, ESP-01, battery, switch, LCD, and push-button visible at the top. A sample holder, LED, and LDR sensor are vertically positioned at the bottom, with the LDR sensor at the bottom, the sample holder in the middle, and the LED at the top in a downward-facing position. Placed such that the LDR sensor may detect the presence or absence of agglutination in a mixture of blood samples and reagents based on the intensity of the LED light.

Results of the interface of a website built as a means of communication between the user and the database are referred to as a website. The results of the interface design are the login display page, patient data and identity page, blood group check table page, and blood type card design. The display of page login illustrated in the figure11 is important as a security measure to ensure that only authorized users can access the main page.

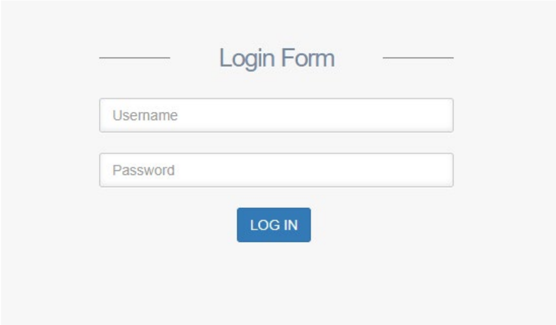

Figure 10. Login Page Display

The awaiting device reading data page illustrated in figure 11 is a page that attempts to confirm the identity that has been previously filled in and to await the sending of data on the blood type and rhesus type results from the device reading.

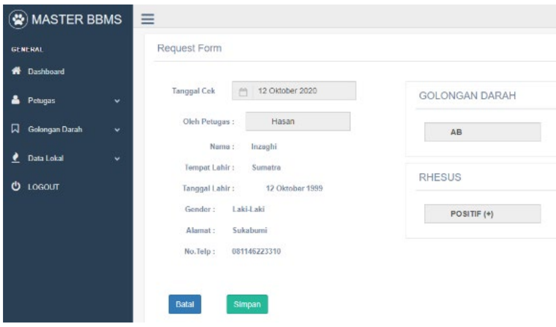

Figure 11. Tool reading results page after data is entered

A table of blood type checking data illustrated in figure 12 has been developed on the Blood Type Check Table page.

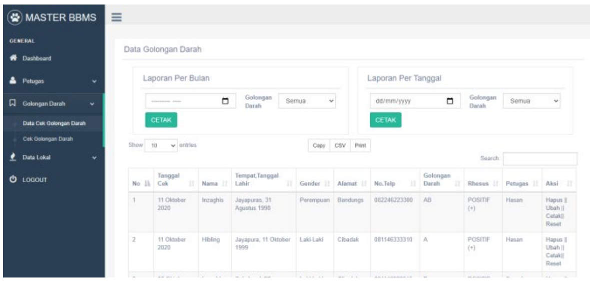

Figure 12. Blood group check table page

The kind of blood group and the identity of the card owner are printed on a blood type card for patients. Figure 23 depicts the situation.

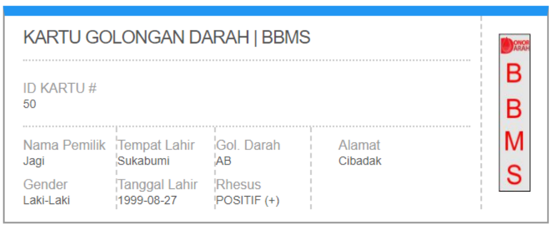

Figure 13. Blood Type Card Design

Figure 14 depicts the procedure of putting a blood sample into an instrument that has been built to process it.

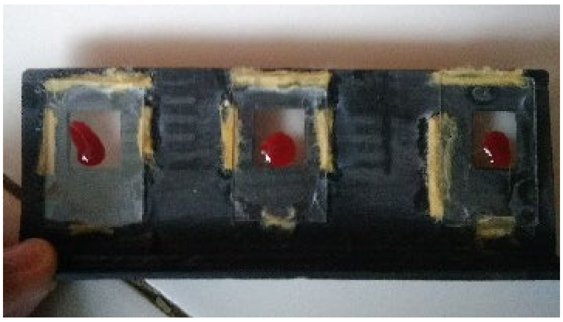

Figure 14. Blood sample

Blood samples were mixed sequentially from left to right, with anti-A reagent in the first place, anti-B reagent in the second place, and two drops of anti-D reagent in the third place, as illustrated in figure 15.

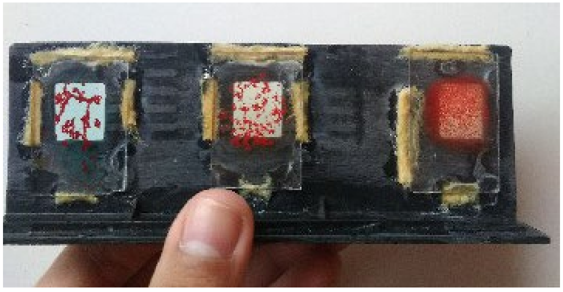

Figure 15. Blood samples and antisera produced mixed findings

The next process is to place the blood sample in the hardware device that is already available, shown in Figure 16. After the data reading process is complete, the information will be displayed on the website page and immediately saved, illustrated in figure 17.

Figure 16. Blood sample storage

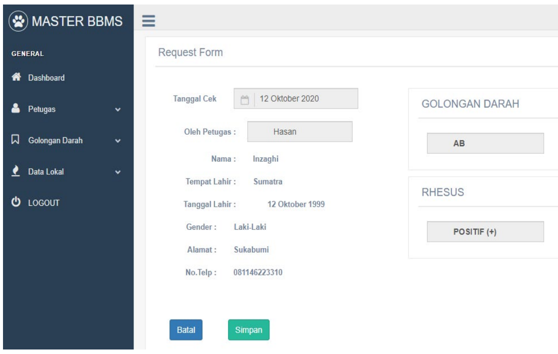

Figure 17. The data appears on the website page

This detector can be tested by directly running it to ensure that it performs as planned. To perform the test, anti-A reagent, anti-B reagent, and anti-D reagent are used to react with four different blood groups: A, B, O, and AB. Twelve male and female respondents who had previously tested their blood type in the health service unit were sampled for test data. The following are the results of the tests that were conducted

Table 2. The results of testing the digital logic value of blood type check

No. Respondent	Reagen Anti-A		Reagen Anti-B		Reagen Anti-D		Reading Results
	Value	Category	Value	Category	Value	Category	
1	0	A	1	NA	0	A	A Rh+
2	1	NA	1	NA	0	A	O Rh+
3	1	NA	1	NA	0	A	O Rh+
4	0	A	0	A	0	A	AB Rh+
5	0	A	1	NA	0	A	A Rh+
6	1	NA	1	NA	0	A	O Rh+
7	1	NA	0	A	0	A	B Rh+
8	0	A	1	NA	0	A	A Rh+
9	1	NA	0	A	0	A	B Rh+
10	1	NA	1	NA	0	A	O Rh+
11	0	A	0	A	0	A	AB Rh+
12	1	NA	0	A	0	A	B Rh+

Table 3. The results of the blood type check voltage test

No. Respondent	Reagen Anti-A		Reagen Anti-B		Reagen Anti-D		Reaction Time (Second)	Reading Result
	Volt	Category	Volt	Category	Volt	Category		
1	1,95 V	A	2,63 V	NA	2,05 V	A	1,32	A Rh+
2	2,53 V	NA	2,59 V	NA	1,79 V	A	1,45	O Rh+
3	2,59 V	NA	2,63 V	NA	1,87 V	A	1,48	O Rh+
4	1,90 V	A	1,87 V	A	1,84 V	A	1,35	AB Rh+
5	1,82 V	A	2,52 V	NA	1,87 V	A	1,30	A Rh+
6	2,58 V	NA	2,60 V	NA	1,90 V	A	1,40	O Rh+
7	2,60 V	NA	1,87 V	A	1,85 V	A	1,24	B Rh+
8	1,78 V	A	2,58 V	NA	1,90 V	A	1,27	A Rh+
9	2,59 V	NA	1,97 V	A	2,08 V	A	1,25	B Rh+
10	2,61 V	NA	2,60 V	NA	1,87 V	A	1,43	O Rh+
11	1,96 V	A	1,88 V	A	2,03 V	A	1,30	AB Rh+
12	2,63 V	NA	1,90 V	A	2,04 V	A	1,26	B Rh+

Decription:
A= Aglutination occurs
NA = No agglutination occurs

Table 2 illustrates that when agglutination occurs in the blood sample, the digital logic on the sensor displays logic 0 and when no agglutination occurs in the sample, the digital logic on the sensor displays logic 1. Table 3 shows that the voltage value read during the agglutination process in blood samples is lower than the stress value in samples that do not experience agglutination. Because there is a gap for light to flow through the blood sample when it goes through the agglutination process, the LDR sensor will get more light from the LED. When the blood sample does not go through the agglutination process, the voltage value rises because the liquid blood sample is equally dispersed, leaving just a small gap for light to enter the blood sample and be measured by the sensor. Table 3 also indicates the reaction time required for accurate blood type determinations. When compared to other blood types, type O blood takes longer to react. This is because blood type O takes longer to determine if the agglutination process is complete. The same sample measurement method was carried out by Windhu Muhamad Ridha, namely using LDR to detect blood sample clots and Arduino will process the data to determine blood groups A, B, AB, and O. due to uneven mixing [6]. Likewise, with the research conducted, there is 1 blood sample that is still not following the blood group based on the results of manual examination.

A comparison of the findings of testing instruments with tests from earlier health service units is shown in Table 4.

Table 4. The results of a blood type check comparison

No. Res	Tool Test Results	Health Service Unit Test Result	Description
1	A Rh+	A Rh+	In Accordance
2	O Rh+	O Rh+	In Accordance
3	O Rh+	O Rh+	In Accordance
4	AB Rh+	AB Rh+	In Accordance
5	A Rh+	A Rh+	In Accordance
6	O Rh+	O Rh+	In Accordance
7	B Rh+	O Rh+	Unsuitable
8	A Rh+	A Rh+	In Accordance
9	B Rh+	B Rh+	In Accordance
10	O Rh+	O Rh+	In Accordance
11	AB Rh+	AB Rh+	In Accordance
12	B Rh+	B Rh+	In Accordance

The percentage of mistakes encountered when testing this tool is 8.33 percent. As a result, the success rate in testing this tool is 91.67 percent. Respondent number 7 made the reading error. Several variables could have contributed to the inaccuracy, including unequal mixing of the reagents and blood sample, an insufficient number of sample comparisons, and the mixing results not being in the centre of the slide.

CONCLUSION

The following conclusions can be drawn based on the blood type detecting gadget that was conceived and produced. Using the amount of light intensity from a light source, namely an LED, and how much light from the LED enters through the gaps in the blood sample as a result of the agglutination process to the LDR sensor, has succeeded in designing and building an IoT-based human blood type and rhesus detection device. The results of the tool's readings will then be shown on the LCD, and the data will be transferred to a web server through ESP-01 over a Wi-Fi network.

The tool's accuracy in recognizing human blood and rhesus groups is 91.67 percent, with an error rate of 8.33 percent among 12 responses. The results were acquired by comparing the results of testing the detecting device with the results of prior health service unit testing. Some reading errors can arise as a result of insufficient mixing between reagents and blood samples, an insufficient number of sample comparisons, and the mixing results not being in the center of the slide, according to tool testing.

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