"GOLDARHES" As a Digitalization Blood Type Test Device Based on Light Sensors

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Abstract. According to the data, high death rate among surgery patients was caused by faulty blood typing which were still manually done and high risk in human error. GOLDARHES is a device to determine blood type uses a light sensor with LDR and LED components and an Arduino microcontroller, then it showed the results on LCD. This device has never been used in Indonesian healthcare facilities. The Casing which is environmental friendly material is made of corn husk waste containing cellulose, lignin, and hemicellulose. In addition, the energy power of the device itself uses a charging system so that it can reduce the amount of chemical waste that is difficult to decompose. The Methods of this research is True Experimental using 100 samples of participants. The results obtained will be displayed on the LCD which is processed in less than 10 seconds. The results of this research was faster than manually test, the mean of test period was take 5 seconds and the sensitivity of the tool is 95%. Thus “GOLDARHES” can be used as an effective, accurate, and fast medical device in determining blood type.

1. Introduction

Before a blood transfusion is carried out, the important thing is determining the patient's blood type. In many cases, a blood transfusion is needed. According to the Accident Research Center (ARC), road accidents claim on average 12,000 lives annually and lead to about 35,000 injuries. Besides that, United Nation’s (UN) 2014 World Risk Report named Indonesia the 38th most ‘at risk’ country for disaster. Other Asian nations with higher overall risk levels like as Bangladesh, Cambodia, Papua New Guinea, Timor-Leste, Japan, and Vietnam [1]. Badan Nasional Penanggulangan Bencana (BNPB) stated that in 2018-2019, Indonesia experienced 5,244 natural disasters which impacted in 5,086 people died and disappeared, while 22,594 people were injured [2]. With those such cases, there is a very high risk of emergency bleeding. This condition illustrates how important blood transfusion is and determination of blood type must be done to the victim. Determination of blood type is something crucial, but the current procedure still using conventional methods. The conventional method has many lacks, which are needed by experts to determine the patient's blood type, and these experts are required to be quick in determining blood type. With the result that patients do not experience delays in handling [3]. In addition, a high death rate among surgery patients was caused by faulty blood typing. That negligence was done by a blood type checker which was done manually and high risk in human error. The conventional system of blood typing may prove to be a lack of trained technicians. The health technicians must decide quickly what procedures they must apply, in order to guarantee the best medical treatment for the patient [3]. Therefore, are needed device a portable, practical, fast, precision and modern, namely GOLDARHES. GOLDARHES is a device that has a function as a determinant of blood groups that
is different from the previous device. This device can examined the ABO and rhesus blood type at once with a light sensor with LDR (Light Dependent Resistor) components and LED (Light Emitting Diode) and Arduino microcontrollers. The results of data retrieval by this device are displayed on LCD (Liquid Crystal Display) in 5 seconds and can be displayed using Android from a smartphone [4], [5] therefore, the device is suitable for use in the era of industrial revolution 4.0. This device has never been used in an Indonesian health facility. GOLDARHES uses environmentally friendly components. The device casing is made of corn husk cesspit containing cellulose, lignin, and hemicellulose so that it is suitable for use [6] In addition, the energy power of the device itself does not require primary batteries such as lithium, zinc-carbon and the like because it can damage the ecosystem of the environment. GOLDARHES uses a charging system so that it can reduce the amount of chemical waste that is difficult to decompose [6].

2. Literature Review

Blood is a long distance carrier, the mass of cells and the external environment or between the cells themselves. Blood consists of plasma fluid where cellular elements erythrocytes (red blood cells), leukocytes (white blood cells), and thrombocytes (platelets) are located [7]. Blood type is a specific pattern of antiserum reaction to testing within a given system. ABO remains the most important in transfusion and transplantation. ABO blood grouping is based on erythrocyte surface membranes in humans which are known to contain antigens which vary depending on blood type. In the main blood classification system, the ABO system, erythrocytes of blood group A people contain A antigen, blood group B contains B antigen, blood group AB contains both A and B antigens, and people with blood groups O do not have erythrocyte surface antigen A or B [7], [8].

Rhesus-system is the most important blood group system after ABO. While the rhesus blood group can be divided into two, namely negative rhesus and positive rhesus. Rh-negative is a person who does not has Rh factor, while Rh-positive is a person who has an Rh factor. This is a contrast to the ABO treatment system, there are no antibodies against the rhesus factor that forms naturally [7], [8].

Antibodies that fight erythrocyte antigens that are not present in the body's own erythrocytes, begin to appear in human plasma after a 6-month-old baby. Therefore, blood type A plasma contains anti-B antibodies, blood group B contains anti-A antibodies, no ABO-related antibodies are present in blood group AB, and both anti-A and anti-B antibodies are in the blood group O [7].

Determination of Blood Type

Determination of ABO blood type generally uses the convensional slide method. The basis of this method is to use the principle reaction between agglutinogen (antigen) on the surface of erythrocytes with aglutinin found in serum / plasma to form clots [9].

ABO blood type can be based on the clotting reaction between antigen and antiserum. In A blood type, clumping occurs when the sample is mixed with anti-A and does not clot when mixed with anti-B. This is because A blood type contains A antigen which will interact with A antibody in anti-A serum, whereas there is no clumping in anti-B mixed samples because anti-B does not contain A antibodies. In B blood type clots occur when the sample is mixed with anti-B and does not clot when mixed with anti-A. This is because blood group B contains B antigen which will interact with B antibodies in anti-B serum, whereas there is no clumping in anti-A mixed samples because anti-A does not contain B antibodies. In blood group AB clots occur. When the sample is mixed with anti-A and anti-B the clumping occur because blood group AB has A antigen and B antigen so that there will be interaction with A antibodies in anti-A and B antibody in anti-B. In O blood type there is no clumping when the sample is mixed with anti-A or anti-B. This happens because O blood type does not have A antigen or B antigen. The results of the interpretation of anti-D is used to determine the rhesus blood type. The principle of examining the rhesus blood group is same as the principle of ABO blood group examination, furthermore, if the antigen is reacted with the appropriate antibody, a
clot will occur. Results (+) has meaning of rhesus group (+) and result (-) has the meaning of rhesus group (-) [11].

Light Emitting Diode (LED)

A light emitting diode (LED) is a semiconductor device which converts electrical energy to light energy. In this study the LED functions as a light source / transmitter that illuminates the test area (blood sample) and type of LED that can emit white light, it cause the intensity of white light is greater, and the light received at 2 points of the blood sample will vary depending on the presence or absence of the clotting process [4], [5].

Light Dependent Resistant (LDR)

LDR is a type of resistor whose resistance. It can be used to sense the presence of light. In this study LDR is used as a receiver to detect the intensity of light that is absorbed by blood in the test area. If at one of the blood sample points there is no agglutination process, then the light intensity received by the LDR will decrease and cause the sensor output voltage to be low. If at another blood sample point there is a agglutination process, the light intensity received by the LDR will increase and cause the sensor output voltage to be high [4], [12], [13].

Arduino Uno

A microcontroller is look like a slightly small computer ("special purpose computers") which is located inside an IC that contains the CPU, memory, timer, serial and parallel communication channels, input / output ports, ADC. Microcontroller is used for a task and runs a program. Microcontrollers have various types, one of that is the Atmega Microcontroller. Atmega microcontroller is an 8 bit microcontroller. Atmega has more peripherals than the ATTiny series [14].

Arduino is a microcontroller that is designed to be used easily by artists and designers (who are not technical people). Thus, without knowing the programming language, Arduino can be used to produce sophisticated works. Arduino is an open-source single-board micro controller, derived from the Wiring platform, designed to facilitate electronic use in various fields. The hardware has an Atmel AVR processor and the software has its own programming language. Arduino Uno is one of the most widely used Arduino types. Especially for beginners it is strongly recommended to use Arduino Uno [14].

Arduino is an open-source physical platform based on microcontroller board having the ATmega32 series controllers and Integrated Development Environment for writing and uploading codes to the microcontroller. It has input and output pins for interaction with the outside world such as with sensors, switches, motors and so on. To be precise it has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller It can take supply through USB or power it with an AC-to-DC adapter or a battery Arduino acts as the processing module of the system. It takes input from the LDR, process the data and gives the output to LEDS directly or through a relay and a transistor mechanism [4], [15].

LCD (Liquid Crystal Display)

LCD (Liquid Crystal Display) is a type of display that uses Liquid Crystal as a medium of reflection. LCD is also often used in designing devices that use a microcontroller. LCD can function to display a sensor result value, display text, or display a menu on a microcontroller application. Depends on commands written on the microcontroller [17].

3. Methodology

The method of data collection in this study consisted of literature studies and field studies. Literature studies were conducted by studying, researching, and examining various sources, namely from medical books, texts, scientific journals, and other readings that have to do with research topics.
Field Study was conducted by visiting the place to be studied and data collection was carried out directly at the Biochemistry Laboratory of the Faculty of Medicine, University of Muhammadiyah Surabaya.

**Providing Tools and Materials Stage**

We undertook the preparation of various tools and materials needed and have made a working system device namely a microcontroller circuit board (Arduino Compatible Uno R3), LCD screen, LED, LDR, Resistor, Male-Male Jumper Cable, Male-Female Jumper Cable, USB Connector Cable, Anti-A reagent, anti-B reagent, anti-AB reagent, anti-D reagent. The second step was test the accuracy and reliability of the tool at the Laboratory of Biochemistry, Faculty of Medicine, University of Muhammadiyah Surabaya.

**Compilation of Hardware and Software Stage**

This Staging Consist of:

a. **Compilation of Component Circuit**

   Compilation of Components in this product is made of a microcontroller circuit (Arduino Compatible Uno R3), LCD Screen, LED, LDR, Resistor, Male-Male Jumper Cable, Male-Female Jumper Cable, USB Connector Cable, Anti-A reagent, Anti-B Reagent, Anti-AB reagents, and anti-D reagents, lancet needles, and lancet pens.

b. **Compilation of Software**

   The preparation of software was started from downloading the Arduino application, compiling the program with the command, sampling to determine the intensity interval of each blood group and rhesus, input data that has been determined from sampling in the form of coding to the Arduino program. Coding data was obtained from the intensity intervals of each blood group carried out by means of a slide test. The intensity interval was obtained by entering the intensity value of each type of blood group in the microcontroller database.

c. **Arrange the design and made the GOLDARHES casing**

   Preparation of design and manufacture of GOLDARHES casings with designs application and printed with three-dimensional print. Researchers work with partners for this.

d. The device was given a casing made from corn starch extract which is environmentally friendly and is more resistant to the effects of the performance of thermal device. In addition, adding a few words such as the words "WELCOME TO GOLDARHES" on the LCD indicates that the device is ready for use.

e. Device that were ready to use, this can then be connected using Bluetooth then be connected to an Android device, besides that for the GOLDARHES application it was automatically connected via a bluetooth connection from the GOLDARHES device to the android of each user. This is very easy.
4. Trial Stage

**GOLDARHES uses 100 Samples and Compare with the Slide Test Method**

a. Informed consent

Before the researcher took a sample, the researcher requested the willingness and approval of the respondent so that no one was harmed by both parties.

b. Sampling

The researcher took blood samples from the respondent's fingertips using a needle and lancet pen. After that, the inspection stage was started by using a slide test and with the GOLDARHES device. Taking this slide test method, the aim was to find intensity intervals from each type of blood type and rhesus from the results of the slide test. The results obtained were compared with cards obtained from PMI or other identity cards to obtain the sensitivity and accuracy of the results of the GOLDARHES device.

c. The results of accuracy can be tested from the PMI Card that the respondent has with the results that appear on the GOLDARHES LCD.

**Data Analysis of Comparison of Average Time and Validity**

When examining blood type each sample was analyzed by SPSS Version 25 using the Man-Whitney method for comparison of the time of the GOLDARHES device with conventional blood type testing. The sensitivity of GOLDARHES is measured using the help of Calculating CAT Maker [18].

**Method for Examining Blood Types**

**Slide test**

We undertook a blood sample from the respondent's fingertip using a needle and lancet pen. After one drop of blood comes out, place the droplets on four slides. Then, drop the anti-A, anti-B, anti-AB reagent, and anti-D reagent onto the four slides. After penetrating the reagent, stir or...
homogenize the reagent with blood using a toothpick. Once homogeneous, wait for about 2 minutes or until it dries. Then, read the results based on blood classification criteria [9], [10].

GOLDARHES

The blood taken from the respondent was placed on the slide glass shelf on GOLDARHES, then mixed with anti-A, anti-B, anti-AB, and anti-D reagents. After mixing, stirring manually. Then the slide glass rack is inserted into the GOLDARHES device. The process is with LED rays reflected on a slide glass shelf containing blood, then received by the LDR and read by the microcontroller. After processing and reading then the results are displayed on the LCD in 3-5 seconds in the form of blood type and rhesus. This is what enables the public to be able to apply this test themselves by simply reading the results that come out on the LCD screen and on smartphone through Android system quickly and practically. And this tool is practically able to be carried everywhere (portable) to various places without having to enter in a laboratory.

Elucidation of the GOLDARHES Device’s Performance Framework

In the Early Stage the GOLDARHES device was connected with the USB port to the power supply so that the device was on and ready. Then, GOLDARHES performs the work initiation process and on the LCD the phrase "WELCOME TO GOLDARHES" appears which also indicates that the LED illumination and reading of the LDR sensor were ready. After that, blood samples were taken through the GOLDARHES slide rack which had been mixed with reagents (anti-A reagent, anti-B reagent, anti-AB reagent, and anti-D reagent). Furthermore was the stage of irradiation by LED and sensor detection by the LDR, when the sensor read, it takes about 5 seconds for the results to appear on the LCD. The results listed on the LCD were one of the blood type (A + blood type, A- blood type, B + blood type, B- blood type, AB + blood type, AB - blood type, O + blood type, or O- blood type.)
5. Results & Discussion

GOLDARHES is a product from the research consists of an Arduino Uno, LDR, LED microcontroller, with a case made from biodegradable corn husk and assembled using C language programming software as a support in the coding process and work function of the device. The mechanism of this device is to put the blood taken from the respondents on the GOLDARHES slide glass rack, then mix with anti-A, anti-B, anti-AB, and anti-D reagents. After manual stirring, the slide glass rack is inserted into the GOLDARHES device. Furthermore, the slide glass shelf containing the blood will be illuminated by the LED and the results will be received by the LDR. The intensity of light received by the LDR will be read by the microcontroller and the results will be displayed on the LCD and smartphone by Android in the form of blood type and rhesus.

GOLDARHES has more advantages compared to the previous blood type test device. It can examine two things at once, the type of ABO blood type and rhesus, which are absolutely necessary for blood transfusion treatment. This device can read ABO and rhesus blood type because the agglutination reaction that occurs in blood samples will result in blood clots. The blood clot will prevent the intensity of the light emitted by the LED. This causes the LDR to capture a low

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![GOLDARHES device’s Flowchart diagram](image-url)
illumination, so the value of the resistance from the LDR and the voltage becomes large. Contrary, if the agglutination reaction does not occur, then the blood remains in liquid form, therefore, the LED light that illuminates the test area can penetrate the blood. Thus, the LDR which is below it can capture illumination with an intensity that is not reduced. With the amount of illumination that can be caught, the value of the resistance in the LDR and the resulting voltage will be decreased [19].

GOLDARHES is a sensitive, prime, and fast compared to previous similar devices. To find out whether GOLDARHES can function properly, the results of the samples examined were matched with blood groups examined by Palang Merah Indonesia (PMI). The accuracy of blood and rhesus examinations was tested for sensitivity using a catmaker and showed a sensitivity of 95%. This happened because of the 100 samples used there were 95 samples which showed the appropriate results. The accuracy of the reading blood type results on the GOLDARHES device was strongly influenced by the level of the agglutination reaction between blood antigen and antiserum. One of the factors that influence the reaction is the ratio between blood and anti-serum, the higher the ratio, the stronger the reaction produced [11]. Agglutination reactions will occur when antigens and antibodies on antiserum were mixed. Stirring was one method used to mix antigens and antibodies in antiserum [11] so that the lack of stirring smoothing will affect the level of agglutination. This has become one of the potentials for further development of GOLDARHES.

Another advantage of GOLDARHES is the speed of examination time is also one of the advantages of this device. The average measurement time with GOLDARHES is 5.28 ± 0.70 seconds, while the average measurement time with the slide test is 118.61 ± 1.002. The data obtained were then analyzed using SPSS version 25 with the Man Whitney Test. The test results showed that there was a significant time difference between blood and rhesus examination using GOLDARHES and slide test method with a value of p <0.05.

In the aspect of the device used, GOLDARHES uses the Arduino Uno microcontroller which is simpler than the work of [20], that uses the Atmega16 device. Simple is meant that Arduino Uno has been designed completely so that the user only needs to make command without making an introduction to the component first whereas in Atmega16 it is necessary to make programming and introduction first. In addition, the Casing section is made of PLA plastic which is made from corn starch and is biodegradable so it is environmentally friendly. This is in line with the research conducted by [6]. Another advantage of GOLDARHES is its functional aspect. GOLDARHES has the dual function of being able to read ABO blood groups and rhesus at the same time which has not been possessed by the blood type examiner [20].

As an examiner of ABO and Rhesus blood type that is fast and precise can be used as a solution for blood type examinations in various places, both in public health service centers, schools, animal care centers, and in rural developing country areas such as Indonesia where access to laboratories and technicians trained is very limited [3].

GOLDARHES is a dynamic device to be developed in accordance with the industrial revolution 4.0 in the health sector, where digitization and intelligenization of manufacturing processes are needed [21]. By 2025, 90% of the population uses smartphones, therefore, GOLDHARES will facilitate this [22]. GOLDARHES can be connected to the Android OS and iOS OS in the form of start-up through applications that can later be downloaded through Apps stores and Apple stores. The purpose of this development is as a storage medium for recall of test results that the patient is likely to forget about blood type and rhesus. Another potential development of GOLDARHES, can be added to an automatic stirrer in its functional circuit, therefore, this tool can be said to be a mechanic automatic system.

Various studies have been carried out to check blood types easily and quickly. In the future, GOLDARHES can be developed into a non-invasive blood sensor based Light sensor examination. The potential of GOLDARHES can be fulfilled through several modifications. Light act as a source for optical signals which detects the varying voltage. As the optical property of blood varies for present antigen on the erythrocytes, the voltage value obtained also varies [23].

Thus GOLDARHES is a device intended for rapid medical diagnostic. Reinforced with a
sensitivity of 95%, and can be easily accessed via a smartphone, accompanied by a display of economical portable devices, GOL DARHES can be considered a diagnostic in determining blood groups and rhesus.

6. Conclusion & Recommendation

GOL DARHES is a mechanic automatic system that can be used as an effective, accurate, and fast medical device in determining the blood type. GOL DARHES is still in the development stage, with the intention that it can make a major contribution to the ease of blood type examination in Indonesia. The constructive advice that can be given in this study is that it is necessary to add a slightly mini size motor as an automatic stirrer, the need for further development is related to the patient database based on Android, and needs to be developed into a non-invasive blood type examination device.

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