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# Development of Non-Invasive Cholesterol Monitoring System Using TCRT5000 Sensor with Android Compatibilty

**Tika Rahmawati, Alvania Nabila Tasyakuranti , Heni Sumarti, Hamdan Hadi Kusuma**

Department of Physics, Faculty of Science Technology, Universitas Islam Negeri Walisongo Semarang, Indonesia

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## Abstract

High cholesterol levels cause several diseases, such as atherosclerosis (narrowing of the arteries), coronary heart disease, high blood pressure, obesity, thyroid disorders, diabetes mellitus, liver disease, and kidney disease. Generally, such checking is carried out invasively in clinical laboratories or hospitals. The checking can be done individually at a lower cost by using non invasive cholesterol measuring devices. This study aims to design and implement an android-based non-invasive cholesterol monitoring device using the TCRT5000 sensor. The tool developed was tested to measure cholesterol levels in 15 respondents aged 20-30 years. The research procedure consisted of several stages, starting with the design stage of the tool, which was carried out by assembling the components; the second stage was the tool coefficient of determination test, the third stage was the accuracy test, and the last stage was the data transfer speed test. The average accuracy of the tool is 83.18%, and the avarage of delay is 8.8 ms. This tool has considerable potential to be used in a telemedicine system that can be accessed remotely regularly to determine the estimated value of cholesterol levels in the blood.



✉ Alamat korespondensi:
E-mail: tika_rahmawati_2008026003@walisongo.ac.id

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## INTRODUCTION

Cholesterol is a natural substance that body humans naturally need because it supports enzymatic processes in the body. Process enzymatic in the body need essential material builders, such as cell membranes and the insulating material around nerve fibers, sex hormones, child kidney vitamin D, and bile. From a chemical point of view, cholesterol is classified as a lipid (fat) with a steroid alcohol component. Exceeding the normal amount can harm the health of the body (Rahmad, 2018). Cholesterol can stick to blood vessels and easily form plaque (atherogenic) (Prasetyo, 2019). Rate Cholesterol in the blood is influenced by several factors, including age, heredity, type of sex, food, physical activity, and cholesterol production from the body (Mulyani et al., 2018). The cholesterol rate in the blood has exceeded the normal limit, that is 200 mg/dl named with hyper cholesterol (Ayu et al., 2017). Riskesdas (2013) has said that the condition hyper cholesterol has been experienced by residents of Indonesia as 69.6% of them And 39.6% of them are female. High cholesterol levels cause severaltypes of disease, like atherosclerosis (narrowing vessels blood), heart coroner, high blood pressure, obesity, thyroid disorders, diabetes mellitus, liver disease, and kidney disease (Maryati & Praningsih, 2018) ; (Goddess, 2018).

Therefore, a tool is needed to check cholesterol levels. Cholesterol levels periodically do not exceed normal limits. Generally, the check is carried out in a clinical or hospital laboratory. Considering the cost of examination in the laboratory requires a fairly expensive cost. The check can be done alone with cheaper costs than the tool measuring cholesterol invasively. (Sulehu & Senrimang, 2018) In his research, he explained that the Invasive method takes blood samples after the finger is pricked with a needle. However, for using this tool, sometimes someone forgets to replace the blood lancet from a previous patient, which is feared there is an infectious disease, and sometimes the patient has a fear or phobia of needles. In addition, the use of blood Lancets will also add to medical device waste. Where medical waste is different from the waste that comes from it from companies or households, thus requiring waste managementmore specific. However, until now, waste management requires cost, which no cheap accompanied rule must fill as the condition in attempt management (Zuhriyani, 2019). Bad management can cause an increase in medical waste because when non-medical waste is mixed with medical waste, the waste will be grouped as medical waste. This, of course, will have an impact on the health of waste management officers, both in terms of safety and health, and can also have an impact on the environment (Adhani, 2018). Therefore many tools have been developed to monitor cholesterol levels using non-invasive methods so that medical waste can be reduced and checked regularly.

Based on a study previously related to making a tool with a method non- invasive has been done by Agus (2018) has done to measure blood sugar levels by utilizing uptake ray non-laser, which originates from sensors MAX30100 And IoT-based Nodemcu microcontroller to produce an accuracy percentage value as big 90.3%. A study similar also done by Nurma'atin (2022) through the manufacture of blood sugar measuring devices using non-invasive methods by utilizing uptake ray *near Infrared* on sensors TCRT5000 and Arduino nano as processing to produce an accuracy percentage of 98.26%. This sensor has mark accuracy tall as supporters instrument non-invasive, so sensors this own opportunity for development for other purposes. Therefore, this sensor was chosen as one of the components used in this study to manufacture measuring instruments to rate cholesterol with non-invasive methods. Progress technology that happens can be utilized in facilitating human work (Nurkholis et al., 2017). This fact triggers the emergence of an innovation that allows any equipment or device in a house to be controlled remotely using internet technology. In previous research, the measuring instrument had not been integrated with the remote control system, therefore an Android-based remote monitoring system was added in this study. One application that is easy to use and can be directly connected to Nodemcu is the Telegram application. Telegram is often used chat messenger, and telegram bots are utilized as an information system. This telegram bot can be used as a monitoring tool controlled by the user (Mulyanto, 2020). Therefore, this research aims to design and implement an Android-based monitoring system using the telegram application in *prototype* form to measure cholesterol levels.

## METHODS

This research uses the type of research and development or *Research and Development* (R&D), namely research in which the processes or steps in developing a tool (Martianingtiyas, 2019). This study used 15 randomly selected samples aged 20-30 years.

Figure 1 shows the research flowchart. The first stage is the tool's design, which is done by assembling the components. The second stage is coefficient of determination test which aims to convert ADC (Analog to Digital Converter) values into cholesterol levels; if the coefficient of determination is $0.8 \leq R \leq 1$, then proceed to the next stage. The third stage is the accuracy test using 15 samples to determine the tool's accuracy by comparing the results of measurements from non-invasive and standard measuring instruments. The fourth step is a delay test using the Wireshark application.

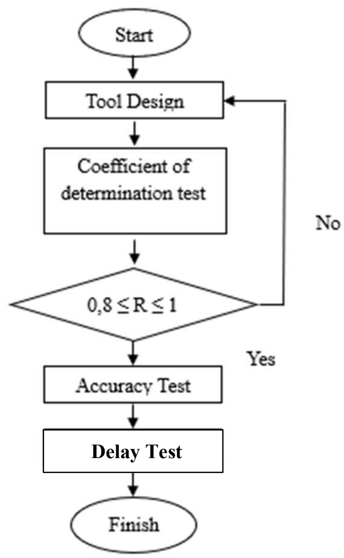


Figure 1. Flowchart of research stages

The design of the tool is shown in Figure 2. The design of this tool utilizes an infrared sensor in the form of a TCRT5000 with a wavelength between 750nm-1000nm. This sensor functions as a light emitter to illuminate objects, which will be researched as a finger hand. Then, the results from sensors accepted by Nodemcu is an ADC value converted using the formula obtained from calibration. Furthermore, cholesterol levels will be displayed on the screen. The 16 x 2 LCD is digital data and is connected to Android (OO, 2020; Pratama, 2017).

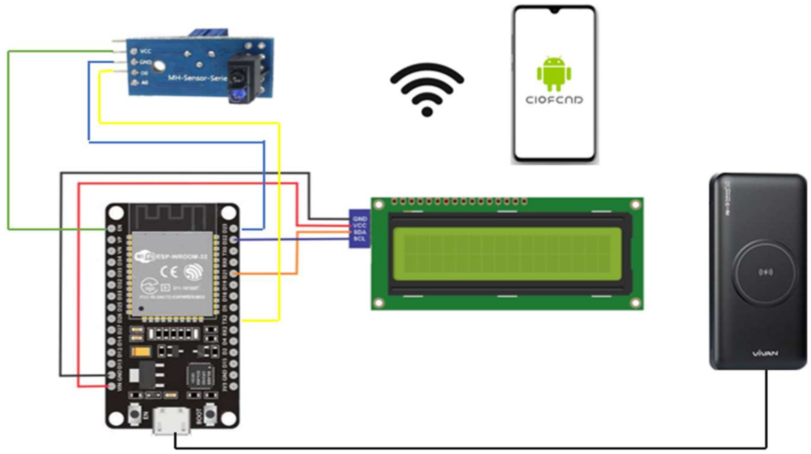

Figure 2. The Cholesterol Monitoring Tool series uses the TCRT5000 sensor

The next stage is coefficient of determination test tool to obtain a straightline equation (y = a + bx) and the value of the coefficient of determination with y as the grade value cholesterol, which has been measured using the tool measuring default, x as mark ADC Which comes from a non-invasive measuring instrument. At the same time, a and b are straight-line equation constants. The value of this straight-line equation is used to convert the ADC value (mV) into cholesterol levels (mg/dl). At the same time, the value of the coefficient of determination is used to determine the level of linear significance between ADC values and cholesterol levels. Suppose the coefficient of determination is $0.8 \leq R \leq 1$. In that case, the linear relationship between non-invasive and standard measuring instruments is very significant, so this tool can proceed to the tool testing stage (Ndruru et al., 2014).

The next stage was testing the tool to determine the level of accuracy of the tool performed by comparing the results of measurements from *non-invasive* measuring instruments and standard measuring instruments. The tool's accuracy was obtained by using the percentage error of the *non-invasive measuring instrument* from equation (1).

$$\%\text{Errors} = \frac{\text{Cholesterol levels( Autocheck 3 in 1} - \text{Sensor TCRT5000)}}{\text{Cholesterol levels Autocheck 3 in 1}} \times 100\% \quad (1)$$

Using equation (1), the percentage error value for *non-invasive measuring instruments* was *obtained* then the values were averaged. Furthermore, the tool's accuracy is obtained from 100% minus the tool error percentage.

The next stage was the measurement of parameter delay. Measurements were made by calculating the delay using the Wireshark application. Delay can be calculated with equation 2.

$$\text{Delay (s)} = \frac{\text{Total Delay}}{\text{Total data received}} \quad (2)$$

## RESULTS AND DISCUSSION

All the components of this instrument have been neatly packaged in a black box, as seen in Figure 3. This packaging is intended to avoid interference from external factors, such as other light sources, during data collection, and to make it easier for the device to be transferred and stored. When a finger is inserted into the hole, the TCRT5000 sensor will detect it, and the NodeMCU will process the data so that the value can appear on the LCD screen. Additionally, the cholesterol level can also be monitored remotely using the Telegram application.

**Figure 3.** Monitoring of cholesterol levels based on Android

*Coefficient of determination*

Coefficient of determination test was carried out by randomly taking five samples from 15 existing samples. Data retrieval using Autocheck 3 in 1 and continued with the non-invasive tool. Figure 4 shows a chart with a tradeline in the form of linear regression, which aims to obtain the value of the straightline equation, namely y = -17.33x + 1096.3 and the value coefficient of determination 0.9846.

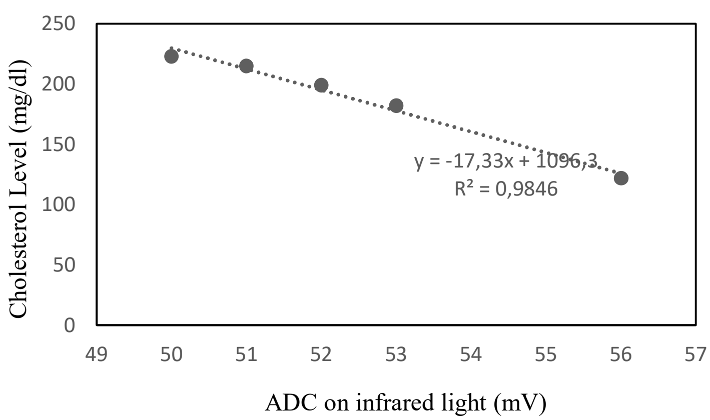


Figure 4. The relationship between the average ADC value on non-invasive devices and invasive devicesstandard Autocheck 3 in 1

Figure 5 shows the Arduino IDE display which the results of implementing the straightline equation y = -17.33x + 1096.3 in coding. This equation is used to convert ADC values on infrared light (mV) to cholesterol levels (mg/dl). Based on the coefficient of determination obtained, the linear connection between mark ADC on tool non-invasive with the rate of cholesterol in invasive devices is very strong. Therefore, this tool can be tested on stage to obtain mark accuracy. As shown in the graph, the ADC value of infrared light is inversely proportional to the concentration of cholesterol in the blood, which means the higher the cholesterol level in the blood, the higher absorption of infrared light is also high. That is, the ADC value received by the photodiode becomes lower, and vice versa. The Beer-Lambert law states that the absorbance (A) of a substance in solution is directly proportional to the concentration (c) of the substance and the thickness (l) of the solution (Oktariadi, 2017). When light passes through a medium, such as a solution, some of its energy is absorbed by its particles or molecules. The higher the concentration of particles or molecules in the medium, the more energy is absorbed and the higher the absorbance (Skoog et al., 2014).

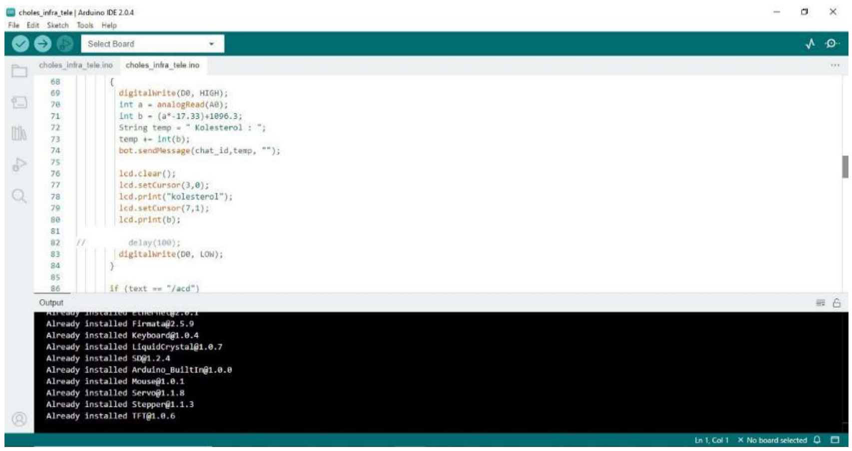


Figure 5. Arduino IDE display

*Accuracy*

Table 1. Tool Accuracy Test Results and Data Transfer Non-invasive

| No. | Cholesterol (Invasive ) mg/dl | Cholesterol (non-invasive) mg/dl | Acuration (%) |
|---|---|---|---|
| 1. | 223 | 229.80 | 96.95 |
| 2. | 172 | 212.47 | 76.47 |
| 3. | 239 | 212.47 | 88.90 |
| 4. | 301 | 195.14 | 64.83 |
| 5. | 178 | 195.14 | 90.37 |
| 6. | 248 | 195.14 | 78.69 |
| 7. | 190 | 160.48 | 84.46 |
| 8. | 182 | 177.81 | 97.70 |
| 9. | 144 | 108.49 | 75.34 |
| 10. | 115 | 160.48 | 60.45 |
| 11. | 215 | 212.47 | 98.82 |
| 12. | 199 | 195.14 | 98.06 |
| 13. | 233 | 177.81 | 76.31 |
| 14. | 280 | 177.81 | 63.50 |
| 15. | 122 | 125.82 | 96.87 |
| **Average** | | | **83.18** |

The accuracy test was performed by comparing the results of measurements from non-invasive and invasive measuring instruments. The average accuracy result is 83.18% can be seen in Table 1.

This shows that this tool has the opportunity to be developed further. Similar to research conducted by Nurma'atin (2022), the Nellcor DS100A sensor to monitor cholesterol levels resulted in an accuracy value of 82.76%. The accuracy obtained still needs to be more accurate because it is less than 95%. This is caused by exposure to ambient light, which can impact the absorption of infrared light, which hits objects in the form of index fingers (Ekawita et al., 2020).

Another study by Nurma'atin (2022) used the TCRT5000 sensor to measure blood sugar levels, showing that the accuracy in people with diabetes was 98.26%, while in normal samples, it was 97.16%. Previous studies have shown high accuracy in measuring blood sugar concentrations because blood sugar concentrations can affect blood viscosity. However, in this study, what was measured was the level of cholesterol which can stick to the walls of blood vessels, forming plaques that affect blood flow but do not affect blood viscosity (Price & Wilson, 1995).

*Parameter Delay*

Delay test is measurment using the Wireshark application to optain the delay value. Delay is the amount of time required for data to arrive at its destination. Delay can be influenced by distance and time, it can be calculated using equation (2). The delay measurement results in 100 data can be seen in Figure 6.

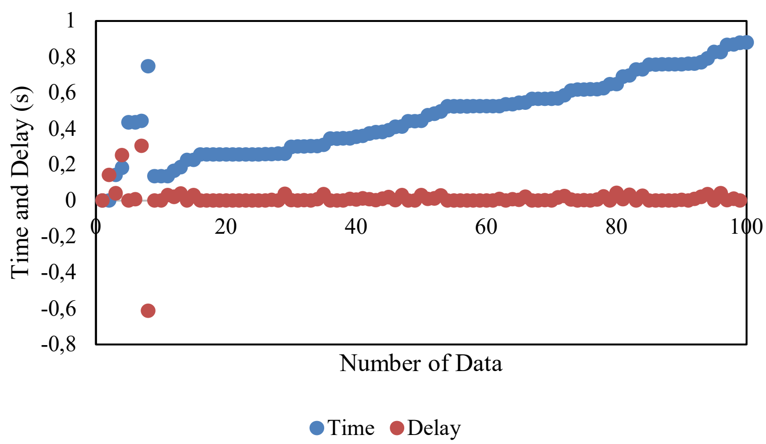


Figure 6. The Result of Parameter Delay

The result of the avarage delay calculation is 8.8 ms. It can be concluded that based on the delay standardization in table 2, the value is included in the excellent category.

Table 2. Standardization delay

| **Category** | **Delay** | **Indeks** |
|---|---|---|
| Excellent | < 150 ms | 4 |
| Good | 150 s/d 300 ms | 3 |
| Poor | 300 s/d 450ms | 2 |
| Unnaceptable | > 450 ms | 1 |

Source : (Prasetyo & Elvin, 2021)

The data transfer speed is influenced by several factors, including the quality of the signal. A strong and stable signal enhances the transfer speed, while a weak or disrupted signal reduces it. The location conditions for data collection also impact the data transfer speed. To achieve optimal data transfer speed, it is important to consider the signal quality and take into account the conditions of the data collection location.

This tool cannot yet use as a standard measuring tool because of the average value. Its accuracy is less than the threshold for medical device accuracy usable for humans, i.e., less than/or equal to 95% (Sulehu & Senrimang, 2018; Suyono, 2020). However, this tool can be added with a correction factor or other algorithms to increase accuracy. This tool has potential large enough to be used in a telemedicine system that can be accessed periodically remotely in determining the estimated value of cholesterol levels in the blood.

## CONCLUSION

Research has been conducted on developing a cholesterol monitoring system using a non-invasive Android-based TCRT5000 sensor. The average accuracy of the tool is 83.18%, and the average of delay 8.8 miliseconds in the excellent category. This tool has potential large enough to be used in a telemedicine system that can be accessed periodically remotely in determining the estimated value of cholesterol levels in the blood.

## REFERENCE

Adhani, R. (2018). Pengelolaan Limbah Medis. In *Global Shadows: Africa in the Neoliberal World Order* (Vol. 44, Issue 2).

Agus Suprayitno, E., Setiawan, A., & Dijaya, R. (2018). Design of Instrumentation in Detecting Blood Sugar Levels with Non-Invasive Technique Base on IoT (Internet of Things). *International Journal of Engineering & Technology*, *7*(4.15), 440. https://doi.org/10.14419/ijet.v7i4.15.25252

Ayu, A. M., Mutalazimah, M., & Herawati, I. (2017). Hubungan Frekuensi Senam Aerobik dan Asupan Kolesterol terhadap Kadar Kolesterol Darah Wanita Usia Subur di Pusat Kebugaran Syariah Agung Fitnes Makamhaji. *Jurnal Kesehatan*, *10*(2), 74. https://doi.org/10.23917/jurkes.v10i2.5536

Dewi, I. G. A. A. Y. (2018). Peran Generasi Milenial Dalam Pengelolaan Sampah Plastik Di Desa Penatih Dangin Puri Kecamatan Denpasar Timur Kota Denpasar. *Public Inspiration : Jurnal Administrasi Publik*, *3*(2), 84–92.

Ekawita, R., Nasution, A. A., Yuliza, E., Suardi, N., & Suwarsono, S. (2020). Development of Non-Invasive Blood Glucose Level Monitoring System using Phone as a Patient Data Storage. *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA)*, *10*(2), 103. https://doi.org/10.26740/jpfa.v10n2.p103-113

Martianingtiyas, E. D. (2019). Research and Development (R&D): Inovasi Produk dalam Pembelajaran. *Researchgate*, *August*, 1–8. https://www.researchgate.net/publication/335227473

Maryati, H., & Praningsih, S. (2018). Karakteristik Peningkatan Kadar Kolestrol Darah Penderita Hiperkolesterolemia di Dusun Sidomulyo Desa Rejoagung Kecamatan Ploso Kabupaten Jombang. *Jn (Scientific Jouurnal Ilmiah Keperawatarnal of Nursing)*, *4*(1), 24–30.

Mulyani, N. S., Al Rahmad, A. H., & Jannah, R. (2018). Faktor resiko kadar kolesterol darah pada pasien rawat jalan penderita jantung koroner di RSUD Meuraxa. *AcTion: Aceh Nutrition Journal*, *3*(2), 132. https://doi.org/10.30867/action.v3i2.113

Mulyanto, A. D. (2020). Pemanfaatan Bot Telegram Untuk Media Informasi Penelitian. *Matics*, *12*(1), 49. https://doi.org/10.18860/mat.v12i1.8847

Ndruru, R. E., Situmorang, M., & Tarigan, G. (2014). Analisa Faktor-faktor yang Mempengaruhi Hasil Produksi Padi di Deli. *Saintia Matematika*, *2*(1), 71–83.

Nurkholis, A., Riyantomo, A., & Tafrikan, M. (2017). Sistem Pakar Penyakit Lambung Menggunakan Metode Forward Chaining. *Jurnal Momentum*, *13*(1), 32–38.

Nurmar'atin, T., Sumarti, H., & Wulandari, A. (2022). Validasi Alat Ukur Kadar Gula Darah Secara Non- Invasive Menggunakan Sensor Tcrt5000 Untuk. *Jurnal Inovasi Dan Pembelajaran Fisika*, *9*, 51–61.

Oktariadi, N. (2017). Sistem Telemedika Berbasis ICT untuk Pengukuran Kadar Kolesterol Dalam Darah dengan Metode Non Invasive. *Jurnal Universitas Mercu Buana*, 1–9.

OO, A. (2020). Design, simulation and implementation of an Arduino microcontroller based automatic water level controller with I2C LCD display. *International Journal of Advances in Applied*

*Sciences*, *9*(2), 77. https://doi.org/10.11591/ijaas.v9.i2.pp77-84

Prasetyo, D. R. (2019). *Rancang Bangun Telemedicine Pengukur Kadar Kolesterol dalam Darah Berbasis Internet of Things*. 1–78.

Prasetyo, S. E., & Elvin. (2021). Analisis Quality of Service (QoS) Jaringan Wireless 2.4 GHz dan 5 GHz di Dalam Ruangan dengan Hambatan Kaca. *Jurnal Ilmiah Teknologi Informasi Asia*, *15*(2), 103. https://doi.org/10.32815/jitika.v15i2.609

Pratama, R. P. (2017). Aplikasi Wireless Sensor ESP8266 Untuk Smart Home Automation. *Seminar Nasional Teknologi Dan Rekayasa (SENTRA)*, *IV*, 1–10.

Price, S. A., & Wilson, L. M. (1995). *Patofisiologi :konsep klinis proses-proses penyakit* (C. Widjaja (ed.); Edisi 4).

Rahmad, A. A. H. (2018). Pengaruh Pemberian Konseling Gizi terhadap Penurunan Kadar Kolesterol Darah. *Jurnal Kesehatan*, *9*(2), 241–247. http://ejurnal.poltekkes-tjk.ac.id/index.php/JK

Riskesdas. (2013). *Riset Kesehatan Dasar*. Science. https://doi.org/10.1126/science.127.3309.1275

Skoog, D. A., Holler, F. J., Crouch, S. R., & West, D. M. (2014). *Fundamentals of analytical chemistry* (9th ed). Cengage Learning.

Sulehu, M., & Senrimang, A. H. (2018). Program Aplikasi Alat Pengukur Kadar Glukosa Dalam Darah Non Invasive Bebasis Desktop. *Inspiration : Jurnal Teknologi Informasi Dan Komunikasi*, *8*(1), 16–24. https://doi.org/10.35585/inspir.v8i2.2454

Suyono, H. (2020). *Perancangan Alat Pengukur Kadar Gula dalam Darah Menggunakan Teknik Non-Invasive Berbasis Mikrokontroler Arduino Uno*. *06*(01), 69–76.

Zuhriyani. (2019). Analisis Sistem Pengelolaan Limbah Medis Padat Berkelanjutan di Rumah Sakit Umum Raden Mattaher Jambi. *Jurnal Pembangunan Berkelanjutan*, *1*(1), 40–52. https://online-journal.unja.ac.id/JPB/article/view/6436