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Monitoring of Blood Cholesterol Measurement System Using ICT-Based Non-Invasive Methods

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ABSTRACT Coronary heart disease is a public health problem because of its very high morbidity and mortality, the death rate caused by coronary heart disease is quite high in the world, including in Indonesia. This study aims to analyze and develop and realize the application of non-invasive blood cholesterol measurement based on ICT. Contribution of this research is that it can be used as a reference or recommendation for developing a non-invasive ICT-based blood cholesterol measurement system. The research method used in this study is the library study method and the experimental method. The results of this study are: (1) The monitoring system for measuring blood cholesterol levels Non-invasive methods using near infrared technology can be implemented properly and can be monitored based on ICT using webBase; (2) Tests were carried out on 25 random samples with two conditions, conditions before eating and conditions after eating and compared with the invasive method (auto check), found an accuracy value in conditions before eating of 98.47% with an error value of 1.53%, while in the condition after eating found an accuracy of 98.55% with an error value of 1.45%; (3) Testing the blood cholesterol level detection tool with Non-invasive shows a more real time with a duration of 10 seconds until the results are displayed on the LCD screen, while with an invasive method it shows a measurement duration of 26 seconds until the results are displayed on the screen. (4) Based on this test, a non-invasive cholesterol level measuring device can be used as a reference in the development of a blood cholesterol measurement tool so that it can be an option for routine measurements.

INDEX TERMS Stunting, Baby scales, IoT, Stunting monitoring.

I. INTRODUCTION

Coronary heart disease is a public health problem because of its high morbidity and mortality. In Indonesia, coronary heart disease is also the highest cause of death. According to data from the Indonesian Ministry of Health for 2018, coronary heart disease causes around 19.9% of deaths in Indonesia [1]. One of the causative factors is cholesterol. Cholesterol has two types of lipoproteins namely High-density lipoprotein (HDL) and Low-density lipoprotein (LDL) [2][3]. In general, cholesterol is very beneficial for the human body, but if the levels are too high, it will cause a buildup on the walls of the arteries and interfere with blood flow, which becomes narrow, thus burdening the space in the closed blood flow, causing blood pressure to rise and causing heart attacks and bleeding in the brain. Strokes) [4][5].

Therefore, to avoid increasing blood cholesterol levels, regular check-ups must be carried out to balance the current lifestyle [6]. Several ways to check blood cholesterol levels have been carried out invasively in various hospitals and clinics, namely by taking a blood sample by inserting a needle into the body and then taking it to the laboratory to be analyzed to obtain a value for cholesterol levels in the blood [7], using a blood sugar meter such as Auto check using a check strip by sticking a needle in the finger and then putting blood on the check strip to get the value [8]. Some of these methods become an obstacle for most people to carry out routine checks because measurements are carried out invasively to collect blood samples which can be quite expensive, laboratory analysis results take quite a long time and can cause trauma, and pain in the part of the body that was stabbed. with a needle for sampling [4].

Several researchers have conducted a lot of research by making blood analysis measuring devices such as blood sugar levels and blood cholesterol levels non- invasively [9], such as Al-Baradie et al utilized Near Monochromatic Light from an LED with a wavelength of 670 nm to perform non-invasive measurements of the hemoglobin system [10], Yusoff et al utilized near-infrared with a wavelength range of 700 nm – 1400 nm to get the results of measuring cholesterol in the blood using a non-invasive method and the results are displayed on the LCD screen [5], then research was also carried out by WangShulei et al using Near Infrared for measuring blood glucose levels with a wavelength of 750 nm – 2500 nm and the results are compared with invasive measuring tools [11].

Many studies have been done using near infrared (NIR), because currently the measurement of cholesterol levels in the body can be done by utilizing light or laser absorption technology in liquid media [12][13]. Near- infrared itself is one of the most widely explored optical techniques because it has high skin penetration [14], but the several studies above only display the results on an LCD screen, but no one has focused on more real-time and accurate results [15]. The purpose of this study is:

1. To analyze, develop and realize the application of ICT-based non-invasive blood cholesterol measurement.
2. Can be used as a reference or recommendation for developing a non-invasive ICT-based blood cholesterol measurement system.

II. MATERIAL AND METHODS

The research method used in this study is the library study method and the experimental method. The following are the stages of the research flow carried out in this study, the first is that the researcher looks for the main problems that often occur and are experienced by people with high blood cholesterol levels that can cause death in sufferers, this problem occurs because many people do not routinely go for checkups, especially carrying out checks Cholesterol levels in the blood on a regular basis, where in the current era there are many unhealthy lifestyles by eating a lot of fast food (junk food) and being lazy to exercise is one of the triggers, moreover, carrying out an examination takes quite a long time and is quite expensive and will leaving a feeling of traumatic pain in the sufferer due to using an invasive method, namely obtaining a blood sample by sticking a needle or taking blood. Therefore, the researchers designed a tool to measure blood cholesterol levels non-invasively.

From the existing anxiety to then conduct a literature study to support the success of the research to be carried out. The literature used includes books, research journals, scientific articles, dissertations and previous research reports. As has been done by I.M.M Yusof (2015), Wang Shulei (2017), Satoshi Shimawaki (2014), Eka Yulia Fitri and Karinma Maisoha (2020) who conducted research by designing a non-invasive measuring instrument for cholesterol levels using near infrared as the sensor. In addition, in this literature study, we learn about non-invasive methods and making Android-based or web-based applications. The next stage is an analysis of the current conditions in terms of the expected increase in mortality due to coronary heart disease, one of which is high levels of cholesterol in the blood, then identifying the problem in order to obtain gaps in the discussion of the problem between the current condition and the expected condition. Next, make a circuit design consisting of electronic circuit simulation and hardware design. The series simulation stage aims to minimize errors in making cholesterol detection devices in this study. Circuit simulation using software. There are differences in the output of hardware and simulation due to the tolerance of electronic components and the quality of these components. Circuit troubleshooting can be done if one of them is a problem with differences in the output of software and hardware. Then the next step is to create a web-based monitoring system using VScode, VScode also has an interesting feature, namely live share. This feature allows users to collaborate in real-time software development, by allowing users to share code or URL links, making it easier to monitor measurement results on a regular and real-time basis. The materials that used in this research are:

A. ANALOG DIGITAL CONVERTER (ADC)

The most important the formation of bile acids to help digest food that enters the body [16]. Digital aids to process control technology are those that translate digital information into analog form and vice versa. Most of the measurements of dynamic variables are performed by these devices which translate information about the variables into the form of analog electrical signals. To connect this signal to a computer or digital logic circuit, it is necessary to first perform an analog-to-digital (A/D) conversion. counter type A/D converter, continuous type A/D converter, and approximation A/D converter respectively. Among the four methods above, the most widely used is the A/D modifier of the approach because it provides the best performance for various uses [18]. The SAR ADC is presented as the most frequently used ADC in industrial applications, as it provides high resolution (12–18 bits) with a moderate sample rate (about 1 MSPS) [17][18].

B. INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

ICT has an important role today. Apart from having an important role in the world of industry or business, ICT also plays an important role in the development of the world of education. Its role is very important in terms of the benefits and advantages contained in it [19]. The miniaturization of electronic components, through the creation of integrated circuits, ultimately gave rise to the microprocessor. The microprocessor is the 'brain' of computer hardware and continues to evolve now [20].

Telecommunication equipment developed rapidly when digital technology began to be used to replace analog technology. The digitization of telecommunication equipment then converges with computer equipment which from the start is a device that adopts digital technology [21]. This convergence product is currently appearing in the form of cellular phones. On top of this telecommunication and computing infrastructure, content in the form of multimedia has the right place to develop. It is the convergence of telecommunications – multimedia computing that characterizes the 21st century, just as the 18th century was characterized by the industrial revolution [22]. If the industrial revolution made machines replace human 'muscles' [23], then the digital revolution (due to the convergence of telecommunications – multimedia computing occurs through the implementation of digital technology) created machines that replaced (or at least increased the capabilities of) the human 'brain' [20].

C. LIGHT EMITTING DIODE (LED)

LED is an optoelectronic component or a technology that combines optics and electronics. LEDs are devices based on the influence of a Pn junction [24]. In a forward-biased LED, free electrons cross the junction and fall into the holes [25]. When electrons fall from high to low energy levels, the electrons will release energy, in the LED the energy is released in the form of light. LEDs produce visible radiation emitting monochromatic light. Monochromatic light is light of one color with one wavelength [26].

D. LIGHT DETECTOR (PHOTORESISTOR)

A photoresistor is a semiconductor device used to detect light. Photoresistors are also known as photoconductive or LDR (Light Dependent Resistors). The photoresistor is a type of variable resistor because the amount of resistance can change, the change in resistance on the photoresistor is determined by the amount of light hitting the cross-section of the photoresistor [27]. If the light hitting the photoresistor cross-section is large, the value of the resistance inside the photoresistor will be smaller, conversely, the smaller the light hitting the photoresistor cross-section, the greater the value of the resistance on the photoresistor. When light hits the photoresistor, the photons will hit the Cadmium Sulfide bonds and release electrons. The greater the intensity of the incident light, the more electrons are released from the bonds. So that the resistance of the photoresistor will decrease when light hits it [28].

E. BLOCK DIAGRAM TOOL

The design and manufacture of hardware consists of several stages, namely making block diagrams, power supply circuits, light source circuits, Arduino microcontrollers, and software on web-based mobile phones.

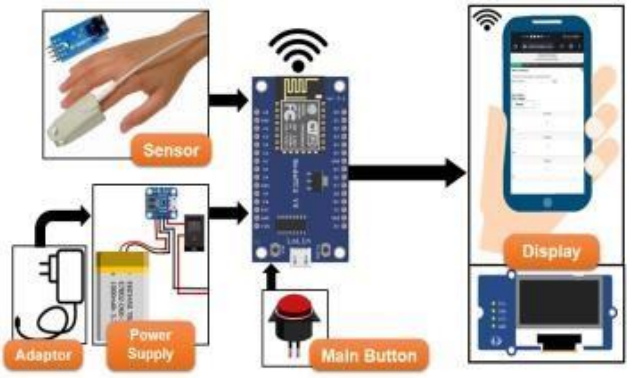

FIGURE 1. The block diagram

FIGURE 1 ilustrates the sensor which consists of an LED and a photodiode detects a change in the volume of flowing blood causing a change in electrical resistance which results in a change in voltage. occur and stabilize the voltage-required voltage stabilizer components to suppress the noise that occurs. Then this analog signal needs to be converted to digital format using the Arduino ESP32 microcontroller. Furthermore, the data is sent serially to a web-based mobile phone to monitor the results. The process of testing and collecting data to prove what is expected or not. Data collection was carried out by inserting the subject's finger into the sensor that had been prepared, and measurements were carried out repeatedly 3 times with an interval of 1 minute for each measurement, wherein the sensor already contained an Infrared LED and a light detector as a light source, where each measurement result will exit after a countdown of 10 seconds. The subject's finger is placed inside the sensor to measure cholesterol levels. The light given by the Infrared Led to the subject's finger will be reflected by the subject's finger and captured by the Photodiode detector, then the light value captured by the Photodiode will be converted or processed into a cholesterol level value by the microcontroller (a small computer in the form of an IC chip) and displayed on the LCD. Data taken from the results of testing software and hardware tools are primary data that is quantitative. Data analysis on error calculation and accuracy level uses the following equation (1):

$$Error = A - x \quad (1)$$

where error is the difference in measurement data with non-invasive methods and invasive methods, A is cholesterol level measurement data on invasive methods, equation (2).

$$Accuracy = \left(1 - \left|\frac{N-A}{A}\right|\right) x100\% \quad (2)$$

where N is cholesterol level measurement data on non-invasive methods, and A is cholesterol level measurement data on invasive devices, equation (3).

$$\%Error = \left(\left|\frac{Error}{A}\right|\right) x100\% \quad (3)$$

where x is average measurement data with non-invasive methods, and A is cholesterol level measurement data on invasive methods.

III. RESULT

In this study, sensor testing was carried out on the module that had been designed and testing the module for measuring cholesterol levels. In testing the photodiode sensor, it is done by placing the probe on the subject's fingertip and comparing it with a multimeter. The LCD will display the output voltage from the photodiode sensor. Testing using a multimeter, the voltage value generated by the photodiode sensor circuit is 1.392 Volts on the fingerless condition and 1.532 Volts on the fingered condition. The VCC source of the Arduino photodiode sensor is 5 volts. In this study, measurements were taken from a sample of 25 subjects with random subjects in various locations, measurements were carried out in two conditions, namely conditions before meals and conditions after meals, measurements were carried out 3 (three) times with a 1- minute measurement interval, results of measuring cholesterol levels with Non-invasive that has been made compared with the results. Invasive measurement method, namely the Auto Check measuring tool. The following are the results of measuring cholesterol levels that have been carried out.

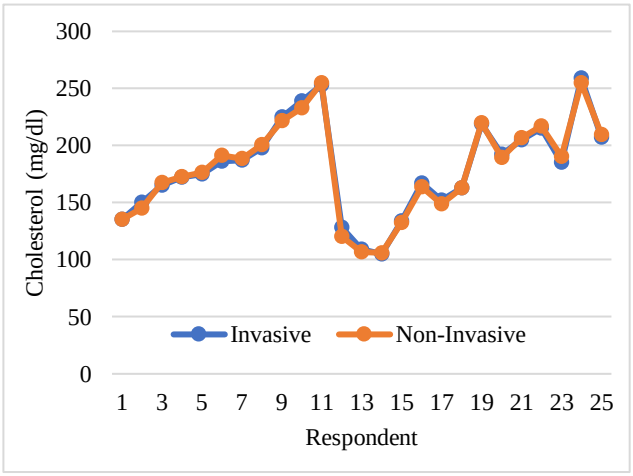

FIGURE 2. Graph of Invasive and Non-invasive cholesterol level measurements with conditions before meals

FIGURE 2 shows the results of a comparison in the conditions before meals, measurements were carried out with 25 respondents at random where the most significant difference occurred in the measurement of respondent L with the results of measurements in the invasive method of 128 mg /dl and the non-invasive method of 120 mg/dl.

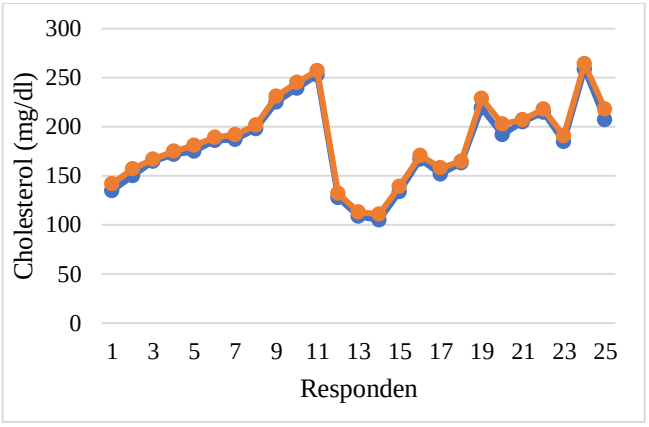

FIGURE 3. Graph of comparison of invasive and non-invasive cholesterol levels with conditions after meals

FIGURE 3 shows the results of a comparison in post- meal conditions, measurements were taken with 25 respondents at random where the most significant difference occurred in respondent Y's measurements with 218 mg of invasive methods. /dl and in the non-invasive method of 211 mg/dl.

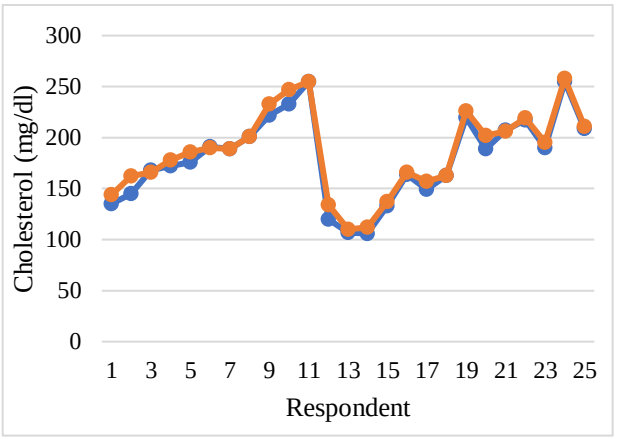

FIGURE 4. Graph of comparison of Invasive cholesterol data with conditions before meals and after meals

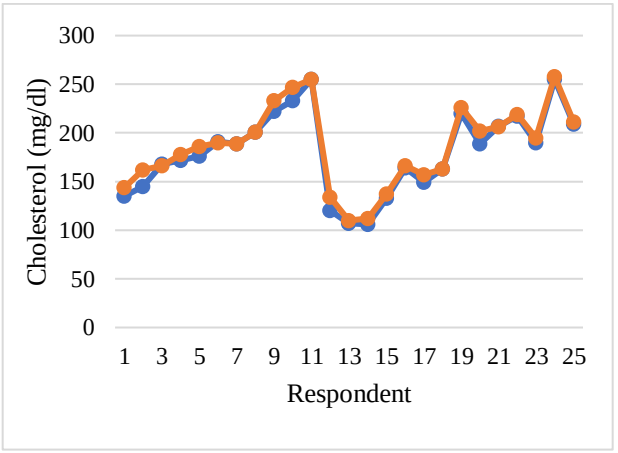

FIGURE 5. Graph of comparison of non-invasive method cholesterol data with conditions before meals and after meals

TABLE 2
Comparison of error results and accuracy of measuring cholesterol levels in invasive and non-invasive conditions before meals

No	Subject	*Invasive* (mg/dl)	Mean *Non-invasive* (mg/dl)	Deviation (mg/dl)	Error (%)	Accuracy (%)
1	A	135	135	0	0.00	100.00
2	B	150	145	13	3.33	96.67
3	C	165	168	5	1.82	98.18
4	D	172	172	0	0.00	100.00
5	E	175	176	1	0.57	99.43
6	F	186	191	13	2.69	97.31
7	G	187	189	2	1.07	98.93
8	H	198	201	5	1.52	98.48
9	I	225	222	5	1.33	98.67
10	J	239	233	18	2.51	97.49
11	K	253	255	2	0.79	99.21
12	L	128	120	32	6.25	93.75
13	M	109	107	2	1.83	98.17
14	N	105	106	1	0.95	99.05
15	O	134	133	1	0.75	99.25
16	P	167	164	5	1.80	98.20
17	Q	152	149	5	1.97	98.03
18	R	163	163	0	0.00	100.00
19	S	219	220	1	0.46	99.54
20	T	192	189	5	1.56	98.44
21	U	205	207	2	0.98	99.02
22	V	215	217	2	0.93	99.07
23	W	185	190	13	2.70	97.30
24	X	259	255	8	1.54	98.46
25	Y	207	209	2	0.97	99.03
	Mean	**181**	**181**		**1.53**	**98.47**

FIGURES 4 and 5 show a graph of the difference in blood cholesterol values from measurements using invasive methods and measurements using non-invasive methods with conditions before meals and after meals where there is a difference in value, seen in TABLE 1 and TABLE 2 where the average measurement is 25 Respondents in the invasive method with pre-meal conditions were 181 mg/dl while in post-meal conditions the average measurement of 25 respondents was 186 mg/dl. The following displays the results of web-based measurements:

FIGURE 6. Display of web-based cholesterol measurement results interface

FIGURE 6 shows the results will be displayed on the LCD screen which has been integrated with the module, and can be monitored using a cellphone, PC, laptop, or other media connected to the internet, this can be done using the ESP32 Wi-Fi module that has been installed in the designed toolkit program. The application used to display is VScode software which has an interesting feature, namely live sharing which allows users to collaborate in real-time by allowing users to share code or URL links. After testing and data collection, data analysis was then carried out to obtain the accuracy of the non-invasive blood cholesterol measuring instrument, with the following results:

From TABLE 2 it shows the difference in the results of measuring blood cholesterol levels with invasive and non-invasive conditions before meals, the largest error value is 6.25% and the smallest error value is 0.00% where the average error is obtained from the results of testing on 25 respondents in the condition before meals was 1.53% with an accuracy of 98.47% with the largest deviation occurring in respondent L.

TABLE 3
Comparison of error results and accuracy of measuring cholesterol levels in invasive and non- invasive conditions before meals

No	Subject	*Invasive* (mg/dl)	Mean *Non-invasive* (mg/dl)	Deviation (mg/dl)	error (%)	Accuracy (%)
1	A	142	144	2	1.41	98.59
2	B	157	162	13	3.18	96.82
3	C	167	166	1	0.60	99.40
4	D	175	178	5	1.71	98.29
5	E	181	186	13	2.76	97.24
6	F	189	190	1	0.53	99.47
7	G	192	189	5	1.56	98.44
8	H	202	201	1	0.50	99.50
9	I	231	233	2	0.87	99.13
10	J	245	247	2	0.82	99.18
11	K	257	255	2	0.78	99.22
12	L	132	134	2	1.52	98.48
13	M	113	110	5	2.65	97.35
14	N	111	112	1	0.90	99.10
15	O	139	137	2	1.44	98.56
16	P	171	166	13	2.92	97.08
17	Q	158	157	1	0.63	99.37
18	R	165	163	2	1.21	98.79
19	S	229	226	5	1.31	98.69
20	T	203	202	1	0.49	99.51
21	U	207	206	1	0.48	99.52
22	V	218	219	1	0.46	99.54
23	W	191	195	8	2.09	97.91
24	X	264	258	18	2.27	97.73
25	Y	218	211	25	3.21	96.79
	Mean	**186**	**186**		**1.45**	**98.55**

TABLE 3 shows the results of measuring blood cholesterol levels using invasive and non-invasive conditions after meals, the largest error value is 3.21% and the smallest error value is 0.00%, where the average error is obtained from the test results on 25 respondents in the condition after meals is 1.45% with an accuracy of 98.55% with the largest deviation in respondent Y.

Based on the results of tests that have been carried out and compared with comparative measuring instruments, it appears that the tools that have been designed can be used to measure blood cholesterol levels non-invasively. The difference in results that occur can be seen, but the measurement deviation is still within the allowable tolerance limits. In principle, the non-invasive method uses light from an LED to penetrate human skin and blood vessels, then the light is transmitted and received by the photodiode sensor and the value is converted to a cholesterol level value.

FIGURE 7. Measurement time with invasive methods

From FIGURE 7 the study of measuring blood cholesterol levels using the invasive method requires a constant time of 26 seconds to display the results of the detection of cholesterol on the screen, while in Figure 8 measuring blood cholesterol levels using the non-invasive method requires a constant time of 10 seconds until the results of the detection of cholesterol displayed on the LCD screen, this shows that measurements

with non-invasive methods are more real-time than invasive methods (FIGURE 8).

FIGURE 8. **Measurement time with non-invasive methods**

IV. DISCUSSION

It is possible to appropriately construct and maintain a monitoring system for measuring blood cholesterol levels utilizing a non-invasive approach and near-infrared technology. The accuracy value in the conditions before meals was 98.47% with an error value of 1.53%, whereas in the condition after meals found an accuracy of 98.55% with an error value of 1.45%. Tests were conducted on 25 random samples with two conditions, conditions before meals and conditions after meals, and compared with the invasive method (auto check). When using a non-invasive method to test blood cholesterol levels, results are displayed on the LCD panel in less than 10 seconds, however when using an intrusive method, results are displayed on the screen after a measurement period of 26 seconds. Based on the results of this test, a non-invasive method for evaluating cholesterol levels can be developed as a guide for routine measures of blood cholesterol. The results of this device development are alternative innovations that can be used to measure cholesterol, which are easy to use, not painful, and low cost because it does not use cholesterol strips. The accuracy of the tool has developed quite well and reliable [29]. The limitation of this research is it does not discuss details about cholesterol, its physical and chemical processes collection and accuracy testing only compares invasive methods and non-invasive methods. The Web-based application is focused as a medium for measuring blood cholesterol levels as a control to retrieve results from the microcontroller contained in the tool that has been realized and can be stored.

V. CONCLUSION

This study aims to analyze and develop and realize the application of non-invasive blood cholesterol measurement based on ICT. Contribution of this research is that it can be used as a reference or recommendation for developing a non-invasive ICT-based blood cholesterol measurement system. From the research that has been done, it can be concluded that (1) a Monitoring system for measuring blood cholesterol levels by Non-invasive method using near- infrared technology can be implemented properly and can be monitored using ICT based using webBase. (2) Tests were carried out on 25 random samples with two conditions, conditions before meals and conditions after meals, and compared with the invasive method (auto check), found the accuracy value in the conditions before meals was 98.47% with an error value of 1.53%, whereas in the condition after meals found an accuracy of 98.55% with an error value of 1.45%. (3) Testing the blood cholesterol level detection tool with Non-invasive shows more real-time with a duration of 10 seconds until the results are displayed on the LCD screen, while with an invasive method, it shows a measurement duration of 26 seconds until the results are displayed on the screen. (4) Based on this test, a non-invasive cholesterol level measuring device can be a reference in the development of a blood cholesterol measurement tool so that it can be an option for routine measurements.

Based on the research conducted, there are differences in results that are still included in the tolerance between invasive methods and non-invasive methods. Basically, measuring blood cholesterol levels in non-invasive methods using near infrared technology. The thickness of the finger will affect the intensity of light received by the sensor. It is recommended to use TCRT5000 infrared sensor with a wavelength of 950nm with a higher light intensity so that readings are more optimal and stable.

REFERENCES

[1] N. S. Mulyani, A. H. Al Rahmad, and R. Jannah, "Faktor resiko kadar kolesterol darah pada pasien rawat jalan penderita jantung koroner di RSUD Meuraxa," AcTion Aceh Nutr. J., vol. 3, no. 2, p. 132, Nov. 2018, doi: 10.30867/action.v3i2.113.

[2] Y. Kudo, S. Nakamura, and Y. Nikawa, "Study on measuring cholesterol level using microwaves," in 14th International Conference on Microwave and High Frequency Hmeals, AMPERE 2013, 2013, pp. 187–190.

[3] M. Kumar, "Non-Invasive Measurement of Cholesterol Levels Using Eye Image Analysis Image analysis based CAD system for cholesterol and diabetic related eye abnormalities View project

Design of Automated Kidney stone detector View project," 2016. [Online]. Available: https://sites.google.com/site/ijcsis/

[4] E. Yulia Fitri, K. Maisoha, P. Studi Ilmu Keperawatan, F. Kedokteran, and U. Sriwijaya, "Seminar Nasional Keperawatan 'Pemenuhan Kebutuhan Dasar dalam Perawatan Paliatif pada Era Normal Baru'

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[10] Chandra, "2013 10th International Multi- Conference on Systems, Signals and Devices, SSD 2013," 2013 10th International Multi-Conference on Systems, Signals and Devices, SSD 2013. 2013.

[11] Wangshulei, "Non-invasive Blood Glucose Measurement Scheme Based on Near-infrared Spectroscopy."

[12] R. N. Hidayati, N. H. Ahniar, G. R. Lestari, A. Hendryani, and F. Al Hakim, "SELF- MONITORING OF BLOOD GLUCOSE WITH A NON-INVASIVE METHOD USING NEAR LEVELS DEVICES 1*." INFRARED SENSOR," SANITAS J. Teknol. dan

[5] I.M.M.Yusoff, R. Yahya, and L. C. K. W.R.W.Omar, Seni Kesehat., vol. 11, no. 2, pp. 111–121, Dec. "2015 Innovation Commercialization of Medical 2020, doi: 10.36525/sanitas.2020.10.

[6] A. Yoeantafara and S. Martini, "Alodiea Yoeantafara : Pengaruh Pola Makan terhadap Kadar Kolesterol Total."

[7] H. T. Sihotang, "SISTEM PAKAR MENDIAGNOSA PENYAKIT KOLESTEROL PADA REMAJA DENGAN METODE CERTAINTY FACTOR (CF) BERBASIS WEB," 2014.

[8] S. Shimawaki, M. Nakabayashi, Y. Kobayashi, and N. Sakai, "Non-invasive Serum Cholesterol Detection Using Near-infrared Light Transmission," Biomed. Eng. Res., vol. 3, no. 3, pp. 80–87, 2014, doi: 10.13140/RG.2.1.3243.3769.

[9] L. Tang, S. J. Chang, C. J. Chen, and J. T. Liu, "Non-invasive blood glucose monitoring technology: A review," Sensors (Switzerland), vol. 20, no. 23. MDPI AG, pp. 1–32, Dec. 01, 2020. doi: 10.3390/s20236925.

[15] A.-B. Dr. Raid Saleem and B. Mr. Anandh Sam Proceedings of 2017 IEEE 3rd Information Technology and Mechatronics Engineering Conference, ITOEC 2017, vol. 2017-Janua. IEEE, 2017.

[16] U. Umar, S. Syarif, I. Nurtanio, and Indrabayu, "A real time non-invasive cholesterol monitoring system," MATEC Web Conf., vol. 331, p. 06005, 2020, doi: 10.1051/matecconf/202033106005 S. Palermo, S. Hoyos, S. Cai, S. Kiran, and Y. Zhu, "Analog-to-Digital Converter-Based Serial Links: An Overview," IEEE Solid-State Circuits Magazine, vol. 10, no. 3. Institute of Electrical and Electronics Engineers Inc., pp. 35–47, Jun. 01, 2018. doi: 10.1109/MSSC.2018.2844603.

[17] M. Sulehu and A. H. Senrimang, "PROGRAM APLIKASI ALAT PENGUKUR KADAR GLUKOSA DALAM DARAH NON INVASIVE BEBASIS DESKTOP," 2018.

[18] J. W. Creswell, Research Design: Qualitative, Quantitative and Mixed Methods Approaches, Fourth. Thousand Oaks, CA: Sage Publications, 2014.

[19] F. Ohnhäuser, Analog-digital converters for industrial applications including an introduction to digital-analog converters. 2015. doi: 10.1007/978- 3-662-47020-6.

[20] E. W. Ningsih, H. R. Fajrin, and A. Fitriyah, "PENDETEKSI HEMOGLOBIN NON INVASIVE," Med. Tek. J. Tek. Elektromedik Indones., vol. 1, no. 1, 2019, doi: 10.18196/mt.010102.

[21] D. Trajanov and V. Bakeva, Eds., ICT Innovations 2017, vol. 778. in Communications in Computer and Information Science, vol. 778. Cham: Springer International Publishing, 2017. doi: 10.1007/978-3- 319-67597-8.

[22] R. Frischer et al., "Commercial ICT smart solutions for the elderly: State of the art and future challenges in the smart furniture sector," Electronics (Switzerland), vol. 9, no. 1. MDPI AG, Jan. 01, 2020. doi: 10.3390/electronics9010149. A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari, and M. Ayyash, "Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications," IEEE Commun. Surv. Tutorials, vol. 17, no. 4, pp. 2347–2376, Oct. 2015, doi: 10.1109/COMST.2015.2444095.

[23] P. Maresova et al., "Health-Related ICT Solutions of Smart Environments for Elderly-Systematic Review," IEEE Access, vol. 8. Institute of Electrical and Electronics Engineers Inc., pp. 54574–54600, 2020. doi: 10.1109/ACCESS.2020.2981315.

[24] A. Meyers, Gateways to Academic writing: effective Sentence Paragraph and Essay. New York: Longman, 2005.

[25] Q. Shao, H. Ding, L. Yao, J. Xu, C. Liang, and J. Jiang, "Photoluminescence properties of a ScBO3:Cr3+ phosphor and its applications for broadband near-infrared LEDs," RSC Adv., vol. 8, no. 22, pp. 12035–12042, 2018, doi: 10.1039/c8ra01084f.

[26] X. Xu, Q. Shao, L. Yao, Y. Dong, and J. Jiang, "Highly efficient and thermally stable Cr3+- activated silicate phosphors for broadband near-infrared LED applications," Chem. Eng. J., vol. 383, Mar. 2020, doi: 10.1016/j.cej.2019.123108.

[27] D. Devianti, S. Sufardi, Z. Zulfahrizal, and A. A. Munawar, "Near Infrared Reflectance Spectroscopy: Prediksi Cepat dan Simultan Kadar Unsur Hara Makro pada Tanah Pertanian," agriTECH, vol. 39, no. 1, p. 12, Sep. 2019, doi: 10.22146/agritech.42430.

[28] E. Hidayanto, H. Sutanto, and Z. Arifin, "Design of Non-Invasive Glucometer using Microcontroller ATMega-8535," J. Sains dan Mat., vol. 23, no. 3, pp. 78–83, 201

[29] Umar, Usman, Syafruddin Syarif, Ingrid Nurtanio4 and Indrabayu. (2022). A real time non-invasive cholesterol monitoring system. MATEC Web of Conferences 331