UNIVERSITAS NAHDLATUL ULAMA SURABAYA
LEMBAGA PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT
Kampus A Wonokromo : Jl. SMEA No.57 Tlp. 031-8291920, 8284508 Fax. 031-8298582 – Surabaya 60243
Kampus B RSIJemursari : Jl. Jemursari NO.51-57 Tlp. 031-8479070 Fax. 031-8433670 – Surabaya 60237
Website : unusa.ac.id Email: info@unusa.ac.id

SURAT KETERANGAN

Nomor: 072/UNUSA-LPPM/Adm-I/I/2023

Lembaga Penelitian dan Pengabdin Kepada Masyarakat (LPPM) Universitas Nahdlatul Ulama Surabaya menerangkan telah selesai melakukan pemeriksaan duplikasi dengan membandingkan artikel-artikel lain menggunakan perangkat lunak **Turnitin** pada tanggal 16 Januari 2023.

Judul	: Implement Android Application for Determination and Monitoring Blood Chemistry
Penulis	: Ima Kurniastuti, Tri Deviasari Wulan, Difran Nobel Bistara
No. Pemeriksaan	: 2023.01.17.044

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Submission date: 16-Jan-2023 09:11AM (UTC+0700)
Submission ID: 1993289259
File name: 2022,_September,_IEEE_-_Difran_Nobel_Bistara.pdf (537.95K)
Word count: 4910
Character count: 26563

Implement Android Application for Determination and Monitoring Blood Chemistry

Ima Kurniastuti
Department of Information System,
Faculty of Economic Business and Digital Technology
Universitas Nahdlatul Ulama Surabaya
Surabaya, Indonesia
ima.kurniastuti@unusa.ac.id

Tri Deviasari Wulan
Department of Information System,
Faculty of Economic Business and Digital Technology
Universitas Nahdlatul Ulama Surabaya
Surabaya, Indonesia
tridevi@unusa.ac.id

Difran Nobel Bistara
Department of Nursing, Faculty of Nursing and Midwife
Universitas Nahdlatul Ulama Surabaya
Surabaya, Indonesia
nobel@unusa.ac.id

***Abstract*— Examination of blood chemistry, especially blood glucose, uric acid and cholesterol in the body is a test carried out in routine health checks or in the process of diagnosing a disease. The research aims to produce an android-based application that can determine and monitor the results of blood chemistry examinations that are user-friendly for the community. The research method is literature study, design flowchart, design user interface (UI), implement application, and testing application. The first stage is a literature study to collect data and information about blood chemistry followed by design application regarding the flowchart design and interface of the application. The next stage was implement application regarding the application implementation process based on the design application using android studio and testing application using black box testing, white box testing and user acceptance testing (UAT). Overall the application has been successfully designed and built according to the research method. The results of testing application show that the application runs well and there are no errors. This indicates that the application has been successful and can be used by the public as a supporting application in routine blood chemistry examinations.**

Keywords—blood chemistry, android studio, mobile application, android application

I. INTRODUCTION

In Indonesia, Prevalence of non-communicable diseases increased in number according to basic health research [1]. The policies made by the Indonesian Government through the Ministry of Health to suppress the increasing prevalence was CERDIK behavior program. CERDIK behavior program, a health slogan that consist of routine health check, get rid of cigarette smoke, diligent physical activity and manage stress [2]. One activity of routine health check is examination of blood chemistry. Blood chemistry included blood glucose, uric acid and cholesterol [3]. Blood glucose was glucose in bloodstream which is used for energy, upon consumption [4]. Condition while blood glucose levels in body exceeding normal limits is called hyperglycemia. Hyperglycemia is the defining common feature of all types of diabetes [5]. Diabetes is categorized in serious disease that needed frequent monitoring and recording of the patient glucose level [6].

The other of blood chemistry was uric acid. Uric acid levels have normal limit. Hyperuricemia is metabolic disorders while uric acid levels more than normal limit. Its prevalence is reached 20% worldwide. Its known to be strongly linked with stroke that may result in crystal deposition-related disorders [7]. Hyperuricemia is also related with some serious diseases such as chronic kidney disease, cardiovascular disease, hypertension, early mortality and has risk of diabetes [8]. Because its related with other disease, frequent monitoring of uric acid levels is required. The level of cholesterol plays a vital role in cardiovascular diseases process. A high level of cholesterol, which also termed as hyperlipidemia, leads to higher risk of developing atherosclerotic cardiovascular disease (CVD) that lead to mortality. Clinically, monitoring cholesterol assists in the screening, diagnosing, and managing diseases [9].

Technology and telecommunications industry nowadays have largest user in worldwide. It looks at the global smartphone market by shipments. Samsung, one of largest vender of the global smartphone market is reached 59 million units in the second quarter of 2021 [10]. Android was the most popular of smartphone operating system in the world with 76,24% usage worldwide [11]. With the increased number of smartphone users, the need for mobile applications is also increase. Mobile application also reached health industry to help user to maintain their health. It is called mobile health application.

StaySafe, a self-administered android tablet application intervention for teaching better decision-making skills regarding health risk behaviors especially HIV risks. The experiment result in feasibility and high levels of satisfaction with StaySafe [12]. Physiological parameters such as subject's ECG, blood pressure, blood oxygenation, respiration, temperature and motion in the body could be monitoring by a wireless health monitoring system based on android operating system. The evaluation of performance of application in capturing, recording, transmitting and displaying ambulatory data is easy to use and have high precision [13]. An interactive telemedicine system based on android is proposed to lessen costs, save time and increase patient care. Using this application, patients available interact with doctors via video conference. This application useful not only for patient but also the doctors [14]. A Medication Adherence App Quality (MedAd-AppQ) is a mobile application as a quality assessment tool for medication adherence apps. With this application, help patients in medications and side-effect management [15].

To improve public health in society, this study design and deployment mobile health application to determination and monitoring examination of blood chemistry such as blood glucose, uric acid and cholesterol on android platform. Actually, this study is a follow-up study from previous research, namely Design and Implement an Application for Determination of Blood Chemistry. In the previous research, application based on desktop. The application is limited to laptop and computer use [3]. Therefore, to eliminate the limitations of using the application, The application was developed into an Android-based mobile application that can be accessed more easily by the public and is user friendly.

II. METHODOLOGY

The method in this study is shown in Figure 1. Figure 1 shows the steps that must be carried out including literature study, design flowchart, design user interface (Design UI), implement application and testing application. While result of testing application is good, the application is ready to use in society. First step is literature study to collect information about blood chemistry. Information comes from journals, conference papers and books. This step is important in this study because it is collaboration study between health and information technology. The second step is design flowchart. Flowchart is a diagram of the steps in a process and their sequence. In this study, a high-level flowchart is build. This type of flowchart displays the major blocks of activity or the major system components in process. These flowcharts useful in the early phases of a project like the study [16]. The processes in the study are process of determining the examination of blood sugar levels, process of determining the examination of uric acid levels, process of determining the examination of cholesterol levels, login process, logout process, process of displaying the examination history.

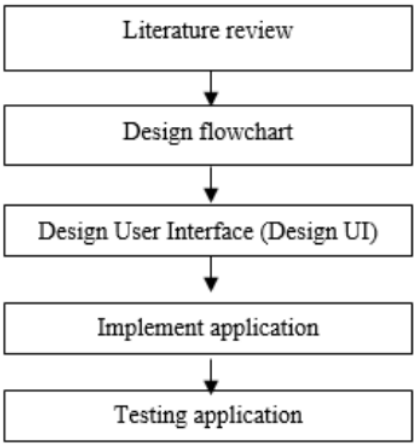


Fig. 1. Methodology research

Design user interface (Design UI) was third steps in the research. In this step, User Interface (UI) is created. UI have purpose as information exchange between the system and the users. With UI, users can understand information of internal system [17]. UI consist of visual and text. UI must be user friendly [18]. UI is designed using figma.com, a design platform for teams who create, share, test and ship designs from start to finish. This platform is free, lightweight, fast, and an online user interface tool [19]. In the application consists of several pages or UI including the home page, login page, log out page, blood sugar level determination page, uric acid level determination page, cholesterol level determination page, examination history page and application info page.

The next steps are implement design into application. This step using android studio with support from Android Development Tools (ADT) and Java Development Kit (JDK) which were bundled with android studio. In this step also integration database is created by Google's firebase real time database. Firebase is free, build serverless apps, optimized for offline use, strong user-based security, store and sync data in real time [20]. The last step is testing application. This step has aim to measure software reliability which refers to the probability of failure-free operation of a system [21]. This step is also the process of verification and validation of software service or application by checking whether application is meeting the user requirements. Testing application plays a vital role in the process of developing a high quality software [22]. The method of testing application is black box testing, white box testing and User Acceptance Test (UAT). Black box testing is common method in testing application [23]. Black-box method is used to examinate function of application without knowing information of structure of application such as hardware and software [24]. The black-box method is based on the functional specification of application and focuses on the specified external behaviors of the software system [25]. White-box testing method is examined logical and analytic test in unit test level and helps hidden errors in the source code. White-box testing using cyclomatic complexity. Cyclomatic complexity was a software metric to indicate the complexity of a program. It is can be calculated using Equation 1.

$$V(G) = E - N + 2 \quad (1)$$

Where V(G) is cyclomatic complexity, E is total of edge in flow graph, N is total of node in flow graph [21].

User Acceptance Test (UAT) is one of step which verifies if a developed requirement works according to the specification of the user. If the user approves on the software product, the software development is done practically. UAT can be called as test is tested in the real world by the users [26]. This method helps the researches to improve the design of the product itself [27]. A popular method to perform the user acceptance testing is the usability testing. Usability testing provides the indication of the essential quality for the client to decide whether to approve or to deny the product. The System Usability Scale (SUS) is one of the techniques to evaluate the usability testing [28]. This technic is a widely used standardized questionnaire for the assessment of perceived usability [29].

In SUS, five quality attributes are used such as learnability, efficiency, memorability, errors and satisfaction. The first quality attributes was learnability, the easiness of the application according to the user when using application for the first time. The second quality attributes was efficiency give information about how fast the user adapts the design of the application. Memorability is obtained from user's proficiency when using the application. The fourth quality attributes was errors give information about the quantity of errors made by the user and how the error is covered and the last quality attributes was satisfaction reflects how pleasant the application used by the user [30]. SUS using the questionnaire to measure the utilizing perception. The questionnaire has five score scale begin with strongly disagree with value one until strongly agree with value five. SUS score scale is shown in Figure 2. The results of the distribution of questionnaires were recapitulated and obtained the calculation of the number of the respondents with a score scale. Maximum score and usability score can be calculated using Equation 2 and Equation 3. In the end of process, classification of the system's usability is shown in Table 1 [31].

$$\text{Maximum score} = R \times Q \times 5 \quad (2)$$

$$\text{Usability score} = (\text{Total score} / \text{Maximum score}) \times 100 \quad (3)$$

Where R is number of respondents, Q is number of questions.

Strongly disagree				Strongly agree
4	2	3	4	5

Fig. 2. SUS score scale

TABLE I. SUS ADJECTIVE RATING

SUS SCORE	ADJECTIVE RATING
> 80.3	EXCELLENT
68 – 80.2	GOOD
67	OKAY
51-66	POOR
< 51	AWFUL

III. RESULT AND DISCUSSIONS

A. Design Flowchart

Design flowchart steps result flowchart of system. Flowchart in the study consist of four flowcharts such as flowchart for profile in application, flowchart determination of blood glucose, flowchart for determination of uric acid and flowchart for determination of cholesterol is shown in Figure 2, 3, 4 and 5. Figure 2 show flowchart of profile with output login or log up success. In log up process, user must input some variable such as name, email, birthday date, phone number and gender. In login process, username and password is needed. Based on Figure 3, input in application is blood glucose level from health tool and the output is normal, prediabetes and diabetes. The output is determined according to International Diabetes Federation [32]. Blood glucose level is determined in two conditions. The first condition was non-fasting conditions. In this condition is categorized by three categories such as normal, prediabetes and diabetes. Category normal is called when blood glucose levels below 90 mmol/L, category prediabetes is called when blood glucose levels are between 90 mmol/L until 199 mmol/L, and when blood glucose levels are above 200 mmol/L is called as category diabetes. The second condition, fasting condition, category normal is shown when blood glucose levels below 90 mmol/L, category prediabetes is called when blood glucose levels around 90 mmol/L until 99 mmol/L and above 100 mmol/L is included in diabetes status [33]. Figure 4 show flowchart for determination of uric acid which input is uric acid level and output is normal and gout arthritis. Gout arthritis or hyperuricemia occurs when uric acid reached more than 5,7 mg/dl in a woman and 7,0 mg/dl in a man [34]. The last flowchart is Figure 5 with input is cholesterol level and output is normal, borderline high and high. In cholesterol level, there are three categories such as normal, borderline high and high. Normal category is shown when cholesterol level is less than 200 mg/dL, borderline high category is shown when cholesterol level is around 200 until 239 mg/dL and when the cholesterol level is 240 mg/dL and above is called as high blood cholesterol [35].

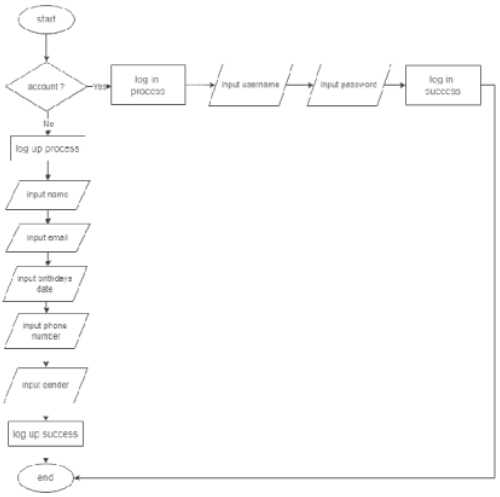


Fig. 2. Flowchart for profile login or log up

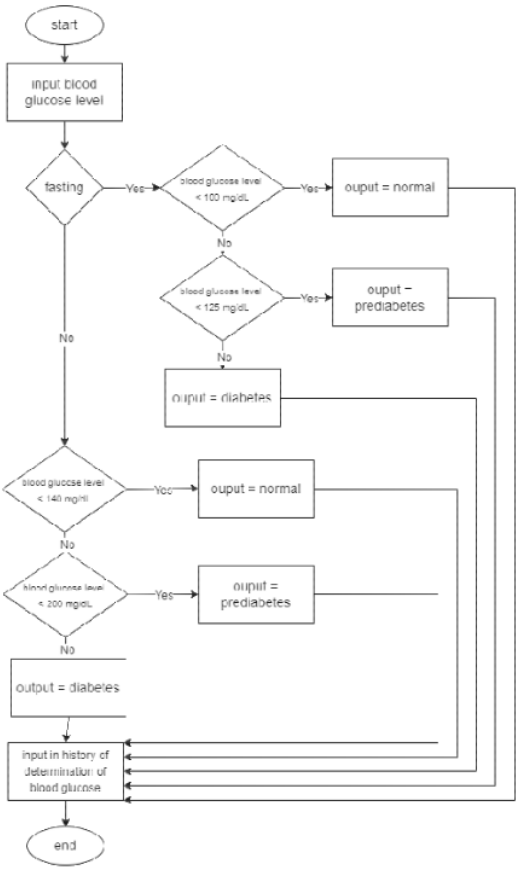


Fig. 3. Flowchart for determination of blood glucose

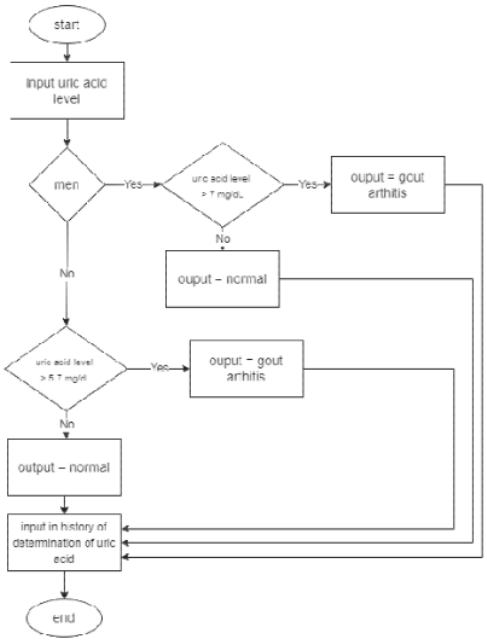


Fig. 4. Flowchart for determination of uric acid

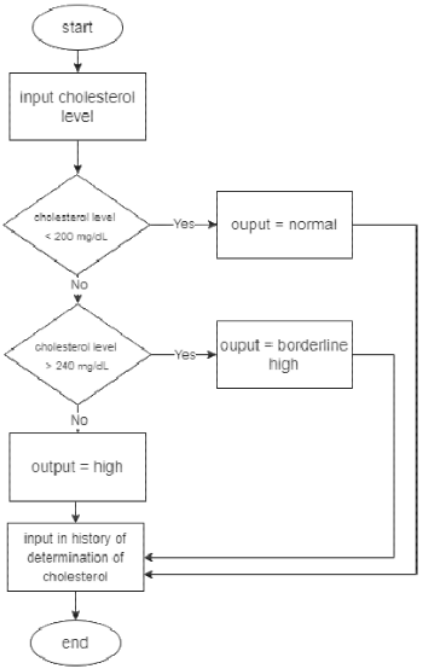


Fig. 5. Flowchart for determination of cholesterol

B. *Design User Interface (UI)*

Design UI using figma.com. In application consist of three menus such as home, determination and profile. The application has total twenty seven UI consist of home page, login page, log out page, sign up page, determination of blood glucose, determination of uric acid, determination of uric acid, profile page, info page and some pop up page. Figure 6 show some UI of application. In Figure 6a show info page that give information about the purpose of application. Figure 6b give information about home menu which display blood status also tips and info about blood chemistry. Figure 6c display determination page which consist of three type of determination. Figure 6d display determination of blood glucose and the result of determination will appear as pop up message is shown in Figure 6e. In Figure 6f, profile page with email and phone number is displayed.

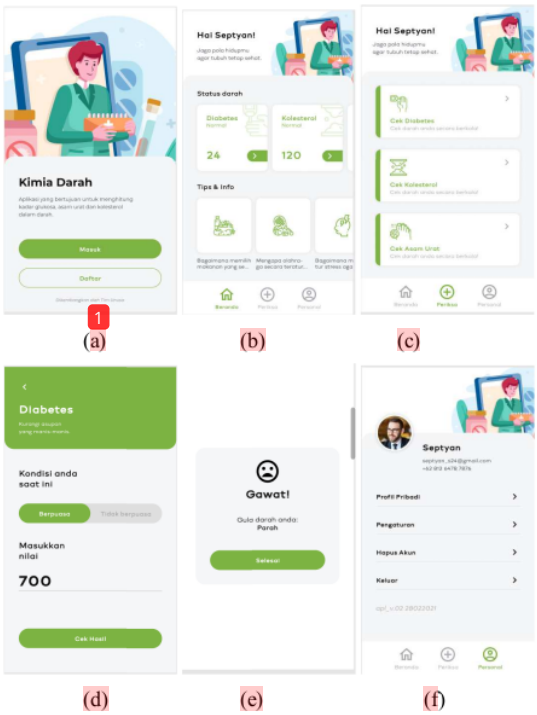
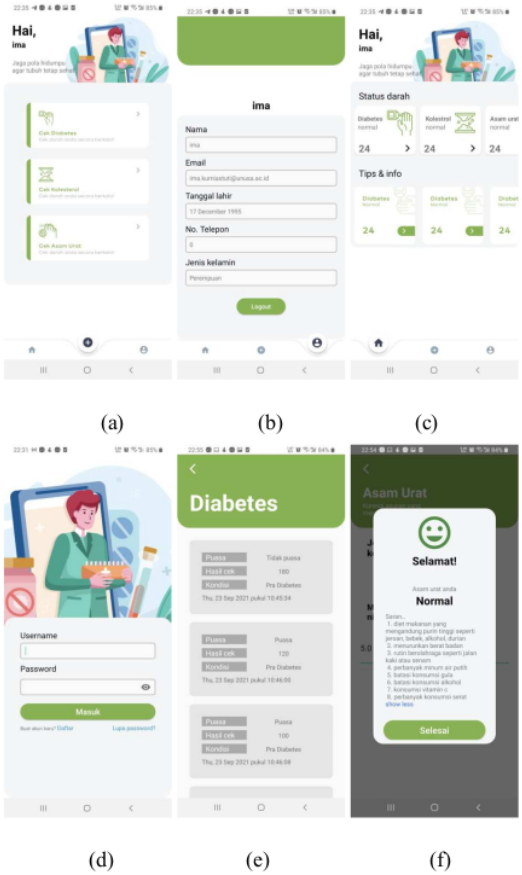


Fig. 6. User Interface of application

C. *Implement Application*

In this step, design flowchart and User Interface (UI) is implemented into Android studio. Result of this step is application which installed in android smartphone. In application provides some feature such as login and log up for user account, blood glucose determination, uric acid determination, cholesterol determination, suggestion action for user based on result of determination, and history of determination. Figure 7 show the result of implement application. Figure 7a show determination menu page, Figure 7b show profile page, Figure 7c show home page of application, Figure 7d show login page, Figure 7e show history of determination of blood glucose, and Figure 7f show result of determination.



(a) (b) (c)

(d) (e) (f)

Fig. 7. Display of application in smartphone

D. Testing Application

Testing application aims to show that software does what it is supposed to do and to realize its defects before it is deployed to the users [26]. In this research using three methods for testing application such as black box testing, white box testing and user acceptance testing (UAT).

a) Black box testing

First method in testing application is black box testing. Focus of black box testing is the functions in application. Process of black box testing consist of function flow of business processes desired by the user. Table 2 show process of black box testing in application. Result from black box testing show that the application works fine.

TABLE II. PROCESS OF BLACK BOX TESTING

Test scenario	Test case	Expected Result	Test Result	Conclusion
Determination of blood glucose	Click check of diabetes	Input blood glucose levels, click process and category of blood glucose levels is shown	Match	Normal
Determination of uric acid	Click check of	Input uric acid levels, click process and	Match	Normal
Determination of blood glucose	Click check of diabetes	Input blood glucose levels, click process and category of blood glucose levels is shown	Match	Normal
acid	uric acid	category of uric acid levels is shown		
Determination of cholesterol	Click check of cholesterol	Input cholesterol levels, click process and category of cholesterol levels is shown	Match	Normal
Exit of application	Click exit button	Closed app	Match	Normal
Login	Click login	Input username, password and login success	Match	Normal
Log up	Click log up	Input data is needed and log up success	Match	Normal

b) White box testing

The second method in testing application is white box testing. White box testing using flow graph based on flowchart. Total number of flowchart is four and flow graph also have total number four. Four flow graphs of application are flow graph for profile in application, flow graph for determination of blood glucose, flow graph for determination of uric acid and flow graph for determination of cholesterol. These flow graphs is shown in Figure 8, 9, 10, and 11. In each flow graphs, cyclomatic complexity is calculated using Equation (1). Cyclomatic complexity is indicator to know the complexity of an application. Equation (4) until Equation (7) is cyclomatic complexity for all flow graphs.

$$V(G) = E - N + 2 = 14 - 14 + 2 = 2 \quad (4)$$
$$V(G) = E - N + 2 = 19 - 15 + 2 = 6 \quad (5)$$
$$V(G) = E - N + 2 = 13 - 11 + 2 = 4 \quad (6)$$
$$V(G) = E - N + 2 = 10 - 9 + 2 = 3 \quad (7)$$

Based on Figure 8, The total of edge is 14 and the total of node is 14. In Equation (4), cyclomatic complexity of flow graph for profile in application is two (2) and independent path of this flow graph is two paths such as 1-2-3-4-5-6-14 and 1-2-7-8-9-10-11-12-13-14. In flow graph for determination of blood glucose is shown in Figure 9, the total of edge is 17 and the total of node is 13. Based on Equation (5), cyclomatic complexity of flow graph for determination of blood glucose is six (6) and independent path of this flow graph is six paths such as 1-2-3-4-5-14-15, 1-2-3-4-6-7-14-15, 1-2-3-4-6-8-14-15, 1-2-3-9-10-14-15, 1-2-3-9-11-12-14-15 and 1-2-3-9-11-13-14-15.

According to Figure 10, flow graph for determination of uric acid have total of edge is 13 and total of node is 11. Cyclomatic complexity of flow graph for determination of uric acid is four (4) and independent path of this flow graph is four paths such as 1-2-3-4-5-10-11, 1-2-3-4-6-10-11, 1-2-3-7-8-10,11 and 1-2-3-7-9-10-11. Cyclomatic complexity of flow graph for determination of uric acid is shown in Equation (5). And in flow graph for determination of

cholesterol 6s shown in Figure 11, the total of edge is 10 and the total of node is 9. Based on Equation (7), cyclomatic complexity of flow graph for determination of cholesterol is three (3) and independent path of this flow graph is three paths such as 1-2-3-4-8-9, 1-2-3-5-6-8-9 and 1-2-3-5-7-8-9. Based on result of white box testing in all flow graph, It show that the total of cyclomatic complexity and independent path is same in each flow graph. It can be concluded that application have not error in source code.

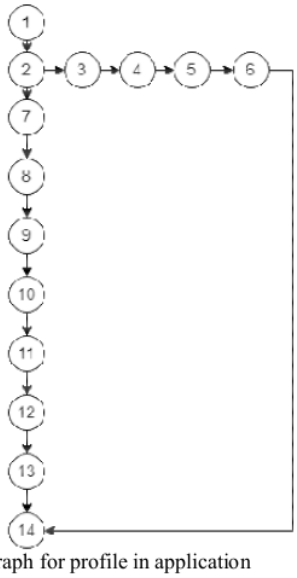


Fig. 8. Flow graph for profile in application

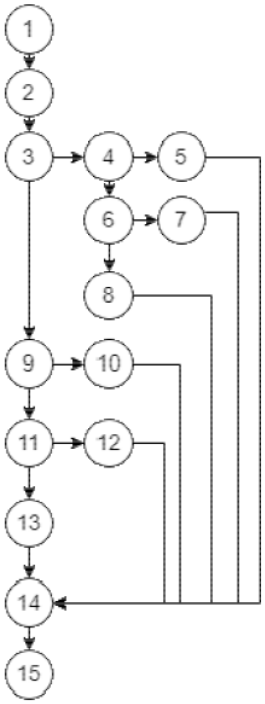


Fig. 9. Flow graph for determination of blood glucose

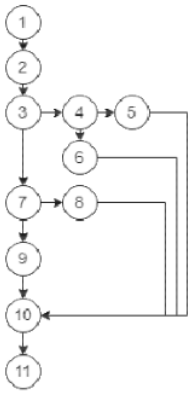


Fig. 10. Flow graph for determination of uric acid

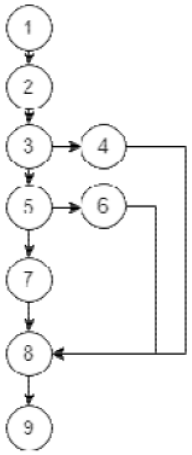


Fig. 10. Flow graph for determination of cholesterol

c) User Acceptance Testing (UAT)

In this method using a questionnaire to obtain results. the number of respondents used as many as thirty respondents. Respondents consist of health workers, academics and the community. Each quality attribute is represented by five questions in the questionnaire so that the total questions are twenty five questions. The recapitulation of questionnaire distribution is shown in table 3. Maximum score and usability score can be calculated using Equation 2 and Equation 3. The calculation results show a value of 89,65 which can be grouped as excellent based on the SUS adjective rating.

TABLE III. THE RECAPITULATION OF QUESTIONNAIRE DISTRIBUTION

Question number	Number of respondents				
	1	2	3	4	5
1	0	0	0	7	23
2	0	0	0	9	21
3	0	1	0	10	19
4	0	0	2	10	18
5	0	1	0	11	18
6	0	0	0	14	16
7	0	0	0	12	18
8	0	1	3	10	16
9	0	3	5	10	12
10	0	0	0	14	16

11	0	0	0	13	17
12	0	0	0	14	16
13	0	0	0	15	15
14	0	0	1	13	16
15	0	0	1	12	17
16	0	0	0	13	17
17	0	0	0	14	16
18	0	1	2	11	16
19	0	0	0	12	18
20	0	0	1	11	18
21	0	0	0	13	17
22	0	0	0	14	16
23	0	0	0	12	18
24	0	0	0	1	19
25	0	0	0	12	18
Number of respondent x score	**0**	**14**	**45**	**1148**	**2155**
Total score	**3362**				

Maximum score = R x Q x 5 = 30 x 25 x 5 = 3750
Usability score = (Total score / Maximum score) x 100
= (3362 / 3750) x 100
= 89,65

IV. CONCLUSIONS

Examination of blood chemistry, especially blood glucose, uric acid and cholesterol in the body is a test carried out in routine health checks or in the process of diagnosing a disease. The research aims to produce an android-based application that can determine and monitor the results of blood chemistry examinations that are user-friendly for th community. The research method is literature study, design flowchart, design user interface (UI), implement application, and testing application. The first stage is a literature study to collect data and information about blood chemistry followed by design application regarding the flowchart and interface of the application. The next stage was implement application regarding the application implementation process based on the design applica n using android studio and testing application using black box testing, white box esting, and user acceptance testing (UAT). Overall the application has been successfully designed nd built according to the research method. The results of testing application show that the application runs well and there are no errors. This indicates that the application has been successful and can be used by the public as a supporting application in routine blood chemistry examinations.

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