Jurnal CoreIT, Vol.10, No.1, Juni 2024
ISSN 2460-738X (Print)
ISSN 2599-3321 (Online)

Health Monitoring Application for COVID-19 Self-Isolation Patients

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Abstract. The self-isolation procedure must be carried out under the supervision of a local health facility which is part of the COVID-19 handling post so that the health condition of the patient can continue to be monitored while undergoing self-isolation. However, in practice, supervision of this self-isolation patient is often neglected, resulting in many patients experiencing deteriorating health conditions and being given treatment late which leads to death. The purpose of this research is to create an android-based application that can be used to monitor the health condition of patients who are undergoing self-isolation. This application was developed using the Java and Kotlin programming languages, the Firebase Realtime Database, and several technologies, namely Smartband, Bluetooth Low Energy, Google Maps API, Google Places API, Firebase Cloud Messaging, COVID-19 Indonesia API, RS Bed COVID-19 Indonesia API and Indonesia News API. The software development method used is the waterfall method. Based on the results of alpha testing using the black-box method, it can be concluded that the application built meets the requirements and works according to its functional requirements. Meanwhile, based on the results of beta testing using the questionnaire method given to 6 respondents with a Likert scale calculation, the percentages for each question were 100% and 93.33%, so it can be concluded that the application built has achieved the desired goals.

Keywords: Android apps, Bluetooth low energy, COVID-19, Self-Isolation, Smartband

Received January 2024 / **Revised** January 2024 / **Accepted** April 2024

INTRODUCTION

Coronavirus Disease (COVID-19) is a new type of virus variant that is currently hitting various countries around the world. The World Health Organization (WHO) on March 9 2020 officially declared the status of the virus outbreak as a pandemic [1]. Positive confirmed cases of COVID-19 continue to increase every day, this is because this virus is highly contagious. Based on data obtained from the COVID-19 Handling Task Force website as of January 10, 2023, a total of 6,722,746 Indonesian residents have been confirmed positive for COVID-19 and 160,673 of them have died [2].

Professor Wiku Adisasmito the Coordinator of the Expert Team and Government Spokesman for Handling COVID-19, stated that currently, hospitals are having difficulty accepting patients due to the spike in cases that have occurred and the limitations of existing healthcare facilities, this is indicated by the full ICU room with an occupancy rate reach above 70% [3]. Seeing the current situation, the hospital will only accept COVID-19 patients who have severe and moderate symptoms and comorbidities.

Therefore, patients with mild or no symptoms are encouraged to do self-isolation, whether at home, boarding houses, hotels, apartments, or in special self-isolation places provided by the Government while monitoring their condition while reducing social activities while maintaining a safe distance from people around them or family [4]. Self-isolation for patients who have mild symptoms is done for 10 days plus 3 days free of fever and respiratory symptoms, while for patients without symptoms, it is recommended to self-isolation for 10 days [5]. However, please note, this self-isolation procedure must be carried out under the supervision/assistance of a local health facility which is part of the COVID-19 handling post. This is done so that the patient's health condition can be continuously monitored while undergoing self-isolation [6].

Direct supervision of patients can be carried out by health workers (health workers) during the throat and airway swab process in the process of diagnosing COVID-19, but apart from this, health workers do not have the opportunity to monitor patients intensively every time. Lack of supervision of this self-isolation patient, according to the facts found. Ganip Warsito as Head of the COVID-19 Handling Task Force said, "Many self-isolation patients experience worsening health conditions due to their unmonitored condition which ultimately results in patients being given treatment late and leading to death" [5]. Based on data obtained from the LaporCOVID-19 website as of August 7, 2021, it was recorded that 2,851 people died while doing self-isolation outside the hospital. The most cases of death were in the DKI Jakarta area, namely 1,342 people [7].

Problems related to the lack of supervision of this self-isolation patient are in line with the results of an interview conducted on December 20, 2021, with Ms. Fuzi Fauzia Khaerunnisa A.Md.Kep. as a health worker at the Sukapakir Health Center. He said that the process of monitoring the health conditions of self-isolation patients was often not carried out or neglected, this was due to the tight schedule of activities at the Health Center (such as vaccinations, etc.) so that there was not enough time for health workers to carry out intensive monitoring of self-isolation patients every time.

In addition, based on the results of a questionnaire related to self-isolation experience given to 15 respondents who have or are currently undergoing self-isolation, it can be concluded that there are two problems experienced by patients when undergoing self-isolation, namely (1) Lack of patient knowledge regarding proper and correct self-isolation implementation procedures, (2) The difficulty of the patient in monitoring and knowing the state of his health condition.

Nowadays, everyone has made it easy to get information, one of which is about health, this is because of the existence of advanced technology such as smart bands. Smartband is a device or technology product attached to the human body that has been added to technological data communication in the form of sensors such as heart rate, oxygen saturation, and others [8]. Thus, smart band can be used as an alternative medical/health tool to obtain information about health.

Several studies have been conducted that can support this research. Based on research by Setiawan and Fatoni [9], it found that wearable device technology can be used as a heart rate detector. Then based on research by Setiawan and Herdianto [10], it was found that the Android platform was chosen because it is an operating system with an open-source license so that everyone can develop it freely to support daily activities and work. Based on the potential and problems described above, it can be concluded that it is necessary to build an Android-based COVID-19 Self-Isolation Patient Health Monitoring Application.

METHODS

The research methodology used in this research is the descriptive method. This method was used in initial research which aimed to collect data on existing conditions such as the condition of existing products as reference material, the conditions of the user, and the conditions of the supporting and inhibiting factors for the development and use of the resulting product [11]. This research is divided into two stages, namely the data collection stage and the software development stage.

The data collection method is the most strategic technique or step in research because the main goal of the research is to obtain data [12]. The data collection methods used in this study are (1) Literature Study, (2) an Interview, and (3) a Questionnaire.

The software development method used for application development in this study is the Waterfall Method. The process stages in the waterfall method can be seen in Figure 1 below [13].

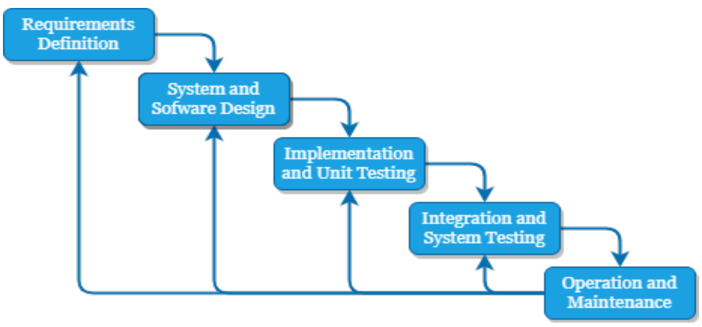

Figure 1. Waterfall method for software development

System Architecture

System architecture analysis aims to identify the architecture of the system to be built. The system architecture of the system to be built can be seen in Figure 2.

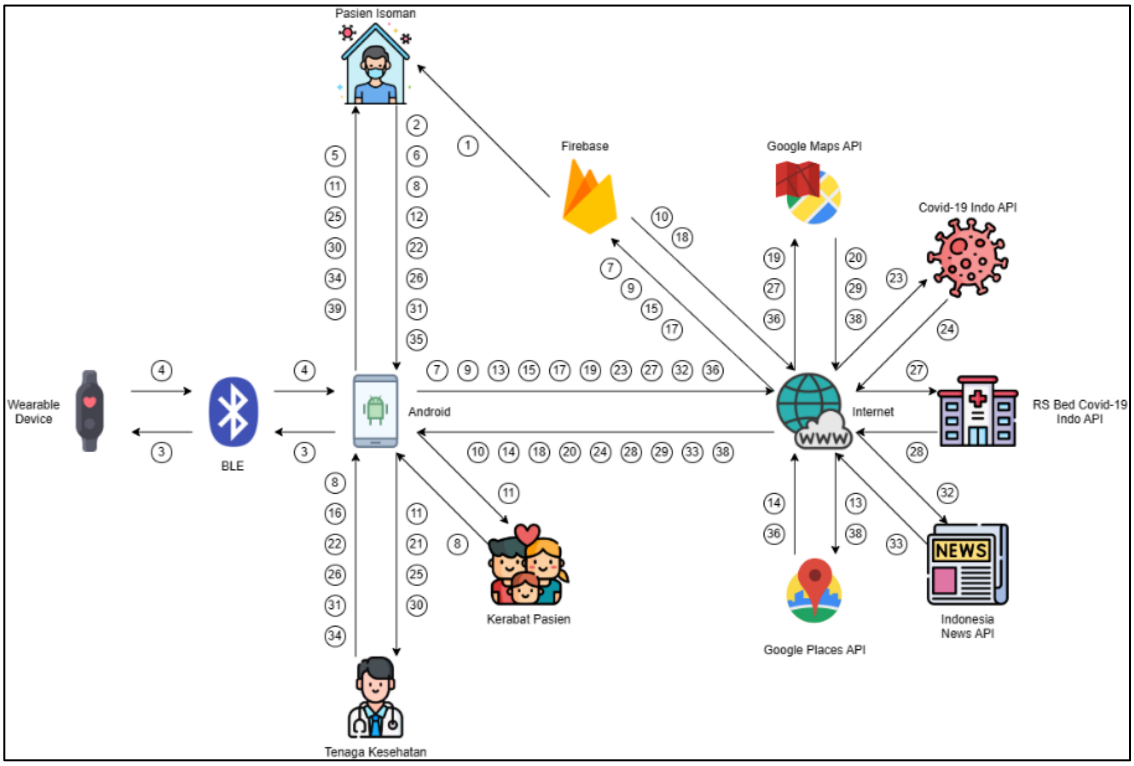

Figure 2. The overall system architecture

explanation of the architectural system in figure 2 namely:

1. Firebase cloud messaging sends push notifications containing reminders to add health status and health data (heart rate, oxygen saturation, and body temperature) to the patient.
2. Patient requests heart rate data from the android system.
3. Android system requests heart rate data from the wearable device via bluetooth low energy.
4. Wearable device performs heart rate measurement and sends heart rate data to android system via bluetooth low energy.
5. Android system displays heart rate data to the patient.
6. Patient adds health status and health data (heart rate, oxygen saturation, and body temperature) to the android system.
7. Android system stores health status and health data (heart rate, oxygen saturation, and body temperature) from the patient in the firebase realtime database.
8. Patient, medic, and relatives of the patient request health status and health data (heart rate, oxygen saturation, and body temperature) from the patient to the android system.
9. Android system requests health status and health data (heart rate, oxygen saturation, and body temperature) from the patient to the firebase realtime database.
10. Firebase realtime database sends health status and health data (heart rate, oxygen saturation, and body temperature) from the patient to the android system.
11. Android system displays health status and health data (heart rate, oxygen saturation, and body temperature) from the patient to the patient, the medic, and the relatives of the patient.
12. Patient added the location of the self-isolation place to the android system.
13. Android system requests longitude and latitude data for self-isolation places from the patient to the google places API.
14. Google places API sends the longitude and latitude data of the self-isolation places from the patient to the android system.
15. Android system saves the longitude and latitude data of the self-isolation places from the patient to the firebase realtime database.

16. Medic requests the location of the self-isolation from the patient to the android system.
17. Android system requests longitude and latitude data for the self-isolation places from the patient to the firebase realtime database.
18. Firebase realtime database sends the longitude and latitude data of the self-isolation places from the patient to the android system.
19. Android system requests the location of the self-isolation places from the patient to the google maps API.
20. Google maps API sends the location of the self-isolation places from the patient to the android system.
21. Android system displays the location of the self-isolation places from the patient to the medic.
22. Patients and medic request data on COVID-19 cases in Indonesia via the android system.
23. Android system requests data on COVID-19 case data in Indonesia to the COVID-19 Indo API.
24. COVID-19 Indo API sends data on COVID-19 cases in Indonesia to the android system.
25. Android system displays data on COVID-19 cases in Indonesia to the patients and medic.
26. Patients and medic request data and the location of the COVID-19 referral hospital to the android system.
27. Android system requests data and the location of the COVID-19 referral hospital to the RS Bed COVID-19 Indo API and google maps API.
28. RS Bed COVID-19 Indo API sends COVID-19 referral hospital data to the android system.
29. Google maps API sends the location of the COVID-19 referral hospital to the android system.
30. Android system displays data and the location of the COVID-19 referral hospital to the patients and medic.
31. Patients and medic request health article data from the android system.
32. Android system requests health article data to the news API.
33. News API sends health article data to the android system.
34. Android system displays health article data to the patients and medic.
35. Patient requests data and the location of the nearest health facility to the android system.
36. Android system requests data and the location of the nearest health facility to the google places API and google maps API.
37. Google places API sends data to the nearest health facility to the android system.
38. Google maps API sends the location of the nearest health facility to the android system.
39. Android system displays data and the location of the nearest health facility to the patient.

Analysis of Searching for Nearest Health Facilities

To search for the nearest health facility to the patient's location, this study used the haversine formula algorithm. The Haversine formula is a method for calculating the distance between two points based on the length of the straight line between two points on longitude and latitude [14]. The formula for the Haversine formula is as follows [15]:

$$x = (long2 - long1) * \cos\left(\frac{lat1 + lat2}{2}\right) \quad (1)$$

$$y = (lat2 - lat1) \quad (2)$$

$$d = sqrt(x * x + y * y) * R \quad (3)$$

Information: lat1 = degree of latitude of the patient
lat2 = degrees of latitude from health facilities
long1 = degree of longitude of the patient
long2 = degrees of longitude from health facilities
x = longitude difference
y = latitude difference
d = distance (km)
R = earth radius (6371 km)
1 degree = 0,0174532925 radians.

The process flow for finding the closest health facility using the haversine formula can be seen in Figure 3.

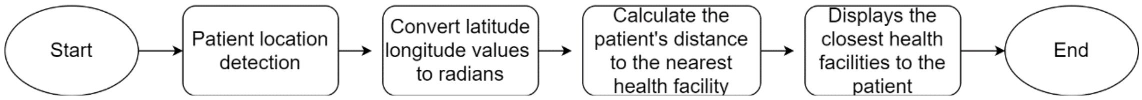

Figure 3. Process finding the closest health facility using the haversine formula

Analysis of Determination of Health Conditions
The assessment parameters used to determine the patient's resting heart rate can be seen in Table 1 [16].

Table 1. Heart rate assessment parameters

No.	Heart Rate (bpm)	Heart Rate Conditions	Information
1	<60	Low	Bradikardia
2	60-100	Normal	Normal
3	>100	High	Takikardia

The assessment parameters used to determine the oxygen saturation condition of the patient can be seen in Table 2 [17].

Table 2. Oxygen saturation assessment parameters

No.	Oxygen Saturation (%)	Oxygen Saturation Conditions	Information
1	<85	Very low	Severe Hypoxia
2	86-90	Low	Moderate Hypoxia
3	91-94	Low Enough	Mild Hypoxia
4	95-100	Normal	Normal

The assessment parameters used to determine the body temperature condition of the patient can be seen in Table 3 [18].

Table 3. Body temperature assessment parameters

No.	Body Temperature (°C)	Body Temperature Conditions	Information
1	<36	Low	Hipotermia
2	36 – 37,5	Normal	Normal
3	>37,5 – 40	High	Pireksia
4	>40	Very High	Hipertemia

For this reason, so that the system can determine the health condition of the patient based on these three parameters, the system needs to use a fuzzy logic algorithm. The fuzzy logic algorithm is a logic set theory that was developed to overcome the concept of values that exist between truth and false. By using fuzzy logic the resulting value is not only yes (1) or no (0) but all possibilities between 0 and 1 [19]. The rule base for the fuzzy logic assessment can be seen in Table 4.

Table 4. Fuzzy logic assessment rule bases

No.	Heart Rate (bpm)	Oxygen Saturation (%)	Body Temperature (°C)	Health Condition
1	<60	<85	<36	Not Good
2	<60	<85	36 – 37,5	Not Good
3	<60	<85	>37,5 – 40	Not Good
4	<60	<85	>40	Not Good
5	<60	86 - 90	<36	Not Good
6	<60	86 - 90	36 - 37,5	Not Good
7	<60	86 - 90	>37,5 - 40	Not Good
8	<60	86 - 90	>40	Not Good
9	<60	91 - 94	<36	Not Good
10	<60	91 - 94	36 - 37,5	Not Good
11	<60	91 - 94	>37,5 - 40	Not Good
12	<60	91 - 94	>40	Not Good
13	<60	95 - 100	<36	Not Good
14	<60	95 - 100	36 - 37,5	Good Enough
15	<60	95 - 100	>37,5 - 40	Not Good
16	<60	95 - 100	>40	Not Good
17	60 - 100	<85	<36	Not Good
18	60 - 100	<85	36 - 37,5	Good Enough
19	60 - 100	<85	>37,5 - 40	Not Good
20	60 - 100	<85	>40	Not Good
21	60 - 100	86 - 90	<36	Not Good
22	60 - 100	86 - 90	36 - 37,5	Good Enough

No.	Heart Rate (bpm)	Oxygen Saturation (%)	Body Temperature (°C)	Health Condition
23	60 - 100	86 - 90	>37,5 - 40	Not Good
24	60 - 100	86 - 90	>40	Not Good
25	60 - 100	91 - 94	<36	Not Good
26	60 - 100	91 - 94	36 - 37,5	Good Enough
27	60 - 100	91 - 94	>37,5 - 40	Not Good
28	60 - 100	91 - 94	>40	Not Good
29	60 - 100	95 - 100	<36	Good Enough
30	60 - 100	95 - 100	36 - 37,5	Good
31	60 - 100	95 - 100	>37,5 - 40	Good Enough
32	60 - 100	95 - 100	>40	Good Enough
33	>100	<85	<36	Not Good
34	>100	<85	36 - 37,5	Not Good
35	>100	<85	>37,5 - 40	Not Good
36	>100	<85	>40	Not Good
37	>100	86 - 90	<36	Not Good
38	>100	86 - 90	36 - 37,5	Not Good
39	>100	86 - 90	>37,5 - 40	Not Good
40	>100	86 - 90	>40	Not Good
41	>100	91 - 94	<36	Not Good
42	>100	91 - 94	36 - 37,5	Not Good
43	>100	91 - 94	>37,5 - 40	Not Good
44	>100	91 - 94	>40	Not Good
45	>100	95 - 100	<36	Not Good
46	>100	95 - 100	36 - 37,5	Good Enough
47	>100	95 - 100	>37,5 - 40	Not Good
48	>100	95 - 100	>40	Not Good

RESULT AND DISCUSSION

The results of this study can be seen in the interface implementation of the applications.

The implementation results of the *Bluetooth Low Energy* can be seen in Figure 4.

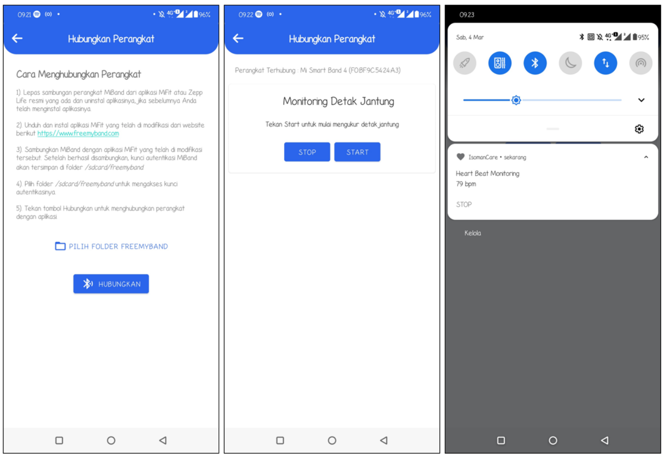

Figure 4. Results of the implementation of the *bluetooth low energy*

The implementation results of the Google Maps API and RS Bed COVID-19 API can be seen in Figure 5. The application has succeeded in displaying the availability of beds in hospitals for COVID-19 patients.

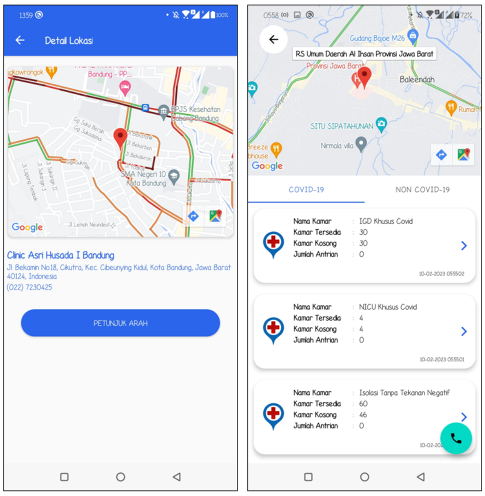

Figure 5. Results of the implementation of the google maps and RS Bed COVID-19 API

The implementation results of the Google Places API and haversine formula can be seen in Figure 6.

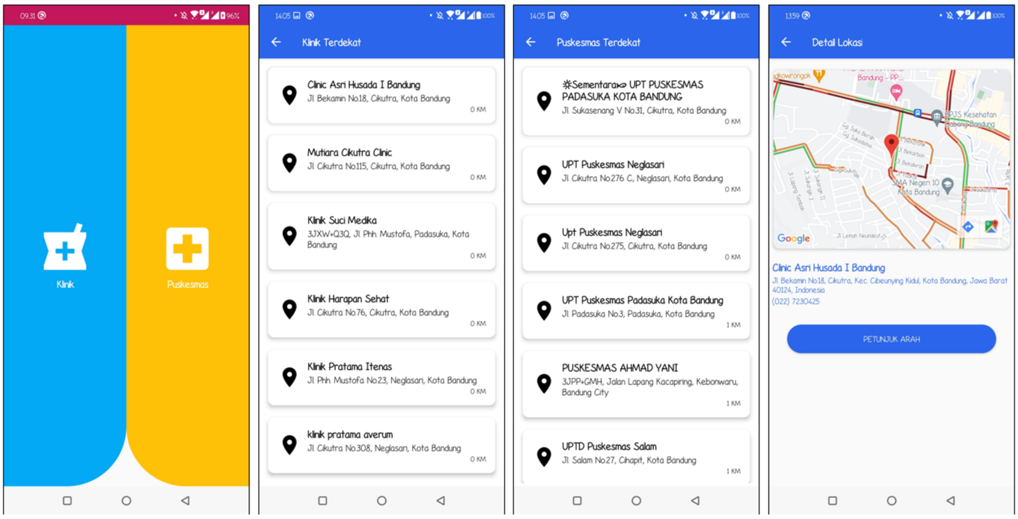

Figure 6. Results of the implementation of the google places API

The implementation results of the COVID-19 Indonesia API can be seen in Figure 7.

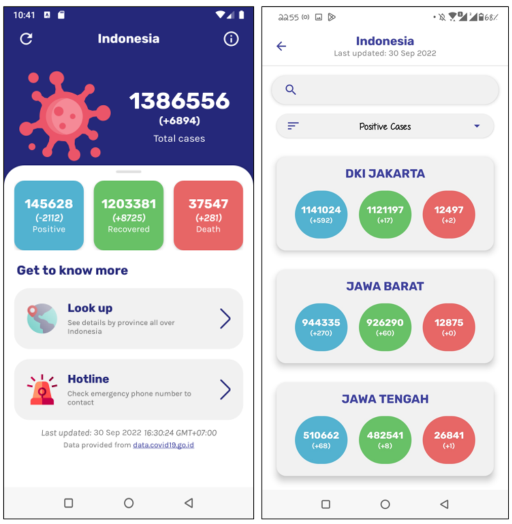

Figure 7. Results of the implementation of the COVID-19 Indonesia API

The implementation results of the Indonesia news API can be seen in Figure 8.

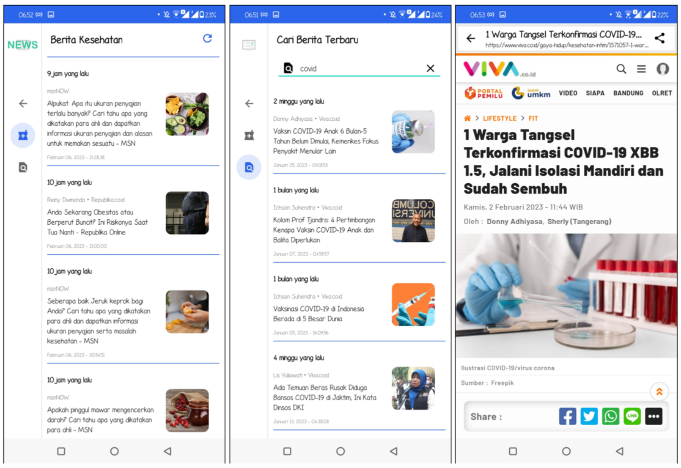

Figure 8. Results of the implementation of the Indonesia News API

System Testing

Alpha testing is carried out using the black-box method which focuses on the functional requirements of the software. The purpose of this black-box method is to find malfunctions in the program [20]. The results of the alpha test can be seen in Table 5.

Table 5. Alpha test results

No.	Tested Functionality	Testing Details	Results
1	Nearest Health Facility	Displays a list of the nearest health facilities	Accepted
2	Register	a. Fill in the registration form b. Validate the registration form	Accepted
3	Add Medic	a. Fill in the form to add a health worker b. Validate the form for adding health workers	Accepted
4	Login	a. Fill in the login form b. Login form validation	Accepted
5	Forgot Password	a. Fill in the forgotten password form b. Forgot password form validation	Accepted
6	List of Patients	Displays a list of monitored self-isolation patients	Accepted
7	Discharge Patient	Removing patients who are on the list of monitored self-isolation patients	Accepted
8	Add Health Status	a. Fill out the health status addition form b. Validate the added health status form	Accepted
9	List of Health Status	Displays a list of health status of self-isolation patients	Accepted
10	Health Status Details	Displays detailed health status of self-isolation patients	Accepted
11	Edit Health Status	a. Fill in the form to change health status b. Validate the health status change form	Accepted
12	Delete Health Status	Deletes the health status in the list of health statuses from self-isolation patients	Accepted
13	Connect Device	Connect smart band device with app	Accepted
14	Add Health Data	a. Fill in the form to add health data b. Validate the form to add health data	Accepted
15	List of Health Data	Displays a list of health data from self-isolation patients	Accepted
16	Health Data Details	Displays detailed health data from self-isolation patients	Accepted
17	Edit Health Data	a. Fill in the health data change form b. Form validation to change health data	Accepted
18	Delete Health Data	Deleting health data in the health data list from self-isolation patients	Accepted
19	Heart Rate Chart	Displays heart rate charts of self-isolation patients	Accepted
20	Oxygen Saturation Chart	Displays oxygen saturation charts of self-isolation patients	Accepted
21	Body Temperature Chart	Displays body temperature charts of self-isolation patients	Accepted
22	Generate QR Code	Create and save qr code	Accepted
23	Add Prescription	a. Fill in the form to add a drug prescription b. Validate the form to add a drug prescription	Accepted
24	List of Prescription	Displays a list of prescription drugs for self-isolation patients	Accepted
25	Edit Prescription	a. Fill out the form to change the drug prescription b. Validate the medication prescription change form	Accepted
26	Delete Prescription	Removing drug prescriptions from the list of drug prescriptions for self-isolation patients	Accepted

No.	Tested Functionality	Testing Details	Results
27	View Profil	Displays the profile of the user	Accepted
28	Edit Profil	a. Fill in the profile change form b. Validate the change profile form	Accepted
29	Edit Password	a. Fill in the change password form b. Validate the password change form	Accepted
30	Logout	Validate process logout account	Accepted
31	Patient Profil	Displays profiles of monitored self-isolation patients	Accepted
32	Medic Profil	Displays the profile of the health worker in charge of monitoring	Accepted
33	COVID-19 Statistics	Displays statistical data on COVID-19 cases in Indonesia	Accepted
34	Detailed COVID-19 Statistics	Displays detailed statistical data on COVID-19 cases in Indonesia	Accepted
35	COVID-19 Hotline Service	Displays a list of COVID-19 hotline services	Accepted
36	COVID-19 Hospital	Displays a list of referral hospitals for COVID-19	Accepted
37	COVID-19 Hospital Details	Displays details of the COVID-19 referral hospital using RS Bed COVID-19 API	Accepted
38	Health Article	Displays a list of health articles	Accepted
39	Health Article Details	Displays health article details	Accepted
40	Scan QR Code	Did a qr code scan	Accepted

From the results of the alpha test, it can be concluded that the application built has fulfilled the requirements and has worked according to its functional requirements.

Beta testing was carried out using the questionnaire method with a Likert scale calculation. The list of questions on the questionnaire that will be asked to respondents can be seen in Table 6.

Table 6. List of Questions in the Questionnaire

No.	Question
1	Do you agree that this application can make it easier for health workers to monitor the health condition of self-isolation patients?
2	Do you agree that this application can increase the knowledge of self-isolation patients regarding good and correct procedures for carrying out self-isolation?
3	Do you agree that this application can make it easier for self-isolation patients to monitor and find out their health conditions while undergoing self-isolation?

For each question in the questionnaire, 5 answer choices and their scores were given, with the conditions that can be seen in Table 7.

Table 7. Terms of the Likert Scale

Abbreviation	Information	Score
SA	Strongly Agree	5
A	Agree	4
N	Neutral	3
D	Disagree	2
SD	Strongly Disagree	1

To find the percentage value of each question in the questionnaire, the Likert scale formula is used, which is as follows [21].

$$P = \frac{\sum score}{ideal\ score} \times 100\% \quad (4)$$

Information: P = The percentage value sought
∑ score = Total score
ideal score = Max score x number of respondents

The results of the questionnaire for each respondent can be seen in Table 8.

Table 8. Questionnaire results for each respondent

Respondent	Question Score			Total
	Question 1	Question 2	Question 3	
1	5	5	5	15
2	5	4	4	13
3	5	4	4	13
4	5	5	5	15
5	5	5	5	15
6	5	5	5	15

The results of the Likert scale calculation for each question can be seen in Table 9.

Table 9. Likert scale calculation results

Question	Information	Score	Frequency	Total Score	Percentage	Results
1	Strongly Agree	5	6	30	(30/30) x 100% = 100%	Strongly Agree
	Agree	4	0	0		
	Neutral	3	0	0		
	Disagree	2	0	0		
	Strongly Disagree	1	0	0		
	Amount		6	30		
2	Strongly Agree	5	4	20	(28/30) x 100% = 93,33%	Strongly Agree
	Agree	4	2	8		
	Neutral	3	0	0		
	Disagree	2	0	0		
	Strongly Disagree	1	0	0		
	Amount		6	28		
3	Strongly Agree	5	4	20	(28/30) x 100% = 93,33%	Strongly Agree
	Agree	4	2	8		
	Neutral	3	0	0		
	Disagree	2	0	0		
	Strongly Disagree	1	0	0		
	Amount		6	28		

From the results of the beta testing it can concluded that the application built has achieved the desired goals.

CONCLUSION

Based on the research that has been done, it can be concluded that the application built can help make it easier for health workers to intensively monitor the health conditions of patients who are undergoing COVID-19 self-isolation, the application built can help increase patient knowledge regarding the procedure for implementing good and correct COVID-19 self-isolation, tthe application built can help make it easier for patients to monitor and find out the state of their health condition while undergoing COVID-19 self-isolation.

Suggestions for future application development are adding a chat feature in the application so that communication between health workers and patients becomes easier, implementing EWS (Early Warning Score) to make it easier for health workers to identify deteriorating patient conditions as early as possible and if necessary seek help more competent, adding several questions to the patient's initial screening to determine baseline health data from patients so that the results of health data processing analysis become more accurate, improve the appearance of the application interface design to make it even more attractive.

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