

APPLICATION DEVELOPMENT OF DIAGNOSTIC EXPERT SYSTEM ANEMIA WITH FORWARD CHAINING METHOD ANDROID BASED

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Abstract

Health is one of the factors to carry out daily activities. However, many humans do not care so much that in the end many diseases are diagnosed too late which will cause the condition to be at a serious stage. The prevalence of anemia is estimated to be up to about 1.6 billion people suffer from anemia. The era of smart smartphone technology encourages various conveniences to occur in many fields, such as in the health sector which has given users the ability to detect their own health. One of them is to detect the condition of someone who has anemia or not. The purpose of this research is to develop an android-based application design for anemia diagnosis expert system. The research used experimental method with a pre-post approach with out control group. The population used is adolescents aged 15-25 years who live in Yogyakarta City and Sleman Regency. The sample used is 110 respondents. Data analysis was carried out using ROC, sensitivity, and specificity tests. The results showed that the android for early detection of anemia had a sensitivity of 100% and a specificity of 98.9%. In addition, the results of the ROC analysis show that the area under the curve is 0.999 or means that it is accurate and feasible to use for anemia detection.

Keywords: Online, ROC, Youth, Detection

1. INTRODUCTION

Anemia is a health problem that affects populations worldwide. The prevalence of anemia is estimated to be up to about 1.6 billion people suffer from anemia.¹ Anemia or lack of blood occurs when the body lacks red blood cells or does not function red blood cells. This condition causes the oxygen supply to the body's organs to decrease. Symptoms that appear include pale skin, shortness of breath, dizziness, stomach, or fast heart rate. The prevalence of anemia in Indonesia is still quite high at 21.70% in all age groups.³ this figure is still below the national target of 28%. The prevalence of anemia in an area is based on the level of the problem, namely severe 40%, moderate 20% -39.9%, mild 5% - 19.9% and normal 4.9%.³ High prevalence of anemia in 1 to 5 years of children in development.^{1,2}

Anemia is a condition of decreased levels of hemoglobin and erythrocytes, causing a decrease in the capacity of red blood cells to carry oxygen. Red blood cells are important oxygen carriers to various cells in the body. Inside the red blood cells is a molecule called hemoglobin which contains a heme group.³

Covid 19 has had an impact on various sectors of society, one of which is the health sector. Families and children who fall into poverty in a short time will experience severe impacts in terms of household food security and limited access, availability and affordability of healthy food ingredients.^{8,9} Surveys show that food needs are increasingly unsafe. 36 percent of respondents stated that they often reduce their eating problems because of their financial condition. 22 Loss of household income will

increase the risk of families becoming micronutrient deficient.⁴

The era of smart smartphone technology encourages various conveniences to occur in many fields, such as in the health sector which has given users the ability to detect their own health. One of them is to detect the condition of someone who has anemia or not. Utilization and implementation of decision support systems in the health sector still needs to be improved. The intelligence possessed by a smartphone and easily accessible to anyone, anytime, and anywhere. The design and manufacture of android/android applications in the health sector has developed a lot. The health sector in Indonesia and internationally is a program that is being considered, and technology development related to public health is always carried out.^{5, 6}

Addressing the nutritional needs of adolescent girls including adolescent anemia is one of the efforts to realize the SDGs (Sustainable Development Goals) program. Health problems of anemia are often experienced by young women. Adolescents who experience anemia will be at risk for iron deficiency and result in pale, weak, tired, decreased concentration in learning, decreased reproductive health, mental motor development, and not achieving maximum height.⁷

Therefore, the author wants to develop an application design for an expert system for diagnosing anemia using an android/android-based forward chaining method

2. MATERIALS AND METHODS

The type of research used was quantitative research with experimental methods. Quantitative research was conducted with a pre post test approach without a control group. The research design carried out includes identifying potentials and problems, collecting data, designing products, product validation, usage trials, product revisions, product trials, design revisions, product revisions, and production. The location of this research is in Puskesmas in Sleman Regency and Yogyakarta City in Indonesia. The population in this study were adolescents aged 15-25 years in Yogyakarta and Sleman districts in Indonesia. Research sample as much as 110 respondents with sampling technique purposive random sampling. The method that will be used in data collection is to use a google form containing a questionnaire. Respondent were asked to click on link access the pretest questionnaire. Information about the study was given on their score on addictive social network use at the end of the survey, which, based on previous studies by the research team, was viewed as an incentive to participate. After the respondent filled out the pre-test, the respondent was asked to carry out early detection and utilize the existing media in the android system developed by the researcher. After that, respondents were asked to do a posttest. Data analysis with independent t test, ROC, sensitivity and specificity test. Analysis results show good or effective use if the area under curve is considered good if >0.7

3. RESULTS

The data analysis stage is a stage in system development. At this stage, performance evaluation, problem identification, system design and steps needed for the desired design are carried out to the expected analysis. The design of data analysis consists of symptom data, solution data.

The study included determining the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of the forward chaining method in the diagnosis of anemia. This research was conducted in an effort to determine the

accuracy of the android-based application system to diagnose anemia. The data obtained were analyzed by diagnostic tests.

There are several stages carried out in data analysis, including the following:

a. Univariate analysis of respondent characteristics

Prior to the diagnostic test stage, the data were analyzed univariately to provide an overview of the frequency distribution of adolescent characteristics and family characteristics. The results of the univariate analysis are as follows:

Table 1: Frequency Distribution of Research Variables

No	Variable	n = 124	%
1.	Gender		
	Woman	66	60
	Man	44	40
2.	Education		
	Basic Education (SD, SMP)	46	41.8
	Higher Education (SMA, PT)	64	58.2
3.	Clean Water Access		
	Well	94	85.5
	Not good	16	14.5
4.	Daily Habits		
	Well	65	59.1
	Not good	45	40.9
5.	Residence		
	Rural	72	65.5
	Urban	38	34.5
6.	Anemia Status		
	Anemia	73	66.4
	No Anemia	37	33.6

Source: Primary Data

Based on the results of the research conducted, it is known that the majority of respondents are female as many as 66 respondents (60%), more education is in higher education (SMA/College) as many as 64 respondents (58.2%), most of the respondents have access to clean water 94 respondents (85.5%), the majority have good daily habits as many as 65 respondents (45%), the majority living environment including rural areas as many as 72 respondents (65.5%), The majority of respondents have anemia status as many as 73 respondents (66.4%).

b. Knowledge and attitude of respondents about anemia

The measurement of knowledge about anemia was carried out twice, namely before intervention was carried out on the respondent. The results from before being given blood-added tablets are as follows:

Table 2: Knowledge of Young Women Before Intervention

Variable	N	mean	SD	Min	Max
Knowledge About Anemia	110	82.12	7.150	65	100
Attitude to Prevent Anemia	110	63.74	17.564	22	94

Source: Primary Data 2022

Based on Table 2. It can be seen that before the Android-based SEKAR application was given, the average respondent's knowledge was 82.12 with a standard deviation of 7.150. The lowest knowledge is 65 and the highest is 100. While for the attitude variable, before being given a leaflet, the average knowledge of the respondents was 63.74. The lowest attitude score is 22 and the highest is 94.

Meanwhile, the knowledge of young women after the intervention was as follows:

Table 3: Young Women Knowledge After Intervention

Variable	N	mean	SD	Min	Max
Knowledge About Anemia	110	92.36	7,861	70	100
Attitude to Prevent Anemia	110	78.33		28	100

Source: Primary Data 2022

Based on Table 3. It can be seen that after being given the Android-based SEKAR application, the average respondent's knowledge is 92.36 with a standard deviation of 7.861. The lowest knowledge is 70 and the highest is 100. While for the attitude variable, before being given a leaflet, the average knowledge of the respondents was 78.33 The lowest attitude score was 28 and the highest was 100.

Based on these results, it can be seen that there is an increase between the provision of the Android-based SEKAR application with knowledge about anemia and anemia prevention attitudes.

c. The Effectiveness of Using the Android-Based SEKAR Application in Increasing Knowledge

The results obtained from the paired t-test are as follows:

Table 4: The Effectiveness of Using SEKAR's android in Increasing Knowledge

Variable	Intervention	n	mean	SD	t	p value
Knowledge About Anemia	Before	110	-	7.051	-7,-	0.000
	After	110	10,227		15,212	

Based on table 4. It is known that there is a statistically significant relationship in the android-based SEKAR application with knowledge about anemia. This is indicated by a sig value of 0.000, which means that the Android-based SEKAR application has effectiveness in increasing knowledge of respondents.

d. The Effectiveness of Using the Android-Based SEKAR Application in Increasing Attitudes in Preventing Anemia

The results obtained from the paired t-test are as follows:

Table 5: The Effectiveness of Using SEKAR android in Early Detection of Anemia

Variable	Intervention	n	mean	SD	t	p value
Knowledge About Anemia	Before	110	-	11,533	-	0.000
	After	110	14,596		13,274	

Based on table 5. It is known that there is a significant relationship between the provision of education through the Android-based SEKAR application and the attitude of the respondents. This is indicated by a sig value of 0.000, which means that the Android-based SEKAR application is effective in improving the attitude of respondents in preventing anemia.

e. The Effectiveness of Using the Android-based SEKAR Application in Early Detection of Anemia

The effectiveness of media use was measured using an independent t-test, all variables were tested for the incidence of anemia in adolescents. The results obtained are as follows:

Table 6: The Effectiveness of Using SEKAR android in Early Detection of Anemia

Variable	t	Sig (2-tailed)	OR (95% CI)
SEKAR android system	27,295	0.000	9.52 - 10.09

Based on table 6. It is known that there is a statistically significant relationship between factors contained in the android with adolescent anemia disorders. This is indicated by a sig value of 0.000, which means that the SEKAR android has an effectiveness in detecting the incidence of anemia in adolescents.

f. SEKAR Android Accuracy Test in Anemia Detection

SEKAR android feasibility/accuracy test using ROC. Diagnostic tests were carried out to see the strength of the diagnostic value of an android-based system as a screening tool for anemia, with an analysis of the ROC curve and the values of sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, and negative likelihood ratio.

ROC analysis is used to determine the diagnostic power by obtaining the Area under the Curve value, and the optimal cut off value between the android system and anemia. The results of the ROC curve analysis showed that the Area under the Curve value was 0.999.

ROC analysis also gets the optimal cut off value.

Table 7: SEKAR Android Validity Test Table

Variable	Pearson Correlation	Sig. (2 Tails)
SEKAR application based on android	0.327	0.000

Source: Primary Data

Based on the results of the validity test carried out, it shows that the sig value is 0.000 or <0.005 and the positive Pearson correlation is 0.327, which means the android-based SEKAR application used is valid, so the android application can be used as a research instrument. Application testing is carried out to determine the performance of the application, namely the sensitivity, accuracy, and precision values of the application in diagnosing anemia. Application testing is done by calculating the performance of the application, namely the ROC method. The ROC test was carried out after the validity test.

The results of the ROC test are as follows:

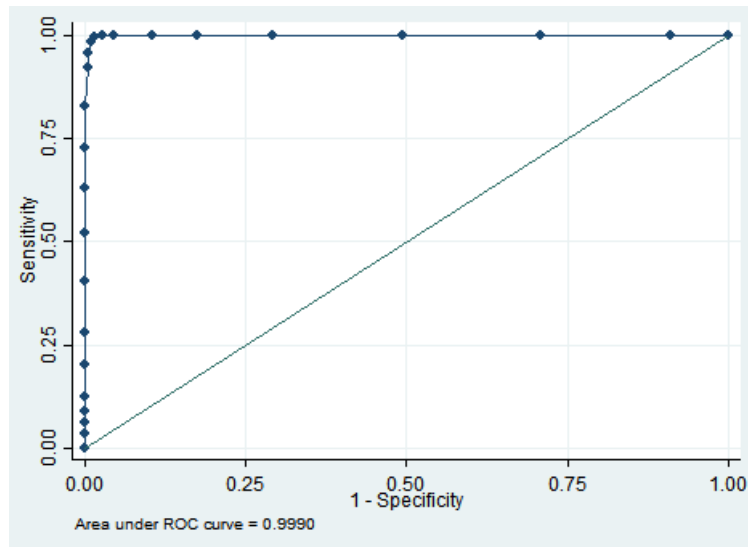


Figure 1: System Accuracy ROC Curve

Based on the graph, it is known that:

Table 8: Area below the Curve

Area	Std. Error	Asymptotic Sig.b	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.999	0.0008	0.000	0.997	1,000

Source: Primary Data

Based on the results of the ROC analysis, it is known that the area under the curve is 0.999 or 99.9%, which means that the early detection of anemia using the SEKAR android is strong and accurate, so it is feasible to be used as an early detection tool for anemia. The under curve area is considered good if >0.7 compared to the gold standard. Based on the results of the sensitivity and specificity of SEKAR based on android, they are as follows:

Table 9: Sensitivity and Specificity System

Positive if Greater Than or Equal To a	Sensitivity	1-Specificity
0	1	1
1.5	1	0.989
2.50	0.855	0.225
4	0	0

Source: Primary Data

Based on these results, it can be seen that the application of detection of anemia disorders has a sensitivity of 100% and a specificity of 98.9%.

1. System Design Stage

a. Application System Usage

The flow of the use of the Android-based SEKAR application is as follows:

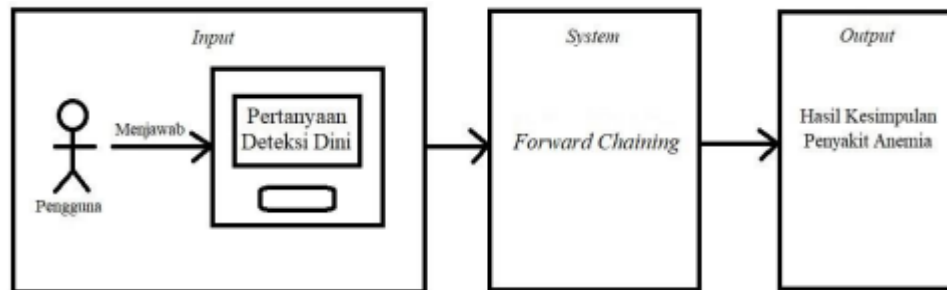


Figure 2: System Usage Diagram

Based on Figure 2 General System Diagram, this application is designed to have 3 stages before determining whether a person is diagnosed with anemia or not, the process is:

- 1) The first stage is a process where application users provide input in the form of answers to questions about early detection of anemia in the application.
- 2) The second stage is an advanced process from the first stage, where the system will process the input provided using the Forward Chaining expert system method and determine the percentage value of how much the user suffers from anemia.
- 3) The third stage is the last stage where the application will display conclusions from the input given by the user in the form of the percentage of users suffering from anemia.

b. System Planning

System Design Flowchart, the process starts from the user will provide input in the form of answers to the symptoms of anemia felt. After that, based on the answers provided by the user, grouping will be carried out according to the expert data in the knowledge base which will then be processed by the expert system using the Forward Chaining method. Furthermore, the system will provide output in the form of a conclusion whether the user suffers from anemia or not.

c. System Validation

1) Design and material validation

This product is validated by 4 validators. The initial product that has not been validated by an expert is called draft 1, while the product that has been revised is called draft 2. At the material validation stage, it consists of 3 material expert validators with assessment aspects covering aspects of content feasibility, language, performance. The purpose of material validation is to see the feasibility of the material on the SEKAR android system. Aspects and criteria are as follows:

Table 10: Aspects and Criteria for Material Experts

No	Aspect	Criteria
1	Content eligibility	1. Material clarity 2. Information provides new knowledge 3. Information according to the times 4. The suitability of the example with the material
2	language	5. The suitability of the language used with the language skills of the general public 6. Ease of understanding the language used 7. Consistency in the use of terms, buttons. Scientific name
3	Performance	8. The attractiveness of android serving 9. Can be used individually / independently

The results of the material expert validation as a whole are as follows:

d. System Test

1) Black Box Test

Black Box Testing is a test to observe the execution results through test data and functional checks from the android

Table 11: Black Box Test

No	Object Name	Expected results	Observation result	Conclusion
1.	About Anemia	Displays information about the background of the application	Displays information about anemia and tips to prevent anemia	Succeed
2.	About	Displays information about the background of making the application along with contacts who can be contacted	Displays information about the background of making the application along with contacts who can be contacted	Succeed
3.	Submit	Save answers from users and display the next page	Save answers from users and display the next page	Succeed
4.	Process	Displays results in the form of diagnosis status along with the diagnosis value	Displays the results in the form of the diagnosis status along with the diagnosis value	Succeed
5.	Next	Show next page	Show next page	Succeed
6.	Log out	Exit the app	Exit the app	Succeed
7.	Home Menu	Display the main page (home)	Show main page (home)	Succeed
8.	Menu Info	Displays detailed disease information	Show detailed disease information	Succeed
9.	Diagnostic Menu	Respond to symptoms according to conditions	Show diagnostic results	Succeed
10.	Login menu	Show login page	Show login page	Succeed
11.	Manage Data	Show data manage page	Show data management page	Succeed
12.	Rules	Displaying diagnostic results	Show the results of the diagnosis and detailed information on anemia	

In Table 11 Black Box Testing, there are 9 features or buttons in this detection application, and everything works as expected.

2) Field Test

The trial was conducted online on the general public as many as 110 respondents. The test results are as follows:

Table 12: Field Trial Results

Aspect	Sub Material	Score	Category
Content Quality	Material clarity	85.18	Interesting
	Information provides new knowledge		
	The suitability of the example with the material		
Appearance	The images used are interesting	88.4%	Interesting
	Characters are clear		
Technical Quality	Clarity of material order	82.45%	Interesting
	Ease of operation of the SEKAR app		
	Features of the SEKAR app		

Based on table 12, it is known that the quality aspect of the content which consists of 3 assessment criteria gets an average score of 85.18%, the display aspect of the SEKAR application gets an average of 88.4% of respondents said that it is interesting because it has interesting images and character is clear. As for the technical quality which consists of 3 assessment criteria, the average score is 82.45%. So that all aspects have a score of 85.34% are in the attractive category. The score shows a number above 70% so that the Android-based anemia detection system in the respondent's test gets a positive response.

3) Product Revision

Product revisions are carried out to improve the weaknesses of the products developed. The results of the improvement in the revision are the final product or the final result can be used as a suitable medium/system to detect anemia.

4. DISSCUSS

Based on the results of the study, obtained sensitivity, specificity, positive predictive value. Based on the results In the research conducted, there is a significant difference in the effectiveness of using a android-based anemia detection application system on the level of adolescent knowledge, attitudes, and behavior after being given the intervention. This is in line with Lawrence Green's theory which states that part of the predisposing factors that exist in individuals, families, groups that make it easier to shape attitudes and behavior ¹. PRECEDE Model education program was more effective in modifying nutritional behaviors of mothers in order to control the IDA of their children and adolescent ².

Analysis of the difference in the average value of knowledge, attitudes and skills before and after the intervention. This was done using the analysis of the paired mean difference test (t-paired). The results show that the variables of knowledge, attitude, and behavior obtained by the test results have a significant average difference ($p < 0.05$). This hypothesis is strengthened by the difference in the average results of knowledge, attitudes, and behavior values showing significant differences between before and after the intervention, substantially the difference is very significant and affects the possibility of behavioral changes to prevent iron deficiency anemia in adolescents.

Health behavior (healthy behavior) are all activities or activities, whether observed or not observed that are related to the maintenance and improvement of health ³. Behavior has a wide and complex area. The behavior proposed by Bloom (1908) divides behavioral domains including knowledge, attitudes, and practices. Likewise, a person's behavior towards health includes the three domains, namely health knowledge, attitudes towards health, and health actions ⁴.

Based on the research results obtained from the data analysis, it is known that there is a significant difference regarding the prevention of iron deficiency anemia in adolescents before and after the intervention ($p=0.000$). This is in accordance with Herlambang's research that there was a significant increase in knowledge of the average score before and after health promotion interventions in the adolescent group. Likewise, Chairani's research shows that there are differences in adolescent knowledge of drug prevention efforts after participating in self-help groups compared to before ^{5,6}.

Previous studies have shown that smartphone application systems have the capacity as a non-invasive anemia self-screening tool that can be used by the general population or at-risk populations. The non-invasive approach undertaken represents a greater degree of accuracy than the reported level of accuracy. The results of the analysis show that the sensitivity and specificity of the system for detecting anemia were 92% (95% CI, 80-97%) and 76% (95% CI, 62-87%), respectively. Using the WHO average Hgb limit for anemia of 12.5 g dL⁻¹ in both men and women, the sensitivity of the test increased to 97% (95% CI, 89-100%), indicating the potential of this test to function as non-invasive screening tool for anemia ⁷. This result line with previous research, The researchers studied conjunctivies photos and correlated the color of the fingernail beds with hemoglobin levels measured by CBC in 337 people: some healthy, and others with a variety of anemia diagnoses. The algorithm for converting fingernail color to blood hemoglobin level was developed with 237 of these subjects and then tested on 100 ⁸.

The development of a juvenile anemia detection system in the form of the SEKAR android is an expert system android that detects anemia in adolescents early based on symptoms, daily habits, and photos of the conjunctiva of the eyes of adolescents. This androidsite also provides material related to anemia. SEKAR's androidsite is presented in an attractive way that supports early detection of anemia independently, especially for adolescents. SEKAR's android target is teenagers aged 15-25 years, both girls and boys. With the introduction of a android-based system in the form of the SEKAR android to adolescents, it is very important, education can be provided through a android system so that it can increase adolescent knowledge about anemia, adolescents also have effort to carry out attitudes and behaviors to prevent anemia. This is in line with the research conducted by Khairah, that teenagers tend to like android-based or digital readings and have an attractive appearance ^{9,10}.

In the other research, These results set the stage for the development of an application within a smartphone which can not only acquire the image but also analyze the elements within the image to predict hemoglobin concentration in real-time. The expected and observed independence of HbC from skin tone is an important observation. Recently, pulse oximetry was observed to significantly overestimate SpO₂ in African-Americans ¹¹. Previous studies also described a method for estimating hemoglobin concentration using conjunctival images obtained from

smartphones. Estimation of hemoglobin concentration by this method can be used as a screening tool for anemia and transfusion thresholds. Improved image quality can improve hemoglobin estimation ¹².

The choice of development in the form of the SEKAR android because the use of the android in providing education is able to provide a stimulus that can help teenagers understand the material and be able to motivate interest in a subject that is considered less attractive. This is supported by research which states that the use of the android provides convenience in conveying material and understanding the material, gaining new knowledge and providing interest in adolescents ¹³. Other research states that having interesting pictures/displays on the android will help provide understanding so that teenagers remember them faster ¹⁴.

SEKAR Android is operated with a computer/HP assisted by an internet network that can be used anytime and anywhere, both inside and outside the room. The selection of internet-based as a supporter in making a android system due to rapid technological developments has become one of the factors for choosing an internet-based system²⁸. The use of internet-based systems knows no place and time. Azhar Arsyad's research states that the use of the internet can be used in educational media that is widely applied in the community. Researchers develop android-based products because they have many advantages, one of which is in their operation, it provides various interesting features that make it easy to use even though they do not have expertise or talent in IT. This is reinforced by the statement of Brigida Intan Printina which states that users can access the android anywhere and anytime. In addition, it can also be used to stimulate the spirit of learning and learning can be visualized easily so that it is more interesting. In the other research, The researchers selected the inner lower eyelid, called the palpebral conjunctiva, because it has the following unique features it is easily accessible for photographing, the distance between the surface and blood vessels is very small ¹⁵.

Based on the assessment that has been done, the SEKAR android site is feasible to use. Online educational media can have an impact on increasing understanding and changing behavior. The analysis of the accuracy of the SEKAR android system aims to determine whether the SEKAR android system is able to detect anemia in adolescents early. The results showed that SEKAR's android was good enough to detect anemia. High specificity causes high-risk subjects to be very likely to have anemia. A high negative predictive value indicates that this scale is good for diagnosing the incidence of anemia

5. CONCLUSION

From the research conducted, it can be concluded that This android-based SEKAR application system is effectively used to detect anemia.

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