Development of a Toddler Nutrition Monitoring System to Prevent Stunting

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Abstract— **Nutritional problems are still a major challenge for developing countries, including Indonesia, which faces a double burden of malnutrition and obesity. Nutritional problems in toddlers can have serious impacts both in the short and long term. The long-term impact of malnutrition can cause stunting, which affects children's physical growth and cognitive development, while obesity in toddlers has the potential to cause various health problems in the future. Stunting is a condition where a person fails to reach their growth potential. This condition can be caused by chronic malnutrition and recurrent illnesses during childhood. Therefore, it is very important to monitor children's growth and development from an early age. This study aims to design and develop a mobile application that can monitor the nutritional status of toddlers based on anthropometric data, such as weight, height, and head circumference, using the Z-score method recommended by the World Health Organization (WHO). This study resulted in the SehatTumbuh application which has an accuracy rate for classifying nutrition of 80 percentage.**

Keywords*— *Nutritional Problems, Stunting, Anthropometry, Monitoring, Toddlers

I. INTRODUCTION

Nutritional problems are still a challenge for developing countries, including Indonesia. Until now, Indonesia has faced a double burden of nutritional problems, namely malnutrition and excess nutrition on the other side. The results of the 2022 National Nutritional Status survey showed that the prevalence of stunting in Indonesia reached 21.6%, this number has decreased compared to the previous year, which was 24.4% [1]. The government is targeting the prevalence of stunting in 2024 to drop to 14%. Meanwhile, based on the results of the Basic Health Research (RISKESDAS), the prevalence of malnutrition and undernutrition has actually increased since 2007, with a figure of 18.4 percent in that year, decreasing to 17.9 percent in 2010, but rising again to 19.6 percent in 2013, and then decreasing to 17.7 percent in 2018 [2].

Nutritional problems in children under five years of age can have serious impacts in both the short and long term. Malnutrition in children in developing countries is often a major cause of child morbidity and mortality [3]. Stunting is a condition where a person fails to reach their growth potential. This condition can be caused by chronic malnutrition and repeated illness during childhood. This will have a permanent impact on the child's physical and cognitive capacity. Malnutrition or stunting also has an impact on the economy which can lead to ongoing poverty [4].

Assessment of the adequacy of nutritional intake and growth of infants and toddlers can be seen from anthropometric measurement indicators [5]. Anthropometric measurements are reference data for evaluating child growth. By comparing age and gender in the physical growth of toddlers [6].

Nutritional anthropometry deals with various measurements of body dimensions and composition for various ages and nutritional levels. Anthropometry is generally used to measure nutritional status from various imbalances between protein and energy intake [7]. Anthropometric measurements can be used as the basis for calculating the Z-score. The Z-score is a measure of the deviation of data from the average value measured in standard deviation units. The Z-score value is positive if the value is above the average and the value is below the average. The Z-score value is also known as the standard value or standard value [8]. The World Health Organization (WHO) categorizes stunting as a height that is more than two standard deviations [9]. Meanwhile, the Ministry of Health (Kemenkes) defines stunting as toddlers whose z-score is less than -2 SD/standard deviation (stunted) and less than -3 SD/standard deviation (severely stunted). Short (stunted) and very short (severely stunted) toddlers are toddlers who have a body length (PB/A) or height (TB/A) less than the WHO Multiculture Growth Study standard in 2006, where stunting conditions are definitely short but short is not necessarily stunting [10].

Meanwhile, the Z-score in determining nutritional status in this study is the deviation value of BB, TB, LK from the normal BB, TB, and LK values according to WHO growth standards. Then this study will focus on the indicators that determine stunting in toddlers aged 24-59 months. Interventions in this age group remain important, especially if the priority targets

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(pregnant women, breastfeeding mothers, and children aged 0-23 months) have been well served [11]. Based on WHO nutritional status classification, Child Growth Standards are used for anthropometric indexes of children aged 0-5 years [12].

Toddler nutritional status is an important indicator in determining the health and development of early childhood [13]. However, nutritional monitoring often faces challenges, especially in areas with limited access to health services and lack of parental knowledge [14]. Mobile technology offers a practical solution for health monitoring, allowing parents and health workers to record, analyze, and monitor toddlers' anthropometric data in real time and get recommendations for necessary nutritional interventions. However, the application must be easy to use by all groups and provide accurate information according to WHO standards [15].

This study aims to design and develop a mobile application to monitor the nutritional status of toddlers based on anthropometric data of weight, height and head circumference using the Z-score method which is the standard deviation unit recommended by the World Health Organization (WHO).

II. METHOD

This study uses a qualitative research type, focusing on the collection and analysis of toddler anthropometric data to design an application that can classify toddler nutritional status.

A. Research Stages

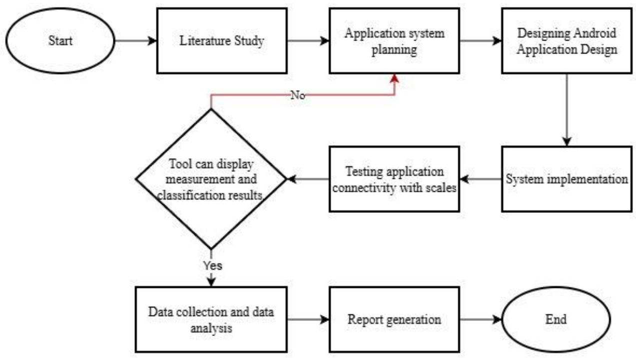

Figure 1. Research Stages

The research process as shown in Fig. 1, involved several main stages. First, a literature review was conducted to identify trends and gaps in research on Z-score and nutritional status of toddlers. Second, system planning included identification of needs, feasibility analysis, determination of project scope, and initial system design. Third, the design stage included the creation of wireframes, mockups, and user interface designs for an intuitive and visually appealing Android application. Finally, the system was implemented, tested for connectivity with a Bluetooth scale, and verified for its ability to display measurement results and classify nutritional status. Documentation of the evaluation and implementation results, along with recommendations for future development, concludes this research.

B. Block Diagram

This system involves users (Posyandu cadres/parents) who enter toddler anthropometric data through a user interface. This system is connected via Bluetooth to a digital scale for weight data. This device is designed to provide convenience in measuring weight and transferring measurement data to other devices, such as smartphones, tablets, or computers, via a Bluetooth connection. While height and head circumference are entered manually. This process is shown as a block diagram in Fig. 2.

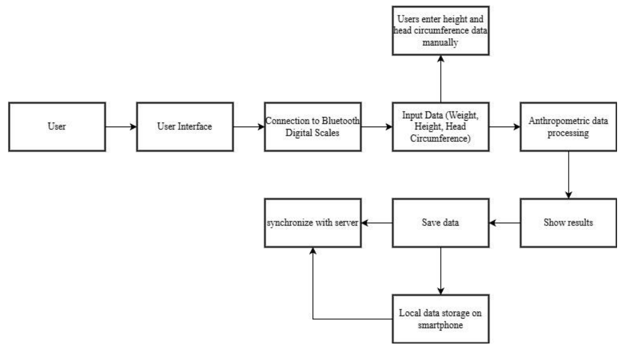

Figure 2. Block Diagram

The data is processed to calculate the Z-score index and classify nutritional status, which is then displayed along with growth charts and recommendations. Data is stored locally on the smartphone and synchronized with the server for backup.

C. Use Case Diagram

The use case diagram helps identify the features that can be accessed by each actor (parents and posyandu comitte) and describes the roles and responsibilities of each actor in the system, as shown in Fig. 3.

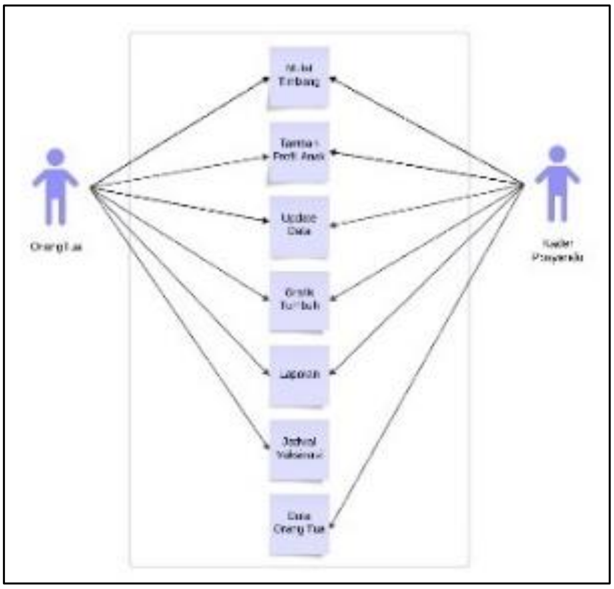

Figure 3. Use Case Diagram

D. Flow chart

The application workflow, illustrated in Fig. 4 and Fig. 5, begins with the user selecting their account type (parent or Posyandu cadre) and logging in or creating a new account. Users can view the main menu, add or select child data, and connect to a Bluetooth scale for measurement. Measurement results will be displayed along with the child's nutritional status, and users can update the data or view growth charts and health recommendations. Parents can also access the vaccination schedule and manage their child's vaccination status.

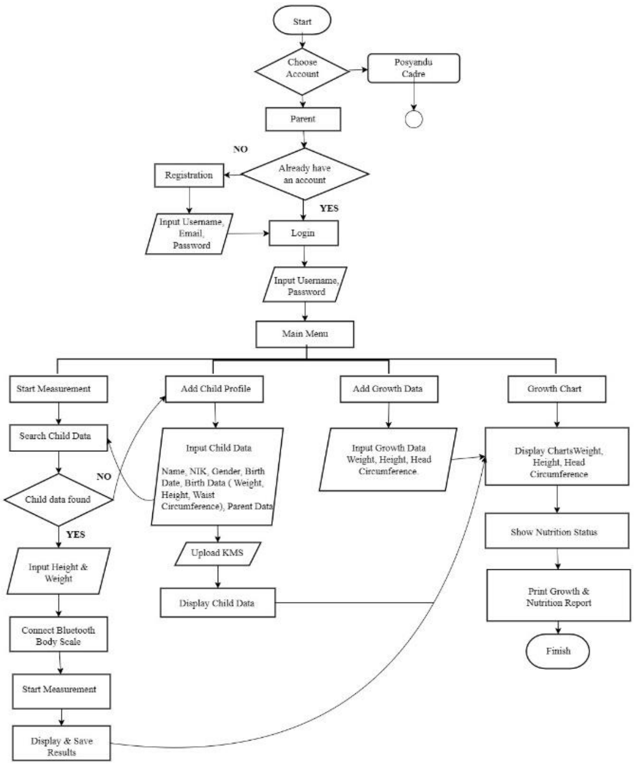

Figure 4. Parent Account Flowchart

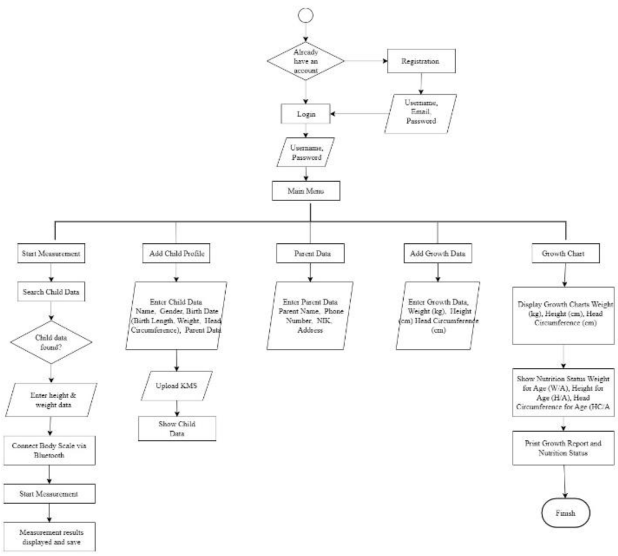

Figure 5. Posyandu Account Flowchart

III. RESULTS AND DISCUSSION

A. Application Implementation Results

This section shows the results of the application implementation that is in accordance with the research plan in terms of design, features and needs in the application. The application that was successfully created is called "SehatTumbuh", this application can be used to classify the nutritional status of toddlers based on anthropometric data. The following are the features that were successfully implemented in the application:

1. Account registration: is a feature for users to register new accounts, like shown in Fig. 6.

Figure 6. Registration Form

2. Login: a feature for users to enter the application after registering, shown in Fig. 7.

Figure 7. Login Form

3. Add child data: feature to add new child data
4. Add parent data: feature to add toddler parent data.
5. Start Weighing: a feature that functions to perform measurements by connecting the application with a digital bluetooth scale to obtain body weight measurements like shown in Fig. 8. While the height and head circumference measurements are added by the user. Then the nutritional status classification is obtained.

Figure 8. Start Weighing Menu

6. Update data/add growth data: feature to add new growth data, like shown in Fig. 9.

Figure 9. Update Data Menu

7. Report: a feature to read child growth data.
8. Growth Chart: a feature to view a child's growth chart accompanied by suggestions according to their nutritional status, like shown in Fig. 10.

Figure 10. Growth Chart Menu

9. Timetable Vaccination: a feature to view your child's vaccination status according to their age, like shown in Fig. 11.

Figure 11. Vaccination Schedule

B. Functionality Test Results

The results of the functionality test refer to the evaluation of various aspects and features of an application to ensure that the application functions according to the specifications that have been set. The functionality test was carried out by 2 users, namely Posyandu Cadres and Parent users as shown in Table 1.

TABLE 1
RESULTS OF FUNCTIONALITY TEST OF PARENT USERS AND POSYANDU CADRE USERS

No	Page	Input	Validation	Test Results
1.	List	Username, email, password	Username, email, password as per	Registration successful, please login
2.	Login		Valid Username	Login successful

No	Page	Input	Validation	Test Results
		Username and Password	and Password	
			Username and Password invalid	Login failed, Username or Password is incorrect
3.	Parent Data	Family Card Number, Father's Name, Mother's Name, NIK, Address	Save	Parent data successfully saved
4.	Add Child Profile	Child's name, NIK, Date of Birth, birth data (BB, TB. LK), select parent data, address, upload KMS	Save	Child data successfully added
5.	Start Weighing	Select the child's name, measurement date, weight, height, head circumference	Start measurement	Success, Data successfully saved, nutritional status (malnutrition/undernutrition/good nutrition/overnutrition)
6.	Update data	Select child data, enter weight, height, head circumference	Update Data	Success, growth data successfully updated
7.	Report	Select child data	-	– Displays data update date, weight, height, head circumference, and nutritional status. – Successfully download the report
8.	Growth Chart	Select child data	-	Display growth charts and suggestions according to nutritional status
9.	Vaccination Schedule	Choose vaccination according to age	-	Vaccination type displayed, but failed to change vaccine status.

Based on functional testing of user parents and cadres, almost all features run normally and provide appropriate validation. But in the start weighing feature, the application still often fails to read the size of the bluetooth scale. From the functional testing of the two users, the failure of the application to read the measurements of the scales can be caused by the android version of the smartphone that does not support the Bluetooth Low Energy (BLE) feature of the scales.

C. QoS Parameter Test Results

Testing QOS (Quality of Service) parameters aims to ensure that the application can function properly and provide an optimal experience to users. Testing is done using Wireshark software, while the application is run by several users. Here are the steps to perform QoS testing on the SehatTumbuh application

1) Download and install Wireshark from the official Wireshark website.
2) Configuring the network: connecting all user devices to the same network.
3) Starting network traffic recording: open Wireshark and select the appropriate network interface (e.g., Wi-Fi or Ethernet). Click the Start Capturing Packets button (blue shark icon) to start recording network traffic.
4) Perform testing with the application: run the application to be tested on all user devices simultaneously and perform activities representative of application usage.
5) Stopping network traffic recording: Once the test is complete, return to Wireshark and click the Stop Capturing Packets button (red square icon) to stop recording.
6) Analyzing data with Wireshark: using Wireshark filters to focus analysis on application traffic, like shown in Fig. 12.

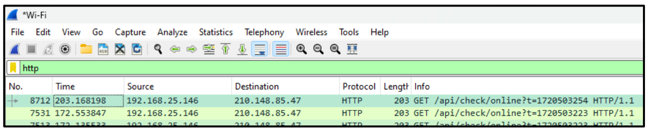

Figure 12. HTTP Filter

7) Calculating throughput: Throughput is the effective data transfer rate, measured in bps (bits per second). To determine throughput, select the Statistics>Capture File Properties menu to view details of the network traffic capture that has been performed, like shown in Fig. 13.

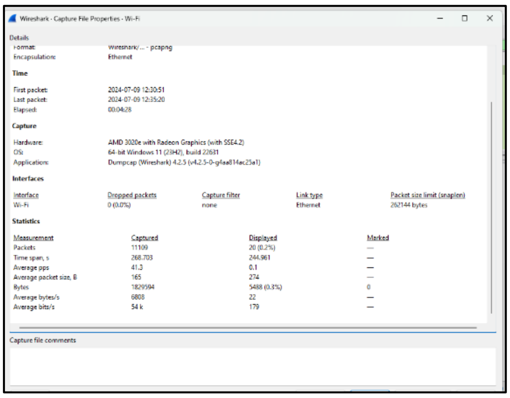
Figure 13. Capture HTTP File

The throughput value can be calculated as follows:

$$\text{Throughput} = \frac{\text{Data packets received}}{\text{Observation duration}} \quad (1)$$

$$\text{Throughput} = \frac{1829594}{268{,}703} = 6.808{,}98240 \text{ bps} = 6.653 \text{ Kbps}$$

The throughput value of 6,653 Kbps is included in the medium category, considering the application needs, the throughput value is quite good.

8) Calculating packet loss, Packet loss is a parameter that indicates the total number of packets that can be lost as a result of collisions and traffic on the network. To find packet loss, use the wireshark filter to search for tcp.analysis.loss_segment, then select one of the search results, then select the Statistics>Capture File Properties menu. Based on Fig. 14, it can be seen that the packet loss is 0% so it is included in the very good category.

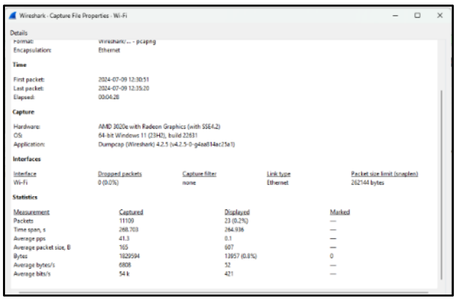

Figure 14.Capture File tcp.analysis.loss_segment

9) Calculating delay, delay is the amount of time it takes for data to calculate the distance from source to destination. use the wireshark filter to search for "tcp" Statistics>Capture File Properties to see the received packets, like shown in Fig. 15.

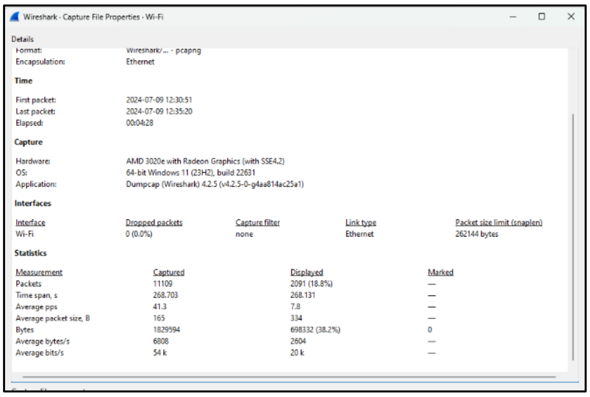

Figure 15. Capture File tcp

Then select the File>Export Packet Dissections>As CSV menu then save the file in the computer folder. Select the data in the "Time" column with a certain range, in the experiment the author took a range of 24 data then copied. Create a new sheet and copy the data as "Time 1" then copy the data range as Time 2 but align the second row with the first row of Time 1. By comparing the two time data, the total delay is obtained as much as 0.43796 s. by using equation (2) the average delay value is as follows:

$$\text{Average Delay} = \frac{\text{Total Delay}}{\text{Total packets received}} \quad (2)$$

$$\text{Average Delay} = \frac{0.43796}{11.109} \times 1000 = 0{,}0394 \text{ ms}$$

A delay of 0.0394 ms is included in the Very Low category. This delay indicates that the time required for a data packet to move from sender to receiver is very short.

Based on the results of the quality of service (QoS) test on the toddler nutrition monitoring application, it was found that this application has quite good performance in terms of throughput, packet loss, and delay. In the test, a throughput value of 6,653 Kbps was obtained, which shows the application's ability to transfer data consistently at a decent speed, supporting responsive application performance when used by users. The recorded packet loss value was 0%, indicating that no data packets were lost during the communication process, meaning that the data sent and received by the application was not corrupted or interrupted. In addition, the measured delay of 0.0394 ms indicates that the delay time required for the application to respond to user requests is very small, providing a smooth and almost lag-free user experience.

D. System Accuracy Test Results

The classification data from the "SehatTumbuh" application was tested by comparing the classification results from the application with the classification results from the WHO anthro application to assess the accuracy of the application in assessing the nutritional status of toddlers. The number of samples in this test consisted of 10 samples of child data between the ages of 2-5 years, like shown in Table 2.

TABLE II
COMPARISON OF CLASSIFICATION RESULT DATA BY THE SEHATTUMBUH APPLICATION WITH WHO ANTHRO

Name	**Date of birth**	**Anthropometric Data**			**WHO Anthro Nutritional Status**	**Nutritional status Healthy Grow**
		Weight (kg)	**TB (cm)**	**LK (cm)**		
Admila Hanifah Baihaqi	2021-11-11	13.3	94	50	Good Nutrition	Good Nutrition
Fazila Hanum Arrokhim	2022-01-18	11.7	87	50	Good Nutrition	Good Nutrition
The Greatest Showman	2019-08-09	12.15	94	51	Good Nutrition	Good Nutrition
The son of Saka Agustiyasyah	2020-08-04	17.1	105	51	Good Nutrition	More Nutrition

Name	Date of birth	Anthropometric Data			WHO Anthro Nutritional Status	Nutritional status
		Weight (kg)	TB (cm)	LK (cm)		Healthy Grow
Muhammad Aidya Alhanan Attallah	2020-03-19	15.5	102	51	Good Nutrition	More Nutrition
Alina Silvana Tresna	2021-09-04	13.8	92	51	Good Nutrition	Good Nutrition
Gracheilla Febrina Arkandini	2021-02-18	15.2	99	49	Good Nutrition	Good Nutrition
Joza Adzkiya Almahyra	2022-06-30	9.2	79	47	Good Nutrition	Good Nutrition
Delisha Fayza El Shanum Setiawan	2021-07-13	12.6	95	49	Good Nutrition	Good Nutrition
Rafan Fathana Shobur	2020-01-29	16.7	102	51	Good Nutrition	Good Nutrition

From the data in Table 2, it is known that out of 10 data samples, there are 8 correct predictions of "Good Nutrition" and 2 predictions of "Over Nutrition" that should have been predicted as "Good Nutrition". Using a confusion matrix is useful for evaluating classification models, which try to predict categories or labels for each given data sample. Therefore, the accuracy value can be determined as follows:

- TP: 8
- FP: 0 (there is no "Good Nutrition" it should be "More Nutrition")
- TN: 0 (there is no true "Overnutrition")
- FN: 2

Then the accuracy value

$$Accuracy = \frac{(TP + TN)}{(TP + FP + FN + TN)} \quad (3)$$

$$Accuracy = \frac{(8 + 0)}{(8 + 0 + 0 + 2)} = 0,8 \times 100\% = 80\%$$

So the accuracy value of the application system in predicting the nutritional status of toddlers is 80%, which means that the quality of the system in predicting is quite good. However, the system still needs further development to determine other algorithms or techniques that can improve accuracy. As well as collecting more varied training data and testing data.

E. Questionnaire Results

The user satisfaction questionnaire was filled out by three Posyandu cadres and seven parents of toddlers. The results of the user satisfaction questionnaire for the SehatTumbuh application are shown in Fig. 16.

Information:

- Scale 1: Represents the lowest level of satisfaction
- Scale 2: Represents medium to high levels of lower satisfaction
- Scale 3: Represents a medium level of satisfaction
- Scale 4: Represents the highest level of satisfaction

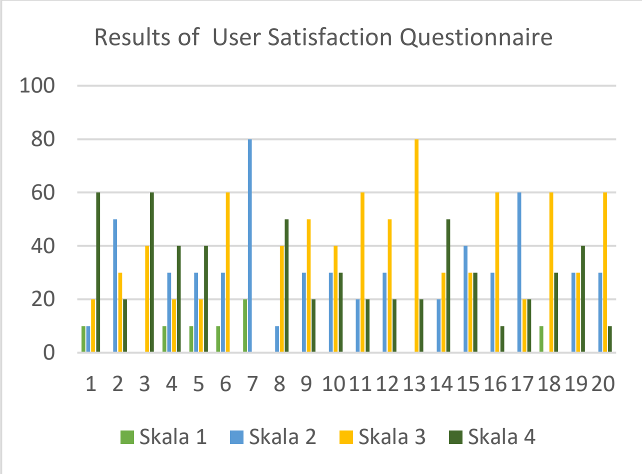

Figure 16.Results of the SehatTumbuh User Satisfaction Questionnaire

In Fig. 16, the X-axis shows the order of the questionnaire questions in sub-chapter 3.7, while the Y-axis shows the questionnaire answers into 4 linear scales in the form of percentages.

The results of the user satisfaction questionnaire showed that the toddler nutrition monitoring application was generally well received, with the majority of respondents giving ratings on a scale of 3 (40%) and a scale of 4 (28.5%), reflecting a fairly high level of satisfaction. For example, the application was considered quite accurate in categorizing toddler nutritional status (scale 3 by 40% and scale 4 by 60%) and helpful in monitoring nutritional growth (scale 3 by 50% and scale 4 by 20%). However, the "Start Weighing" feature using Bluetooth still faces problems, with scales 1 and 2 receiving significant votes (20% and 80%). Although the application is generally useful, several aspects, especially related to the Bluetooth feature, need improvement to improve performance in preventing stunting.

IV. CONCLUSION

Based on the research that has been conducted, it can be concluded that most of the application features, both for cadre and parent accounts, function well and provide appropriate validation. This application is able to record and display information on toddler nutritional status effectively. However, the "Start Weighing" feature with Bluetooth still experiences problems in reading scale data, which affects overall performance. Furthermore, application testing at partner locations showed good technical performance with a throughput of 6,653 Kbps, 0% packet loss, and very low delay (0.0394 ms). This shows that the application is able to manage data efficiently without data loss or disruption in communication, thus providing a smooth user experience. The application also shows a nutritional status prediction accuracy rate of 80%, indicating that the system has worked well in classifying. However, further improvements are still needed to ensure more optimal results. Then the questionnaire results showed that the majority of users were satisfied with this application, especially in terms of ease of use, attractive appearance, and benefits for monitoring toddler nutritional status with an average scale assessment of 3 and 4 of 40% and 28.5% of the overall results. However, there is still room for improvement in some technical features, such as the Bluetooth feature.

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