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The Implementation of the TOPSIS Method in Determining Stunting Toddlers

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Abstract
Stunting is a growth disorder in children due to chronic malnutrition and recurrent infections, especially in the first 1,000 days of life. Assessment of stunting status that only relies on height and weight measurements is considered ineffective because it does not cover all aspects that affect a child's nutritional status. At Posyandu Bougenvile, stunting identification is still done manually and it is at risk of causing errors in decision making. This study aims to develop a web-based Decision Support System (DSS) using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to assist Posyandu cadres in determining toddler stunting status quickly, accurately, and efficiently. This system processes data from four main anthropometric indicators, namely Height/Age, Weight/Age, Weight/Age, Weight/Age, and BMI/Age. The results of the system calculations show agreement with manual calculations, which proves that the system is working optimally. An example of the results shows that toddlers with code A1 (Rafasya Malik) have the lowest preference value of 0, followed by A4 (Ihsan Dwi Hanggoro) with a value of 0.4022149 which is included in the high stunting risk category. This system has proven to be able to help Posyandu cadres in prioritizing the handling of at-risk toddlers, as well as supporting the stunting monitoring process in a more structured and data-based manner.

Keywords— *Stunting, Decision Support System, TOPSIS, Toddlers*

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1. INTRODUCTION

Lack of adequate nutritional intake for children during the first 1,000 days of life starting from pregnancy until two years old is an indicator that the child is experiencing stunting. According to the World Health Organization (WHO), stunting is a condition of stunted growth and development in children caused by chronic malnutrition and repeated infections [1]. Nutritional status assessment is based on the Body Length for Age (PB/A) or Body Height for Age (TB/A) index, which is included in the standard for assessing children's nutritional status. The measurement results are categorized as short (stunted) if the Z-score value is between less than -2 SD to -3 SD, and categorized as very short (severely stunted) if the Z-score value is less than -3 SD [2]. As they get older, children who experience stunting are at higher risk of developing various other diseases, such as diabetes, heart disease, stroke, and even cancer [3].

Identification of stunting is part of an effort to improve the health of toddlers. At Posyandu Bougenvile, determining whether a toddler is stunted is often only based on measuring height and weight. This approach is less effective and has the potential to cause errors in determining stunting status in toddlers. Efforts to monitor and analyze stunting data are often hampered by the limited availability of effective decision-making tools. In addition, because stunting data involves various criteria, such as four anthropometric indicators, namely height for age (TB/A), weight for age (BB/A), weight for height (BB/TB), and body mass index for age (BMI/A), an analysis method is needed that can handle the complexity of the data as a whole.

Decision Support System (DSS) is a system designed to assist decision makers at the managerial level, especially in semi-structured decision-making conditions. This system can be interpreted as a process of selecting the best alternative from a number of available choices systematically, which is used as a method in solving a problem [4]. Therefore, the use of DSS can help reduce excessive use of time, energy, and costs. DSS aims to support a more effective decision-making process by choosing the right and efficient steps in carrying out these steps optimally [5]. Therefore, this study applies a decision support system that can be used by Posyandu Bougenvile cadres to facilitate the determination of stunted toddlers. Research conducted by Ayu and Reni on malnutrition

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using the SAW method resulted in a decision support system that is able to classify the nutritional status of toddlers, but does not yet include identification or determination of stunting conditions in toddlers [6].

The web-based decision support system that will be developed in this study is designed by utilizing the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. TOPSIS is a multi-attribute decision-making method that is based on finding ideal and anti-ideal solutions and comparing the distance of each alternative with the alternative [7]. TOPSIS is the best method for decision-making cases compared to other methods [8].

The purpose of this study is to develop a web-based decision support system (DSS) that can assist in determining stunting status in toddlers quickly, accurately, and efficiently. This system is designed by implementing the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method which is able to process data based on several anthropometric criteria. With this approach, it is expected that the decision-making process will be more systematic and objective. In addition, this system also aims to increase the effectiveness and efficiency of identifying toddlers who are at risk or have experienced stunting, as well as providing support for Posyandu Bougenvile cadres in carrying out appropriate monitoring and preventive measures. Through an easy-to-use web interface, this system can be accessed widely and in real-time, so it is expected to support government or health agency efforts in mapping and handling stunting problems in a more integrated and data-based manner.

2. RESEARCH METHODS

This section explains the research methods used in this study. The research was conducted through several stages, namely data and criteria analysis, calculations using the TOPSIS method, calculation results, and system development. In the process of creating the system, the waterfall software development method was used. The waterfall method is an approach in software development that allows the system development process to be carried out in a structured and sequential manner [9]. This method has several stages, namely, requirement analysis, system design, implementation, testing, and maintenance. The following stages of the research method can be seen in Figure 1.

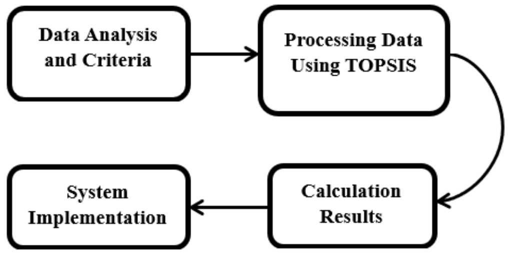

Figure 1. Methods

2.1. Data Analysis and Criteria

Data analysis is a process carried out systematically with the aim of processing and changing raw or unstructured data into meaningful information [10]. In this study, data was collected from Posyandu Bougenvile, which includes important information such as age, weight and height, immunization status, and diet. Then, the criteria that are the basis for decision making are determined, such as height according to age, weight according to age, weight according to height, and body mass index according to age. Each criterion is weighted according to its level of influence on the risk of stunting.

2.2. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)

In this study, the TOPSIS method was used for data processing. The TOPSIS method is based on the principle that the best alternative is the one that has the closest distance to the positive ideal solution and at the same time the furthest distance from the negative ideal solution [11]. The following are the stages of calculating the TOPSIS method, namely [11]:

1. Creating a normalized decision matrix
   $$r_{ij} = \frac{x_0}{\sqrt{\sum_{i=1}^{m} \quad x_{ij}^2}} \quad (1)$$
   Where i = 1,2, …, m; and j = 1, 2, n.
   r_{ij} = normalized decision matrix.
   x_{ij} = weight of criterion j on alternative i.
   i = alternative i.
   j = alternative j.
2. Create a weighted normalized decision matrix
   $$y_{ij} = w_i r_{ij} \quad (2)$$
   i = 1, 2, …, m; and j = 1, 2, …, n.
   Where wj is the weight of criterion j.
3. Determine the positive ideal solution matrix and negative ideal solution matrix.
   $$A^+ = (y_1^+, y_2^+, \dots, y_n^+); \quad (3)$$
   $$A^- = (y_1^-, y_2^-, \dots, y_n^-); \quad (4)$$
   Where

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$$y_i^+ = \{y_{ij};\ if\ j\ is\ a\ benefit\ attribute\ y_{ij};$$
$$if\ j\ is\ a\ cost\ attribute$$
$$y_j^- = \{y_{ij}; if\ j\ is\ a\ benefit\ attribute\ \ y_{ij}\ ;$$
$$if\ j\ is\ a\ cost\ attribute$$

4. Determine the distance between the value of each alternative with the positive ideal solution matrix and the negative ideal solution matrix.
   positive ideal
   $$D_i^+ = \sqrt{\sum_{j=i}^{n} \left(y_1^+ - y_{ij}\right)^2}; \quad (5)$$
   negative ideal
   $$D_i^- = \sqrt{\sum_{j=1}^{n} \left(y_{ij} - y_1^-\right)^2} \quad (6)$$

5. Determine the preference value for each alternative.
   $$V_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (7)$$
   V_i is the preference value that shows the value of the i alternative. after getting the value V_i, then the alternatives will be ranked based on the order of value V_i.

2.3. Calculation Result

In this study, the calculation results stage of the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method which will be implemented into a web-based Decision Support System (DSS) aims to determine the ranking or priority of a number of alternatives based on their proximity to the ideal solution.

2.4. Implementation System

1. Requirement Analysis

This process involves system analysts and business analysts in identifying the functional and non-functional requirements of the system to be developed [12]. Researchers conducted an analysis of the system requirements that became the basis for developing a web-based Decision Support System to determine stunted toddlers at the Bougenvile Posyandu.

2. System Design

This process involves creating a picture of the system to be developed to determine a solution plan that includes software design, architectural design, and database [13]. Researchers prepare a system design or draft, which includes database design and system model creation using UML (Unified Modeling Language). In database design, researchers use ERD (Entity Relationship Diagram), ERD is a database design diagram that describes entities as potential tables and relationships as relationships between these entities [14]. ERD is a tool used to visualize the logical structure of a database by displaying entities, attributes, and relationships between entities [15]. UML (Unified Modeling Language) is one of the tools used in developing object-based systems [16]. The UML used is Use Case Diagram and Activity Diagram. A use case is a series or description of a group of activities that are interconnected and form a structured system, which is carried out or monitored by an actor [16]. Activity diagram is a modeling that is done on a system to describe a series of activities that occur in the system. This diagram is used to explain program activities visually without requiring code or interface displays [17].

3. Implementation

This stage is the process of writing program code compiled into an application that can be run, including creating the necessary database and text files [12]. Researchers implement the design that has been made into a program code using the PHP (Hypertext Preprocessor) programming language. In addition, this step also includes the application of the TOPSIS method which is realized in the form of a system. PHP is a server-side programming language for developing various types of websites and web applications [18]. PHP allows the creation of dynamic web applications, meaning it can generate web pages that are influenced by data. This means that changes in data will automatically update the web page without the need to change the script or code that builds it [19].

4. Testing

This process is known as verification and validation, which is the process of ensuring that the software solution meets the requirements and successfully achieves the desired goal [12]. At this stage, researchers carry out testing of the software that has been developed using the black box testing method. Black Box Testing focuses on testing system functions by assessing input and output without viewing or analyzing the source code [20]. Black box testing plays an important role in the software testing process, namely to ensure that all system functions run well and are dynamic [21].

5. Maintenance

The Maintenance process includes fixing errors that were not identified in previous stages [12]. This stage aims to ensure that the system continues to run well and meets user needs over time [22]. This stage is carried out if there are

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updates or modifications to existing software, but not to develop completely new software.

3. RESEARCH RESULTS

3.1. TOPSIS method calculation

1. Create Alternative Data and Determine Criteria

Alternative data is taken from toddler data at the Bougenvile Posyandu, the following is a sample of the toddler data used:

Code	Name
A1	Rafasya Malik
A2	Fando Kurniawan
A3	Cakra Syahputra
A4	Ihsan Dwi Hanggoro
A5	Kelvin Permana
A6	Mira Putriasari
A7	Mutiara Cantika Putri
A8	Pelita Pertiwi
A9	Shaka Putra Atmaja

Table 1. Alternative Data

The criteria data are the child's anthropometric standards, the following criteria data are used:

Code	Criteria	Description	Attribute	Weight
C01	Height According to Age (H/A)	Tall	benefit	4
		Normal		3
		Short		2
		Very Short		1
C02	Body Weight According to Age (BW/A)	Fat	benefit	4
		Normal		3
		Thin		2
		Very Thin		1
C03	Body Weight According to Height (BW/H)	Over-nutrition	benefit	4
		Normal		3
		Undernutrition		2
		Malnutrition		1
C04	Body Mass Index by Age (BMI/A)	Over-nutrition	benefit	4
		Normal		3
		Undernutrition		2
		Malnutrition		1

Table 2. Criteria Data

In the table above there is a weight, the weight here is the limit of the criteria points that can be given, the maximum limit that can be given is 4. In the benefit attribute column, it means that the greater the points entered, the better the toddler's condition.

2. Input Alternative Values

Based on the weights and criteria determined above, here is a sample of the weighting given to each toddler:

alternative	C01	C02	C03	C04
A1	1	1	1	1
A2	3	3	3	3
A3	4	3	3	3
A4	2	2	2	2
A5	3	3	3	3
A6	3	3	3	3
A7	3	3	3	3
A8	3	3	3	3
A9	3	3	3	3

Table 3. Alternative Value Data

3. Normalized Decision Matrix

The first step is to square each element of the matrix in table 3. Here are the results:

alternative	C01	C02	C03	C04
A1	1	1	1	1
A2	9	9	9	9
A3	16	9	9	9
A4	4	4	4	4
A5	9	9	9	9
A6	9	9	9	9
A7	9	9	9	9
A8	9	9	9	9
A9	9	9	9	9
Total	75	68	68	68

Table 4. Square Result

Then normalize by dividing each matrix element in table 3 by the root of the total of each criterion in table 4. Sample calculation alternative A1, C01.

$$r_{11} = \frac{1}{\sqrt{75}} = \frac{1}{8{,}6602} = 0{,}11547$$

1 is obtained from table 3 and 75 is obtained from table 4.

The following are the results of the normalization:

alternative	C01	C02	C03	C04
A1	0,11547	0,121268	0,121268	0,12126781
A2	0,34641	0,363803	0,363803	0,36380344
A3	0,46188	0,363803	0,363803	0,36380344
A4	0,23094	0,242536	0,242536	0,24253563
A5	0,34641	0,363803	0,363803	0,36380344
A6	0,34641	0,363803	0,363803	0,36380344
A7	0,34641	0,363803	0,363803	0,36380344
A8	0,34641	0,363803	0,363803	0,36380344

A9	0,34641	0,363803	0,363803	0,36380344

Table 5. Normalization Results

4. Weighted Normalization

Weighted normalization is obtained by multiplying the normalization matrix in table 5 with the maximum limit of the criteria weights contained in table 2. Sample calculation alternative A1, C01.

$$r_{11} = 0{,}11547 \times 4 = 0{,}46188$$

0,11547 is obtained from table 5 and 4 is obtained from table 2 (the maximum limit of the criteria weights).

The following matrix is obtained:

alternative	C01	C02	C03	C04
A1	0,46188	0,485071	0,48507125	0,48507125
A2	1,385641	1,455214	1,45521375	1,45521375
A3	1,847521	1,455214	1,45521375	1,45521375
A4	0,92376	0,970143	0,9701425	0,9701425
A5	1,385641	1,455214	1,45521375	1,45521375
A6	1,385641	1,455214	1,45521375	1,45521375
A7	1,385641	1,455214	1,45521375	1,45521375
A8	1,385641	1,455214	1,45521375	1,45521375
A9	1,385641	1,455214	1,45521375	1,45521375

Table 6. Weighted Normalization

5. Ideal solution matrix

The ideal solution matrix is obtained based on weighted normalization and criterion attributes (benefits). The criterion attribute used in this study is benefit, so the positive ideal solution is taken from the maximum value of the weighted normalization in table 6. Conversely, the negative ideal solution is taken from the minimum value of the weighted normalization in table 6. The results are as follows:

Ideal Solution	C01	C02	C03	C04
Positive	1,847521	1,455214	1,45521375	1,45521375
Negative	0,46188	0,485071	0,48507125	0,48507125

Table 7. Ideal Solution

6. Distance Between Alternative Weighted Values and Ideal Solution

Squaring the difference of each weighted normalization matrix in table 6 with the ideal solution matrix in table 7, then summing each alternative, then rooting it. The distance of the positive ideal solution uses the positive ideal solution, the distance of the negative ideal solution uses the negative ideal solution. Preferences are obtained by dividing the negative ideal by the sum of the positive and negative ideals.

Positive A1

$$\sqrt{\begin{array}{c}(((0{,}46188-1{,}847521)^2)\\ +((0{,}485071-1{,}455214)^2)\\ +\left(\begin{array}{c}(0{,}485071-1{,}455214)^2)\\ +((0{,}485071-1{,}455214)^2))\end{array}\right)\end{array}} = 2{,}177965$$

Negative A1

$$\sqrt{\begin{array}{c}(((0{,}46188-0{,}46188)^2)\\ +((0{,}485071-0{,}485071)^2)\\ +\left(\begin{array}{c}(0{,}485071-0{,}48507)^2)\\ +((0{,}485071-0{,}48507)^2))\end{array}\right)\end{array}} = 0$$

Preferences A1

$$\frac{0}{2{,}177965-0} = 0$$

The results are as follows:

alternative	Positive	Negative	preference	Results
A1	2,177965	0	0	Stunted
A2	0,46188	1,9175147	0,8058833	Normal
A3	0	2,177965	1	Normal
A4	1,248686	0,958757	0,4343293	Stunted
A5	0,46188	1,9175147	0,8058833	Normal
A6	0,46188	1,9175147	0,8058833	Normal
A7	0,46188	1,9175147	0,8058833	Normal
A8	0,46188	1,9175147	0,8058833	Normal
A9	0,46188	1,9175147	0,8058833	Normal

Table. 8 Calculation Results

Based on the results of the preference values, 2 toddlers were declared stunted from 9 toddler data samples, namely alternative A1 (Rafasya Malik) and alternative A4 (Ihsan Dwi Hanggoro). in the table above, toddlers who are declared stunted are toddlers who have the smallest preference value, besides that, toddlers are declared in normal condition. this will be a rule in the decision support system for determining stunted toddlers.

3.2. System Design

1. ERD

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The following is the database design in this study, namely ERD. There are 4 entities, namely Criteria, Toddler, User and Stunting which are shown in Figure 2:

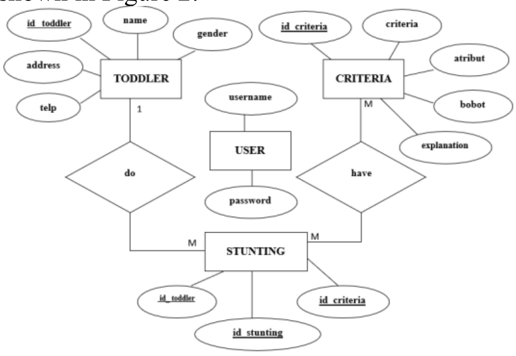

Figure 2. Entity Relationship Diagram

2. Use Case Diagram

The following is a Use Case Diagram for a decision support system for determining stunted toddlers, the actor in this Use Case is the admin.

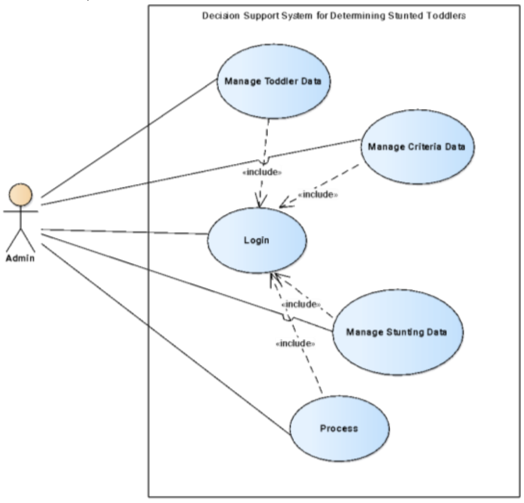

Figure 3. Use Case Diagram

At this stage, the admin first logs in using a username and password. After logging in, the admin can access and manage all menus in the system, including Manage Toddler Data, Manage Criteria Data, Manage Stunting Data and Manage Process Menu.

Activity Diagrams are used to model systems related to Login activities, Toddler Data, Stunting Data, Stunting Process and Criteria Data. For example, a toddler data activity diagram, in the toddler activity diagram the admin can manage toddler data which includes adding, deleting, and changing toddler data. The following activity diagram for Managing Toddler Data is shown in Figure 4.

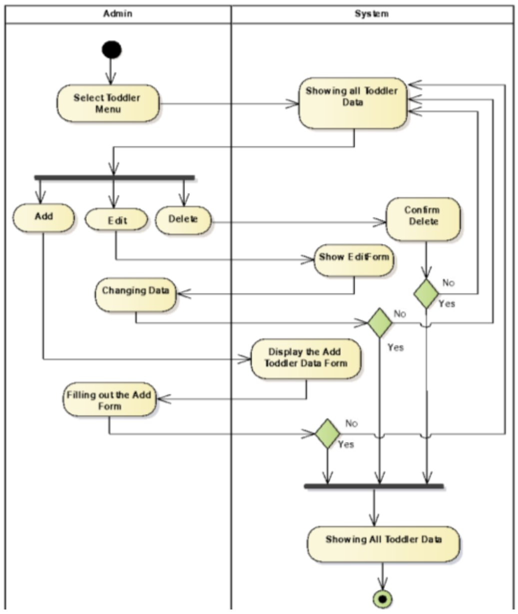

Figure 4. Activity Diagram Toddler Data

3.3 Implementation

1. Home Page View

Figure 5. Home Page View

In Figure 5 it is explained that after the admin logs in using the correct username and password, the home page will appear. On the home page there is a Stunting menu, this menu is used to see the results of determining stunted toddlers. Then the Toddler menu, this menu is used to manage toddler data. The Criteria menu is used to manage criteria data, and the Stunting Data menu is used to input toddler data based on existing criteria. The menu can be accessed and managed by the admin.

2. Toddler Menu Page View

Figure 6. Toddler Menu Page View

In the toddler menu, the admin can manage toddler data including adding, changing and deleting toddler data.

3. Criteria Menu Page View

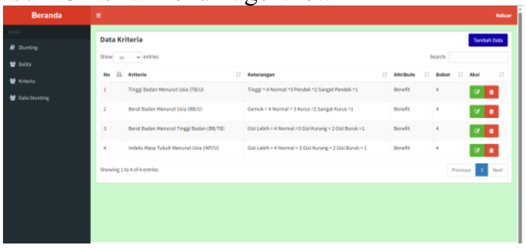

Figure 7. Criteria Menu Page View

in figure 7 is the criteria menu, the admin can manage criteria data in the form of adding, changing, deleting criteria data. in this menu the admin can also see the value of each criterion that has been determined, there is a description column to make it easier for the admin in the process of inputting toddler data values according to the criteria.

4. Stunting Menu Page View

Figure 8. Stunting Menu Page View

Figure 8 shows the results page of the toddler value calculation process according to the anthropometric criteria that have been inputted. In the results, there are 2 toddlers who are included in the stunting category, namely Rafasya Malik (A1) and Ihsan Dwi Hanggoro (A4) according to the calculation of stunting determination using the TOPSIS method explained above.

3.3 Black Box testing

No	Functions Tested	Black Box Testing
1.	Login Page	Succeed
2	Home Page	Succeed
3.	Toddler Page	Succeed
4.	Add Toddler Data	Succeed
5.	Change Toddler Data	Succeed
6.	Delete Toddler Data	Succeed
7.	Criteria Data Page	Succeed
8.	Add Criteria Data	Succeed
9.	Change Criteria Data	Succeed
10.	Delete Criteria Data	Succeed
11.	Stunting Data Page	Succeed
12.	Add Stunting Data	Succeed
13.	Change Stunting Data	Succeed
14.	Delete Stunting Data	Succeed
15.	Stunting Page	Succeed
16.	Results of Calculation Process	Succeed
17.	Exit	Succeed

Table 9. Black Box Testing Results

The results of system testing using black box testing on the decision support system for determining stunted toddlers run and work well.

4. CONCLUSION

Based on the results of the discussion of the problems raised by the researcher, it was concluded that a Decision Support System (DSS) has been successfully developed to determine the stunting status of toddlers at the Bougenvile Posyandu. This system applies the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method in its calculation process. The results of manual calculations and system calculations show similar results, so it can be concluded that the system works well and accurately. An example of the preference results shows that toddlers with code A1 (Rafasya Malik) have a preference value of 0, followed by A4 (Ihsan Dwi Hanggoro) with a preference of 0.4022149 which is included in the high stunting risk category. This system is able to assist Bougenvile Posyandu cadres in determining the priority of handling toddlers at risk of stunting effectively and efficiently.

5. SUGGESTION

For further research, it is recommended that the TOPSIS method used in this decision support system be compared with other decision-making methods. This comparison aims to evaluate the advantages and disadvantages of each method in the context of determining stunted toddlers. In addition, it is to develop this decision support system by integrating it into the health information system that has been used in health service facilities such as Puskesmas. This integration will facilitate the process of data collection, monitoring the nutritional status of toddlers, and reporting to related parties in real-time and centrally. With this integration, the system can contribute to supporting government programs in overcoming stunting more efficiently, collaboratively, and sustainably.

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