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Implementation of a Stunting Monitoring System for Toddlers Using the Analytical Hierarchy Process Method in Southeast Aceh Regency

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Abstract

Stunting is one of the public health problems that remains a major challenge in Indonesia, including in Southeast Aceh Regency. Based on data from the Indonesian Nutritional Status Study (SSGI), the prevalence of stunting in Southeast Aceh Regency reached 34.1%, which is higher than the average prevalence in Aceh Province of 33.2%. The high rate of stunting indicates the need for more effective monitoring and handling efforts to support the growth and development of toddlers. Currently, the process of monitoring stunting in community health centers is still carried out manually, causing delays in data processing, calculation errors, and a lack of objectivity in assessing the nutritional status of toddlers. Manual recording also makes it difficult for health workers to monitor toddler development accurately and periodically. Therefore, an effective and computerized monitoring system is needed to support health services in determining stunting status more efficiently. This study aims to implement a web-based stunting monitoring system using the Analytical Hierarchy Process (AHP) method to assist health workers in determining the stunting status of toddlers more quickly, accurately, and systematically. The AHP method is applied by assigning weights to several assessment criteria, namely age, weight, height, and nutritional status. Through the weighting and calculation process, the system generates a final score used as the basis for determining whether a toddler is categorized as normal or stunted. The results of this study indicate that the application of the AHP method can support decision-making processes more objectively compared to manual methods. In addition, the developed system provides a toddler growth chart feature that helps health workers and parents monitor child development regularly. Therefore, this system is expected to improve the effectiveness and efficiency of stunting monitoring in Southeast Aceh Regency and support government efforts to reduce the prevalence of stunting.

Keywords: *Stunting, Analitycal Hierarchy Process, Monitoring System, Toddlers, Decision Making.*

1. Introduction

Stunting in toddlers is a condition caused by prolonged hunger due to inadequate food intake over a long period resulting from feeding practices that do not meet health requirements. Stunting may begin while the fetus is still in the womb but generally becomes visible when the child reaches two years of age [1]. Stunting occurs due to chronic malnutrition that lasts for a long period, especially during the first 1,000 days of a child's life. This condition causes children to have a height lower than the standard for their age and increases the risk of cognitive, physical, and future health disorders. According to data from the Ministry of Health of the Republic of Indonesia, the prevalence of stunting in Indonesia is still relatively high although it has decreased from year to year. The government targets reducing the stunting rate to below 14% by 2024. However, several regions, including Southeast Aceh Regency, still face difficulties in identifying the main factors causing stunting quickly and accurately. This is due to limitations in the decision-making process, especially in assessing various criteria related to toddler conditions, environment, parenting patterns, family economy, and nutritional status. Aceh ranks third highest after East Nusa Tenggara. Based on the results of the 2021 Indonesian Nutritional Status Study (SSGI) conducted by BKKBN Aceh, the stunting rate in Southeast Aceh Regency reached 34.1%, placing the region among the top eight regencies/cities in Aceh Province. This figure is still higher than the Aceh provincial average of 33.2% [2]. The Analytical Hierarchy Process (AHP) method is one of the decision-making methods that can be used to determine priorities based on comparisons among criteria. By using AHP, each criterion can be assigned a weight according to its level of importance, resulting in more systematic and measurable decisions. Based on these problems, this study aims to implement a web-based stunting monitoring system for toddlers using the AHP method in Southeast Aceh Regency. This

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system is expected to help health workers assess stunting status more quickly, accurately, and objectively, as well as support government efforts to reduce the prevalence of stunting in the region.

2. Literature Review

2.1. Stunting

Stunting is a condition of growth failure in toddlers caused by chronic malnutrition and repeated infections, especially during the first 1,000 days of life, characterized by height that is lower than the standard for their age [1]. Stunting generally occurs due to insufficient nutritional intake over a long period, poor parenting patterns, lack of exclusive breastfeeding, and inadequate environmental sanitation [2]. If not treated properly, stunting can affect children's physical growth, cognitive development, learning abilities, and future productivity [3]. Therefore, prevention efforts are very important, including fulfilling balanced nutritional intake, improving environmental hygiene, and increasing parental awareness regarding child nutrition and healthcare [4]. According to the Indonesian Nutritional Status Study (SSGI), stunting remains one of the major nutritional problems in Indonesia and requires serious attention from both the government and health institutions. Monitoring toddler growth regularly is considered an important step in preventing stunting and improving children's nutritional status [2][4].

2.2. Monitoring System

A monitoring system is a system designed to observe, record, process, and analyze data continuously and systematically in order to support supervision and decision-making processes [21]. Monitoring systems are widely used in various sectors, including health, education, and information technology, to improve effectiveness and efficiency in data management processes. In the health sector, monitoring systems are used to monitor patient conditions, growth, and development periodically. A computerized monitoring system can reduce data recording errors, speed up data processing, and improve data accuracy compared to manual systems [7]. In the context of stunting monitoring, the system assists health workers in managing toddler data, monitoring growth results, and determining stunting status more effectively and accurately [5].

2.3. Decision Support System

A Decision Support System (DSS) is a computer-based system used to assist decision-making processes by utilizing data, models, and analytical methods systematically [20]. DSS aims to improve the quality and effectiveness of decision-making processes without replacing the role of decision-makers. Decision support systems are commonly implemented in various fields such as healthcare, education, business, and government services [7]. Research conducted by [18] showed that DSS implementation can improve the accuracy of customer credit selection processes. Another study by [19] demonstrated that DSS using the AHP method can support medicine selection processes based on disease symptoms more objectively and effectively. Therefore, DSS is considered suitable for supporting the process of determining toddler stunting status based on several assessment criteria.

2.4. Analitycal Hierarchy Process

Analytical Hierarchy Process (AHP) is a multi-criteria decision-making method developed by Thomas L. Saaty in the 1970s [8]. The AHP method works by structuring problems into a hierarchy, conducting pairwise comparisons between criteria, calculating priority weights, and testing consistency using the Consistency Ratio (CR) [9]. The pairwise comparison scale in AHP ranges from 1 to 9, where higher values indicate a greater level of importance of one criterion compared to another criterion [9]. The stages of the AHP method include defining the problem, determining criteria, creating pairwise comparison matrices, normalizing the matrix, calculating priority weights, and performing consistency testing using the Consistency Index (CI) and Consistency Ratio (CR). If the CR value is less than 0.1, the comparison matrix is considered consistent and acceptable for decision-making processes [8][9]. The AHP method has been widely implemented in various decision support systems. Research conducted by [10] implemented AHP in a tourism recommendation system and produced accurate recommendation results. Another study by [14] applied the AHP method in department selection systems and demonstrated that the method could improve decision-making objectivity. In addition, [15] implemented AHP in new student admission systems, while [16] applied AHP in supplier selection systems. These studies indicate that AHP is effective for solving multi-criteria decision-making problems systematically and objectively.

Table 1. Pair Comparison Scale Values

Intensity of Importance	Description
1	Both components are equally important and have the same impact.
3	One component has a slightly higher level of importance than the other. Experience and judgment strongly favor one component over its counterpart.
5	Certain elements have different priorities than others.
7	Certain factors are clearly more important than others.
9	One component is more important than the others.
2,4,6,8	A value that lies between two adjacent consideration values. This value is given when there are two compromises between two options.

The pairwise comparison scale uses a scale from 1–9 to assess the importance level of one element compared to another element [8]. The steps of the AHP calculation method are as follows:

a. Define the problem and determine the desired solution.
b. Arrange the hierarchy of the problem.
c. Determine priorities by conducting pairwise comparisons.
d. Fill in the pairwise comparison matrix.

e. Performing synthesis by considering the comparison of pairs across priorities such as adding up the values of each matrix column, then each column value is divided by the number of columns concerned to obtain the matrix normalization, after that each matrix value is added and divided by the number of elements to obtain the average value, then measuring its consistency for example multiplying the first column by the first priority and so on until the last column by the last priority, after multiplying, add up each row. The result of the row sum is then divided by the priority concerned. The result of this division is called the Consistency Vector.
f. Calculate the Consistency Index (CI) using the formula: CI = (λmax − n) / (n − 1) Where: CI = Consistency Index λmax = Eigen value n = Number of elements
g. Calculate the Consistency Ratio (CR) using the formula: CR = CI / IR Where: CR = Consistency Ratio CI = Consistency Index IR = Random Index

The Random Consistency Index (RI) values can be seen in the following table:

Table 2. Random Index Values

Ordo Matriks	Indeks Random (IR)
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51
12	1.48
13	1.56
14	1.57
15	1.59

2.4. Previous Research

Several previous studies have discussed the implementation of decision support systems and the Analytical Hierarchy Process (AHP) method in various fields. Research conducted by [10] implemented the AHP method in a tourism recommendation system and showed that the method was capable of producing accurate recommendations based on several assessment criteria. Another study by [11] applied the AHP method in a vehicle service monitoring system and demonstrated that the system could improve monitoring effectiveness and reduce manual calculation errors. Furthermore, research conducted by [12] implemented the AHP method in a smartphone recommendation decision support system and showed that the method was able to generate objective recommendations through pairwise comparison calculations. Similar research by [13] applied the AHP method in determining toddler nutritional status and concluded that the method could support more accurate and structured decision-making processes in the health sector. Studies by [14], [15], and [16] also demonstrated that the AHP method is effective in supporting decision-making processes in department selection, student admission systems, and supplier selection systems. Several previous studies have also discussed monitoring systems and stunting prevention. Research by [2] explained that stunting is generally caused by chronic malnutrition, poor parenting patterns, and inadequate sanitation. In addition, [4] stated that stunting prevention can be carried out through balanced nutritional intake, proper parenting, environmental hygiene, and increasing parental awareness regarding child nutrition. Meanwhile, [3] explained that children experiencing stunting generally have weaker immune systems and may experience learning difficulties in the future. However, most previous studies focused on recommendation systems, selection systems, and nutritional assessments using the AHP method. Research specifically discussing the implementation of a web-based stunting monitoring system for toddlers using the Analytical Hierarchy Process (AHP) method in Southeast Aceh Regency is still limited. Therefore, this study proposes the implementation of the AHP method to support the process of determining and monitoring toddler stunting status based on several criteria, namely age, weight, height, and nutritional status.

3. Methods

This study used the Analytical Hierarchy Process (AHP) method to implement a stunting monitoring system for toddlers in Southeast Aceh Regency. The study used primary data obtained from the Southeast Aceh Health Office. Data collection was conducted in 2026 and continued until the entire research process was completed.
At the research stage, this process represents the research steps carried out from the beginning until the completion of the study. The steps are as follows:

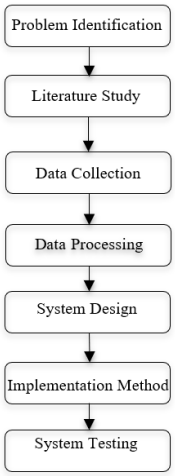

Fig 1. Research Flowchart

a. Problem Identification
At this stage, problems were identified and followed by finding solutions to the identified problems. This study aims to implement the AHP method for determining stunting in toddlers.
b. Literature Study
The literature study was conducted by reviewing various scientific sources such as books, research journals, and official documents from the Ministry of Health and WHO related to stunting, toddler nutritional status, and the Analytical Hierarchy Process (AHP) method.
c. Data Collection
Collecting anthropometric data (age, height, weight, and nutritional status) from toddlers registered at the Health Office.
d. Data Processing
Data processing was carried out according to the method being tested, namely the Analytical Hierarchy Process (AHP) method.
e. System Design
To support the application development process using the PHP programming language, the system design utilized context diagrams, Data Flow Diagrams (DFD), and Entity Relationship Diagrams (ERD).
f. Implementation of the *Analitycal Hierarchy Process* (AHP) Method
Using the AHP method for the system of determining and monitoring stunting in toddlers.
g. System Testing
After the system was successfully developed, the next stage was system testing to ensurethat the developed program functioned properly and met the intended objectives.

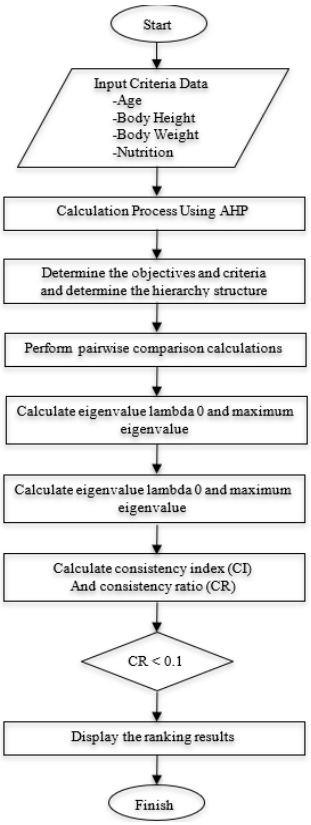

Fig 2. System Diagram

The figure above shows the workflow of the decision support system using the AHP method to determine and monitor stunting in toddlers.

4. Result And Discussion

The stunting monitoring system for toddlers in Southeast Aceh Regency was successfully designed and developed using the Analytical Hierarchy Process (AHP) method as the decision-making method. The system was developed as a web-based application using the PHP programming language and MySQL database. In the design process, the system utilized four main criteria, namely age, weight, height, and nutritional status. The AHP method was implemented through stages of pairwise comparison among criteria, matrix normalization, priority weight calculation, and consistency testing using the Consistency Ratio (CR) value. The calculation results showed that the height criterion had the greatest influence in determining stunting status. The developed system is also equipped with toddler data management features, automatic stunting status calculation, and growth charts for each toddler based on periodic measurement results, thereby facilitating the monitoring process for health workers.

4.1. Toddler Data

The toddler data used in this study were obtained from the Southeast Aceh Regency Health Office.

Table 3. Toddler Data

No	Toddler Name	Date of Birth	Date of Measurement	Age (Months)	Weight (kg)	Height (cm)	Nutrition
1	Afif Ahwal	1/12/2021	12/8/2025	47	15	100	Good
2	Natanael Sianturi	2/23/2021	12/19/2025	46	13.3	96.5	Good
3	Aisyah Aurora Fahlevi	4/16/2022	4/10/2026	47	17.2	109	Good
4	Gowan	9/24/2021	12/19/2025	39	13.8	95.1	Good
5	Asifa	5/8/2022	12/8/2025	31	13	91	Good
…	…	…	…	…	…	…	…
495	Muhammad Al Hakim	1/4/2022	12/9/2025	35	13.4	92	Good
496	Ezra Amora Br Hasibuan	2/12/2022	4/2/2026	49	16.8	111	Good
497	M.Haikal	3/3/2022	4/10/2026	49	11.8	96	Less
498	Annisa Ajira Apriadi	1/13/2022	4/3/2026	49	16.3	106	Good
499	Razka Tirta	2/4/2021	12/14/2025	46	15	99.6	Good
500	Shafina Aulia	7/31/2022	12/14/2025	29	8.2	84.1	Poor

4.2. Determining Criteria

This study used four criteria, namely age, weight, height, and nutritional status.

Table 4. Determining Criteria

Criterion Code	Criteria
C1	Age
C2	Weight
C3	Height
C4	Nutrition

4.3. Calculating the Pairwise Comparison Matrix of Criteria

At this stage, comparisons are carried out for each established criterion. The table below shows the rules for the comparison procedure.

Table 5. Calculating the Pairwise Comparison Matrix of Criteria

Criteria	C1	C2	C3	C4
C1	1	0.33	0.20	0.25
C2	3	1	0.50	0.50
C3	5	2	1	2
C4	4	2	0.50	1
Total	13	5.33	2.20	3.75

Where C1 represents the age criterion, C2 represents weight, C3 represents height, and C4 represents nutritional status. The value of 1 in row C1 column C1 indicates that the age criterion has the same level of importance as itself. The value of 3 in row C2 column C1 indicates that the weight criterion is more important than age in the process of determining stunting status. The value of 5 in row C3 column C1 indicates that height has a much higher level of importance compared to age because height is the main indicator in stunting assessment. The value of 4 in row C4 column C1 indicates that nutritional status is more important than age. Furthermore, the value of 2 in row C3 column C2 indicates that height is slightly more important than weight, while the value of 2 in row C4 column C2 indicates that nutritional status is slightly more important than weight. The value of 2 in row C3 column C4 indicates that height is more important than nutritional status in the stunting monitoring process. The values of 0.33, 0.25, 0.20, and 0.50 are reciprocal values of the previous comparisons or are obtained from the calculation of 1 divided by the value in the previous column. For example, the value of 0.33 is obtained from 1/3, the

value of 0.25 is obtained from 1/4, the value of 0.20 is obtained from 1/5, and the value of 0.50 is obtained from 1/2. The other values are obtained in the same way according to the pairwise comparison rules in the Analytical Hierarchy Process (AHP) method.

4.4. Calculating the Matrix Normalization Value of Criteria

This matrix normalization is obtained by dividing each column value of the criteria in the pairwise comparison matrix by the total value of each corresponding criterion column in the pairwise comparison matrix. Then, the values in each row of the criteria are summed.

Table 6. Calculating the Matrix Normalization Value of Criteria

Criteria	C1	C2	C3	C4	Total
C1	0.077	0.063	0.091	0.067	0.297
C2	0.231	0.188	0.227	0.133	0.779
C3	0.385	0.375	0.455	0.533	1.747
C4	0.308	0.375	0.227	0.267	1.177

Next is determining the priority values, where each total column value is divided by 4 because there are four criteria factors, and the same process applies to the others. Then, the eigenvalue is obtained by multiplying each priority value by the total column value of each criterion in the pairwise comparison matrix.

Table 7. Priority Values and Eigenvalues of Criteria

Criteria	Priority	EigenValue
C1	0.074	1
C2	0.195	1.0385004
C3	0.437	0.9611218
C4	0.294	1.1030922
Total	1.000	4.068

4.5. Calculating the Consistency Index and Consistency Ratio

The formulas for CI and CR are presented in Chapter 2. The calculation results are as follows:
CI = (4,068 – 4) / (4-1)
CI = 0,02
The CR value is obtained by dividing the CI value by the IR value. Table 2.2 shows the provisions for the IR value.CR = 0,02 / 0,90
Since CR < 0.1, the consistency ratio is considered acceptable.

4.6. Calculating Priority Weights

Priority weights are obtained from the average result of each row. The total normalization result is divided by the number of criteria.

Table 8. Priority Weights

Criteria	Total	Weight
Age	0.074	0.07
Weight	0.195	0.20
Height	0.437	0.44
Nutrition	0.294	0.29

Priority Weight Formula :
Weight = total normalization result / number of criteria
For the age criterion:
0,077 + 0,063 + 0,091 + 0,067 / 4 = 0,074
Therefore, the weight for the age criterion is 0.07.

4.7. Consistency Test

Multiply the pairwise comparison matrix by the weights to obtain the lambda max (λ max) value.
Age Row :
(1 x 0,074) + (0,33 x 0,195) + (0,20 x 0,437) + (0,25 x 0,294) = 0,300
0,300 / 0,074 = 4,04
Weight Row :
(3 x 0, 074) + (1 x 0,195) + (0,50 x 0,437) + (0,50 x 0,294) = 0,783
0,783 / 0,195 = 4,02
Height Row :
(5 x 0,074) + (2 x 0,195) + (1 x 0,437) + (2 x 0,294) = 1,786
1,786 / 0,437 = 4,09
Nutritional Status Row :
(4 x 0,074) + (2 x 0,195) + (0,50 x 0,437) + (1 x 0,294) = 1,199
1,199 / 0,294 = 4,08
Lambda max (λ *max*) = (4,04 + 4,02 + 4,09 + 4,08) / 4 = 4,057

4.8. Calculating the Consistency Index (CI)

CI = (*lambda max* – n) / (n -1)
CI = 4,057 – 4 / 4 – 1 = 0,02

4.9. Calculating the Consistency Ratio (CR)

CR = CI / CR
CR = 0.02 / 0.90 = 0,021 < 0,1 therefore the matrix is considered consistent.

4.10. Calculating the Final Score

Formula :
Score = $(n_1 \times b_1) + (n_2 \times b_2) + (n_3 \times b_3) + (n_4 \times b_4)$
Description :
n = normalized criteria value
b = criteria weight
Score = (0,6 x 0,07) + (0,6 x 0,20) + (0,6 x 0,44) + (0,6 x 0,29)
= 0,6 STUNTING
Penentuan status
Score ≥ 0,5 stunting
Score < 0,5 normal
At this stage, the final results of the implementation of the stunting monitoring system for toddlers using the AHP method in Southeast Aceh Regency are obtained.

Table 9. Final Results of AHP Calculation

No	Toddler Name	Date of Birth	Date of Measurement	Age (Months)	Weight (kg)	Height (cm)	Nutrition	Final Result	Status
1	Afif Ahwal	1/12/2021	12/8/2025	47	15	100	0.6	0.6	Stunting
2	Natanael Sianturi	2/23/2021	12/19/2025	46	13.3	96.5	0.6	0.6	Stunting
3	Aisyah Aurora Fahlevi	4/16/2022	4/10/2026	47	17.2	109	0.6	0.4	Normal
4	Gowan	9/24/2021	12/19/2025	39	13.8	95.1	0.6	0.6	Stunting
5	Asifa	5/8/2022	12/8/2025	31	13	91	0.6	0.6	Stunting
…	…	…	…	…	…	…	…	…	…
495	Muhammad Al Hakim	1/4/2022	12/9/2025	35	13.4	92	0.6	0.6	Stunting
496	Ezra Amora Br Hasibuan	2/12/2022	4/2/2026	49	16.8	111	0.6	0.4	Normal
497	M.Haikal	3/3/2022	4/10/2026	49	11.8	96	0.8	0.6	Stunting
498	Annisa Ajira Apriadi	1/13/2022	4/3/2026	49	16.3	106	0.6	0.4	Normal
499	Razka Tirta	2/4/2021	12/14/2025	46	15	99.6	0.6	0.6	Stunting
500	Shafina Aulia	7/31/2022	12/14/2025	29	8.2	84.1	1	0.6	Stunting

4.11. System Implementation

The implementation strategy of the system design reaches its final stage during implementation, which is the stage where the system is ready to be used. The implementation stage consists of the environmental implementation and program implementation processes.

Fig 3. Dashboard Page

5. Conclusion

This study successfully developed a web-based stunting monitoring system for toddlers using the Analytical Hierarchy Process (AHP) method in Southeast Aceh Regency to support the monitoring process in a faster, more effective, and more structured manner. The AHP method was successfully implemented in determining stunting status based on the criteria of age, weight, height, and nutritional status, resulting in more objective decision-making. The developed system is capable of displaying toddler data, assessment results, stunting status, and monitoring charts automatically, thereby assisting health workers in monitoring toddler development conditions. The testing

results showed that the system improves the effectiveness and efficiency of the monitoring process because assessments can be carried out more quickly, accurately, and with reduced manual calculation errors. In addition, the obtained Consistency Ratio (CR) value was less than 0.1, indicating that the comparison matrix used was consistent and feasible for decision-making.

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