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DECISION SUPPORT SYSTEM FOR TODDLER VACCINATION COVERAGE AT BUNGA TERATAI POSYANDU, LOKON HAMLET, USING THE SMART METHOD

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Abstract

Posyandu (Integrated Healthcare Center) is a primary health facility that plays a vital role in monitoring growth and providing immunizations for toddlers. However, at the Bunga Teratai Posyandu in Lokon Hamlet, the decision-making process regarding toddler vaccination coverage is still conducted manually and remains suboptimal. This can lead to inaccuracies in vaccination prioritization and data collection. This study aims to develop a Decision Support System (DSS) to assist Posyandu cadres and health officers in determining toddler vaccination coverage more quickly and accurately.

The method used in this system is SMART (Simple Multi-Attribute Rating Technique), which operates by assigning weights to predefined criteria, such as the toddler's age, body temperature, and vaccine type. The system is designed to process data structurally and provide recommendations based on the highest calculated values. The results of this study indicate that the SMART method can effectively rank vaccination priorities, thereby facilitating more efficient data management and decision-making for health officers at Bunga Teratai Posyandu.

*System testing results show that the implementation of the **SMART** method in this Decision Support System (DSS) has successfully increased time efficiency and decision accuracy compared to the previous manual process. With this system, the posyandu can more easily identify toddlers who need to be prioritized for immunization, leading to a significant increase in vaccination coverage at Posyandu Bunga Teratai.*

Keywords:*Decision Support System, SMART Method, Vaccination, Toddlers, Posyandu*

1. INTRODUCTION

Vaccination is one of the most effective health interventions for preventing infectious diseases in toddlers. Through immunization, toddlers can be protected from various dangerous diseases—such as polio, measles, hepatitis B, and diphtheria—which can be fatal.Consequently, toddler vaccination is an integral part of public health programs held at various healthcare facilities, including Integrated Healthcare Centers (Posyandu). However, in its implementation, several obstacles remain, such as a lack of systematic record-keeping, limited information for health workers, and difficulties in prioritizing toddlers who must receive immediate vaccination. [8].

Posyandu (Pos Pelayanan Terpadu or Integrated Healthcare Center) is a community health facility that plays a vital role in improving the welfare of mothers and children. In Dusun Lokon, the Posyandu functions to provide health services and information to mothers and children, as well as to monitor child growth and development.

The Posyandu also plays a role in preventing increases in maternal and infant mortality rates. Its presence in Dusun Lokon is essential because it helps the local community access health services more easily and affordably. Furthermore, the Posyandu serves to increase public awareness regarding the importance of maintaining family health.

With the existence of the Posyandu, it is hoped that the quality of public health in Dusun Lokon will improve, and that rates of stunting and malnutrition-related diseases can be reduced.

Currently, decision-making regarding vaccination coverage remains subjective and lacks a data-driven basis, posing a risk of inaccurate vaccine allocation and delayed immunization. To address these issues, a Decision Support System (DSS) is required to assist health workers in identifying which toddlers must receive immediate vaccination.
One of the methods that can be applied in this DSS is the Simple Multi-Attribute Rating Technique (SMART). The SMART method is frequently used in decision support systems to determine priorities across various contexts, including vaccination.

SMART is a multi-criteria decision-making method based on the theory that every alternative consists of several criteria, each possessing a specific value and weight. These weights reflect the relative importance of each criterion compared to others [2].

With the implementation of this decision support system, it is expected that the process of identifying and monitoring vaccination coverage at the Bunga Teratai Posyandu can be carried out more efficiently, accurately, and transparently. This will contribute to increasing immunization coverage and preventing the spread of vaccine-preventable diseases, thereby supporting efforts to improve toddler health in Dusun Lokon.
The application of a Decision Support System (DSS) using the SMART (Simple Multi-Attribute Rating Technique) method is expected to assist health workers and Posyandu volunteers in managing toddler vaccination data more effectively. This method works by assigning weights to each criterion that influences vaccination decisions, such as:

1. Toddler age – Determining whether the toddler has reached the appropriate age to receive a specific vaccine.
2. Previous immunization status – Evaluating whether the toddler has received the mandatory vaccines according to the schedule.
3. Health condition – Considering the toddler's health status, which may affect their eligibility for vaccination.

With this system, health workers will no longer rely solely on manual record-keeping, which is prone to errors, but will instead be able to access more accurate and systematic data. Through the development of a DSS based on the SMART method, it is hoped that the Bunga Teratai Posyandu in Dusun Lokon can increase toddler immunization coverage, reduce the risk of vaccination delays, and contribute to achieving national immunization targets.Consequently, this system will not only benefit the Posyandu but also the community at large in the effort to create a healthier environment free from vaccine-preventable diseases.

2. RESEARCH METHODOLOGY

2.1. System Development Methodology

The procedural stages in building this decision support system are as follows:

a. Requirements Gathering

At this stage, the data collection process is conducted through literature reviews, interviews, and observations. This involves gathering data related to toddlers, their ages, and other factors relevant to determining vaccination priorities. Interviews are conducted with Kader (Posyandu volunteers). Observations are carried out to support the interview activities at the Bunga Teratai Posyandu in Dusun Lokon by collecting toddler data from the volunteers.The obtained data is then compiled, combined with suggested new or additional data, and processed for calculation using the SMART method. Requirements gathering includes data such as toddler identity, age, body temperature, and vaccine types.

b. Design Construction

The system workflow design is developed using tools such as Flowcharts, DFD (Data Flow Diagrams), and ERD (Entity Relationship Diagrams).

c. **System Testing**

Once the decision support system application is completed, it enters the system testing phase. This involves demonstrating the finished system and testing both the data input/output processes and the system's accuracy in determining targeted vaccination schedules for toddlers.

2.2. System Analysis and Design

2.2.1. Analysis and Requirements Gathering

In this research method, there are specific criteria and weight values required to determine recommendations based on the results of the predefined criteria assessment..

a) Assessment Criteria

The criteria or variables used to determine appropriate recommendations or suggestions for toddler vaccination coverage are age, body temperature, and vaccine type. For further details, please refer to Table 1.

Table 1: Assessment Criteria
[Source: Author, 2026]

CRITERIA	DESCRIPTION
C1	Age
C2	Body Temperature
C3	Vaccine Type

b) Value Weights

Once the criteria are established, the next step is to determine the assigned value weights. These weights can be modified or adjusted in the future in accordance with the decisions or policies of the assessors. The value weights for each criterion can be seen in Table 2.

Table 2: Value Weights
[Source: Author, 2026]

NORMALIZATION	**WEIGHT**	**TYPE**
0,4	40	Benefit
0,3	30	Benefit
0,3	30	Benefit

2.2.2. Manual Calculation

a) Determining criteria

1) Age
2) Body Temperature
3) Vaccine Type

b) Determining criteria weights

1) Age =40
2) Body Temperature = 30
3) Vaccine Type= 30

c) Normalization of criteria weights

The formula used to calculate the weight normalization is:

Formula$W^0 = \frac{W_j}{\Sigma_{j-i}^{m} W_j}$

1) Age = 40/100 = 0,4
2) Body Temperature= 30/100 = 0,3
3) Vaccine Type = 30/100 = 0,3

d) Assigning values to each alternative

Table 3: alternative
[Source: Author, 2026]

No	Alternative Name	Age	Body Temprature	Vaccine Type
1	Nabila Hanin Ramadani	16 bulan	37^o	MMR
2	Anindiya Nabiha	28 bulan	36^o	Booster
3	Ata Aldan Alfalah	36 bulan	38^o	Booster
4	M.Farhan W	12 bulan	36,5^o	JE
5	Ziraya Agustina	14 bulan	38^o	MMR
6	Nurul Oktavia	23 bulan	37,5^o	MMR
7	Khalista Khumairoh	4 bulan	37^o	BCG
8	Hasya Amazila	6 bulan	38^o	PCG
9	Halid Ramadan Padana	25 bulan	38,5^o	Booster
10	M.Afzal Alif	29 bulan	36^o	Booster

The values for each criterion can be seen below. The alternative table for each criterion can be found in table 4.

Table 4: Alternative Criteria
[Source: Author, 2026]

No	Alternative Name	Age	Body Temprature	Vaccine Type
1	Nabila Hanin Ramadani	3	35	4
2	Anindiya Nabiha	2	45	3
3	Ata Aldan Alfalah	2	20	3
4	M.Farhan W	4	45	2
5	Ziraya Agustina	3	20	4
6	Nurul Oktavia	3	35	4
7	Khalista Khumairoh	5	35	5
8	Hasya Amazila	5	20	5
9	Halid Ramadan Padana	2	20	2
10	M.Afzal Alif	2	45	2

e) Calculating Utility Values

Calculate the utility value for each alternative using Equation 3. The utility formula depends on the nature of the criterion (Benefit or Cost). Therefore, the Benefit value is calculated first using the formula: $u_i(a_i) = (\frac{C_{out} - C_{min}}{C_{max} - C_{min}})$x100%

Table 5: Utility Values
[Source: Author, 2026]

No	Alternative Name	Age	Body Temprature	Vaccine Type
1	Nabila Hanin Ramadani	3	35	4
2	Anindiya Nabiha	2	45	3
3	Ata Aldan Alfalah	2	20	3
4	M.Farhan W	4	45	2
5	Ziraya Agustina	3	20	4
6	Nurul Oktavia	3	35	4
7	Khalista Khumairoh	5	35	5
8	Hasya Amazila	5	20	5
9	Halid Ramadan Padana	2	20	2
10	M.Afzal Alif	2	45	2

The results of the Benefit values can be seen in the following Table 6:

Table 6: Benefit Values
[Source: Author, 2026]

No	Alternative Name	Age	Body Temprature	Vaccine Type
1	Nabila Hanin Ramadani	0,333	0,6	0,666
2	Anindiya Nabiha	0	1	0,333
3	Ata Aldan Alfalah	0	0	0,333
4	M.Farhan W	0,666	1	0
5	Ziraya Agustina	0,333	0	0,666
6	Nurul Oktavia	0,333	0,6	0,666
7	Khalista Khumairoh	1	0,6	1
8	Hasya Amazila	1	0	1
9	Halid Ramadan Padana	0	0	0
10	M.Afzal Alif	0	1	0

The final scores derived from the utility values using the formula: $u_i = \sum w_j u_{ij}$ can be seen in the following Table 7:

Table 7: Final score of the utility values
[Source: Author, 2026]

No	Alternative Name	$u_i = w_j . u_{ij}$			∑U (i)
		Age	Body Temprature	Vaccine Type	
1	Nabila Hanin Ramadani	0,133	0,18	0,266	0,579
2	Anindiya Nabiha	0	0,3	0,133	0,433
3	Ata Aldan Alfalah	0	0	0,133	0,133
4	M.Farhan W	0,266	0,3	0	0,566
5	Ziraya Agustina	0,133	0	0,266	0,399
6	Nurul Oktavia	0,133	0,18	0,266	0,579
7	Khalista Khumairoh	0,4	0,18	0,3	0,88
8	Hasya Amazila	0,4	0	0,3	0,7
9	Halid Ramadan Padana	0	0	0	0
10	M.Afzal Alif	0	0,3	0	0,3

f) Determining the Final Value (Ranking)
Based on the data in Table 8, the recommendation is determined using a threshold value of 0.50. If the final value meets or exceeds this threshold, the individual is categorized as eligible to receive the vaccine.

Table 8: Final Values
[Source: Author, 2026]

Alternative Name	Ranking	Final Result	Recommendation
Khalista Khumairoh	1	0,88	Ya
Hasya Amazila	2	0,7	Ya
Nabila Hanin Ramadani	3	0,579	Ya
Nurul Oktavia	4	0,579	Ya
M.Farhan W	5	0,566	Ya
Anindiya Nabiha	6	0,433	Tidak
Ziraya Agustina	7	0,399	Tidak
M.Afzal Alif	8	0,3	Tidak
Ata Aldan Alfalah	9	0,133	Tidak
Halid Ramadan Padana	10	0	Tidak

2.2.3. Prototype Planning

a) Proposed System Design

The proposed system design is created using flowcharts. The current existing system can be seen in Figure 1, while the proposed system design can be seen in Figure 2.

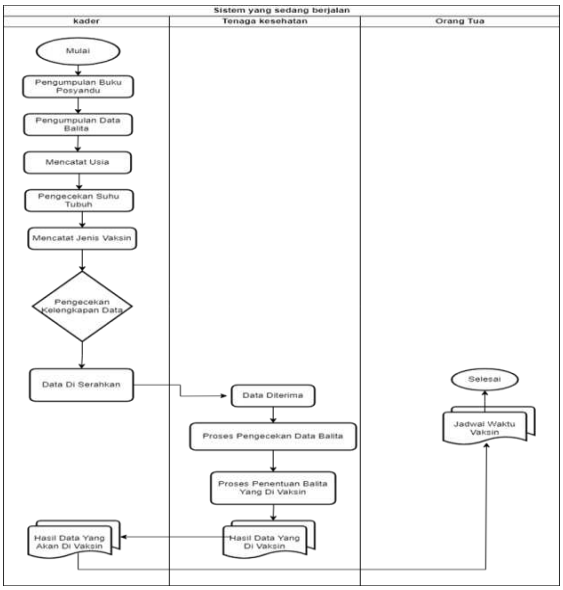

Figure 1: Current System Workflow
[Source: Author, 2026]

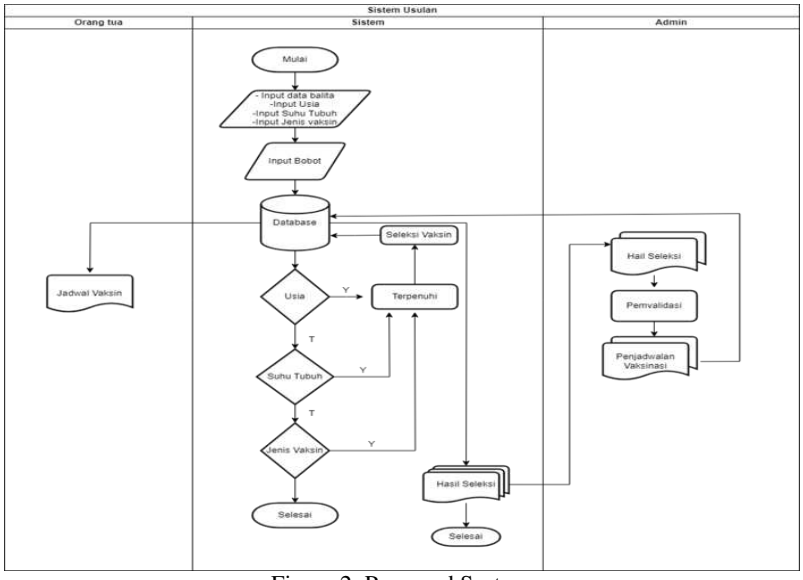

Figure 2: Proposed System
[Source: Author, 2026]

b) *ERD (Entity Relationship Diagram)*

*ERD (Entity Relationship Diagram)*This illustrates the relationship between entities. The ERD also explains the relationships for each entity within the system being developed. For further details, the ERD of the system design can be seen in Figure 3.

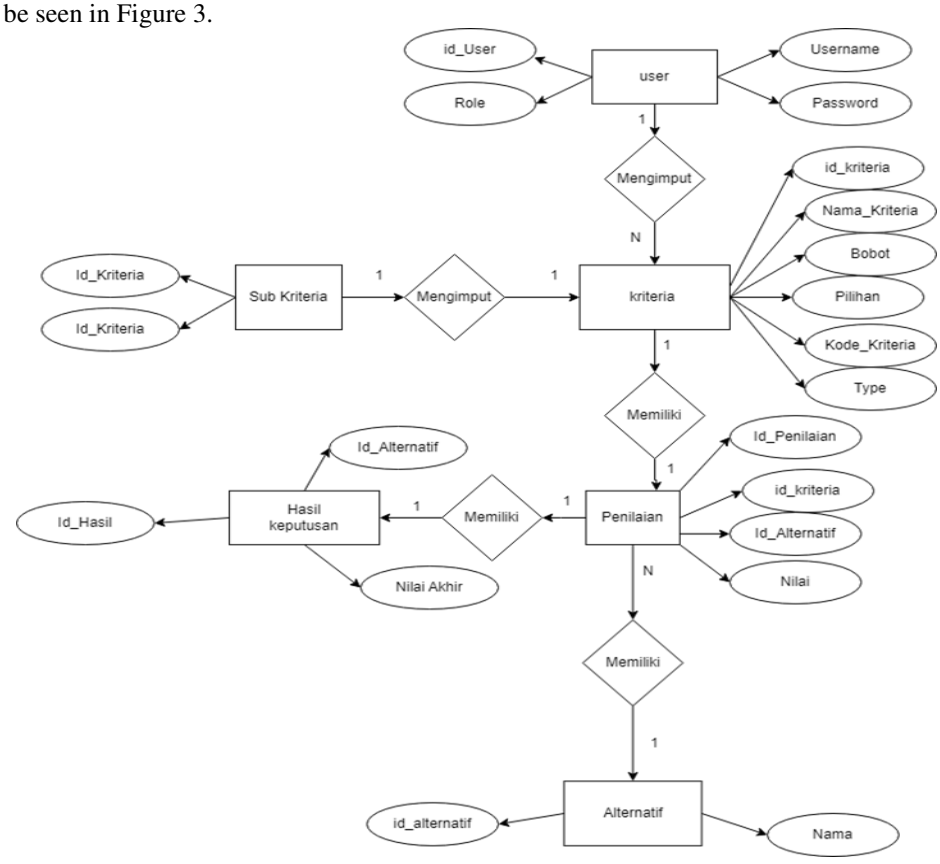

Figure 3: Proposed System ERD
[Source: Author, 2026]

c) *Data Flow Diagram (DFD)*

1) Context Diagram

Context Diagram of the DSS for toddler vaccination coverage at the Bunga Teratai Posyandu in Lokon Village using the SMART method. The Context Diagram itself explains the processes of the system/application, illustrating the tasks performed by the cadre or admin, the outputs provided by the application, and the information received by the students. The context diagram can be seen in Figure 4.

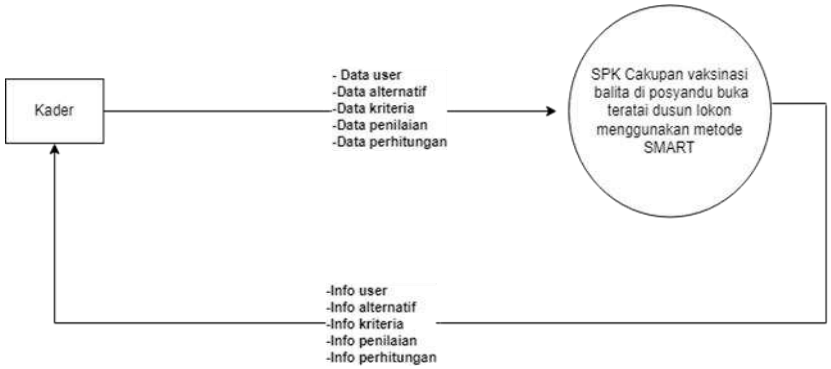

Figure 4 ContextDiagram
[Source: Author, 2026]

2) DFD Level 0: DSS for Vaccination Candidate Selection using the SMART Method
This Level 0 DFD explains the flow of each process and the overall system. It illustrates how input is transformed into output within the developed system. For further details, please refer to Figure 5.

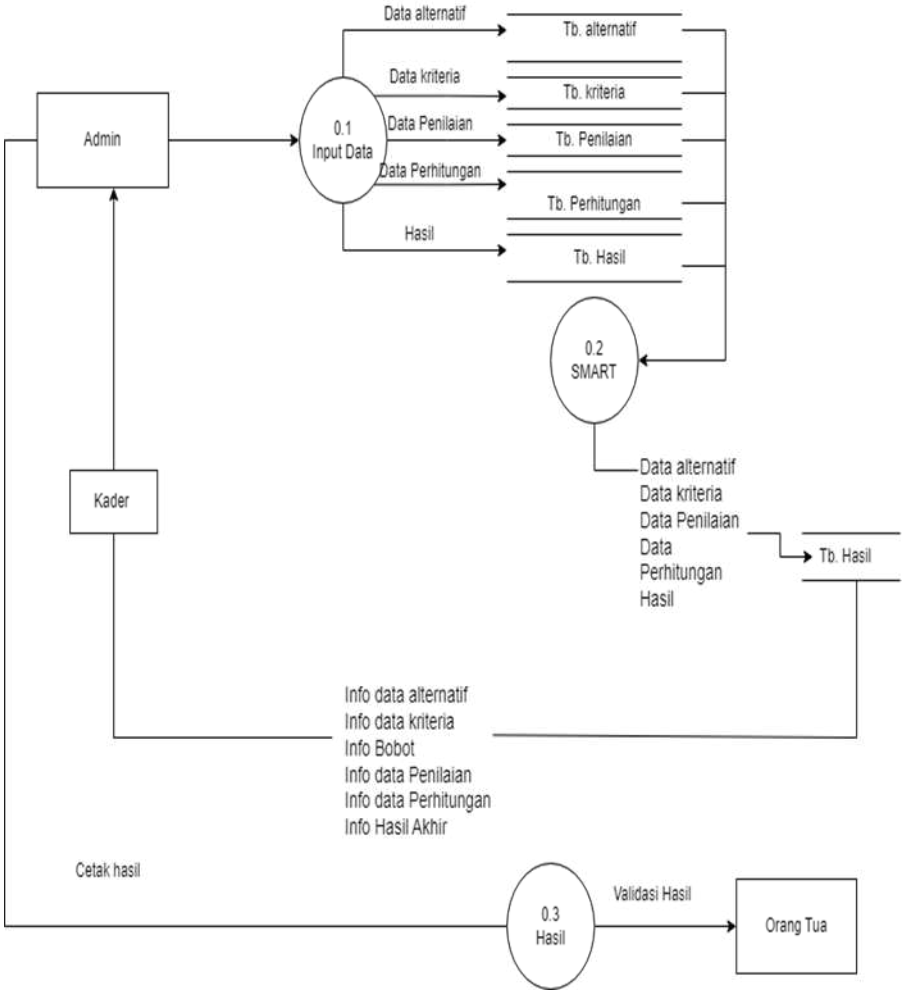

Figure 5: DFD Level 0: DSS for Vaccination Candidate Selection using the SMART Method
[Source: Author, 2026]

3) DFD Level 1 and Level 2: DSS for Toddler Vaccination Selection using the SMART Method
The Context DFD in Figure 4 and the Level 0 DFD in Figure 5 are further elaborated in the Level 1 DFD shown in Figure 6, which provides a detailed breakdown of the DSS for Toddler Vaccination Selection using the SMART method. The Level 1 DFD can be seen in Figure 6.

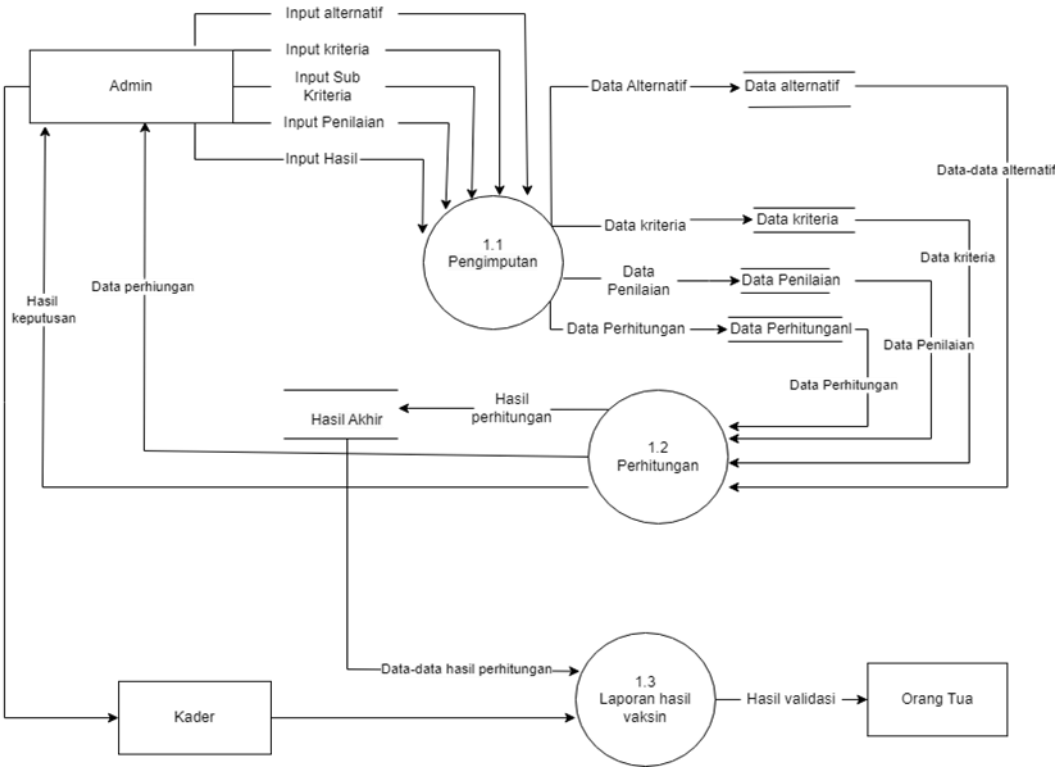

Figure 6: DFD Level 1 and Level 2: DSS for Toddler Vaccination Selection using the SMART Method
[Source: Author, 2026]

4) Calculation Process

The calculation process for the input data is further detailed in the Level 2 DFD, as shown in Figure 7 below:

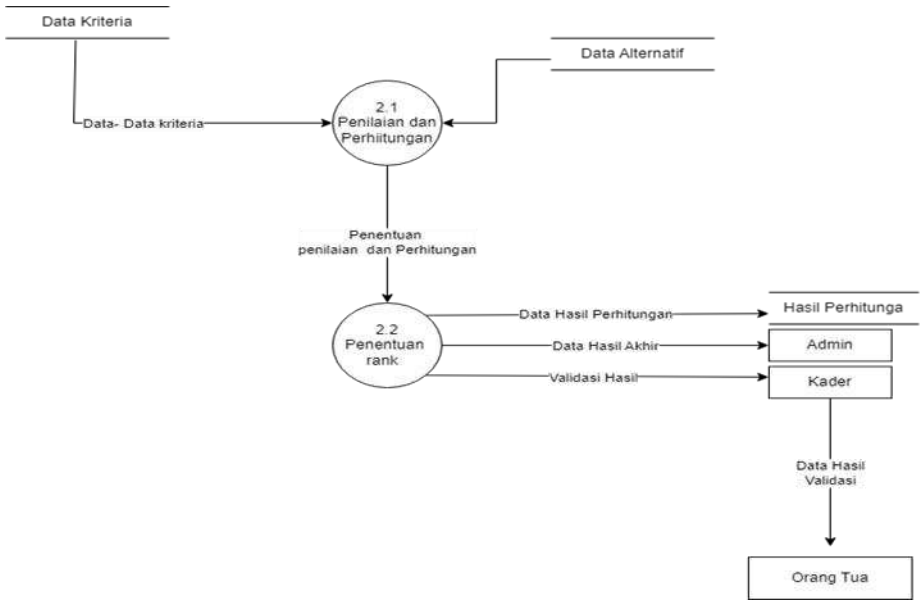

Figure 7 DFD Level 2 Calculation Process
[Source: Author, 2026]

Figure 7 explains the calculation of criteria weights with their respective alternative values. The results of these calculations, using the SMART method, will determine the selection outcome. Following the calculation process, a selection process is conducted to obtain the final result in the form of validation from Health Workers.

3. RESULT AND DISCUSSION

3.1 System Implementation and User Interface

The following are the interface displays of the program developed by the researcher for the Toddler Vaccination Candidate Selection Decision Support System at the Bunga Teratai Posyandu using the SMART method::

a. Login Page Interface

On this login page, the admin is required to log in first to be able to add, modify, and delete data within the application. The login page interface is shown in Figure 8.

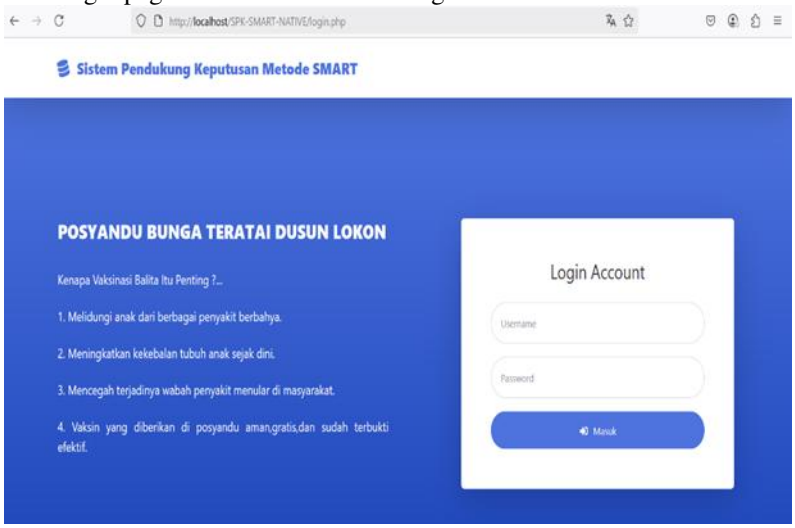

Figure 8 Login Page
[Source: Author, 2026]

b. Main Page

This page can only be accessed by the admin, who is responsible for managing data, specifically adding, updating, and deleting records. This page provides several menus consisting of criteria data, sub-criteria data, alternative data, assessment data, calculation data, final results data, user data, profile data, and a logout menu located in the profile image section. The page interface can be seen in Figure 9.

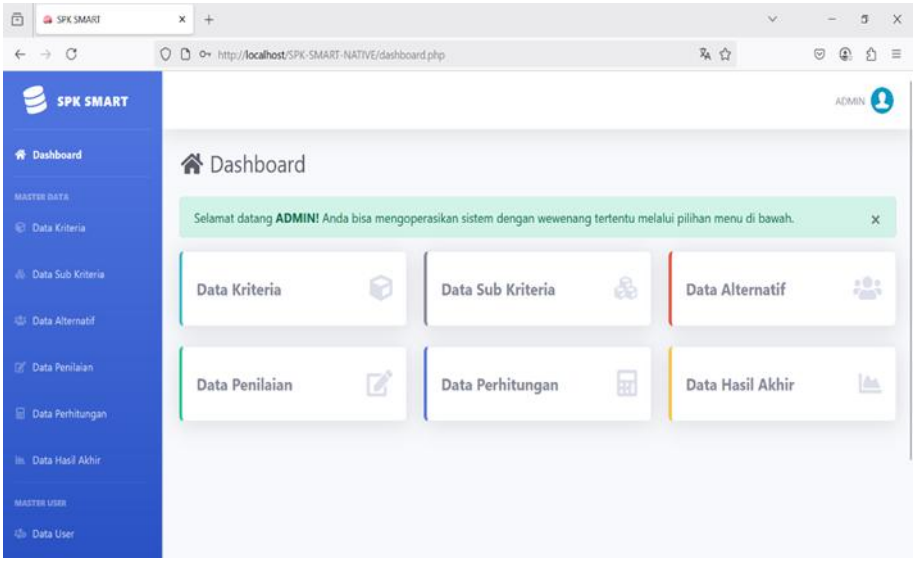

Figure 9 Main Page
[Source: Author, 2026]

c. Calculation Data Page

This page retrieves data from previous pages, such as the criteria and assessment pages, to be processed according to the SMART formula. The interface for the calculation data menu can be seen in Figure 10, Figure 11, Figure 12, and Figure 13..

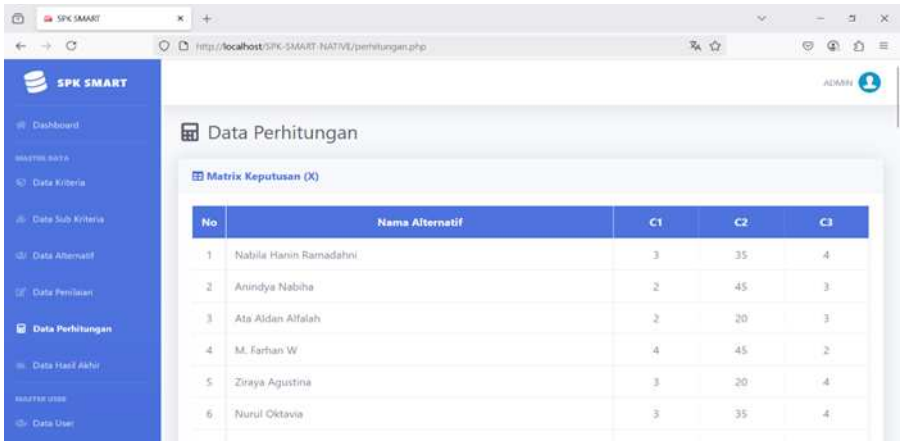

Figure 10 Calculation Page: Decision Matrix (X) Section
[Source: Author, 2026]

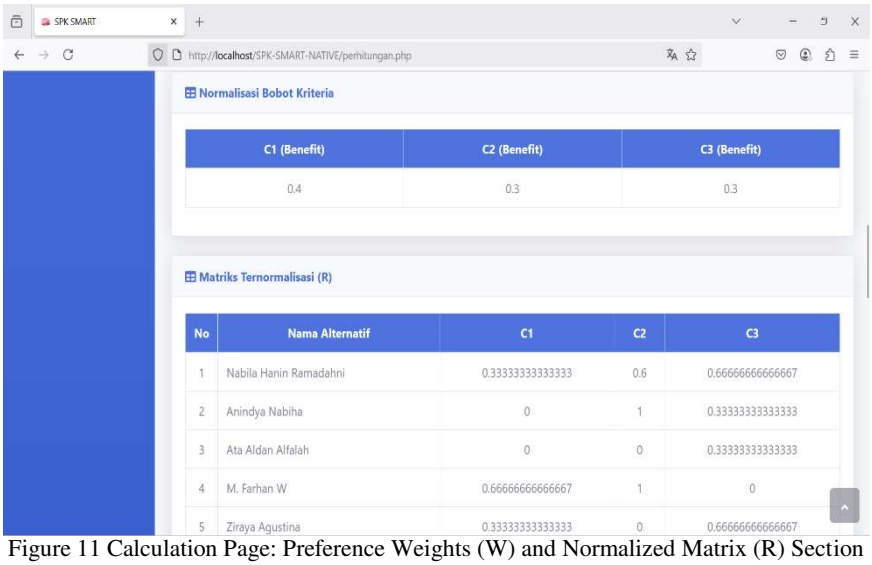

Figure 11 Calculation Page: Preference Weights (W) and Normalized Matrix (R) Section
[Source: Author, 2026]

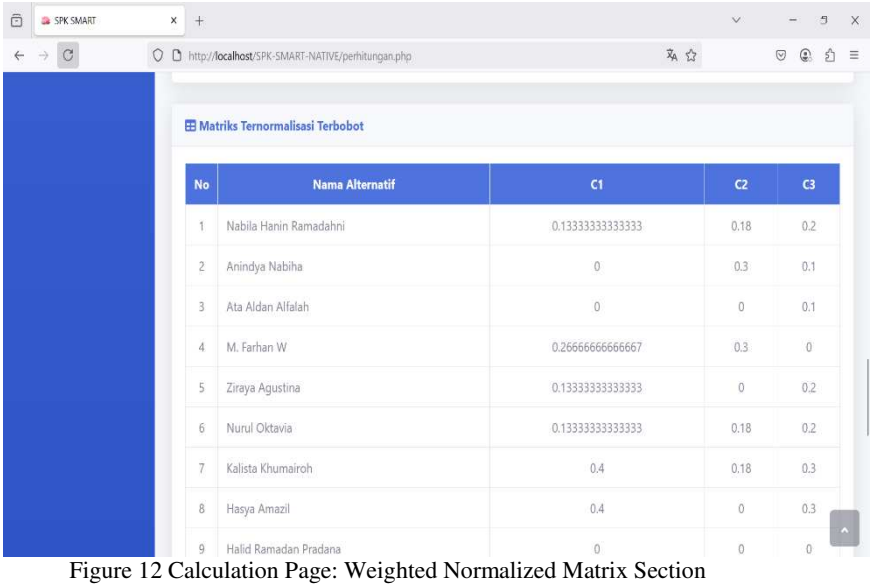

Figure 12 Calculation Page: Weighted Normalized Matrix Section
[Source: Author, 2026]

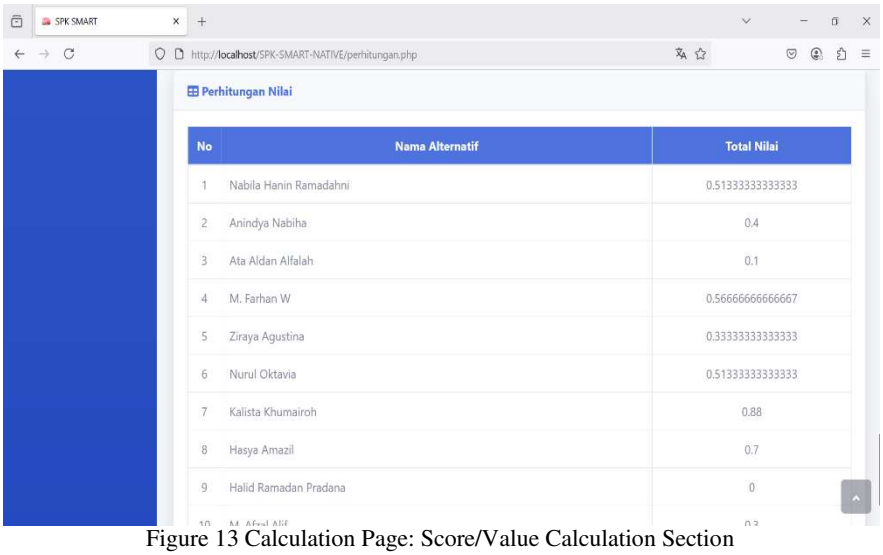

Figure 13 Calculation Page: Score/Value Calculation Section
[Source: Author, 2026]

d. Final Results Page

This page is the section where the Head of Cadres and Health Workers perform the validation of toddlers who qualify as candidates to be vaccinated immediately. The interface for this menu can be seen in Figure 14.

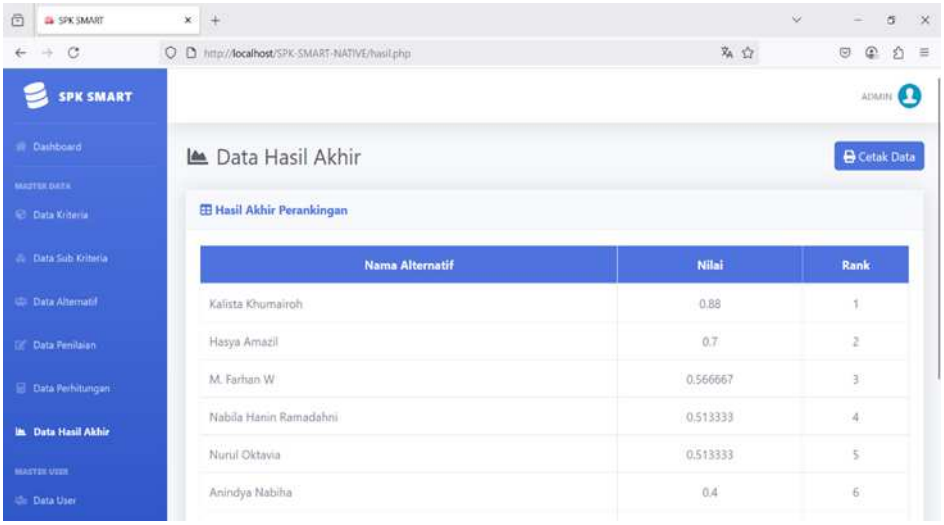

Figure 14 Final Results.
[Source: Author, 2026]

3.2 System Testing

At this stage, a system feasibility test will be conducted, which the author personally performed on the developed system. The results can be seen in Table 9..

Table 9: Testing Table
[Source: Author, 2026]

No	UJI COBA	RESULT	
		T	F
CRITERIA DATA PROCESS			
1	Proses Input	P	
2	Proses Update	P	
3	Proses Hapus	P	
SUB CRITERIA DATA PROCESS			

1	Proses Input	P	
2	Proses Update	P	
3	Proses Hapus	P	
ALTERNATIVE DATA PROCESS			
1	Proses Input	P	
2	Proses Update	P	
3	Proses Hapus	P	
ASSESSMENT DATA PROCESS			
1	**Proses Update**	**P**	
CALCULATION PROCESS			
1	Proses Menentukan Matrix keputusan (X)	P	
2	Proses Normalisasi Pembobotan (W)	P	
3	Proses Menentukan Matrix Ternormalisasi (R)	P	
4	Proses Menentukan Matrix Ternormalisasi Terbobot	P	
5	Proses Menentukan Perhitungan Nilai	P	
FINAL RESULT VALIDATION PROCESS			
1	Proses Validasi Perankingan	P	
2	Proses Cetak Data	P	
USER DATA PROCESS			
1	Proses Input	P	
2	Proses Update	P	
3	Proses Hapus	P	
PROFILE DATA PROCESS			
1	Proses Update	P	
2	Proses Hapus	P	

Based on the results of the testing analysis conducted by the author above, it can be concluded that the implementation of the system is in accordance with the design. However, there are still shortcomings in some areas and imperfections in terms of form, features, and interface.
In addition, the author also performed a comparison between the calculation results from the developed application and the manual calculations, which can be seen in Table 10..

Table 10: Comparison Table of Manual and System Calculations
[Source: Author, 2026]

NO	Calculation	Match	Mismatch
1	Menentukan Matrix keputusan (X)	P	
2	Pembobotan Preferensi (W)	P	
3	Menentukan Matrix Ternormalisasi (R)	P	
4	Menentukan Matrix Ternormalisasi Terbobot	P	
5	Menentukan Nilai Akhir Utility	P	
6	Menentukan Perankingan	P	

Based on the comparison results above, the manual calculations and those performed by the developed application are consistent; the only difference lies in the decimal rounding.

4. CONCLUSION

Based on the results of the system development process, from the design phase to the implementation of the Decision Support System for Vaccinated Toddler Selection using the SMART method, it can be concluded that this application can assist in providing suggestions and recommendations for toddlers who urgently need vaccination at the Bunga Terati Posyandu, Lokon Hamlet. By utilizing this Decision Support System, the selection process for toddlers to be vaccinated becomes easier and more time-efficient. Through this application, Cadres, the Head of Cadres, and Health Workers can identify which toddlers should prioritize receiving vaccination services. Furthermore, the application successfully performs data input, deletion, and updates, as well as executing the required calculations accurately.

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