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Application of Naive Bayes and Forward Chaining Methods in a Web-Based Expert System for Stunting Diagnosis in Toddlers

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ABSTRACT

The high rate of stunting in toddlers shows the need for accurate early diagnosis to prevent long-term impacts on children's growth and development. One of the main obstacles to early diagnosis is parents' lack of knowledge about the early symptoms of stunting, so treatment is often delayed. To overcome this problem, a web-based expert system was developed that applies the Naïve Bayes and Forward Chaining methods in diagnosing stunting in toddlers. The Naïve Bayes method is used to calculate the possibility of stunting based on the symptoms experienced by toddlers. This method is a probability-based algorithm that is used to classify the possibility of a condition based on existing symptoms. The process begins by calculating the probability of each symptom of stunting disease based on historical data that has been collected from experts. Then, using Bayes' Theorem, the system calculates the greatest probability of a disease based on the symptoms selected by the user. The final output is the diagnosis that has the highest probability, along with the recommended solution. Meanwhile, Forward Chaining is used to trace the rules that lead to a diagnosis conclusion. The Naïve Bayes method focuses more on calculating probabilities to determine a diagnosis with a certain level of confidence, while the Forward Chaining method works by matching rules to obtain conclusions based on the facts provided. The combination of these two methods allows the expert system to make a more accurate diagnosis by considering the probabilities and rules set by the expert. The web-based system built using these two methods aims to help parents detect stunting in toddlers early, so they can immediately take appropriate preventive or treatment steps. The results of the research show that it is found that the symptoms experienced by children are likely to be diagnosed as Not Stunting with the highest value of 0.5192 or around 51.9% with the solution being that children who do not experience stunting show growth and development appropriate to their age. The system developed is able to provide diagnoses in accordance with expert evaluations, so that it can be used as a tool to assist parents in providing.

I. INTRODUCTION

Stunting is a condition of failure to grow in children under five due to chronic malnutrition, especially in the first 1,000 days of life (HPK). Short toddlers (stunting) is a nutritional status based on the PB/U or TB/U index where in the anthropometric standard for assessing children's nutritional status, the measurement results are at the threshold (Z-Score) < -2 SD to -3 SD (short/stunted) and < -3 SD (very short/severely stunted) measured from the child growth standards issued by WHO [1].

Stunting occurs when the fetus is still in the womb and only appears when the child is two years old. Malnutrition at an early age increases infant and child mortality, causing sufferers to get sick easily and have a suboptimal posture as an adult [2]. Stunted children have an average Intelligence

Quotient (IQ) score eleven points lower than the average IQ score in normal children [3]. In 2018, stunting threatened the lives of children aged <5 years around 7.3% or 49 million children globally. This means that for every 5 children, there is 1 child who is stunted. In addition, Southeast Asia accounts for around 25% of stunting cases. This is relatively high compared to East Asia and West Asia. Indonesia is one of the countries that has a very high risk for stunting cases. According to data obtained from Basic Health Research (Riskesdas), in 2013, stunting cases occurred in 37% of children under the age of five, or nearly nine million children in Indonesia [4]. However, what needs to be noted is that children with short bodies do not necessarily experience stunting. Because stunting can only occur when there is a lack of daily nutritional intake so that it affects the development of the child's height. Stunting is caused by many factors, both direct and indirect. Factors are directly determined by food intake, birth weight and disease. Meanwhile, indirect factors such as economic factors, education and employment, health service facilities [5].

Early detection of stunting is one of the important things in the child's growth period. Often parents see the development and growth of their children only based on weight and assume that the nutritional status of their children is good without the need to check with a nutritionist. This is sometimes the cause of children experiencing stunting and delays in handling [6]. Children who suffer from stunting may never reach the normal height they should have and their brains are unable to develop their cognitive abilities perfectly. This is detrimental to their lives in the future, both in terms of learning, and socializing with their community [7].

Therefore, a system is needed that can help the community, especially the elderly, in the process of detecting early symptoms of the disease. Detecting the symptoms of stunting in toddlers can be applied an expert system that can be used is a computer system designed to do or match or imitate the abilities of an expert or expert. An expert system is a computer-based system built based on facts, knowledge, and reasoning that can help solve a problem. The problems that occur can often only be solved by people who are competent in a field and are difficult for ordinary people to solve [8]. The expert system can be applied in various fields, one of which is the health sector, which can be applied in health centers, clinics engaged in the medical world and hospitals. The reason why the expert system was chosen can help detect stunting in toddlers is because one of the benefits obtained by developing an expert system is that non-expert laypeople can take advantage of expertise in the field of expertise without the direct presence of an expert [9].

Some previous studies used the Bayes method that had been conducted before. Among them is the Implementation of the Forward Chaining and Naïve Bayes Methods to the Talent Determination Expert System. The result of the study was the level of test accuracy with 20 data testing of 95% and a precision value of 96% and a recall value of 100%. In the system performance test, there is one error in the results of the consultation on the system that is not in accordance with the expert data, but for the rest of the data, there is no data error obtained and accurate values are obtained according to the calculation of the system performance test [10].

The Naïve Bayes method focuses more on calculating probabilities to determine a diagnosis with a certain level of confidence, while the Forward Chaining method works by matching rules to obtain conclusions based on the facts provided. The combination of these two methods allows the expert system to make a more accurate diagnosis by considering the probabilities and rules set by the expert.

Use of the Naive Bayes method due to the ability to overcome uncertainty. In diagnosing disease, the symptoms that appear can vary and are not always certain. Naïve Bayes uses probability to deal with this uncertainty by calculating the probability of a disease based on existing symptoms. Naïve Bayes uses the assumption that each symptom is independent of each other, so the calculations are simpler and more efficient than more complex rule-based methods. Despite its simple assumptions, this method often provides fairly accurate results in most cases. Diagnosis in expert systems generally involves grouping a health condition into a certain category (for example "stunting" or "not stunting"). Naïve Bayes is one of the best classification algorithms that is able to predict categories with a high level of accuracy.

Forward Chaining is combined with Naïve Bayes in a diagnosis expert system because this combination can increase the accuracy and effectiveness of the system in making decisions. Here are some of the main reasons: Combination of Probabilistic and Rule-Based

Naïve Bayes uses a probabilistic approach to determine the probability of a disease based on given symptoms. Forward Chaining uses a rule-based approach (IF-THEN) to infer a diagnosis based on known symptoms. By combining the two, the system can rely on probabilities from Naïve Bayes to determine the likelihood of disease, then strengthen the conclusions with the rules established in Forward Chaining. Then, increase Diagnostic Accuracy. Naïve Bayes provides results based on probability, but does not directly consider the relationship between symptoms. Forward Chaining allows the system to logically trace symptoms one by one, thereby providing additional validation of the results obtained from the Naïve Bayes method. This combination helps in reducing the possibility of misdiagnosis and increases the accuracy of system decisions.

The rules used in this system follow the following pattern: If a certain number of symptoms are met, the system will conclude the appropriate disease. Rules are determined based on a combination of symptoms that have been identified by experts. Forward Chaining works from facts (symptoms) to conclusions (diagnosis).

Based on this, the researcher will also compare in terms of the difference in the object being studied (Talent Interest) by

the researcher above, whether the Naïve Bayes and Forward Chaining methods can also be applied to stunting objects in toddlers until the application developed is able to provide solutions like an expert as has been done by previous researchers. This study aims to build an expert system to detect stunting by applying the naïve bayes and forward chaining methods. The expert system will diagnose stunting disease based on the symptoms experienced and provide solutions regarding actions that must be taken to overcome problems in handling stunting in toddlers [11].

II. METHOD

This type of research is field research, which is conducting research by collecting data from the field. Judging from the type of data, the research approach used in this study is a qualitative approach. A qualitative approach is a method that describes phenomena from the perspective of informants, discovers diverse realities and develops a holistic understanding of a phenomenon in a particular context [4].

The selection of this type of research is based on the research objectives and data on the symptoms of stunting children, the existing symptoms will affect the conclusion in the form of a child diagnosis. The following is the research framework in this study.

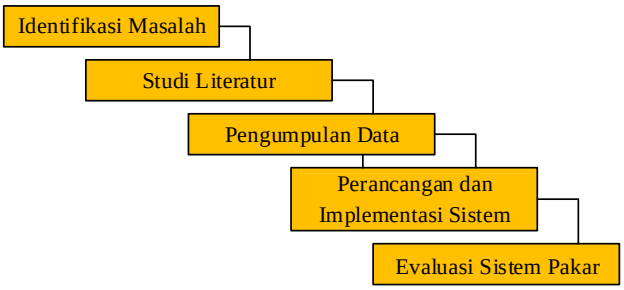

Figure 1. Research Stages

A. Problem Identification

The identification of problems in the creation of an expert system for diagnosing stunting in toddlers focuses on the lack of knowledge of novice users in detecting and diagnosing stunting problems in toddlers. Many users have difficulty recognizing the symptoms of stunting and determining the right treatment. For this reason, researchers developed a web-based expert system to assist users in diagnosing stunting in toddlers. This system works by identifying the symptoms that appear in toddlers, which are then associated with possible stunting conditions and providing appropriate solutions based on the results of the diagnosis.

B. Literature Studies

At this stage, literature studies are carried out as a basis to obtain rting theories for research. The literature is obtained from scientific articles, books, and ebooks from the internet that cover theories about Expert Systems, Naïve Bayesian methods, Forward Chaining and Stunting.

C. Collection Data

Data collection was carried out through interviews and orvations at the Asam Kumbang Auxiliary Health Center to obtain data and information about stunting diseases in toddlers. In addition, data was also obtained from an expert who provided solutions related to handling stunting in toddlers.

D. System Design and Implementation

The design stage in this study includes several aspects, including knowledge base, rule base, process design, database, and interface design. The implementation stage of this expert system is built using the PHP programming language by applying the Naïve Bayes method for decision-making. The software used in the creation of this system includes Visual Studio Code, XAMPP, and web browsers.

E. Expert System Evaluation

This system evaluation stage is a stage to see the reliability of a system, whether the system we create is in acco with the existing provisions and in accordance with the expected desires and the extent to which the system is implemented. In addition, this study also uses the Naïve Bayes method and the Forward Chaining method to calculate the weighting of the value of the symptom data provided by experts through interviews, then the results of the calculation will provide a diagnosis of stunting disease in toddlers.

1. Naïve Bayes

Naïve Bayes is a method used to calculate the property, the occurrence of an event based on the influence obtained from the results of observation. Bayes' theorem refers to a classification system that uses probability and statistical techniques developed by Thomas Bayes, a scientist from England [12].

Naive Bayes uses conditional probability as a foundation and a direct level of categorization based on the observed features, being able to predict the odds from the previous period. In determining probability or opportunity, it can be found using the following equation [13] :

$$P(H/E) = \frac{P(E/H_i).P(H_i)}{\sum_{i=0}^{n} P(E/H_k).P(H_k)}$$

Based on these symptom data, the following calculations can be made:

1) Find the Probability of Each Symptom

In this process, the probability of symptoms entered by the user for each disease will be searched, for example, G01 x G02 x G03 in P01, namely Stunting disease, the value of the symptom weight given by the expert is then multiplied

by the disease weight value (the probability of the disease occurring without looking at the symptoms). This calculation is carried out until the 3rd disease.

1. P (E|H1) P(H1) = (G01 x G02 x G03 x G04 x G07 x G08 x G012) x P01
= (0.9 x 0.9 x 0.8 x 0.8 x 0.8 x 0.8 x 0.8) x 0.7
= **0. 1858**

2. P (E|H2) P(H2)= (G15 x G16 x G20) x P02
= (0.8 x 0.8 x 0.8) x 0.3
= **0.1536**

2) Find the Total Number of Probabilities

The results of multiplying the values above are added together to find the total probability.

$\sum_{k=1}^{H} P(E/Hk)\ P(Hk)$ = 0.1858 + 0.1536
= 0.3394

3) Then the results of each probability are:

1. $P(H1/E) = \frac{P(E/H1).P(H1)}{\sum_{k=1}^{H} P(E/H1).P(H1)} = \frac{0.1858}{0.3394}$ = 0.5474

2. $P(H2/E) = \frac{P(E/H2).P(H2)}{\sum_{k=1}^{H} P(E/H2).P(H2)} = \frac{0.1536}{0.3394}$ = 0.4526

From the conclusion of the probability calculation above, it is found that the symptoms experienced by the child are likely to be a diagnosis of Stunting disease with the highest value of 0.5474 or around 54.7% with the solution being to provide foods high in protein (lean meat, fish, nuts), complex carbohydrates (brown rice, wheat), as well as vegetables and fruit that are rich in nutrients. Provide nutritional supplements, such as iron, vitamin A, and vitamin D. Conduct regular growth monitoring to evaluate response to interventions and ensure optimal growth.

Case example 2: Suppose a child aged 3-4 years experiences symptoms. The toddler's weight tends to decrease, the toddler shows very poor memory, the toddler has difficulty concentrating or focusing on an activity, the toddler appears lethargic or lacks enthusiasm, the toddler shows a good appetite, the toddler's head circumference is according to development standards for his age, the toddler's muscles and bones look strong and healthy, the toddler has good body posture, the child's behavior is interactive and responsive, and there are no symptoms of edema (swelling on the body).

Based on these symptom data, the following calculations can be made:

1) Look for the Probability of Each Symptom

In this process, the probability of symptoms entered by the user for each disease will be searched, for example, G01 x G02 x G03 in P01, namely Stunting disease, the value of the symptom weight given by the expert is then multiplied by the disease weight value (the probability of disease occurrence without looking at the symptoms). This calculation is carried out until the 3rd disease.

1. P (E|H1) P(H1) = (G02 x G07 x G08 x G09) x P01
= (0.9 x 0.8 x 0.8 x 0.9) x 0.4
= **0. 2074**

2. P (E|H2) P(H2) = (G15 x G17 x G18 x G19 x G20 x G21) x P02
= (0.8 x 0.9 x 0.9 x 0.8 x 0.8 x 0.9) x 0.6
= **0.2239**

2) Find the Total Number of Probabilities

The results of multiplying the values above are added together to find the total probability.

$\sum_{k=1}^{H} P(E/Hk)\ P(Hk)$ = 0.2074 + 0.2239
= **0. 4313**

3) Then the results of each probability are:

1. $P(H1/E) = \frac{P(E/H1).P(H1)}{\sum_{k=1}^{H} P(E/H1).P(H1)} = \frac{0.2074}{0.4313}$ = 0.4808

2. $P(H2/E) = \frac{P(E/H2).P(H2)}{\sum_{k=1}^{H} P(E/H2).P(H2)} = \frac{0.2239}{0.4313}$ = 0.5192

From the conclusion of the probability calculation above, it is found that the symptoms experienced by the child are likely to be a diagnosis of Not Stunting disease with the highest value of 0.5192 or around 51.9% with the solution being that children who do not experience stunting show growth and development appropriate to their age. To support and maintain optimal health, make sure your child gets a balanced diet that includes protein, complex carbohydrates, healthy fats, and nutrient-rich vegetables and fruit. Provide adequate intake of vitamins and minerals, such as vitamin A, vitamin D, iron, and calcium, to support good health and growth. Encourage children to be physically active through age-appropriate games and sports, and monitor growth regularly to ensure healthy development.

2. Forward Chaining

Forward chaining is one of the expert system methods used for forward tracking, which starts from a problem and ends with a solution. This method is used to find new facts using a set of rules that have been adjusted to the facts [14]. The Forward Chaining method is a search technique that starts with known facts, then matches those facts with the IF part of the IF-THEN rule. If there are facts that match the IF section, then the rule is executed. When a rule is executed, then a new fact (the THEN part) is added to the database. Each rule can only be executed once. The search process

with the Forward Chaining method departs from left to right, namely from the premise to the final conclusion, this method is often called data-driven, i.e. the search is controlled by the data provided [15].

III. RESULT AND DISCUSSION

As for the description of the system flow chart of the application of the Naive Bayes and Forward Chaining methods in designing an expert system application to diagnose stunting in toddlers in patients, the following is the flowchart on the application that was built :

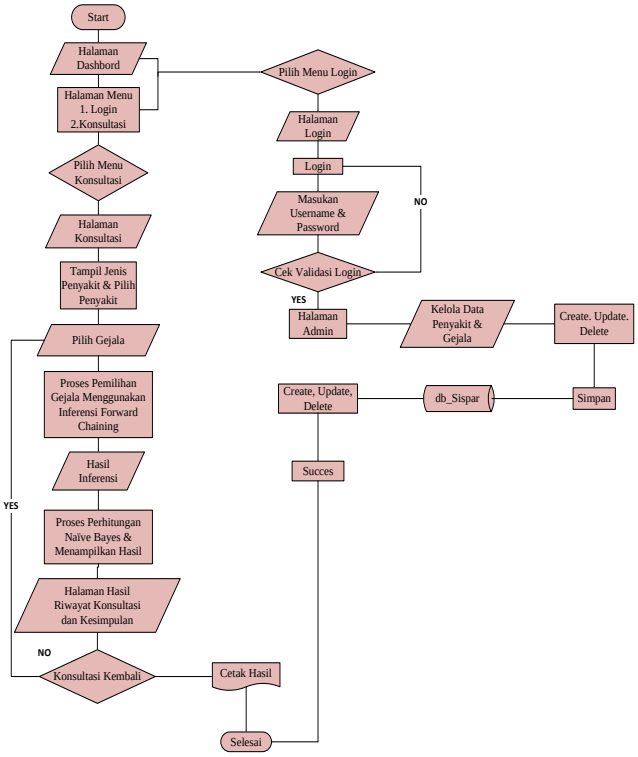

Figure 2. System Flowchart

The following interface will explain the results of the program design which can be seen as follows :

A. Main Page

The main page is the initial view when the application is accessed. On this page there is an admin and consultation menu, the description designed is as follows :

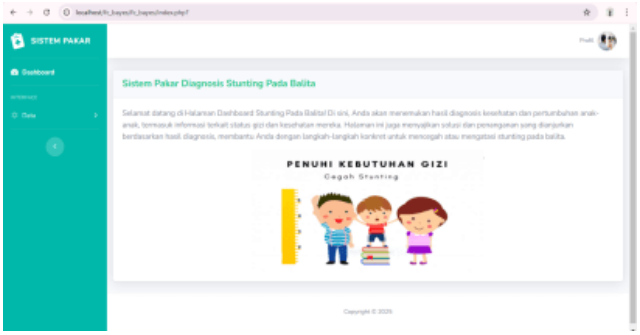

Figure 3. Main Page

B. Consultation Page Display

On this page is an overview of the patient consultation menu, where the patient conducts a consultation by selecting the symptoms felt by the patient, then the patient or user chooses on the available button, yes or no.

Figure 4. Consultation Page

C. Diagnosis Results Page

The Naïve Bayes method is used to calculate the likelihood of a child experiencing stunting based on the symptoms observed. This approach enables the system to classify cases based on probabilities derived from historical data collected from experts. By applying Bayes' Theorem, the system can determine the highest probability of a condition based on the symptoms entered by the user. For instance, research findings indicate that in a certain scenario, the probability of a child not experiencing stunting has the highest value of 51.9%, prompting the system to provide appropriate recommendations.

On the other hand, the Forward Chaining method works by tracing rules established by experts to draw conclusions. This approach ensures that the diagnosis provided is not only based on probability but is also supported by logical rules structured according to expert knowledge. Thus, the system does not rely solely on statistical calculations but also applies relevant medical rules to enhance diagnostic accuracy.

This diagnosis results page contains the results of the diagnosis of the disease after the user or user enters the symptoms experienced in the form of diseases suffered by the patient with the highest score results and there is a solution. The page view of the consultation page can be seen as follows:

Figure 5. Diagnosis Results Page

D. *Admin Login Page Display*

The admin page is a page that can only be accessed by admins. On this page, the admin manages the data on the application. To access the admin page, the admin first logs in to the system by entering the username and password.

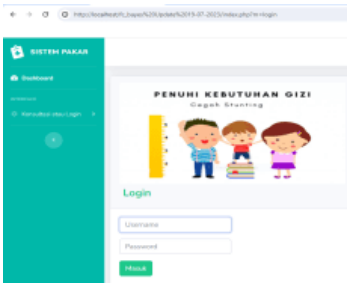

Figure 6. Admin Login Page Display

E. *Admin Menu Main Page Display*

On the main admin page is the initial display when the admin login is accessed. Admins can change their personal data in the profile edit group. On the admin page, there are 5 menu options, namely disease diagnosis data, symptoms, relationships, rules and consultations.

Figure 7. Admin Menu Main Page Display

F. *Disease Page Display*

On this page, admins can manage disease data. On this page, admins can view disease data and can change disease data.

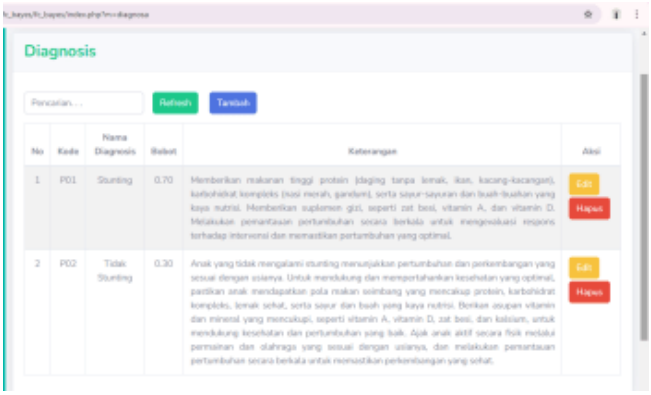

Figure 8. Disease Page Display

G. *Display of Symptoms*

On this page is an overview of the symptom page that can be managed by admins to add, change, and delete symptom data.

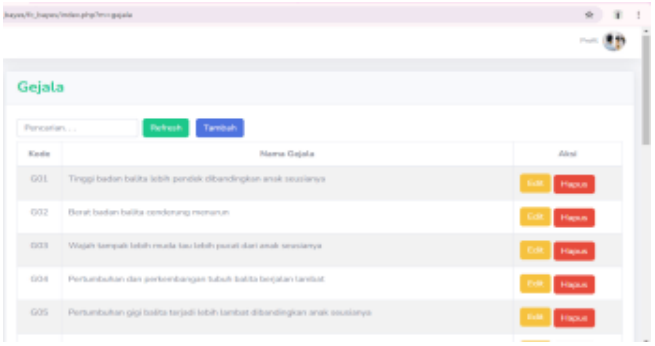

Figure 9. Display of Symptoms

H. *Relationship Page Display*

On this page is an overview of the relationship page which contains about diseases, symptoms, weight, which can be managed by the admin.

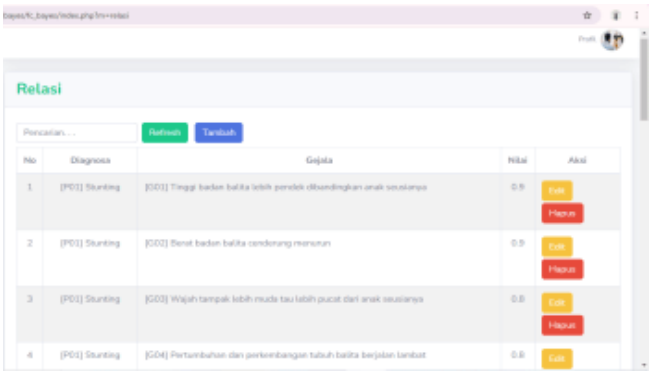

Figure 10. Relationship Page Display

I. Forward Chaining Rules Page View

This page is an overview of the forward chaining rules page based on symptoms and facts.

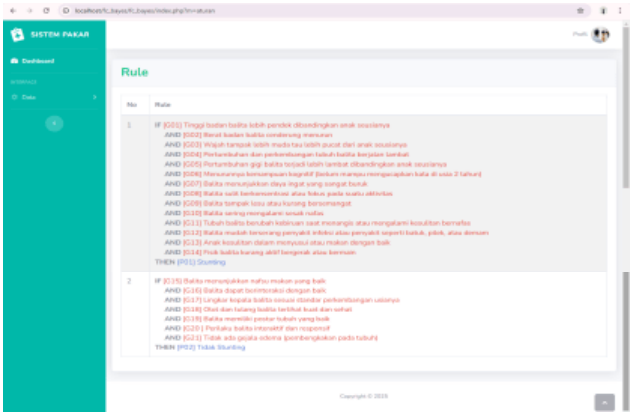

Figure 11. Forward Chaining Rules Page View

The primary advantage of this system is its ability to integrate two different approaches to achieve more accurate results. With the implementation of a web-based system, accessibility for parents is improved, allowing them to easily assess the potential risk of stunting in their children without relying solely on direct medical examinations at healthcare facilities. This can contribute to early detection and faster intervention, thereby minimizing the long-term impact of stunting. Although the research findings demonstrate the system's effectiveness in providing diagnoses that align with expert evaluations, there are several aspects that can be improved. One of these is enhancing the quality of historical data used in probability calculations, as well as further developing the rule-based system to accommodate more variables influencing stunting. Additionally, broader testing of this system in various conditions and larger populations will further strengthen its validity.

IV. CONCLUSIONS

Based on the description of the discussion, it can be concluded that the expert system for diagnosing stunting in toddlers has been successfully implemented using the Naïve Bayes and Forward Chaining methods and has been successfully applied so that it can be used. This expert system is used to diagnose and provide treatment or the first solution to stunting in toddlers. The existence of this web-based expert system will make it easier for experts and parents to diagnose stunting in toddlers. In the process of its development, this system is made based on current knowledge, so there needs to be future development to add new diseases and symptoms. This expert system can also be redesigned with other methods. Then it can be developed again with a better version and appearance.

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