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# Forward Chaining Method of Expert System to Detect Malnutrition for Toddlers

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***Abstract***

*Nutrition is really important for toddlers because it helps them grow both physically and mentally. To make sure toddlers and kids are growing properly for their age, they need to be checked regularly. Social community services are already helping mothers and toddlers, especially in rural areas. But there are still a lot of challenges, one of which is that there isn't enough technology to help social workers keep track of nutrition. According to the Health Ministry Regulation No. 2 of 2020, there are several ways to calculate nutrition, like checking body weight for age, body length for age, height for age, body weight for body length, and body weight for height, as well as body mass index for age. These calculations are based on measurements of the child's body, called anthropometry, and the results are used to check if a toddler is getting enough nutrition or if they are malnourished. The way they decide this is through a method called forward chaining. Using a special app that helps detect malnutrition makes it easier for social workers to do the calculations and save the data on an Android device without needing internet. When they tested the app with data from five children, it worked perfectly with 100% accuracy. This expert system can be used for mothers to independently check their children nutrition status themselves. Also, the application can also be used by the social workers in the healtcare facility.*

***Keywords:*** *Expert System, Forward Chaining, Malnutrition, Toddlers*

***Abstrak***

*Kebutuhan gizi yang cukup sangat penting bagi pertumbuhan balita. Di Indonesia, ada aturan khusus yang mengatur tentang gizi. Menurut Peraturan Menteri Kesehatan No. 2 Tahun 2020, standar perhitungan gizi secara umum dibagi mejadi Berat Badan menurut Umur (BB/U), Panjang Badan menurut Umur (PB/U), Tinggi Badan menurut Umur (TB/U), Berat Badan menurut Panjang Badan (BB/PB) atau Berat Badan menurut Tinggi Badan (BB/TB) dan Indeks Massa Tubuh menurut Umur (IMT/U). Status Gizi tersebut didapatkan dari perhitungan antropometri sehingga hasil perhitungan dapat digunakan sebagai acuan untuk menentukan status gizi, terutama pada balita yang sedang mengalami fase penting pertumbuhan kehidupan. Metode yang digunakan untuk menentukan status gizi adalah menggunakan metode forward chaining. Aplikasi sistem pakar dengan metode forward chaining untuk mendeteksi gizi buruk balita ini diharapkan dapat membantu kader posyandu dalam melakukan perhitungan gizi dan menyimpan data balita di dalam sistem android secara offline. Hasil pengujian aplikasi dengan 5 data balita didapatkan tingkat akurasi mencapai 100%. Aplikasi sistem pakar ini dapat digunakan oleh orang*

*tua untuk memantau status gizi balita mereka, maupun oleh tenaga medis atau kades posyandu dalam membantu menentukan status gizi balita sehingga lebih akurat dan cepat.*

***Kata Kunci:*** *Sistem Pakar, Forward Chaining, Gizi Buruk, Balita*

## 1. INTRODUCTION

Nowadays, technology has been developed rapidly, and one of them is the invention of application that can translate the opinion of an expert into a system or commonly called an expert system. An expert system is a system that adopts human work methods or knowledge to a computer designed to model problem abilities like an expert [1]. Expert systems make it simple for users to solve problems or simply ask an expert for information. Expert systems can be useful in the medical industry as well, for instance, in diagnosing patient symptoms of specific diseases.

A vital component of health is nutrition. The primary factor influencing a child's healthy development and growth is their diet. Future efforts to improve the quality of human resources will be hampered by children's malnutrition [2]. Determining nutritional status is one of the efforts to improve health in the growth of toddlers. It also makes it easier for parents to find out whether a toddler is suffering from malnutrition or good nutrition.

Social Community Service (Posyandu) is an activity carried out to monitor the health condition of pregnant women and children under five years (toddlers) every month [3]. The activities of the service are measurements of weight, height, and BMI (Body Mass Index) to determine the nutritional status of children. Posyandu activities are carried out by midwives and social workers using manual method. And for nutritional anthropometric calculations still use manual calculations. This resulted in posyandu activities being quite draining and time-consuming. Therefore, an android-based offline application is needed for inputting, calculating nutritional anthropometry automatically and the data is stored in a database.

Based on these problems, it is necessary to design an expert system application that has features for the Posyandu data input process and grouping the nutritional status of toddlers based on Android using the Forward Chaining method. The Forward Chaining method is a method of matching facts or statements starting from the left side (IF) to a conclusion [4].

## 2. RESEARCH METHOD

necessary to use appropriate methods to achieve research objectives. The method used in the research is as follows:

1. Data gathering
   The data collection method aims to collect the data needed to create the system. The data collection method in this study was interview with Mr. Showabi Ikhsan as the Treasurer, Observation and Literature Study
2. Forward Chaining method
   The forward chaining method is said to be an inference method that does reasoning on a problem in its solution [1]. Forward Chaining starts working with data that has rules leading to a conclusion clause (IF-THEN). When the rules have been found, the machine will look for conclusions (THEN). If the machine has not found a suitable rule then the machine will repeat this process until the target is found. The data used is data from Minister of Health Regulation No. 2 of 2020 is mapped into the Forward Chaining rules and divided according to the anthropometric index
3. Anthropometric method
   Anthropometry is the most commonly used method. Anthropometry from a nutritional point of view is divided into 4 indices: Weight for Age (BB/U), Body Length for Age (PB/U) or Height for Age (TB/U), Body Weight for Length (BB/PB) or Weight for Height (BB/TB) and Body Mass Index for Age (BMI/U) [5]. To calculate each anthropometric index using the z-score calculation. Z-score is a measure that determines how far a value is (from the observation of a sample set) to its average in standard deviation units [6]. The formula for calculating the z-score is:

Z-Score = (NIS – NMBR)/NSBR (1)

Notes:
NIS = Individual Value of Objects
NMBR = Reference Standard Median Value
NSBR = Reference Standard Deviation Value
The reference standard deviation value means the difference between cases with +1SD or -1SD standard [7].
If the result of the NIS minus the negative NSBR then the NSBR is -1SD. If NIS minus the Median is positive then NSBR is the value +1SD minus the median. When calculating the z-score for weight/age, NIS is body weight. When calculating the z-score for PB/U, NIS uses Body Length.

4. Waterfall method
This research method carries the concept of the waterfall which is one of the models of the System Development Life Cycle (SDLC) [8]. The stages in the waterfall model can be seen in the image below:

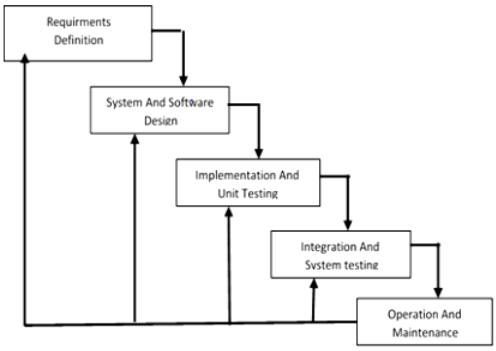


Figure 1. Waterfall method
(source: [9])

In Figure 1 it is stated that there are 5 stages of development using the waterfall method. Explanation of the stages in the waterfall method:

a. Requirements Definition
At this stage, the problem will be defined and the system requirements (software) will be gathered in the form of the desired input and output data.
b. System and Software Design
It is necessary to create a complete system flow in this step. Subsequently, a design for the Android application program that will be created must be formulated.
c. Implementation and Unit Testing
At this stage in the design process, the results are converted into a form comprehensible to machines, utilizing programming languages. The objective is to generate an application output that aligns with the researcher's preferences and requirements. Subsequently, the data is subjected to rigorous testing on the application.
d. Intergration and System Testing
The testing phase of the application process precedes its utilization. The objective of testing is twofold: first, to ascertain the suitability of the resulting data according to the specified criteria, and second, to identify and rectify any errors in the program code prior to its execution.
e. Operation and Maintenance
At this stage, maintenance is performed on applications that have been utilized. In the event that the application is found to contain bugs or errors in the system, the appropriate measures are taken to rectify the situation. These measures may include the implementation of repairs or the addition of features to the application.

## 3. RESULT AND DISCUSSION

### 3.1 Data description

**1. Data gathering**

The reference data used is the Anthropometric Standards for assessing the nutritional status of children originating from the Regulation of the Minister of Health no. 2 of 2020. The rules set are seen in Table 1 below.

Table 1 Category threshold for Toddlers Nutrition Status
(source: [5])

| Index | Nutrition Status | Z-Score |
|---|---|---|
| Weight for Age (BB/U) for children aged 0-60 months | Very Underweight | <-3 SD |
| | Underweight | - 3 SD sd <- 2 SD |

| | | |
|---|---|---|
| | Normal weight | -2 SD sd +1 SD |
| | The risk of being overweight | > +1 SD |
| PB / U and TB / U according to the age of children aged 0 - 60 months | Very short | <-3 SD |
| | Short | - 3 SD sd <- 2 SD |
| | Normal | -2 SD sd 3 SD |
| | Tall | > 3 SD |
| BB/PB or BB/TB children aged 0 - 60 months | Bad malnutrition | <-3 SD |
| | Light malnutrition | - 3 SD sd <- 2 SD |
| | Good | -2 SD sd +1 SD |
| | Risk of being overnutrition | > + 1 SD sd + 2 SD |
| | Overnutrition | > + 2 SD sd + 3 SD |
| | Obesity | > + 3 SD |
| Body Mass Index by Age (BMI/U) for children aged 0-60 months | Bad malnutrition | <-3 SD |
| | Light malnutrition | - 3 SD sd <- 2 SD |
| | Good | -2 SD sd +1 SD |
| | Risk of being overnutrition | > + 1 SD sd + 2 SD |
| | Overnutrition | > + 2 SD sd +3 SD |
| | Obesity | > + 3 SD |

Table 1 states the thresholds of guidelines for determining a child's nutritional status. After knowing the z-score value of the child, then match it with the category in table 1 in order to get the results of the nutritional status value.

2. Forward Chaining Method
   Rule of forward chaining can be seen in Table 2 below:

Table 2 Forward Chaining Rules

| No | Rules |
|---|---|
| 1 | IF age >= 0 AND age <= 60 AND BB/U > -3 THEN Very Underweight |
| 2 | IF age >= 0 AND age <= 60 AND BB/U = -3 AND BB/U > -2 THEN Underweight |
| 3 | IF AND age >= 0 AND age <= 60 AND BB/U = -2 AND BB/U < 1 THEN Normal weight |
| 4 | IF age >= 0 AND age <= 60 AND BB/U > 1 THEN The risk of being overweight |
| 5 | IF age >= 0 AND age<= 60 AND PB/U < -3 THEN Very short |
| 6 | IF age >= 0 AND age<= 60 AND PB/U > -3 AND PB/U <= -2 THEN Short |
| 7 | IF age >= 0 AND age<= 60 AND PB/U > -2 PB/U = 3 THEN Normal |
| 8 | IF age >= 0 AND age <= 60 AND PB/U > 3 THEN Tall |
| 9 | IF age >= 0 AND age <= 60 AND BB/PB atau BB/TB < -3 THEN Bad malnutrition |
| 10 | IF age >= 0 AND age<= 60 AND BB/PB atau BB/TB >= -3 AND BB/PB atau BB/TB < -2 THEN Light malnutrition |
| 11 | IF age >= 0 AND age<= 60 AND BB/PB atau BB/TB >= -2 AND BB/PB atau BB/TB <= 1 THEN Good |
| 12 | IF age >= 0 AND age<= 60 AND BB/PB atau BB/TB > 1 AND BB/PB atau BB/TB <= 2 THEN Risk of being overnutrition |
| 13 | IF age >= 0 AND age <= 60 AND BB/PB atau BB/TB < 2 AND BB/PB atau BB/TB <= 3 THEN Overnutrition |
| 14 | IF age >= 0 AND age <= 60 AND BB/PB atau BB/TB > 3 THEN Obesity |
| 15 | IF age >= 0 AND age<= 60 AND IMT/U < -3 THEN Bad malnutrition |
| 16 | IF age >= 0 AND age<= 60 AND IMT/U >= -3 AND IMT/U < -2 THEN Light malnutrition |
| 17 | IF age >= 0 AND age<= 60 AND IMT/U >= -2 AND IMT/U < 1 THEN Good |
| 18 | IF age >= 0 AND age<= 60 AND IMT/U >= 1 AND IMT/U < 2 THEN Risk of being overnutrition |
| 19 | IF age >= 0 AND age <= 60 AND IMT/U >= 2 AND IMT/U <= 3 THEN Overnutrition |
| 20 | IF age >= 0 AND age<= 60 AND IMT/U > 3 THEN Obesity |

In Table 2 is the making of forward chaining rules based on data from Minister of Health Regulation No. 2 of 2020. There is an experimental scenario for determining nutritional status as an example case of the forward chaining method. There is a toddler with the following facts:

Child A :
Male gender
Age : 6 Months
Body Weight: 8 Kg
Body Length: 70 cm

Based on this scenario, the first step is to calculate the z-score according to each anthropometric index. Calculation of the z-score for the above experimental scenario is described in the next point.

3. Anthropometric method
   a. Weight for Age (BB/U)
      Before calculating the z-score BB/U, the median value of the age of the toddler must be obtained. To see the median

value, it is available in Minister of Health Regulation No. 2 of 2020 Standard Weight by Age (BB/U) [10]. Table of Standard Weight for Age (BB/U) is as follows:

Table 3 Standard Weight for Age (BB/U) (source: [5])

| Age | Weight | | | | | | |
|---|---|---|---|---|---|---|---|
| | -3SD | -2SD | -1SD | Median | +1SD | +2SD | +3SD |
| 5 | 5.3 | 6.0 | 6.7 | 7.5 | 8.4 | 9.3 | 10.4 |
| 6 | 5.7 | 6.4 | 7.1 | 7.9 | 8.8 | 9.8 | 10.9 |
| 7 | 5.9 | 6.7 | 7.4 | 8.3 | 9.2 | 10.3 | 11.4 |

The next step is to calculate the z-score.

Z-Score = (NIS – NMBR)/NSBR (2)
= (NIS – NMBR)/NSBR
= (8 – 7.9)/NSBR
= 0.1/(7.9 - 7.1)
= 0.1/0.8
= 0.125

The rule used is rule number 3. So the weight/age status of child A is normal weight.

b. Body Length by Age (PB/U)
The indicator used in PB/U is the Body Length According to Age Standard (PB/U). Table of Standard Weight for Age (BB/PB) is seen in Table 4 below:

Table 4 Standard PB/U boys (source: [5])

| Age | Body Length | | | | | | |
|---|---|---|---|---|---|---|---|
| | -3SD | -2SD | -1SD | Median | +1SD | +2SD | +3SD |
| 5 | 59.6 | 61.7 | 63.8 | 65.9 | 68.0 | 70.1 | 72.2 |
| 6 | 61.2 | 63.3 | 65.5 | 67.6 | 69.8 | 71.9 | 74.0 |
| 7 | 62.7 | 64.8 | 67.0 | 69.2 | 71.3 | 73.5 | 75.7 |

Calculation of PB/U z-score for Child A:

Z-Score = (NIS – NMBR)/NSBR (3)
= (70 – 67.6)/(69.8-67.6)
= 2.4/(2.2)
= 1.09

The rule used is rule number 7. So, the PB/U status of child A is Normal.

c. Body Weight by Body Length (BB/PB)
The standard used for BB/PB is Body Length According to Age (BB/PB). The data used is body weight and body length. Table of Standard Weight for Age (BB/PB) is seen in Table 5 below:

Table 5 Standard BB/PB for boys (source: [5])

| TB | BBPB | | | | | | |
|---|---|---|---|---|---|---|---|
| | -3SD | -2SD | -1SD | Median | +1SD | +2SD | +3SD |
| 69.5 | 6.6 | 7.1 | 7.7 | 8.3 | 9.0 | 9.8 | 10.8 |
| 70.0 | 6.6 | 7.2 | 7.8 | 8.4 | 9.2 | 10.0 | 10.9 |
| 70.5 | 6.7 | 7.3 | 7.9 | 8.5 | 9.3 | 10.1 | 11.1 |

Calculation of the z-score BB/PB of child A:

Z-Score = (NIS – NMBR)/NSBR (4)
= (8 – 8.4)/( 8.4-8)
= (-0.4)/( 0.4)
= -1

The rule used is rule number 11. So, the BB/PB status of child A is Good Nutrition.

d. Body Mass Index by Age (BMI/U)
The benchmark used for BMI/U is the Body Length According to Age (IMT/U). The data used is body weight and body length. Table of Standard Body Mass Index by Age (BMI/U) is seen in Table 6 below:

Table 6 BMI/U standards for boys (source: [5])

| Age | Body Mass Index | | | | | | |
|---|---|---|---|---|---|---|---|
| | -3SD | -2SD | -1SD | Median | +1SD | +2SD | +3SD |
| 5 | 13.5 | 14.7 | 15.9 | 17.3 | 18.8 | 20.5 | 22.3 |
| 6 | 13.6 | 14.7 | 16.0 | 17.3 | 18.8 | 20.5 | 22.3 |
| 7 | 13.7 | 14.8 | 16.0 | 17.3 | 18.8 | 20.5 | 22.3 |

Before calculating BMI/U, we must first know the BMI value. To find out the BMI value:

BMI=(weight)/((body length)/100)^2 (5)
= 8/(70/100)^2

= 8/0.49
= 16.3

After knowing the BMI value, the BMI/U z-score calculation is performed. Calculation of BMI/U:

Z-Score = (NIS – NMBR)/NSBR (6)
= (16.3 – 17.3)/(17.3-16.0)
= (-1)/(1.3)
= 0.07

The rule used is rule 17. So, child A's BMI/U status is Good Nutrition.

Display the results of testing Child A in the application that the author made is seen in Figure 2.


Figure 2. Application

This application has been tested with the existing system at the real environment based on VBA Excel. The results of testing the system with the Excel VBA system obtained a 100% match.

### 3.2 Discussion

The evaluation of the system was conducted employing the black box testing methodology. The black box system testing method prioritizes the functional requirements of the system. This evaluation encompasses the assessment of the entire system's readiness for utilization, with the objective of identifying and rectifying any discrepancies that may be present.

The objective of this study is to assess the efficacy of the expert system in detecting malnutrition in toddlers. This evaluation is designed to ensure that all processes within the system have been thoroughly tested. This is done to minimize errors or bugs in the application and ensure the output is as desired. The implementation of an expert system designed to detect malnutrition in toddlers has been conducted in a real-world setting. This system is intended to assist social workers in the prevention of malnutrition.

## 4. CONCLUSION

The extant research has demonstrated that the application has the capacity to calculate z-scores, determine nutritional status, and store posyandu data. The application's primary function is to assist social workers in monitoring the nutritional status of toddlers. This monitoring is intended to ensure the toddlers' normal development and to prevent malnutrition. And the system is already being implemented in Puskesmas Purwokerto Utara, used by the workers to assist in detecting the malnutrition of toddlers.


## STATEMENT OF APPRECIATION

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