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DEVELOPMENT OF NUTRITIONAL FULFILLMENT FUNDS FOR PREGNANT WOMEN USING WEB-BASED SUGENO METHOD Case Study: "NURANI" Maternity Clinic and Maternity Hospital

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ABSTRACT

The high rate of malnutrition in various regions and the increasing prevalence of obesity, especially in big cities, is a double burden of nutritional problems in Indonesia. Meanwhile, the utilization of health facilities by those lower classes people in particular is still low and the health service itself is far from optimal. Besides, the pregnant women are also reluctant to consult their nutrients experienced during pregnancy. From the above problems, an application which can help pregnant women in making nutritional decisions at the time of pregnancy without consulting to consult a doctor / nutritionist was finnally made, that is Sugeno Fuzzy method. This method can provide the right nutritional decisions for pregnant women. The purpose of this study is to assist and facilitate pregnant women in the fulfillment of nutrition during pregnancy. Input used in this study is BMI, age of pregnant woman and age of pregnancy. While the output of the end result of this application system is to provide decisions about the nutrients experienced by pregnant women, they are less nutrition, ideal nutrition and excessive or much nutrition. The results of the experiment gives the calculation; the error rate of 62 % and the accuracy of 38 %.

Keywords: *Decision Support System, Nutrition, Sugeno Fuzzy Method, Pregnant Women, Web.*

1. INTRODUCTION

1.1 Background

According to William Heird (1999), the effect of insufficient initial nutrition on the growth and development of the central nervous system is a major concern. In human infants, a critical period of growth throughout the brain is believed to last for at least the first 18 months of life. Thus, early malnutrition improvement before an 18 month old baby theoretically can avoid the entire deficit (Heird, 1999). Based on the results of Asmi's research in Soetjiningsih (1997), it was reported that there was a strong relationship between the nutritional condition of pregnant women before pregnancy and the weight of babies born. Weight gain during pregnancy is one predictor of fetal outcome. All that stems from the "reluctance" of mothers to undergo antenatal care.

Inpatient Clinic and Maternity Hospital "Conscience" is a company engaged in the field of health. Namely clinics that are engaged in maintaining the health of pregnant women, since pregnancy planning until after delivery. In research conducted by Rista Rahmawati and Rina Harimurti Faculty of Engineering Department of D3 Informatics Management - FT UNESA designed an intelligent application system specifically intended by nutritionists or midwives. But not all pregnant women can take the time to consult with a nutritionist. Here provides a solution to minimize the impact of mal nutrition on pregnant women, which is made an intelligent application in the field of nutrition fulfillment for pregnant women that can facilitate all general users in providing solutions to pregnant women. This application will help general users to find out the nutritional fulfillment of pregnant women without having to consult a nutritionist or midwife. So that it is expected to be able to provide solutions to the problems of pregnant women about mal nutrition and can add insight into science in applying the concept of Fuzzy logic to medical science.

2. METHODOLOGY

The methodology used in developing decision support systems is the waterfall method which can be explained as follows:

1. Need Analysis
   System Requirement Analysis to find out the problems that occur and collect production data needed.
2. System Design
   At this stage do system design and software to get an overview of the system to be built.
3. Implementation
   At this stage start to create a system with php programming language and conduct tests to look for errors that might occur in the programming.
4. Testing the System
   At this stage, a trial is carried out on a system that is built until it is declared feasible. By testing the functionalities that have been made, especially in the input and output applications (whether it is as expected or not).
5. System Implementation and Maintenance
   At this stage the application is carried out by the designated admin to keep the system able to operate properly through the ability of the system to adapt itself as needed. And maintenance on the system regularly.

2.1 *Fuzzy* Logic

Fuzzy logic was first formulated in a seminar by Lotfi A Zadeh of the University of California, Berkeley in 1965. Fuzzy logic is an appropriate way to map an input space into an output space, having a continuous value.

2.1.1 *Fuzzy* Sugeno

This method was introduced by Takagi-Sugeno Kang (TSK) in 1985, so this method is often also called the Sugeno Method. According to Cox (1994), the TSK Method consists of 2 types, namely:

a. Zero-Order

In general, the form of the Zero-Order Fuzzy Sugeno model is:

IF (x_1 is A1) • (x2 is A2) • (x3 is A3) • ..... • (xN is AN) *THEN* z=k 1

The explanation of formula 1 with Ai is the set of Fuzzy i as an antecedent, and k is a constant (firm) as a consequence.

b. First Order

In general, the form of the First-order Fuzzy Sugeno model is:

IF (x_1 is A_1) o ..... o (x_N is A_N) THEN $z = p_1*x_1+..... + p_N*x_N + q$..... 2

The explanation of formula 2 with Ai is the set of Fuzzy i as an antecedent, and pi is a constant (firm) i and q is also a constant in consequence. If the composition of the rules uses the Sugeno method, deffuzification is done by finding the average value. So it can be assumed that the total number of assistants is more than the number of assistants leaving.

2.2 System Requirements

The system built has two main needs including input and output requirements. Inputs or inputs needed by the system are variables that determine the nutritional status of pregnant women such as BMI, Age of Mother, and Age of Content. Calculate BMI with formula 3

IMT = Body Weight before Pregnanc…… ..... ……3

Height (m2)

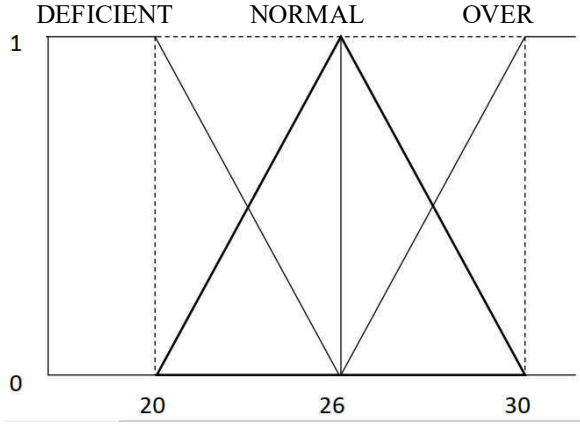
(Quoted from: [1]. Expected output for the system is if nutrition is lacking <19, moderate <27, and more <∞.

2.2.1 Fuzzy Design

This application uses Sugeno fuzzy and has fuzzy parameters namely BMI, Maternal Age and Gynecology.

2.2.2 Fuzzy Curve Input Variable

This application calculation uses the Triangle curve. There are 3 curves that will be counted as variables, namely BMI, Maternal Age, Gestational Age. BMI criteria are divided into 3 fuzzy sets, namely Less, Normal and More as shown in Figure 1 and formula 4 for calculating BMI.



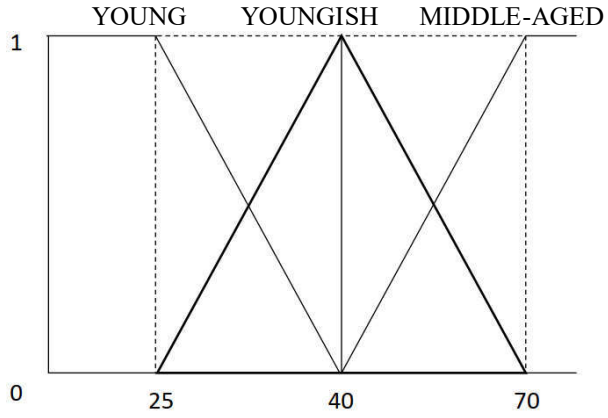
$$\mu Kurang\ [s1] = \begin{cases} 0, & s1 \geq 26 \\ \frac{26-s1}{26-20}, & 20 \leq s1 \leq 26 \\ 1 & s1 \leq 20 \end{cases}$$

$$\mu Sedang\ [s1] = \begin{cases} 0, & s1 \leq 20 \text{ atau } s1 \geq 30 \\ \frac{s1-20}{26-20}, & 20 \leq s1 \leq 26 \\ \frac{30-s1}{30-26} & 26 \leq s1 \leq 30 \end{cases}$$

$$\mu Lebih\ [s1] = \begin{cases} 0, & s1 \leq 26 \\ \frac{s1-26}{30-26}, & 26 \leq s1 \leq 30 \\ 1 & s1 \geq 30 \end{cases}$$

Figure 1 IMT Membership function

The criteria for maternal age are divided into 3 fuzzy sets, namely Young, Youngish and Middle-aged see figure 2 and formula 5.



Formula 5 Calculation of Mother's Age

$$\mu Muda\ [s2] = \begin{cases} 0, & s2 \geq 40 \\ \frac{40-s2}{40-25}, & 25 \leq s2 \leq 40 \\ 1 & s2 \leq 25 \end{cases}$$

$$\mu AgakMuda\ [s2] = \begin{cases} 1, & s2 \leq 25 \text{ atau } s2 \geq 40 \\ \frac{s2-25}{40-25}, & 25 \leq s2 \leq 40 \\ \frac{70-s2}{70-40} & 40 \leq s2 \leq 70 \end{cases}$$

$$\mu Parobaya\ [s2] = \begin{cases} 0, & s2 \leq 40 \\ \frac{s2-40}{70-40}, & 40 \leq s2 \leq 70 \\ 1 & s2 \geq 70 \end{cases}$$

Figure 2 Membership function Age

Age criteria the content is divided into 3 fuzzy sets, namely T1, T2, and T3 see figure 3 and calculation formula see 6.

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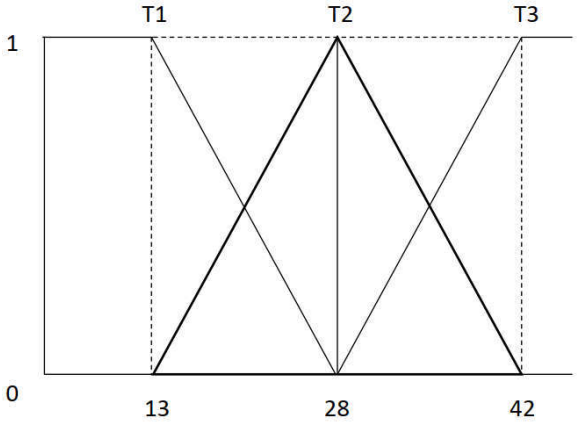

Figure 3. Membership function of Gynecology

Formula 6 Calculation of UK

$$\mu T1\ [s3] = \begin{cases} \frac{28-s3}{28-13}, & 13 \le s3 \le 28 \\ 1 & s3 \le 13 \end{cases}$$

$$\mu T2\ [s3] = \begin{cases} 1, & s3 \le 13 \text{ atau } s3 \ge 42 \\ \frac{s3-13}{28-13}, & 13 \le s3 \le 28 \\ \frac{42-s3}{42-28} & 28 \le s3 \le 42 \end{cases}$$

$$\mu T3\ [s3] = \begin{cases} 0, & s3 \le 28 \\ \frac{s3-28}{42-28}, & 28 \le s3 \le 42 \\ 1 & s3 \ge 42 \end{cases}$$

Information:

IMT: Indeks Massa Tubuh

T1 : Trimester 1

T2 : Trimester 2

T3 : Trimester 3

UK : Usia Kandungan

UI : Umur Ibu

M : Muda

3. RESULTS AND DISCUSSION

In this section a trial is carried out by entering the data obtained into the formula.

3.1 Trials

If a pregnant woman named Ita Rahmawati has a name Ita Rusmawati has a body weight (bb) before becoming pregnant 53 kg, height 154 cm, age 28 years, and the womb is 18 weeks. First, to calculate the BMI with the formula 4, the BMI 22.35 results. The calculation results can be seen in table 1 and figure 4 of the results of the system interface as follows.

$$\mu\text{IMT} - \text{Kurang} = \frac{26-22{,}35}{26-20} = \frac{3{,}65}{6} = 0{,}61$$
$$\mu\text{IMT} - \text{Sedang} = \frac{22{,}35-20}{26-20} = \frac{2{,}35}{6} = 0{,}39$$
$$\mu\text{IMT} - \text{Lebih} = 0$$

Table 1 Calculation results for the IMT Membership function

Name	IMT	µIMT – Less	µIMT – Normal	µIMT – More
Ita Rusmawati	22,35	0,61	0,39	0

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Figure 4 Application Interface Results of IMT

Third, calculate the *Membership Function* for Mother's Age. The results of calculations can be seen in table 2 and the Application Interface of the *Membership Function* in Figure 5.

$$\mu\text{UmurIbu} - \text{Muda} = \frac{40-28}{40-25} = \frac{12}{15} = 0{,}8$$
$$\mu\text{UmurIbu} - \text{AgakMuda} = \frac{28-25}{45-25} = \frac{3}{15} = 0{,}2$$
$$\mu\text{UmurIbu - Parobaya} = 0$$

Table 2 Results of Calculation of Membership Function for Mother Age

Name	Mother Age	µIMT – Young	µIMT – Youngish	µIMT – Middle-Age
Ita Rusmawati	28	0,61	0,39	0

Figure 5. Application Interface foreshipfunction

The fourth is calculating the *Membership Function* of Gynecology. Calculation results in table 3.

$$\mu\text{UK} - \text{T1} = \frac{28-18}{28-13} = \frac{10}{15} = 0{,}67$$
$$\mu\text{UK} - \text{T2} = \frac{18-13}{28-13} = \frac{5}{15} = 0{,}33$$
$$\mu\text{UK} - \text{T3} = 0$$

Table 3 Results of Calculation of Membership Function for Gest

Name	UK	µUK-T1	µUK-T2	µUK-T3
Ita Rusmawati	18	0,67	0,33	0

Then the calculation results from the three Membership functions are entered in table 4 as in formula 7 to find the MIN value (αpredicate) or the smallest value. The next step is looking for formula 5 and the results in table 8. The last step is looking for fuzzyfication with formula 9 and the results in table 6.

R1 = μIMT_K ∩ μUI_M ∩ UK_T1
= [0,61] ∩ [0,8] ∩ [0,67]
= 0,61 7

Table 4 Results MIN values

Rules	IF	IMT	Operator	Mother Age	Operator	UK	Min Value (αpredicate)
R1.	IF	0,61	AND/∩	0,8	AND/∩	0,67	0,61
R2.	IF	0,61	AND/∩	0,8	AND/∩	0,33	0,33
R3.	IF	0,61	AND/∩	0,8	AND/∩	0	0
R4.	IF	0,61	AND/∩	0,39	AND/∩	0,67	0,2
R5.	IF	0,61	AND/∩	0,39	AND/∩	0,33	0.2
R6.	IF	0,61	AND/∩	0,39	AND/∩	0	0
R7.	IF	0,61	AND/∩	0	AND/∩	0,67	0
R8.	IF	0,61	AND/∩	0	AND/∩	0,33	0
R9.	IF	0,61	AND/∩	0	AND/∩	0	0
R10.	IF	0,39	AND/∩	0,8	AND/∩	0,67	0.39
R11.	IF	0,39	AND/∩	0,8	AND/∩	0,33	0.39
R12.	IF	0,39	AND/∩	0,8	AND/∩	0	0.39
R13.	IF	0,39	AND/∩	0,39	AND/∩	0,67	0.2
R14.	IF	0,39	AND/∩	0,39	AND/∩	0,33	0.2
R15.	IF	0,39	AND/∩	0,39	AND/∩	0	0
R16.	IF	0,39	AND/∩	0	AND/∩	0,67	0
R17.	IF	0,39	AND/∩	0	AND/∩	0,33	0
R18.	IF	0,39	AND/∩	0	AND/∩	0	0
R19.	IF	0	AND/∩	0,8	AND/∩	0,67	0
R20.	IF	0	AND/∩	0,8	AND/∩	0,33	0
R21.	IF	0	AND/∩	0,8	AND/∩	0	0
R22.	IF	0	AND/∩	0,39	AND/∩	0,67	0
R23.	IF	0	AND/∩	0,39	AND/∩	0,33	0
R24.	IF	0	AND/∩	0,39	AND/∩	0	0
R25.	IF	0	AND/∩	0	AND/∩	0,67	0

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R26.	IF	0	AND/∩	0	AND/∩	0,33	0
R27.	IF	0	AND/∩	0	AND/∩	0	0

$$Defuzzyfikasi = \sum \alpha predikat \text{ dan } \sum \alpha predikat * z \quad \ldots\ldots 8$$

Table 5 Defuzzification

Rules	**Min Value**	**Z Value**	**αpredicate*Z**
R1.	0,61	10	6,1
R2.	0,33	1	0,33
R3.	0	50	0
R4.	0,2	15	3
R5.	0.2	19	3,8
R6.	0	50	0
R7.	0	17	0
R8.	0	15	0
R9.	0	22	0
R10.	0.39	0	0
R11.	0.39	5	1,9
R12.	0.39	30	14,87
R13.	0.2	7	1,4
R14.	0.2	9	1,8
R15.	0	2	0
R16.	0	3	0
R17.	0	4	0
R18.	0	27	0
R19.	0	20	0
R20.	0	18	0
R21.	0	8	0
R22.	0	25	0
R23.	0	21	0
R24.	0	30	0
R25.	0	25	0
R26.	0	36	0
R27.	0	32	0
∑ *αpredikat*	**2,46**	**∑ *αpredikat*z***	**18,08**

$$Fuzzyfikasi = \sum \frac{\sum \alpha predikat * z}{\sum \alpha predikat} \quad \ldots\ldots 9$$

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Table 6 Fuzzification

Name	Fuzzification	System Diagnostic Results
Ita Rusmawati	7,35	Malnutrition

Figure 6. Fuzzyfication Application Interface

Explanation of table 6 and figure 6 is if a pregnant woman has a BMI, Young Mother Age and T1 Content, the result of Underweight Nutrition is obtained.

3.2 System Calculation Results

After all data obtained and calculated, the data is then classified. A classification system is expected to be able to classify data correctly. Although the performance of a system cannot work 100% correct. In this application using the confusion matrix to measure the performance of clarification. The quantity of a confusion matrix can be summarized into two values, namely accuracy and error rate. By knowing the amount of data that is classified correctly, it can be known the accuracy of the prediction results, and by knowing the amount of data that is classified incorrectly, it can be known the error rate of the predictions made [2].

In Table 7 is an example of the results of the nutritional decision system and the results of the doctor's decision. In the table it can be seen that the correct prediction is the decision of the system and the doctor is the same, while the wrong prediction is the decision of the system and the doctor is different. So that the predictions are correct as many as 25 data and as many as 40 wrong predictions. To calculate accuracy and calculate the error rate as below.

$$\text{Akurasi} = \frac{\sum Prediksi\ Benar}{\sum Data} \times 100\%$$
$$= \frac{25}{65} \times 100\%$$
$$= 38\ \%$$

$$\text{Error} = \frac{\sum Prediksi\ salah}{\sum Data} \times 100\%$$
$$= \frac{40}{65} \times 100\%$$
$$= 62\ \%$$

Table 7 Results of Patient Data Decisions

No	Name	Total Fuzzyfikasi	Decision System Result	Decision Docter	Suitability
1	ITA RUSMAWATI	7,35	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
2	AI' JUARIAH	-2,97	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
3	WINDI PUJIASTUTIK	18,14	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
4	LINAKE	17,79	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
5	ARIE SATITI	16,57	Malnutrition	Nutrition Obesity / More	Not Corresponding
6	ROSYIDATUL LAILI	37,3	More nutrition	Normal / Ideal Nutrition	Not Corresponding

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7	NURUL	10,47	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
8	NURHAYATI	19,12	Ideal Nutrition	Nutrition Obesity / More	Not Corresponding
9	FATKUL FATIMAH	16,07	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
10	ELYNDA	-21,71	Malnutrition	Nutrition Obesity / More	Not Corresponding
11	LAZIMATUL	19,85	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
12	ERIS	9,67	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
13	URIFATIH	48,33	More nutrition	Nutrition Obesity / More	Corresponding
14	ANTERAWATI	11,03	Malnutrition	Malnutrition	Corresponding
15	KHOIRUN NISA	8,29	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
16	ARIK DWI	13,33	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
17	ARSIATUN	19,34	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
18	DEWI MASRUROH	18,42	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
19	DEWI PUTRI	16,53	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
20	DEWI	-4,4	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
21	EVI NURHAYATI	14,67	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
22	ELIZA	19,44	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
23	FITRI AMELIA	19,78	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
24	ISWATUN	2,44	Malnutrition	Nutrition Obesity / More	Not Corresponding
25	ISMAWATI	15,73	Malnutrition	Nutrition Obesity / More	Not Corresponding
26	FEBRIWANTI	8,12	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
27	INDAH	17,31	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
28	HARTIAN	20,52	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
29	IDA WAHYUNI	14,39	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
30	LIAMATUS	90	More nutrition	Normal / Ideal Nutrition	Not Corresponding
31	LIA ABRIANTI	16,93	Malnutrition	Nutrition Obesity / More	Not Corresponding
32	LUDFIA	16,28	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
33	LAILATUL	17,73	Malnutrition	Nutrition Obesity / More	Not Corresponding
34	LILIK HANDAYANI	14,74	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
35	LINDA M	15,16	Malnutrition	Malnutrition	Corresponding
36	LULUK	16,5	Malnutrition	Malnutrition	Corresponding
37	MAHMUDAH	18,48	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
38	RIANTISARI	17,87	Malnutrition	Normal / Ideal Nutrition	Not Corresponding

39	NUR AZIZAH	33,43	More nutrition	Nutrition Obesity / More	Corresponding
40	NUR LAILIYAH	56,76	More nutrition	Nutrition Obesity / More	Corresponding
41	PUPUT WIJAYANTI	14,57	Malnutrition	Malnutrition	Corresponding
42	RINDIMEGA	18,56	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
43	RUMINI	29,29	More nutrition	Nutrition Obesity / More	Corresponding
44	PINTA ANDRISARI	14,26	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
45	SRIWAHYUNI	16,62	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
46	SITI RODIYAH	16,58	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
47	TUTIK YULIANTI	31,47	More nutrition	Nutrition Obesity / More	Corresponding
48	TITIK SUSANTI	18,4	Ideal Nutrition	Malnutrition	Not Corresponding
49	ROSSY	20,18	Ideal Nutrition	Normal / Ideal Nutrition	Corresponding
50	YANA	13,81	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
51	YEYEN	16,67	More nutrition	Normal / Ideal Nutrition	Corresponding
52	ZULIANAH	12,41	Malnutrition	Malnutrition	Corresponding
53	TIRINGSRI	659	More nutrition	Normal / Ideal Nutrition	Corresponding
54	TIYAN	17,63	Malnutrition	Nutrition Obesity / More	Not Corresponding
55	RINDA	13,21	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
56	DIAN PARAMITA	13,86	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
57	EMA ARISTANTO	5,52	Malnutrition	Nutrition Obesity / More	Not Corresponding
58	RIRIN ARI	13,79	Malnutrition	Malnutrition	Corresponding
59	SRI WARDIANI	11,01	Malnutrition	Malnutrition	Corresponding
60	MARGARETA	19,2	Ideal Nutrition	Nutrition Obesity / More	Not Corresponding
61	PRIHATIN	129,53	More nutrition	Normal / Ideal Nutrition	Not Corresponding
62	ELLEN YUNIARTI	16,83	Malnutrition	Normal / Ideal Nutrition	Not Corresponding
63	ELEN OKTASARI	14,1	Malnutrition	Malnutrition	Corresponding
64	WURI ANDRIYANI	14,13	Malnutrition	Malnutrition	Corresponding
65	SRIHATIN	17,44	Malnutrition	Malnutrition	Corresponding

From the above calculation it can be seen that 38% for the accuracy value and 62% for the error value for pregnant women data.

4. CONCLUSION

After going through several processes of analysis and implementation of a decision support system with the title Development of Nutrition Fulfillment Applications for Pregnant Women Using the Sugeno Method Web-Based Case Study: Clinic and Maternity Hospital "Conscience" then it can be concluded as follows:

a Development of Nutrition Filling Applications for Pregnant Women Using Sugeno Method Web-Based Case Study: Clinic and Maternity Hospital "Conscience" has been able to produce nutritional decisions for pregnant women with the Sugeno fuzzy method,
b Testing the functionality of the system to produce nutritional decisions for pregnant women is based on original data, resulting in an error rate of 62 percent and an accuracy rate of 38 percent.
c The final output of the application system is to provide decisions about nutrition experienced by pregnant women, namely Malnutrition, Ideal Nutrition and More nutrition.

This application system can be further developed by adding graphic features to the application, so as to make it easier to monitor the nutrition of pregnant women to the maximum.

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