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Diagnosing Malnutrition In Toddlers Using The Dempster Shafer Method

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Abstract: Indonesia was the 5th most malnourished country in the world in 2012. The number of malnourished children under five is currently around 900,000, which is 4.5% of the total number of children under five in Indonesia. Malnutrition can have an impact on children's growth and health, even potentially causing death if not treated properly. Toddler nutrition can be seen from the food consumed and nutritional status by calculating anthropometric indicators based on age, gender, weight and height. The Dempster Shafer method is one of the expert system methods used to calculate probabilities. This method is used to calculate the data input made by the patient to get the percentage of accuracy of the diagnosis results. Based on research, the Dempster Shafer method can produce accurate data. This developed system aims to help provide clear information for patients or the general public and for medical personnel is expected to help in handling it provide the right solution, by only paying attention to the symptoms experienced.

Keywords: Dempster Shafer, Malnutrition, Expert System

1. Introduction

In 2012, Indonesia was the fifth most malnourished country in the world. Ranked fifth because Indonesia's population is also the fourth largest in the world, the number of under-fives who are malnourished in Indonesia is currently around 900 thousand people. This is 4.5 percent of Indonesia's total number of under-fives, which is 23 million. Malnourished areas are spread throughout Indonesia, not only in the eastern part of the country. To this day, Indonesia is still haunted by cases of malnutrition (Hamid et al., 2018).

Malnutrition is a condition where children do not receive enough nutrients, minerals and calories to help develop vital organs. Malnutrition will affect a child's growth and health, potentially even causing death if not treated properly. In this case, excess nutrient intake also causes toddlers to experience malnutrition.

The Dempster Shafer method is one of the expert system methods. The Dempster Shafer method is part of the branch of mathematics and can be used to calculate probabilities

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(Kanggeraldo, Sari, & Zul, in Mubarok et al., 2020). This method shows a way to give confidence weights according to the facts collected then combine separate pieces of information and calculate the likelihood of an event. This logic is used to calculate data input made by patients to get the percentage of accuracy of diagnosis results Hasibuan & Batubara (in Mubarok et al., 2020).

From research conducted by Dina Hastari and Fitri Bimantoro in 2018 entitled Expert System for Diagnosing Child Mental Disorders Using the Dempster Shafer Method resulted in an accuracy of 95%. In addition, research conducted by Jansen Kanggeraldo, Rika Perdana Sari and Muhammad Ihsan Zul in 2018 entitled Expert System for Diagnosing Hemorrhagic and Ischemic Stroke Disease Using the Dempster Shafer Method resulted in an accuracy of 97%. From these two studies the Dempster Shafer method can produce accurate data.

So it is necessary to have an auxiliary media in the form of a system that can provide the right solution to be able to handle these problems. This developed application aims to help provide clear information for patients or the general public and for medical personnel it is hoped that it can help in handling it provide the right solution, by only paying attention to the symptoms experienced. The subject of this research is an expert system to diagnose malnutrition in toddlers (Hamid et al., 2018).

Therefore, based on the problems that have been described above, this research raises the diagnosis of determining malnutrition in toddlers using the Dempster Shafer method.

2. Literature

This research was strengthened by Chandra kirana, Lukas tomy, M indra wijaya in 2019 with the research title "Expert System for Diagnosing Malnutrition in Toddlers with Certainty Factor Method" with the results of research Expert systems using the Certainty Factor method should be combined with other methods that can provide maximum results and can predict uncertainty factors. Tests that have been carried out using an expert system with several symptoms and diseases obtained a suitability value of 80%.

This research was strengthened by Aprilia Indah Friska, Tedy Rismawan, Syamsul Bahri in 2018 with the research title "Application of Expert System for Diagnosing Diseases in Children with Inference Forward Applying the Web-Based Dempster Shafer Method" Producing a density / weight value of each symptom of each type of disease in children is done by filling out a questionnaire with a pediatrician. Symptoms that have the highest density / weight value are characteristic / specific symptoms of a type of disease. The results of Medical Record testing of the system were carried out using 60 data, the percentage of success obtained was 88.33%.

The following is reinforced by research by Nita Merlina, Nur Hilalia Fitriyati in 2016 with the research title "Expert System in Diagnosing Infectious Diseases in Children with the Dempster Shafer Method". This research can represent medical personnel to deal with a patient suffering from a disease by providing diagnostic results according to the symptoms he is experiencing and calculating the trust value This expert system is published to make it easier for anyone who will consult about complaints of pain suffered.

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3. Methods

3.1 Dempster Shafer

Dempster Shafer is a mathematical theory to prove the possibility based on belief functions and plausible reasoning, and serves to combine parts of information, where the information is separate, so that the level of probability of an event will be calculated. This theory was developed by Arthur P. Dempster and Glenn Shafer (Syahputri, 2022).

In general, Dempster Shafer Theory is written in an interval: [Belief, Plausibility] Belief (Bel) is a measure of the strength of evidence in supporting a set of propositions. If it is 0, it indicates that there is no evidence, and if m is 1, it indicates certainty. Plausibility (Pl) is denoted as:

$$P1(s) = 1 - Bel(s)$$

Plausibility also has a value of 0 to 1. If we are sure of -s, then we can say that Bel(-s), and P1(-s) = 0. Plausibility will reduce the confidence level of the evidence. In Dempster Shafer theory, we recognize the frame of discernment denoted by (θ) and mass function denoted by m. The combination function of m1 and m2 as m3 is formed by the equation:

$$M3(Z) = \frac{\sum X \cap Y = Zm1(X)m2(y)}{1 - \sum X \cap Y = \theta m1(X)m2(Y)}$$

Description:
m1 = Density for the first symptom
m2 = Density for the second symptom
m3 = Combination of the two densities above
θ = A set of hypotheses (X' and Y')
X and Y = Subset of Z
X' and Y' = Subset of θ

3.2 Application of the Method

Table III. 4 Disease Codes and Names

Disease Code	Disease Name
P1	Anemia
P2	Undernourished
P3	Poor Nutrition

Table III. 5 Symptoms

Code	Symptom
G1	Weakness and lethargy
G2	Decreased appetite

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G3	Low body weight
G4	More prominent bone conditions
G5	Thin arms and legs
G6	Growth and development disorders
G7	Dry skin
G8	Hair loss
G9	Cheeks and eyes look sunken
G10	Enlarged head
G11	There is a possibility of belly bulging
G12	Old wounds heal
G13	Being irritable
G14	Mood swings
G15	Often experience symptoms of infection, such as fever, cough, runny nose or ulcers appear on the skin
G16	Intellectual impairment

Table III. 6 Diseases and Symptoms of Development

Code	Symptom	P1	P2	P3
G1	Weakness and lethargy	✓	✓	✓
G2	Decreased appetite	✓	✓	✓
G3	Low body weight		✓	✓
G4	More prominent bone conditions			✓
G5	Thin arms and legs			✓
G6	Growth and development disorders	✓	✓	
G7	Dry skin		✓	✓
G8	Hair loss		✓	✓
G9	Cheeks and eyes look sunken		✓	
G10	Enlarged head			✓
G11	There is a possibility of belly bulging			✓
G12	Old wounds heal		✓	✓
G13	Yellowing of the eyes	✓		
G14	Pale or yellowish skin	✓		
G15	Often experience symptoms of infection, such as fever, cough, runny nose or ulcers appear on the skin	✓	✓	✓
G16	Intellectual impairment	✓		

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Table III. 7 Values of Symptoms

Disease Code	Disease	Symptom	Symptomatic Name	Symptomatic Values
P1	Anemia	G1	Weakness and lethargy	0.77
		G2	Decreased appetite	0.60
		G6	Growth and development disorders	0.70
		G13	Yellowing of the eyes	0.80
		G14	Pale or yellowish skin	0.90
		G16	Intellectual impairment	0.50
P2	Undernourished	G1	Weakness and lethargy	0.77
		G2	Decreased appetite	0.60
		G3	Low body weight	0.50
		G6	Growth and development disorders	0.70
		G7	Dry skin	0.72
		G8	Hair loss	0.90
		G9	Cheeks and eyes look sunken	0.50
		G12	Old wounds heal	0.70
		G15	Often experience symptoms of infection, such as fever, cough, runny nose or ulcers appear on the skin	0.63
P3	Poor Nutrition	G1	Weakness and lethargy	0.77
		G2	Decreased appetite	0.60
		G3	Low body weight	0.49
		G4	More prominent bone conditions	0.83
		G5	Thin arms and legs	0.40
		G7	Dry skin	0.72
		G8	Hair loss	0.90
		G10	Enlarged head	0.90
		G11	There is a possibility of belly bulging	1.0
		G12	Old wounds heal	0.70
		G15	Often experience symptoms of infection, such as fever, cough, runny nose or ulcers appear on the skin	0.63

In testing, several symptoms experienced by toddlers are given as follows:

- G1 : Weakness and lethargy
- G4: More prominent bone condition

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- G7 : Dry skin
- G8 : Hair Loss
- G15: Often experience symptoms of infection, such as fever, cough, runny nose or ulcers appear on the skin

From the results of the consultation, to obtain the probability value with the table of Dempster's Rule of Combination of selected symptoms can be calculated:

Symptom 1: Weakness and lethargy (G1)

$\{P\ 1, P\ 2, P3\} = 0.77$

$\{\theta\}=1 - 0.77= 0.23$

Symptom 2: More prominent bone condition (G4)

$\{ P3\} = 0.83$

$\{\theta\} =1 - 0.83 = 0.17$

Based on the data then combined with the formula according to Dempster's Rule of Combination as in table III.8 below:

Table III. 8 Table Dempster Rule of Combination 1

	$\{P3\} = 0.83$	$\{\theta\} = 0.17$
$\{P\ 1, P\ 2, P3\} = 0.77$	$\{P3\} = 0.63$	$\{P\ 1, P\ 2, P3\} = 0.13$
$\{\theta\} = 0.23$	$\{P3\} = 0.19$	$\{\theta\} = 0.03$

$$m_3(Z) = \frac{\sum X \cap Y = Z m_1(X) m_2(y)}{1 - \sum X \cap Y = \theta m_1(X) m_2(Y)}$$

$$m_3\{P3\} = \frac{0.63 + 0.19}{1-0} = 0.82$$

$$m_3\{P1, P2, P3\} = \frac{0.13}{1-0} = 0.13$$

$$m_3\{\theta\} = \frac{0.03}{1-0} = 0.03$$

Then toddlers have symptoms of "dry skin" (G7) as symptom 3, then:

Symptom 3: Dry skin (G7)

$\{P\ 2,P3\} = 0.72$

$\{\theta\} = 1 - 0.72 = 0.28$

Table III. 9 Dempster Rule of Combination 2

	$\{P\ 2, P3\} = 0.72$	$\{\theta\} = 0.28$
$\{P3\} = 0.82$	$\{P3\} = 0.59$	$\{P3\} = 0.22$

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{P 1, P 2, *P*3} = 0.13	{P 2, *P*3} = 0.09	{P 1, P 2, *P*3} = 0.03
{θ} = 0.03	{P 2, *P*3} = 0.03	{θ} = 0.01

$$m_5(\mathrm{Z}) = \frac{\sum \mathrm{X} \cap \mathrm{Y} = \mathrm{Z} m_3(\mathrm{X}) m_4(\mathrm{y})}{1 - \sum \mathrm{X} \cap \mathrm{Y} = \theta m_3(\mathrm{X}) m_4(\mathrm{Y})}$$

$$m_5\{P3\} = \frac{0.59 + 0.22 + 0.02}{1 - 0} = 0.83$$

$$m_5\{P2, P3\} = \frac{0.09 + 0.03}{1 - 0} = 0.12$$

$$m_5\{P1, P2, P3\} = \frac{0.03}{1 - 0} = 0.03$$

$$m_5\{\theta\} = \frac{0.01}{1 - 0} = 0.01$$

Then toddlers have symptoms of "Hair loss" (G8) as symptom 4, then:

Symptom 4: Hair loss (G8)

{P 2, *P*3} = 0.90

{θ} = 1 - 0.90 = 0.1

Table III. 10 Dempster Rule of Combination 3

	{P 2, *P*3} = 0.90	{θ} = 0.1
{*P*3} = 0.83	{*P*3} = 0.74	{*P*3} = 0.083
{P 2, *P*3} = 0.12	{P 2, *P*3} = 0.11	{P 2, *P*3} = 0.012
m_5 {P 1, P 2, *P*3} = 0.03	{P 2, *P*3} = 0.027	{P 1, P 2, *P*3} = 0.003
m_5 {θ} = 0.01	{P 2, *P*3} = 0.009	{θ} = 0.001

$$m_7(\mathrm{Z}) = \frac{\sum \mathrm{X} \cap \mathrm{Y} = \mathrm{Z} m_5(\mathrm{X}) m_6(\mathrm{y})}{1 - \sum \mathrm{X} \cap \mathrm{Y} = \theta m_5(\mathrm{X}) m_6(\mathrm{Y})}$$

$$m_7\{P3\} = \frac{0.74 + 0.083}{1 - 0} = 0.83$$

$$m_7\{P2, P3\} = \frac{0.11 + 0.012 + 0.27 + 0.009}{1 - 0} = 0.15$$

$$m_7\{P1, P2, P3\} = \frac{0.003}{1 - 0} = 0.003$$

$$m_7\{\theta\} = \frac{0.001}{1 - 0} = 0.001$$

Then the toddler has symptoms of "Hair loss" (G8) as the 5th symptom, then:

Symptom 5: Often experience symptoms of infection, such as fever, cough, runny nose or ulcers appear on the skin (G8)

{P 2, *P*3} = 0.63

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{θ} = 1 – 0.63 = 0.37

Table III. 11 Dempster Rule of Combination 4

	{P 2, *P*3} = 0.63	{θ} = 0.37
{*P3*} = 0.83	{*P*3} = 0.52	{*P3*} = 0.30
{P 2, *P*3} = 0.15	{P 2, *P*3} = 0.10	{P 2, *P*3} = 0.05
{P 1, P 2, *P*3} = 0.003	{P 2, *P*3} = 0.0018	{P 1, P 2, *P*3} = 0.0011
{θ} = 0.001	{P 2, *P*3} =0.00063	{θ} = 0.00037

$$m_9(Z) = \frac{\sum X \cap Y = Z m_7(X) m_8(y)}{1 - \sum X \cap Y = \theta m_7(X) m_8(Y)}$$

$$m_9\{P3\} = \frac{0.52 + 0.30}{1-0} = 0.82$$

$$m_9\{P3, P3\} = \frac{0.10 + 0.05 + 0.0018 + 0.00063}{1-0} = 0.15243$$

$$m_9\{P1, P2, P3\} = \frac{0.0011}{1-0} = 0.0011$$

$$m_9\{\theta\} = \frac{0.00037}{1-0} = 0.00037$$

Based on the order above, with the Dempster Rule of Combination the possibility of toddlers with symptoms G1, G4, G7,, , G8 and G15 towards $m_9\{P3\}$ **Malnutrition** with the largest value of 0.82.

4. Result And Discussion

Based on the results of the analysis and design that has been achieved, an expert system application for diagnosing malnutrition diseases can be applied to determine whether the functional system has run according to using the Dempster Shafer method and is able to produce a diagnosis of the disease in accordance with the results of expert diagnosis.

5. Conclusion

Based on the previous problems and discussion in designing an expert system to diagnose malnutrition in toddlers, it is concluded as follows:

1. This system provides information to users about Malnutrition disease in toddlers through symptoms that are in accordance with the rules.
2. From the analysis conducted, the results obtained from Malnutrition disease in toddlers are Malnutrition with a value of 82% of the symptoms that have been processed.

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