The Nutrition Status Classification of PetroChina International Jabung Ltd Employees using Fuzzy Logic

**C Amri1, A M Abadi2 and Puspitarani3**

1,3Department of Mathematics Education, Graduate School Program, Universitas Negeri Yogyakarta, Indonesia

2Department of Mathematics Education, Universitas Negeri Yogyakarta, Indonesia

[c.amri.unja@gmail.com](mailto:c.amri.unja@gmail.com)

**Abstract.** Poor or over nutritional status affects employees at work and can cause work fatigue. The Company of Betara Gas Plant - PetroChina International Jabung Ltd always checks periodically the nutrition of its employees to anticipate work fatigue and the risks that can occur. Therefore, the company must be able to determine carefully the nutritional status of its employees following the actual situation. The nutritional status classification according to BMI used is a strict or rigid classification, while the nutritional status can change in a scale of nutritional values ​​that can be tolerated because nutritional status is not constant. So, with fuzzy logic by the Mamdani method can determine the nutritional value of employees who are more tolerant, flexible, more intuitive, and acceptable according to the actual nutritional status of employees. Thus, the company can determine the right decision.

**1. Introduction**

Employees are accomplices and drivers of the course of a company. The progress and success of a company depend on the quality of employee performance. Therefore, each company will be selective in choosing prospective employees who have good human resources. Human resources are abilities and characteristics possessed by a person such as knowledge, skills, and attitudes needed at work so that employees can carry out their duties professionally, effectively and efficiently [1].

The first step taken in managing human resources is the stage where the selection of prospective employees is an important stage where the results will determine the course of a company to achieve its goals. The process of selecting effective employees must be carried out by taking into account the criteria that are expected by a company and aspects of the assessment generally include education, skills, expertise, and work experience according to company criteria [2]. However, these criteria are not enough in practice, the problems that arise in the future are about employee fatigue that affects company productivity.

Work fatigue is a multidimensional state that causes a reduction in functional capacity because of the cumulative effects of physical and psychological work due to the body, both physical and mental body conditions that are different due to work and result in decreased work power and reduced endurance to work [3]. Therefore, companies need to check the conditions of prospective employees and employees, with regard to work fatigue this has also been regulated in Indonesian Law No. 1 of 1970 concerning work safety article 8 [4].

The main factor causing work fatigue is due to a body condition, nutrition that is not good. Poor or over nutritional status is lacking or excessive, symbolizes poor body condition. It can affect employees at work and can cause work fatigue [5]. The Company of Betara Gas Plant - PetroChina International Jabung Ltd is a company located in Jambi that pays close attention to the nutritional conditions of prospective employees and their employees to maintain work quality, productivity, and employee health and safety. Therefore, in this case, the company always checks periodically the nutrition of its employees to anticipate work fatigue and the risks that can occur.

A simple effective way that can be done to determine the nutritional status of prospective employees or employees who are in employment regulations is the category of adults (over 18 years) is to use an anthropometric method called body mass index (BMI) [6]. Nutrition status classification according to BMI is a strict or rigid classification, for example, a difference of BMI 0.01 can result in different categories, while nutritional status can change on a short scale. Therefore, fuzzy logic provides a solution so that companies can consider the nutritional status of prospective employees or employees to take action to smooth the performance of their employees in anticipating work fatigue through classification with fuzzy logic.

How does logic fuzzy tolerate the rigid nutritional value of the nutritional status classification data of Betara Gas Plant - PetroChina International Jabung Ltd employees, so that very small changes will not result in significant category differences. To obtain the classification of nutritional values, then it is done this research.

**2. Method**

Data reviewed from 17 employees in the administration section to determine the nutritional status of the employees. Data analysis is based on BMI nutritional status tables and presentation procedures with fuzzy logic to classify nutritional status from the 17 employees based on fuzzy logic and compare the results of nutritional status data with nutritional status data obtained based on BMI classification.

To classify nutritional status data based on fuzzy logic by following the rules fuzzy system in the chart below [7].

Fuzzy Rule Based

Defuzzifier

Fuzzifier

Fuzzy Inference Engine

Fuzzy set

Fuzzy sets

**Figure 1**. Fuzzy rule based.

Application of fuzzy logic in inference using a fuzzy inference system (FIS) which is a computational framework based on fuzzy set theory, IF-THEN rules, and fuzzy reasoning [8]. One of the FIS methods is the Mamdani method used in this study. Mamdani method or min-max method in producing output through stages including forming a fuzzy set, doing the min implication function, doing the composition of the implication functions using the max function, and the last is to confirm the output (defuzzification) [9] in this study using the centroid method. This study also uses the MATLAB application for help.

**3. Results and Discussion**

*3.1* *Data Clarification*

Nutrition status data of 17 employees are re-examined to anticipate any data errors according to the BMI formula using the acquisition of height and weight data from 17 employees. Body Mass Index (BMI) is formulated below [10]:

The classification of the Indonesian body mass index can be seen in the following table [11].

**Table 1**. Indonesian BMI Threshold

|  |  |  |
| --- | --- | --- |
| Classification | Category | Value Index |
| Severely underweight | Weight loss in weight level | BMI < 17.0 |
| Underweight | Weight loss in mild level | 17.0 ≤ BMI < 18.5 |
| Normal | Healthy weight | 18.5 ≤ BMI ≤ 25.0 |
| Overweight | Overweight in mild level | 25.0 < BMI ≤ 27.0 |
| *Obese* | Overweight in weight level | BMI > 27.0 |

The results obtained from the administration (office) of employee nutritional status data are by the specified body mass index. Therefore, it can be used as a comparison of results with the acquisition of classification according to fuzzy logic at the end of the study.

*3.2. Implementation of the Mamdani Method*

The initial stage in determining employee nutritional status based on fuzzy logic is to form a fuzzy set. Based on the data needed to measure nutritional status under the BMI provisions above, the input variables are weight and height variables with the desired output in the form of nutritional value. The data is presented in the following table.

**Table 2**. Universal set for each variable of fuzzy

|  |  |  |
| --- | --- | --- |
| Function | Variable | Universal Set |
| Input | Weight | [35,80] |
| Height | [145,190] |
| Output | Nutritional Value | [13,33] |

Universal set intervals based on the average interval of body weight, height, and nutritional value with tolerance based on Recommended Dietary Allowances (RDA) of Indonesian adults [12]. Bodyweight in intervals [35,80] is classified in the categories of underweight, normal, and overweight. The membership function is represented in equations (1), (2), and (3). While for height in the interval [145,190] classified into short, normal/ medium and tall with membership functions represented in equations (4), (5) and (6). As for the nutritional value in the range [13,33], it is categorized into severely underweight, underweight, normal, overweight, and obese which is represented in equation (7), (8), (9), (10), and (11) as follows.

(1)

(2)

(3)

(4)

(5)

(6)

(7)

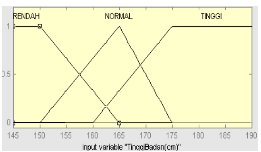
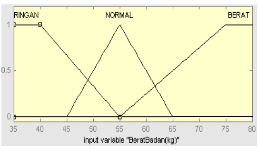
(8)

(9)

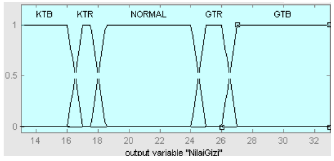
(10)

(11)

The membership function above is illustrated in Figure 2 below.



1. (b)



(c)

**Figure 2**. (a) a graph of the weight membership function, (b) a graph of the height membership -function, (c) a graph of the nutritional value membership function.

The next process after the fuzzy set is formed is to carry out the process of implication through rules that can be formed based on the provision of nutritional status based on body mass index or BMI. So that obtained several of rules in the following table 3.

**Table 3.** Rules on the implications of nutritional status based on BMI

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | Weight | | |
|  | | Underweight | Normal | Overweight |
| Height | Tall | Severely underweight | Underweight | Normal |
| Normal | Underweight | Normal | Overweight |
| Short | Normal | Overweight | Obese |

From table 3 above, 9 rules are obtained in determining the nutritional status of employees based on height and weight. An employee with tall height and underweight, his nutritional status is categorized severely underweight. An employee with short height and overweight is said to have an obese nutritional status. And so on for the seven other rules.

The rules formed, subject to the MIN implication function, this implication makes the level of membership made as a consequence in this process the smallest value of the two variables in determining the value or nutritional status of employees. So, we get fuzzy areas on the nutritional value variable for the nine rules. Furthermore, these rules are made by the composition of rules with the MAX function by taking the maximum value of the output then combining the fuzzy area of each rule with OR operators [13].

μsf[x]= max (μkf1 [x],μkf 2 [x],μkf 3 [x],μkf 4 [x],μkf 5 [x],μkf 6 [x],μkf 7 [x],μkf 8 [x],μkf9 [x]) (12)

with μsf[x] is the membership value of fuzzy solutions up to-the i and μkf i [x] is the fuzzy consequent membership value of each i-rule, where i = 1, 2,3 …

The final step is to reaffirm or defuzing. Defuzzification is done by the centroid method, using a crisp solution obtained through the center point (Z0) in a continuous fuzzy region that is formulated with [14]:

(13)

Where Z0 is the defuzzification value, μ (z) is the degree of membership of the point and Z is domain size to-i.

The steps above will be described to determine the nutritional status of employees. One employee who was the subject of the study had a height of 170 cm and a weight of 45 kg. Following the interpretation of the graph in Figure 2 (b) for 170 cm height is included in a short set fuzzy and normal with the level of membership shown in equations (5) and (6). By substituting for the x value, we get:

(14)

(15)

from the results, the employee with a normal height with a membership rate of 50%, or can also be said to be tall with a membership rate of 67 %. As for the 45 kg body weight according to the graph interpretation in Figure 2 (a) is included in the fuzzy set of underweight and normal weight. By substituting the x value, we get:

(16)

from the results above, the employee is underweighted with a 67% membership rate. From (14), (15) and (16) obtained a relationship between normal height and underweight (α-predicate1) and tall of height and underweight (α-predicate2) obtained relationship with MIN function:

α-predikat1 = min (0.67, 0.5) = 0.5

α-predikat2 = min (0.67, 0.67) = 0.67

from the data, the output data in the following table 4.

**Table 4**. Rules for nutritional status implications based on BMI for employee 1

|  |  |  |
| --- | --- | --- |
|  | | Weight |
| Underweight |
| Height | Normal | Underweight (0.5) |
| Tall | Severely underweight (0.67) |

The next step is to determine the fuzzy solution area with the MAX function:

μsf[x]= max (μunderweight [x],μseverely underweight [x])

= max (0.5, 0.67)

The membership function area of the solution is obtained from:

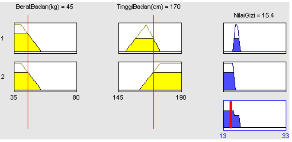
* The intersection point between rule-1 and rule-2 is when μunderweight = μseverely underweight is 17- x = 0.5 so x = 16.5.
* For μseverely underweight [x] = 0.67, then 17 - x = 0.67 so x = 16.33.
* For μunderweight [x] = 0.5, then 18.5 – x = 0.5 so x = 18.

From the points above, the membership function area of the solution is as follows:

The last step is defuzzification using the centroid method:

=

The nutritional value of 15.4 in the BMI classification states that the employee's status is severely underweight. The fuzzy logicusing MATLAB also obtained the same results as shown in Figure 3 below.



**Figure 3**. (a) graph of the weight membership function

That's the step to determine the nutritional status of other employees. In the calculation of BMI not with fuzzy logic, the nutritional values of the first employee gives a value of 15,571 or rounded 15.6 (severely underweight). In this case, the calculation of BMI with and without fuzzy logic gives the same nutritional status but has different nutritional value. However, for other employees, there are differences as shown in table 5 below.

**Table 5**. Acquisition of Employee Nutrition Status Data

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Employees to | Height (cm) | Weight (kg) | Nutritional status | | Nutritional status with fuzzy logic / based on *fuzzy* set membership | |
| 1 | 170 | 45 | 15.6 | Severely underweight | 15.4 | Severely underweight |
| 2 | 181 | 81 | 24.7 | Normal | 21.2 | Normal |
| 3 | 158 | 66 | 26.4 | overweight | 28.6 | Obese |
| 4 | 184 | 80 | 23.6 | Normal | 21.2 | Normal |
| 5 | 165 | 51 | 18.7 | Normal | 19.8 | Normal |
| 6 | 180 | 70 | 21.6 | Normal | 21.2 | Normal |
| 7 | 160 | 73 | 28.5 | Obese | 28.1 | Obese |
| 8 | 161 | 50 | 19.3 | Normal | 21 | Normal |
| 9 | 165 | 75 | 27.6 | Obese | 23.1 | Normal |
| 10 | 156 | 77 | 31.6 | Obese | 29 | Obese |
| 11 | 171 | 65 | 22.2 | Normal | 22.1 | Normal |
| 12 | 157 | 48 | 19.5 | Normal | 21.2 | Normal |
| 13 | 163 | 68 | 25.6 | overweight | 24.9 | Normal |
| 14 | 167 | 76 | 27.2 | Obese | 22.6 | Normal |
| 15 | 155 | 54 | 22.5 | Normal | 22.7 | Normal |
| 16 | 164 | 67 | 24.9 | Normal | 23.8 | Normal |
| 17 | 160 | 53 | 20.7 | Normal | 21.7 | Normal |

*3.3 Discussion*

Data clarification is carried out to ensure the accuracy of the data obtained, moreover, the data is not through direct research into the field but is obtained as primary data from PetroChina International Jabung Ltd. This is a good step taken in the study of data literature [15]. The results by the classification of nutritional status according to a strict calculation using the BMI formula are appropriate, namely the results of checking one by one the data show the same results after being recalculated using the BMI formula whose results are shown in Table 5 of the fourth column, then it can be used as a comparison result from employee nutritional status with nutritional status based on fuzzy logic.

The difference in the nutritional value of the employee occurs because of the different calculation patterns between the firm and those using membership levels. For various reasons the BMI formula in determining the nutritional status of its value needs to be questioned because it is inaccurate due to other health factors, but mathematically it can be estimated in its surroundings [16].

Input variables in fuzzy logic are intervals, provide tolerance due to the nature of nutritional status that can change or is not constant. So, the input in a strict number i.e. weight and height are changed into the membership level of the interval. Whereas calculations using firm logic, the input used is a single firm number. Therefore, determining nutritional status with fuzzy logic is better than just based on a firm formula. This is because fuzzy sets in the form of intervals provide a finer process than calculations using formulas in the form of single numbers [17].

For acquisition with strict rules, with a very small difference can change the classification of determining the nutritional status of employees, for example to the employee 13. fuzzy Logically, the employee is normal, with a nutritional value difference of 0.7. However, it will be classified as overweight if only using strict rules in the BMI formula. In this case, fuzzy logic can be flexible, tolerant, more intuitive, and acceptable according to the state of a person's nutritional status which can change on a very small scale and the absence of errors when compared to statistical forecasting [18]. Likewise, for the case of the employees 3 who are categorized as overweight in the strict classification, it turns out that they are more inclined to obese by looking at the membership function according to the fuzzy set so that in this case the fuzzy approach produces output that is closer to the actual situation [19].

Fuzzy logic is containing elements of uncertainty, therefore it is suitable for measuring something changes or contain elements of uncertainty too [20], as seen in the results above, no data shows the same results with certainty of value and nutritional status according to the classic BMI formula. Nutritional status is one of the measurements that can change in each individual [21], therefore the calculation is done in the intervals, to determine it is done using fuzzy rules as has been done above.

Determination of nutritional status using firm logic has critical values, where there is a small change in the value resulting in different categories. Whereas the determination of nutritional status using fuzzy logic allows values to fall into two categories [22], as shown for example in the case of the employee 13 being in overweight and normal. Then the highest degree of membership is taken to determine the nutritional status so that a normal nutritional value is obtained.

The nutritional status results are based on table 5 of the company Betara Gas Plant - PetroChina International Jabung Ltd can carry out company procedures to anticipate work fatigue and the risks that can occur because of it, by giving a warning to employees who have nutritional status that is not health or abnormal. 7 employees are given a reprimand to maintain nutritional status if the determination uses the classical BMI calculation. Meanwhile, if using BMI calculations with fuzzy logic only recommends 4 employees who are given a reprimand. The three employees who are not subject to reprimand according to the fuzzy logic are employees with number 9, 13 and 14. This is because the degree of membership of their nutritional status tends to be normal rather than overweight or obese.

**4. Conclusions**

This method of determining the nutritional status of employees can ensure the data accuracy of 76.5% nutritional status based on the classic BMI and provide tolerance of 42.9 % or 3 of 7 employees who are classically categorized with bad nutritional status of all employees in administration position of Betara Gas Plant - PetroChina International Jabung Ltd. So, it is more efficient for the number of employees who work, and the company can efficiently and appropriately also give a warning to employees who have a bad nutritional status to improve their nutrition or enforce other company procedures to maintain company productivity and anticipate work fatigue and its consequences.

**References**

[1] Dewi A and Yusrawati 2015 Pengaruh Kompetensi Sumber Daya Manusia dan Penerapan Sistem Akuntansi Keuangan Daerah terhadap Kualitas Laporan Keuangan Daerah. *PhD Proposal* **1** pp 65–82.

[2] A Maulidinnawati A K P and Wayan F M 2016 Seleksi Calon Karyawan Menggunakan Metode Fuzzy Tsukamoto *Sentika* **245** 135

[3] Jessica L P and Hayley C O 2015 Occupational fatigue and other health and safety issues for young Australian workers: An exploratory mixed methods study *Industrial Health* **29** 295

[4] UU No 1 Tahun 1970 tentang keselamatan kerja pasal 8

[5] Daniel T Halinda S L Eka L M 2015 *Jurnal Kesehatan Masyarakat Nasional* **7** 4 pp 180-185

[6] Peraturan Menteri Kesehatan RI No 41 tahun 2014 tentang gizi seimbang.

[7] Wang L X 1997 A course in fuzzy systems and control (Upper Saddle River: Prentice-Hall

International)

[8] Alberto Carboni 2017 *Journal Conf. IEEE* **320** 366457

[9] Segismundo S I and Luis R 2010 *Journal of Artificial Societies and Social Simulation* **21** 3 p 2

[10] Narayan and Khan Body 2007 mass index and nutritional status of adults in two rural villages in Northern Malaysia *Malaysian Journal of Nutrition* **13** 1 pp 9-17

[11] Dewi M S, Yahwardiah S and Putri C 2019 *Indonesian Journal of Medicine* **4** 1 pp 21-27

[12] Sri M, Agus T, Nurhandayani U, and Hermina 2016 *Healthy Indonesian Journal* **39** 2 pp 137-144

[13] Edit T L, Imre J R and Marta T 2014 *International Journal of Fuzzy Systems* **16** 1 pp 57-72

[14] Ajayi O, Aderele T B, Elemese T 2017 *International Journal of Advanced Engineering, Management and Science (IJAEMS)* **3** 9 10

[15] Alshenqeeti H 2014 *English Linguistics Research* **3** 1 p 39

[16] Frank Q N 2015 *Nutrition Today* **50** pp 117-118

[17] Klir, George J, Clair, Ute S T, Yuan B 1997 *Fuzzy Set Theory Foundations and Aplications* (New Jersey: Prentice Hall International, Inc) p 75

[18] Sundari R 2013 *J. Phys.: Conf. Ser.* **21** 112120

[19] Zadeh and Lotfi A 1975 *Fuzzy Sets and Their Applications to Cognitive and Decision Processes* (New York :Academic Press) p 54

[20] Athia Saelan 2009 *J. Phys.: Conf. Ser.* **821** 012329

[21] James M P 2017 Nutrition in Lifestyle Medicine *American Journal of Lifestyle Medicine* **978** 3319

[22] Bojadziev G and Bojadziev M 2007 *Fuzzy Logic for Business, Finance, and Management* (USA: Clearance Center, Inc) p 27