Classification of Iraqi Children According to Their Nutritional Status Using Fuzzy Logic

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Abstract
In this paper, we build a fuzzy classification system for classifying the nutritional status of children under 5 years old in Iraq using the Mamdani method based on input variables such as weight and height to determine the nutritional status of the child. Also, classifying the nutritional status faces a difficult challenge in the medical field due to uncertainty and ambiguity in the variables and attributes that determine the categories of nutritional status for children, which are relied upon in medical diagnosis to determine the types of malnutrition problems and identify the categories or groups suffering from malnutrition to determine the risks faced by each group or category of children. Malnutrition in children is one of the most important contributing factors to diseases and mortality. This research aims to develop a fuzzy classification system to assist in classifying the nutritional status of children under the age of five in Iraq using fuzzy logic, the fuzzy rules in the classification are derived from the Mamdani method. Therefore, by classifying the nutritional status of children more accurately, we reduce the chances of misdiagnosis and provide them with appropriate treatment more precisely to improve the health level of children and build a society more immunity and a good level of health.

The Cluster Sampling size is 16,487 observations for children under 5 years old in Iraq, consisting of 8,427 males and 8,060 females. The sample was divided into 12 age categories. The results showed that age categories less than 2, 4, 6, and 8 months had a underweight of approximately 30%. On the other hand, the age categories from 8 months to less than 2 years had an overweight of approximately 30%. While for the rest of the children in the other age groups, they had a normal nutritional status.

Paper type: Research paper
Keywords: Fuzzy Logic, Fuzzy Classification, Nutritional Status, Mamdani Method, Defuzzification

This research is taken from a master's thesis.
1. Introduction

Classification is considered an important topic in statistics as it deals with how to handle real data and how to classify it into categorical groups. This classification forms the basis for making more accurate statistical decisions, rather than relying solely on raw data. There are several methods used in this field, including cluster analysis, nearest neighbour analysis, as well as classification using fuzzy sets, such as the Mamdani Method.

1.1 Literature review

Given the importance of the topic, several researchers have conducted different studies. Mohammed (2011) classified children in Iraq under the age of 6 years based on their nutritional status using data for 2006, and body mass index (BMI) was used for the classification process. On the other hand, Permatasari et al. (2017) presented a nutritional status classification system for children using a fuzzy inference system (FIS) with the Mamdani method and concluded nine fuzzy rules through which they classified the nutritional status of children. Moktar et al. (2018) evaluated weight deficiency among children using a fuzzy logic approach with the Mamdani method and concluded that the Mamdani method was effective due to its flexibility in controlling inputs and outputs. Mohammed (2020) assessed the nutritional status of children under 5 years old in Iraq in 2018 and compared the results with those from 2006; they concluded that there is an improvement in the nutritional status of children. Hedawi and Hatim (2020) assessed the nutritional status of children under 5 years old in the Najaf province, studying the impact of various social, demographic, maternal educational, and economic characteristics, as well as breastfeeding, on the nutritional status of children. Faradisa et al. (2022) developed a system that automatically determines the value and category of body mass index (BMI) using fuzzy logic to monitor nutritional status, and tested the BMI with five attributes in the system (very low, low, normal, high, obese), which matched manual calculations.

In 1965 Lotfi Zadeh introduced the theory of fuzzy sets, and he applied multi-valued logic and introduced the concept of fuzzy logic. Hooda and Raich (2017) this transformation from classical logic which represents only true or false and the values of one or zero, into a multi-valued, between zero and one, in order to make inferences and reasoning in uncertain conditions.

Azevedo et al. (2011) with the presence of uncertain and fuzzy attributes, it is not possible to achieve precise classification. To deal with these uncertain attributes are addressed through the study of fuzzy sets. Permatasari et al. (2017) in dealing with uncertain and fuzzy attributes, the aim is to provide a description that is acceptable and analyzable. This results in the occurrence of multiple characteristics within a single fuzzy set, leading to ambiguity in classification. Therefore, the tool of classification using fuzzy sets is robust in handling uncertain or ambiguous terms, providing consistent and straightforward solutions to real problems (Azevedo et al., 2011).

In this research, we focus on studying one of the important indicators of children's health, which is their nutritional status. Therefore, it is necessary to monitor their nutritional status, as malnutrition in children leads every year to 1.3 million deaths or 45% of all child deaths. The nutritional status of the child has a significant role in the success of human growth in general, and it is considered the golden age of life, and nutrition is an important role in the human life cycle from pregnancy to old age. The highest priority in all societies is given to infants and young children under 5 years of age, as malnutrition in them may interfere with growth and development and may persist until adolescence if not treated early. These age categories are important in society as they represent the nucleus of the community and are the future, as they are important pillars in society.

In this research, we presented a classification of Iraqi children (under the age of 5) based on their nutritional status using linguistic variables such as weight and height. Due to the uncertainty and ambiguity in these variables that determine the nutritional status of children, we opted for fuzzy classification methods.
fuzzy logic is known for its ability to handle uncertain and ambiguous situations, and the Mamdani Method is one of the fuzzy logic approaches. Using this method, we classify Iraqi children under the age of 5 according to their nutritional status.

2. Material and Methods

2.1 Membership function

The membership function is of great importance in the theory of fuzzy sets, as it represents one of the ordered pair members that represents the fuzzy set. Membership functions are used to determine how an element belongs to a fuzzy set. There are several types of functions: (Shi et al, 2009).

a- Triangular Membership Function:

The membership values of elements to the fuzzy set are represented in the form of a linear function, which possesses three basic parameters (bounds) \( k_1, k_2, k_3 \). This function can be defined according to the following formula (Zhang and Liu 2006).

\[
\mu_A (x; k_1, k_2, k_3) = \begin{cases} 
0 & x \leq k_1 \\
\frac{x - k_1}{k_2 - k_1} & k_1 < x \leq k_2 \\
\frac{k_3 - x}{k_3 - k_2} & k_2 < x < k_3 \\
0 & x \geq k_3
\end{cases}
\]

Figure 1: Triangular Membership Function

b- L – Membership Function

This is a special case of a Trapezoidal Membership Function where \( k_3 = k_4 = +\infty \). This function can be defined according to the following formula (Faradisa et al, 2022).

\[
\mu_A (x, k_1, k_2) = \begin{cases} 
0 & \text{if } x \leq k_1 \\
\frac{x - k_1}{k_2 - k_1} & \text{if } k_1 < x < k_2 \\
1 & \text{if } x \geq k_2
\end{cases}
\]

Figure 2: L Membership Function

c- R –Membership Function

This is a special case of a Trapezoidal Membership Function where \( k_1 = k_2 = -\infty \). This function can be defined according to the following formula (Faradisa et al, 2022).
2.2 Mamdani Method

This method is the most commonly used in making decisions using fuzzy logic and was introduced by Mamdani. It relies on the operations of (min-max). According to this method, the minimum value for each rule is found, then the maximum value for all rules is determined, as in the following steps: (Wulandari et al, 2018)

**Step 1: fuzzification**
Fuzzification: is the process of converting numerical inputs into fuzzy numbers using membership functions for use in a fuzzy system (Wulandari et al, 2018).

**Step 2: Creating fuzzy rules**
Hooda and Raich (2017) Fuzzy rules are a set of linguistic expressions that describe how a decision should be made regarding the classification of inputs or the control of outputs. All input combinations should be considered when creating rules. The rules contain fuzzy IF-THEN statements, and the IF part can have multiple conditions using the fuzzy "AND" operator (Ross, 2009).

**Step 3: Aggregate results for all outputs**
In this step, the outputs are merged for each case. In the fuzzy rule in the first part of the IF where there are multiple conditions linked by the fuzzy operator "and", the minimum operator is used. In the case of a single observation give the same result or inference for the fuzzy rule, the fuzzy operator "or" is used, represented by the maximum operator (Ross, 2009).

**Step 4: Defuzzification**
To obtain a clear final result that gives us a single non-fuzzy value for the class or category, the process of defuzzification is used. Defuzzification is the process of converting fuzzy numbers (outputs) into crisp values, and there are several methods, one of which is the center of mass method. This is done according to the following equation: (Wulandari et al, 2018)

\[
    z = \frac{\sum_{j=1}^{n} z_j \mu(z_j)}{\sum_{j=1}^{n} \mu(z_j)}
\]

(4)

Where \( z \) represents the final output after defuzzification. Where \( \mu(z_j) \) is the membership value of \( z_j \) to the fuzzy set or category. Figure (4) illustrates the four steps of the Mamdani method (Permatasari et al, 2017).

**Figure 2:** Membership Function L

**Figure 3:** Membership Function R
2.3 Case Study

This case study focuses on classifying the nutritional status of children under the age of 5 years in Iraq based on data obtained through the multiple indicator cluster survey 6 (MICS6) conducted in 2018 by the central Statistical Organization in Iraq in collaboration with the Ministry of Health and the World Health Organization. Data was collected on 16,689 children under the age of 5, including 8,532 males and 8,157 females. Table (1) presents the data divided into 12 age categories according to the age variable.

<table>
<thead>
<tr>
<th>Set</th>
<th>Age</th>
<th>Female</th>
<th>Male</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set1</td>
<td>2 Months</td>
<td>228</td>
<td>239</td>
<td>467</td>
</tr>
<tr>
<td>Set2</td>
<td>4 Months</td>
<td>296</td>
<td>320</td>
<td>616</td>
</tr>
<tr>
<td>Set3</td>
<td>6 Months</td>
<td>314</td>
<td>272</td>
<td>586</td>
</tr>
<tr>
<td>Set4</td>
<td>8 Months</td>
<td>268</td>
<td>292</td>
<td>560</td>
</tr>
<tr>
<td>Set5</td>
<td>10 Months</td>
<td>268</td>
<td>292</td>
<td>560</td>
</tr>
<tr>
<td>Set6</td>
<td>12 Months</td>
<td>203</td>
<td>247</td>
<td>450</td>
</tr>
<tr>
<td>Set7</td>
<td>16 Months</td>
<td>554</td>
<td>546</td>
<td>1100</td>
</tr>
<tr>
<td>Set8</td>
<td>20 Months</td>
<td>524</td>
<td>579</td>
<td>1103</td>
</tr>
<tr>
<td>Set9</td>
<td>24 Months</td>
<td>477</td>
<td>507</td>
<td>984</td>
</tr>
<tr>
<td>Set10</td>
<td>3 years</td>
<td>1498</td>
<td>1610</td>
<td>3108</td>
</tr>
<tr>
<td>Set11</td>
<td>4 years</td>
<td>1786</td>
<td>1809</td>
<td>3595</td>
</tr>
<tr>
<td>Set12</td>
<td>5 years</td>
<td>1644</td>
<td>1714</td>
<td>3358</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td>8060</td>
<td>8427</td>
<td>16487</td>
</tr>
<tr>
<td></td>
<td>Missing observations and recording errors</td>
<td>97</td>
<td>105</td>
<td>202</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td>8157</td>
<td>8532</td>
<td>16689</td>
</tr>
</tbody>
</table>

The variables studied for classifying the nutritional status include the child's weight as a linguistic variable denoted by the symbol X, with linguistic limits \(x_1\) represents Scrawny, \(x_2\) represents Light, \(x_3\) represents normal, \(x_4\) represents obese, \(x_5\) represents very obese, and the child's height as a linguistic variable denoted by the symbol Y, with linguistic limits \(y_1\) represents stunted, \(y_2\) represents short, \(y_3\) represents normal, \(y_4\) represents tall, \(y_5\) represents very tall) (input variables). The classification categories are the body mass index (BMI) and its linguistic limits (malnutrition, underweight, normal, overweight, obesity) (output variable).

The MAMDANI method for classifying the nutritional status of children involves four main sequential steps and is implemented using the R programming language through the frbs package. These steps are as follows:

**Step1: fuzzification**

The membership functions are built according to the age categories, where for the first year, there are six functions every two months, for the second year, there are three functions every four months, and for the third, fourth, and fifth years, there is one function per year. The input data is fuzzified using the triangular membership function, as well as the L and R
functions. In our current study, we will select the parameters for classifying children's nutritional status based on the World Health Organization's tables (https://www.who.int). The fuzzification functions for the variable Y, for age category less than two months for males, are as follows, as adopted in the mathematical formulas (1, 2, 3):

\[
\mu_{AY_1}(y; 50.8, 52.8) = \begin{cases} 
1 & y \leq 50.8 \\
\frac{y - 50.8}{52.8 - 50.8} & 50.8 < y < 52.8 \\
0 & y \geq 52.8
\end{cases} \tag{5}
\]

\[
\mu_{AY_2}(y; 50.8, 52.8, 54.7) = \begin{cases} 
0 & y \leq 50.8 \\
\frac{52.8 - y}{54.7 - 50.8} & 50.8 < y < 52.8 \\
\frac{52.8 - y}{54.7 - 52.8} & 52.8 < y < 54.7 \\
0 & y \geq 52.8
\end{cases} \tag{6}
\]

\[
\mu_{AY_3}(y; 52.8, 54.7, 56.7) = \begin{cases} 
\frac{y - 52.8}{54.7 - 52.8} & 52.8 < y \leq 54.7 \\
\frac{y - 54.7}{56.7 - 52.8} & 54.7 < y \leq 56.7 \\
0 & y \geq 56.7
\end{cases} \tag{7}
\]

\[
\mu_{AY_4}(y; 54.7, 56.7, 58.6) = \begin{cases} 
\frac{y - 54.7}{56.7 - 54.7} & 54.7 < y \leq 56.7 \\
\frac{y - 58.6}{58.6 - 56.7} & 56.7 < y \leq 58.6 \\
0 & y \geq 58.6
\end{cases} \tag{8}
\]

\[
\mu_{AY_5}(y; 56.7, 58.6) = \begin{cases} 
\frac{y - 56.7}{58.6 - 56.7} & 56.7 < y \leq 58.6 \\
1 & y \geq 58.6
\end{cases} \tag{9}
\]

Figure (5) represents the membership function for the variable of length based on the nutritional status data of Iraqi children under two months of age.

![Figure 5: The membership functions for the length variable Y](image)

The horizontal axis represents the input values which is the length variable, while the vertical axis represents the degree of membership for the input value of the length variable. To apply the fuzzification functions for variable X for males under the age of two months, the following mathematical formulas (1,2,3) were adopted:

\[
\mu_{AX_1}(x; 3.4, 3.9) = \begin{cases} 
1 & x \leq 3.4 \\
\frac{3.9 - x}{3.9 - 3.4} & 3.4 < x < 3.9 \\
0 & x \geq 3.9
\end{cases} \tag{10}
\]
\[ \mu_{A\mathcal{X}_2}(x; 3.4, 3.9, 4.5) = \begin{cases} 0 & x \leq 3.4 \\ \frac{x - 3.4}{3.9 - 3.4} & 3.4 < x \leq 3.9 \\ \frac{4.5 - x}{4.5 - 3.9} & 3.9 < x < 4.5 \\ 0 & x \geq 4.5 \end{cases} \]  \tag{11}

\[ \mu_{A\mathcal{X}_3}(x; 3.9, 4.5, 5.1) = \begin{cases} 0 & x \leq 3.9 \\ \frac{x - 3.9}{4.5 - 3.9} & 3.9 < x \leq 4.5 \\ \frac{5.1 - x}{5.1 - 4.5} & 4.5 < x < 5.1 \\ 0 & x \geq 5.1 \end{cases} \]  \tag{12}

\[ \mu_{A\mathcal{X}_4}(x; 4.5, 5.1, 5.8) = \begin{cases} 0 & x \leq 4.5 \\ \frac{x - 4.5}{5.1 - 4.5} & 4.5 < x \leq 5.1 \\ \frac{5.8 - x}{5.8 - 5.1} & 5.1 < x < 5.8 \\ 0 & x \geq 5.8 \end{cases} \]  \tag{13}

\[ \mu_{A\mathcal{X}_5}(x; 5.1, 5.8) = \begin{cases} 0 & x \leq 5.1 \\ \frac{x - 5.1}{5.8 - 5.1} & 5.1 < x < 5.8 \\ 1 & x \geq 5.8 \end{cases} \]  \tag{14}

Figure (6) represents the membership function for the weight variable based on the nutritional status data of Iraqi children under the age of two months.

![Figure 6](image_url)

**Figure 6:** The membership function for the weight variable X.

The horizontal axis represents the input value, which is the weight variable, while the vertical axis represents the degree of membership for the input value of the weight variable. Similarly, the remaining age categories for both males and females are fuzzified using the tables of the World Health Organization (https://www.who.int).

**Step 2: Creating fuzzy rules**

In this study, rules are created to express the relationship between the inputs (weight and height) and the outputs (nutritional status). Based on Table 2, which illustrates the creation of rules for classifying nutritional status, a total of 25 fuzzy rules were inferred.
**Table 2:** Fuzzy rule of classification of toddler nutritional status

<table>
<thead>
<tr>
<th>Weight (kg)</th>
<th>Scrawny</th>
<th>Light</th>
<th>Normal</th>
<th>Obese</th>
<th>Very Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stunted</td>
<td>Underweight</td>
<td>Normal</td>
<td>Obesity</td>
<td>Obesity</td>
<td>Obesity</td>
</tr>
<tr>
<td>Short</td>
<td>Malnutrition</td>
<td>Underweight</td>
<td>Overweight</td>
<td>Obesity</td>
<td>Obesity</td>
</tr>
<tr>
<td>Normal</td>
<td>Malnutrition</td>
<td>Underweight</td>
<td>Normal</td>
<td>Overweight</td>
<td>Obesity</td>
</tr>
<tr>
<td>Tall</td>
<td>Malnutrition</td>
<td>Malnutrition</td>
<td>Underweight</td>
<td>Obesity</td>
<td>Obesity</td>
</tr>
<tr>
<td>Very Tall</td>
<td>Malnutrition</td>
<td>Malnutrition</td>
<td>Underweight</td>
<td>Normal</td>
<td>Overweight</td>
</tr>
</tbody>
</table>

After aggregating the results for all outputs and applying defuzzification using the center of mass method, a clear final result is obtained that gives a single non-fuzzy value for the class or category. Table (3) illustrates the weight, length, and nutritional status classification of male infants under two months of age, using the Mamdani method. The same process was applied for the rest of the age categories, as well as for females and males.

**Table 3:** presents the results of nutritional status classification for male Iraqi children under the age of two months.

<table>
<thead>
<tr>
<th>No.</th>
<th>X</th>
<th>Y</th>
<th>Classification Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.80</td>
<td>36.00</td>
<td>Z₅</td>
</tr>
<tr>
<td>2</td>
<td>9.30</td>
<td>52.40</td>
<td>Z₅</td>
</tr>
<tr>
<td>3</td>
<td>5.40</td>
<td>41.20</td>
<td>Z₅</td>
</tr>
<tr>
<td>237</td>
<td>3.90</td>
<td>60.70</td>
<td>Z₁</td>
</tr>
<tr>
<td>238</td>
<td>2.50</td>
<td>50.10</td>
<td>Z₂</td>
</tr>
<tr>
<td>239</td>
<td>2.60</td>
<td>51.80</td>
<td>Z₂</td>
</tr>
</tbody>
</table>

**3. Discussion of Results**

After applying the Mamdani method to all age categories for males and females, the final results are presented in Tables (4, 5). Table (4) shows the number of male children in each category of nutritional status and the percentage of each category for all age categories. The results showed that the majority of children in the age categories less than 4, 6, 8 months suffered from Underweight with percentages of 41.6%, 37.9%, and 30.1% respectively. Moreover, the majority of children in the age categories less than 2, 10, 12, 16, 20, 24 months suffered from overweight with percentages of 31.4%, 32.5%, 35.2%, 26.4%, 28.7%, and 29.8% respectively. Finally, the majority of children in the age categories less than 3, 4, 5 years had normal weight with percentages of 33%, 36.5%, and 32.7% respectively.
Table 4: Results of the number and percentage of children classified according to nutritional status for all age categories and for males

<table>
<thead>
<tr>
<th>Age</th>
<th>Malnutrition</th>
<th>Underweight</th>
<th>Normal</th>
<th>Overweight</th>
<th>Obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Per%</td>
<td>N</td>
<td>Per%</td>
<td>N</td>
</tr>
<tr>
<td>Less than 2 Months</td>
<td>13</td>
<td>5.4</td>
<td>70</td>
<td>29.3</td>
<td>54</td>
</tr>
<tr>
<td>Less than 4 Months</td>
<td>31</td>
<td>9.7</td>
<td>133</td>
<td>41.6</td>
<td>79</td>
</tr>
<tr>
<td>Less than 6 Months</td>
<td>26</td>
<td>9.6</td>
<td>103</td>
<td>37.9</td>
<td>56</td>
</tr>
<tr>
<td>Less than 8 Months</td>
<td>13</td>
<td>4.5</td>
<td>88</td>
<td>30.1</td>
<td>62</td>
</tr>
<tr>
<td>Less than 10 Months</td>
<td>14</td>
<td>4.8</td>
<td>74</td>
<td>25.3</td>
<td>65</td>
</tr>
<tr>
<td>Less than 12 Months</td>
<td>8</td>
<td>3.2</td>
<td>54</td>
<td>21.9</td>
<td>56</td>
</tr>
<tr>
<td>Less than 16 Months</td>
<td>20</td>
<td>3.7</td>
<td>116</td>
<td>21.2</td>
<td>139</td>
</tr>
<tr>
<td>Less than 20 Months</td>
<td>6</td>
<td>1.0</td>
<td>112</td>
<td>19.3</td>
<td>146</td>
</tr>
<tr>
<td>Less than 24 Months</td>
<td>10</td>
<td>2.0</td>
<td>103</td>
<td>20.3</td>
<td>131</td>
</tr>
<tr>
<td>Less than 3 years</td>
<td>18</td>
<td>1.1</td>
<td>1457</td>
<td>28.4</td>
<td>532</td>
</tr>
<tr>
<td>Less than 4 years</td>
<td>27</td>
<td>1.5</td>
<td>486</td>
<td>26.9</td>
<td>660</td>
</tr>
<tr>
<td>Less than 5 years</td>
<td>24</td>
<td>1.4</td>
<td>512</td>
<td>29.9</td>
<td>560</td>
</tr>
<tr>
<td>Sum</td>
<td>210</td>
<td>2.5</td>
<td>2308</td>
<td>27.4</td>
<td>2540</td>
</tr>
</tbody>
</table>

Table (5) shows the number of female children in each category of nutritional status and the percentage of each category for all age categories. The results showed that the majority of children in the age categories less than 4 and 6 months suffer from Underweight with percentages of 40.5% and 35.7%, respectively. However, the majority of children in the age categories less than 2, 8, 10, 12, 16, 20, and 24 months suffer from Overweight with percentages of 32.5%, 30.6%, 29.5%, 42.9%, 31.8%, 28.8%, and 27.5%, respectively. The majority of children in the age categories less than 3 and 4 years have normal weight with percentages of 31.3% and 34.3%, respectively. The majority of children in the age categories less than 5 years suffer from Underweight with a percentage of 34.3%.

Table 5: Results of the number and percentage of children classified according to nutritional status for all age categories of females

<table>
<thead>
<tr>
<th>Age</th>
<th>Malnutrition</th>
<th>Underweight</th>
<th>Normal</th>
<th>Overweight</th>
<th>Obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Per%</td>
<td>N</td>
<td>Per%</td>
<td>N</td>
</tr>
<tr>
<td>Less than 2 Months</td>
<td>15</td>
<td>6.6</td>
<td>57</td>
<td>25.0</td>
<td>45</td>
</tr>
<tr>
<td>Less than 4 Months</td>
<td>33</td>
<td>11.1</td>
<td>120</td>
<td>40.5</td>
<td>68</td>
</tr>
<tr>
<td>Less than 6 Months</td>
<td>17</td>
<td>5.4</td>
<td>112</td>
<td>35.7</td>
<td>69</td>
</tr>
<tr>
<td>Less than 8 Months</td>
<td>17</td>
<td>6.3</td>
<td>67</td>
<td>25.0</td>
<td>67</td>
</tr>
<tr>
<td>Less than 10 Months</td>
<td>14</td>
<td>5.2</td>
<td>67</td>
<td>25.0</td>
<td>65</td>
</tr>
<tr>
<td>Less than 12 Months</td>
<td>4</td>
<td>2.0</td>
<td>40</td>
<td>19.7</td>
<td>43</td>
</tr>
<tr>
<td>Less than 16 Months</td>
<td>6</td>
<td>1.1</td>
<td>106</td>
<td>19.1</td>
<td>131</td>
</tr>
<tr>
<td>Less than 20 Months</td>
<td>9</td>
<td>1.7</td>
<td>76</td>
<td>14.5</td>
<td>136</td>
</tr>
<tr>
<td>Less than 24 Months</td>
<td>7</td>
<td>1.5</td>
<td>103</td>
<td>21.6</td>
<td>129</td>
</tr>
<tr>
<td>Less than 3 years</td>
<td>14</td>
<td>0.9</td>
<td>448</td>
<td>29.9</td>
<td>469</td>
</tr>
<tr>
<td>Less than 4 years</td>
<td>22</td>
<td>1.2</td>
<td>527</td>
<td>29.5</td>
<td>613</td>
</tr>
<tr>
<td>Less than 5 years</td>
<td>29</td>
<td>1.8</td>
<td>564</td>
<td>34.3</td>
<td>535</td>
</tr>
<tr>
<td>Sum</td>
<td>187</td>
<td>2.3</td>
<td>2287</td>
<td>28.4</td>
<td>2370</td>
</tr>
</tbody>
</table>
4. Conclusion

We can use fuzzy classification with the Mamdani method to classify the nutritional status of children under 5 years old using linguistic variables as inputs representing weight and height, and the output being the child's nutritional status classification, represented by the body mass index (BMI) indicator consisting of five categories: malnutrition, underweight, normal, overweight, and obesity. Based on fuzzy logic and the Mamdani method, we derived 25 fuzzy rules to determine the category of each child under 5 years old. We found that the majority of children from birth to the age of 8 months suffer from underweight, while the majority of children from 8 to 24 months suffer from overweight. Finally, we found that the majority of children aged 3 to 5 years have a normal weight.

References

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العنوان: تصنيف أطفال العراق حسب الحالة التغذوية باستعمال المنطق الضبابي

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البحث مسحل من رسالة ماجسحيز

تم مسح نتائج البحث عن المنطق الضبابي لتصنيف الحالة التغذوية للأطفال العراقية في 5 سنوات باستخدام طريقة Mamdani táctico لتحديد الحالة التغذوية للأطفال والتصنيف للحالة التغذوية بواجهة تحديد صعوب في المجال الطبي بسبب حالة عدم التأكد والغموض في المتغيرات والصفات التي تحدد فئات الحالة التغذوية للأطفال والتي يعتمد عليها التشخيص الطبي في تحديد نوع الإمساك المتعلقة في مشاكل سوء التغذية لعمر الأطفال أو المجموعات التي تتعالى من سوء التغذية تحديد المخاطر التي تتعرض لها كل مجموعة أو فئة من الأطفال حيث أن سوء التغذية لدى الأطفال تكون من أهم العوامل المساهمة في الأمراض والوفاة. يهدف هذا البحث إلى وضع نظام تصنيف ضبائي للإجابة في تصنيف الحالة التغذوية للأطفال العراقية دون من الحالة في استخدام المترضي الخاصي حيث تتم الفعالة وبالتالي تصنيف للحالة التغذوية للأطفال بشكل أكثر دقة من فرص التشخيص الخاصي وتقديم العلاج المناسب لهم بدقة أكثر للارتقاء بالمستوى الصحي للأطفال لدى مجتمع أكثر مناعة وذات مستوى صحي جيد.

البحث مسحل من رسالة ماجسحيز

التوصيات: المناسبة: المنطقة الضبابية، التصنيف ضبائي، الحالة التغذوية، طريقة مامدن، إزالة التقييم.