Vitiligo Disease Diagnosis Expert System using The Web-Based Fuzzy Mamdani Method

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ABSTRACT

Vitiligo is a disease that causes skin color to fade. Besides being able to attack any skin area on the body, this fading can also occur on the inside of the mouth, eyes, and hair. In this study, an expert system for diagnosing vitiligo has been built, in order to make it easier for patients to find out the level of vitiligo that is being suffered. The problem of this study is how to build an expert system to diagnose vitiligo by implementing Fuzzy Logic using the Mamdani Method. Fuzzy logic is an approach that uses several specific stages. The system is built using a structured approach with use cases, sequences, and activity diagrams as tools for designing the system. The results of this study are in the form of an expert system that is able to produce a risk level for vitiligo.

Keywords: Vitiligo, Expert System, Mamdani Method, Fuzzy Logic.

1. INTRODUCTION

An expert system is a computer program that contains the knowledge of one or more human experts on a field in specific[1], [2]. Expert systems can solve problems according to an expert's knowledge that is entered into the system[3]. Expert systems are generally often used to carry out activities to diagnose a problem that only an expert can solve[4].

Good accuracy is obtained from the activity of diagnosing a disease using a computerized expert system so that it is strongly influenced by the expert system method used[5]. Expert system methods generally consist of several kinds of methods, one of which is the fuzzy mamdani method[6], which is a method capable of modeling the human thought process into a system to diagnose a disease, especially vitiligo[7].

Vitiligo is a skin disease that can cause skin color to fade, in addition to attacking the skin area, vitiligo can also occur in any skin area such as the eyes and hair[8], [9]. For people commonly usually to determine the diagnosis of disease vitiligo should do a consultation to a specialist who is an expert in the field of diagonsa disease this, but problem that often occurs is the use of a less efficient for experts to serve patients a lot to do consultations so hard to deal with the problem of patients with time efficient, effective and accurate diagnosis[10], [11].

2. RESEARCH METHOD

The research framework used is the waterfall model.
Data collection was carried out in two ways, namely: Observation (Observation) namely making direct observations to the research location to collect data related to the diagnosis of vitiligo. Interview Conducting interviews with related parties regarding the ongoing system for the diagnosis of Vitiligo at the research site.

Problem analysis Analyzing data obtained from the research site that has been carried out at the data collection stage to identify problems that occur in vitiligo diagnosis research.

System planning System design is divided into two parts, namely system logic design and interface design design.

System Encoding Doing the implementation of the program code into a system expert diagnosis of the disease Vitiligo that has been designed for the system expert diagnosis of the disease Vitiligo can be used to resolve the problem of diagnosis of disease Vitiligo in the research of this.

System Testing Test the expert system for diagnosing Vitiligo in order to find out the deficiencies of the system that has been built in this study.

System Implementation Implementation of the system is a form of real-system data that has been built to resolve the problems in the process mendiangno s a disease Vitiligo is real.

Documentation report research in accordance with the topic of research that has been done.

3. RESULTS AND DISCUSSION

Analysis is a problem-solving techniques with a way to solve the system into components with the aim of studying these components work and interact to complete their objectives. System design is a complement to system analysis into a complete system with the aim of getting a better system.

Data analysis is an effort or way to process data into information so that the characteristics of the data can be understood and are useful for solving problems, especially problems related to research.

<table>
<thead>
<tr>
<th>No</th>
<th>Kode Pasien</th>
<th>Nama Pasien</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P01</td>
<td>Rio Wirawan</td>
</tr>
<tr>
<td>2</td>
<td>P02</td>
<td>Ilham Akbar</td>
</tr>
<tr>
<td>3</td>
<td>P03</td>
<td>Shinta Suci</td>
</tr>
</tbody>
</table>

Table 1. Patient data
Method analysis is a step taken to solve the problem of the patient's diagnosis of vitiligo by applying the fuzzy mamdani method that was chosen in this study as a problem solving method.

1. **Fuzzy Set Formation**

<table>
<thead>
<tr>
<th>Nama Pasien</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
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<td>15</td>
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<td>Shinta Suci</td>
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<td>27</td>
<td>19</td>
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<td>28</td>
<td>19</td>
</tr>
</tbody>
</table>

1. **Fuzzy Association**

<table>
<thead>
<tr>
<th>Fungsi Output</th>
<th>Gejala Input</th>
<th>Himpunan</th>
<th>Semesta</th>
<th>Domain</th>
</tr>
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<tbody>
<tr>
<td>C7</td>
<td>C6</td>
<td>Rendah</td>
<td>[0 – 40]</td>
<td>[0 1020]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sedang</td>
<td>[0 – 40]</td>
<td>[102030]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tinggi</td>
<td>[0 – 40]</td>
<td>[203040]</td>
</tr>
<tr>
<td>C6</td>
<td>C10</td>
<td>Rendah</td>
<td>[0 – 40]</td>
<td>[0 1020]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sedang</td>
<td>[0 – 40]</td>
<td>[102030]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tinggi</td>
<td>[0 – 40]</td>
<td>[203040]</td>
</tr>
<tr>
<td>C3</td>
<td>C4</td>
<td>Rendah</td>
<td>[0 – 40]</td>
<td>[0 1020]</td>
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<tr>
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<td></td>
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<td>[0 – 40]</td>
<td>[102030]</td>
</tr>
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<td></td>
<td></td>
<td>Tinggi</td>
<td>[0 – 40]</td>
<td>[203040]</td>
</tr>
<tr>
<td>C2</td>
<td>C3</td>
<td>Rendah</td>
<td>[0 – 40]</td>
<td>[0 1020]</td>
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<tr>
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<tr>
<td></td>
<td></td>
<td>Tinggi</td>
<td>[0 – 40]</td>
<td>[203040]</td>
</tr>
<tr>
<td>C1</td>
<td>C2</td>
<td>Rendah</td>
<td>[0 – 40]</td>
<td>[0 1020]</td>
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<tr>
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<td>Sedang</td>
<td>[0 – 40]</td>
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<td></td>
<td></td>
<td>Tinggi</td>
<td>[0 – 40]</td>
<td>[203040]</td>
</tr>
</tbody>
</table>

**Table 2. Symptoms of Vitiligo Disease**

<table>
<thead>
<tr>
<th>No</th>
<th>Gejala</th>
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</tr>
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<tbody>
<tr>
<td>1</td>
<td>Riwayat vitiligo atau penyakit autoimun dalam keluarga</td>
<td>C1</td>
</tr>
<tr>
<td>2</td>
<td>Kulit seperti terbakar sinar matahari</td>
<td>C2</td>
</tr>
<tr>
<td>3</td>
<td>Kanker Kulit</td>
<td>C3</td>
</tr>
<tr>
<td>4</td>
<td>Gangguan pada mata</td>
<td>C4</td>
</tr>
<tr>
<td>5</td>
<td>Penurunan pendengaran</td>
<td>C5</td>
</tr>
<tr>
<td>6</td>
<td>Efek samping terapi, seperti kulit kering dan gatal</td>
<td>C6</td>
</tr>
<tr>
<td>7</td>
<td>Resiko Vitiligo</td>
<td>C7</td>
</tr>
</tbody>
</table>

**Table 3. Patient Result Data**

<table>
<thead>
<tr>
<th>No</th>
<th>Nama Pasien</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rio Wirawan</td>
<td>40</td>
<td>28</td>
<td>34</td>
<td>38</td>
<td>35</td>
<td>17</td>
</tr>
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<td>2</td>
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<td>15</td>
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<tr>
<td>3</td>
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<td>22</td>
<td>27</td>
<td>19</td>
<td>30</td>
<td>28</td>
<td>19</td>
</tr>
</tbody>
</table>
Based on the symptoms and predetermined set domains, the next step is to determine the membership function of each variable and calculate the value or degree of membership based on the predetermined membership function.

a. Fuzzy Variable C1 Set (Family history of Vitiligo or autoimmune disease)

Figure 2. Triangle Curve Variable Degree Membership Function C1

Its membership functions are:
1. Low
   \[
   \mu_{(C1)}^{Rendah} = \begin{cases} 
   1; & x \leq 10 \\
   \frac{20 - x}{20 - 10}; & 5 \leq x \leq 20 \\
   0; & x \geq 20
   \end{cases}
   \]
2. Middle
   \[
   \mu_{(C1)}^{Sedang} = \begin{cases} 
   0; & x \leq 10 \text{ atau } x \geq 20 \\
   \frac{x - 10}{20 - 10}; & 10 \leq x \leq 20 \\
   \frac{30 - x}{30 - 20}; & 20 \leq x \leq 30
   \end{cases}
   \]
3. High
   \[
   \mu_{(C1)}^{Tinggi} = \begin{cases} 
   0; & x \leq 20 \\
   \frac{x - 30}{30 - 20}; & 20 \leq x \leq 30 \\
   1; & 30 \leq x \leq 40
   \end{cases}
   \]

b. C2 Fuzzy Variable Set (Skin Like Sunburn)

Figure 3. Triangle Curve Function Degree Membership Variables C2

Its membership functions are:
1. Low
   \[
   \mu_{(C1)}^{Rendah} = \begin{cases} 
   1; & x \leq 10 \\
   \frac{20 - x}{20 - 10}; & 5 \leq x \leq 20 \\
   0; & x \geq 20
   \end{cases}
   \]
2. Middle
   \[
   \mu_{(C1)}^{Sedang} = \begin{cases} 
   0; & x \leq 10 \text{ atau } x \geq 20 \\
   \frac{x - 10}{20 - 10}; & 10 \leq x \leq 20 \\
   \frac{30 - x}{30 - 20}; & 20 \leq x \leq 30
   \end{cases}
   \]
3. High
\[ \mu_{(C1)}Tinggi = \begin{cases} 
0; & x \leq 20 \\
\frac{x - 30}{30 - 20}; & 20 \leq x \leq 30 \\
1; & 30 \leq x \leq 40 
\end{cases} \]

c. C3 Fuzzy Variable Set (Skin Cancer)

\[ \mu_{(C1)}Rendah = \begin{cases} 
1; & x \leq 10 \\
\frac{20 - x}{20 - 10}; & 10 \leq x \leq 20 \\
0; & x \geq 20 
\end{cases} \]

\[ \mu_{(C1)}Sedang = \begin{cases} 
\frac{x - 10}{20 - 10}; & 10 \leq x \leq 20 \\
\frac{30 - x}{30 - 20}; & 20 \leq x \leq 30 \\
0; & x \geq 20 
\end{cases} \]

\[ \mu_{(C1)}Tinggi = \begin{cases} 
0; & x \leq 20 \\
\frac{x - 30}{30 - 20}; & 20 \leq x \leq 30 \\
1; & 30 \leq x \leq 40 
\end{cases} \]

d. C4 Fuzzy Variable Set (Eye Disorders)

\[ \mu_{(C1)}Rendah = \begin{cases} 
1; & x \leq 10 \\
\frac{20 - x}{20 - 10}; & 10 \leq x \leq 20 \\
0; & x \geq 20 
\end{cases} \]

\[ \mu_{(C1)}Sedang = \begin{cases} 
\frac{x - 10}{20 - 10}; & 10 \leq x \leq 20 \\
\frac{30 - x}{30 - 20}; & 20 \leq x \leq 30 \\
0; & x \geq 20 
\end{cases} \]

\[ \mu_{(C1)}Tinggi = \begin{cases} 
0; & x \leq 20 \\
\frac{x - 30}{30 - 20}; & 20 \leq x \leq 30 \\
1; & 30 \leq x \leq 40 
\end{cases} \]

e. C5 Fuzzy Variable Set (Hearing Loss)
Figure 6. Triangle Curve Variable Degree Membership Function C5

Its membership functions are:
1. Low
\[
\mu_{(C1)\text{Rendah}} = \begin{cases} 
1; & x \leq 10 \\
\frac{20 - x}{20 - 10}; & 15 \leq x \leq 20 \\
0; & x \geq 20 
\end{cases}
\]
2. Midle
\[
\mu_{(C1)\text{Sedang}} = \begin{cases} 
0; & x \leq 10 atau x \geq 20 \\
\frac{x - 10}{20 - 10}; & 10 \leq x \leq 20 \\
\frac{30 - x}{30 - 20}; & 20 \leq x \leq 30 
\end{cases}
\]
3. High
\[
\mu_{(C1)\text{Tinggi}} = \begin{cases} 
0; & x \leq 20 \\
\frac{x - 30}{30 - 20}; & 20 \leq x \leq 30 \\
1; & 30 \leq x \leq 40 
\end{cases}
\]

f. C6 Fuzzy Variable Set (Side Effects of therapy, such as Dry and Itchy Skin)

Figure 7. Triangle Curve Variable Degree Membership Function C6

Its membership functions are:
1. Low
\[
\mu_{(C1)\text{Rendah}} = \begin{cases} 
1; & x \leq 10 \\
\frac{20 - x}{20 - 10}; & 15 \leq x \leq 20 \\
0; & x \geq 20 
\end{cases}
\]
2. Midle
\[
\mu_{(C1)\text{Sedang}} = \begin{cases} 
0; & x \leq 10 atau x \geq 20 \\
\frac{x - 10}{20 - 10}; & 10 \leq x \leq 20 \\
\frac{30 - x}{30 - 20}; & 20 \leq x \leq 30 
\end{cases}
\]
3. High
\[
\mu_{(C1)\text{Tinggi}} = \begin{cases} 
0; & x \leq 20 \\
\frac{x - 30}{30 - 20}; & 20 \leq x \leq 30 \\
1; & 30 \leq x \leq 40 
\end{cases}
\]

g. C7 Variable Fuzzy Set (Risk of Vitiligo)

Figure 8. Triangle Curve Variable Degree Membership Function C7
Its membership functions are:

1. Low

$$\mu_{(C_1)Rendah} = \begin{cases} 1; & x \leq 10 \\ \frac{20 - x}{20 - 10}; & 10 \leq x \leq 20 \\ 0; & x \geq 20 \end{cases}$$

2. Middle

$$\mu_{(C_1)Sedang} = \begin{cases} 0; & x \leq 10 \text{ atau } x \geq 20 \\ \frac{x - 10}{20 - 10}; & 10 \leq x \leq 20 \\ \frac{30 - x}{30 - 20}; & 20 \leq x \leq 30 \\ 0; & x \leq 20 \end{cases}$$

3. High

$$\mu_{(C_1)Tinggi} = \begin{cases} 0; & x \leq 20 \\ \frac{x - 30}{30 - 20}; & 20 \leq x \leq 30 \\ 1; & 30 \leq x \leq 40 \end{cases}$$

2. Establishment of Rule

The following are the rules for diagnosing Vitiligo which are the provisions of this study.

a. R1: IF History of vitiligo or autoimmune disease in the family = high AND Skin like sunburn = moderate AND Skin cancer = high AND Eye disorders = moderate AND Hearing loss = high AND side effects of therapy, such as dry and itchy skin = moderate THEN Risks Vitiligo = High

b. R2: IF History of vitiligo or autoimmune disease in the family = moderate AND Skin like sunburn = high AND Skin cancer = moderate AND Eye disorders = high AND Hearing loss = moderate AND side effects of therapy, such as dry and itchy skin = high THEN Risks Vitiligo = High

c. R3: IF History of vitiligo or autoimmune disease in the family = high AND Skin like sunburn = high AND Skin cancer = Moderate AND Eye disorders = Moderate AND Hearing impairment = High AND Side effects of therapy, such as dry and itchy skin = High THEN Risk Vitiligo = High

d. R4: IF History of vitiligo or autoimmune disease in the family = moderate AND Skin like sunburn = high AND Skin cancer = Moderate AND Eye disorders = High AND Hearing loss = Moderate AND Side effects of therapy, such as dry and itchy skin = high THEN Risk Vitiligo = High

e. R5: IF History of vitiligo or autoimmune disease in the family = moderate AND Skin like sunburn = moderate AND Skin cancer = high AND Eye disorders = moderate AND Hearing loss = moderate AND Side effects of therapy, such as dry and itchy skin = moderate THEN Risk Vitiligo = Moderate

f. R6: IF History of vitiligo or autoimmune disease in the family = moderate AND Skin like sunburn = moderate AND Skin cancer = Moderate AND Eye disorders = moderate AND Hearing loss = moderate AND Side effects of therapy, such as dry and itchy skin = moderate THEN Risk Vitiligo = Moderate

g. R7: IF History of vitiligo or autoimmune disease in the family = moderate AND Skin like sunburn = moderate AND Skin cancer = Low AND Eye disorders = Moderate AND Hearing impairment = Moderate AND Side effects of therapy, such as dry and itchy skin = Moderate THEN Risk Vitiligo = Moderate

h. R8: IF History of vitiligo or autoimmune disease in the family = Moderate AND Skin like sunburn = Low AND Skin cancer = Low AND Eye disorders = Moderate AND Hearing impairment = Moderate AND Side effects of therapy, such as dry and itchy skin = Moderate THEN Risk Vitiligo = Moderate

i. R9: IF History of vitiligo or autoimmune disease in the family = Low AND Skin like sunburn = Low AND Skin cancer = Moderate AND Eye disorders = Moderate AND Hearing impairment = Moderate AND Side effects of therapy, such as dry and itchy skin = Moderate THEN Risk Vitiligo = Low
j. R10: IF History of vitiligo or autoimmune disease in the family = Low AND Skin like sunburn = Low AND Skin cancer = Low AND Eye disorders = Low AND Hearing impairment = Moderate AND Side effects of therapy, such as dry and itchy skin = moderate THEN Risk Vitiligo = Low

k. R11: IF History of vitiligo or autoimmune disease in the family = Low AND Skin like sunburn = Moderate AND Skin cancer = Moderate AND Eye disorders = Low AND hearing loss = Low AND Side effects of therapy, such as dry and itchy skin = Low THEN Risk Vitiligo = Low

l. R12: IF History of vitiligo or autoimmune disease in the family = Low AND Skin like sunburn = Low AND Skin cancer = Moderate AND Eye disorders = Low AND hearing loss = High AND Side effects of therapy, such as dry and itchy skin = Low THEN Risk Vitiligo = Low.

3. Fuzzy Value

a. Fuzzy Value for Symptoms C1

<table>
<thead>
<tr>
<th>Nama Pasien</th>
<th>Riwayat vitiligo atau penyakit autoimun dalam keluarga</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio Wirawan</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ilham Akbar</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shinta Suci</td>
<td>0</td>
<td>0.8</td>
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b. Fuzzy Value for Symptoms C2

<table>
<thead>
<tr>
<th>Nama Pasien</th>
<th>Kulit Seperti Terbakar Sinar Matahari</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
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<td>0.2</td>
<td>0.8</td>
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</tr>
<tr>
<td>Ilham Akbar</td>
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<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Shinta Suci</td>
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<td>0.7</td>
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</table>

c. Fuzzy Value for Symptoms C3

<table>
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<tr>
<th>Nama Pasien</th>
<th>Kanker Kulit</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
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</thead>
<tbody>
<tr>
<td>Rio Wirawan</td>
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<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ilham Akbar</td>
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d. Fuzzy Value for Symptoms C4

<table>
<thead>
<tr>
<th>Nama Pasien</th>
<th>Gangguan Pada Mata</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
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<tbody>
<tr>
<td>Rio Wirawan</td>
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</tr>
<tr>
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<tr>
<td>Shinta Suci</td>
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<td>1</td>
<td></td>
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</table>

e. Fuzzy Value for Symptoms C5

<table>
<thead>
<tr>
<th>Nama Pasien</th>
<th>Penuruan Pendengaran</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio Wirawan</td>
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<td>1</td>
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<tr>
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<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Shinta Suci</td>
<td>0.2</td>
<td>0.8</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

f. Fuzzy Value for Symptoms C6

<table>
<thead>
<tr>
<th>Nama Pasien</th>
<th>Efek Samping Terapi, Seperti Kulit Kering Dan Gatal</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio Wirawan</td>
<td>0.3</td>
<td>0.7</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
4. **Affirmation (Defuzzification)**

The overall conclusion is by taking the maximum membership level of each consequent application of the implication function and combining all the conclusions of each rule, in order to obtain the following ranking results:

<table>
<thead>
<tr>
<th>Nama Pasien</th>
<th>Hasil</th>
<th>Total</th>
<th>Resiko Vitiligo (C7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio Wirawan</td>
<td>Tinggi</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Ilham Akbar</td>
<td>Sedang</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Shinta Suci</td>
<td>Rendah</td>
<td>7.5</td>
<td></td>
</tr>
</tbody>
</table>

Based on the analysis of patients using the Mamdani method based on symptoms, the results showed that Rio Wirawan's patient was declared to have vitiligo with a total of 30 which means he has a high risk of vitiligo, while Ilham Akbar's patient has a moderate risk of vitiligo with a value of 20, and Shinta Suci has a low risk of vitiligo with value 7.5.

4. **CONCLUSION**

Research on the Expert System to Diagnose Vitiligo Using the Fuzzy Mamdani method, several conclusions can be drawn, including This study has produced a Web-based Vitiligo Disease Diagnosis Expert System using the Fuzzy Mamdani method using 7 variables where 6 variables are for symptoms and 1 is for output in the form of the level of vitiligo experienced by the patient. The diabut expert system can help users to determine the level of vitiligo that is experienced based on the symptoms and rules that have been determined by the expert.

**REFERENCES**


