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Decision Making System Using Fuzzy Mamdani in Detecting Cholestrol Disease

Nanda Novita[1)*], Yuan Anisa[2)], Muhammad Khahfi Zuhanda [3)], Eliska[4)], Yuri Widiantho[5)]
[1,2,3)]Universitas MedanArea
[4)]Universitas Islam Negeri Sumatera Utara
[5)]Universitas Sumatera Utara
[1)]nandanovita@staff.uma.ac.id, [2)]Yuan@staff.uma.ac.id [3)]khahfi@staff.uma.ac.id, [4)]eliska@uinsu.ac.id,
[5)]yuriwidiantho@students.usu.ac.id

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Abstract: Cholestrol is a physical property of natural substances in the form of fat which is useful as an essential building material for the body for the synthesis of important substances such as cell membranes and insulation materials around nerve fibers. In addition, it is useful for sex hormones, kidney children and bile acids. High cholesterol levels or hypercholesterolemia in the blood triggers hypertension. This is because high cholesterol is the cause of blockages in peripheral blood vessels that reduce blood supply to the heart. Based on these studies, it shows that the influence of obesity (overweight) and blood pressure has a role in the risk of cholesterol disease. Based on the rule view, it can be seen that the cholesterol level is 210 or it can be said that it is in the alert category, it can be seen for blood pressure 100.6 and BMI 31.8.The fuzzy mamdani method is often also known as the min-max method. Where it uses min or minimum on the implication function and max or maximum on the composition between implication functions. In its application, the madani fuzzy method uses 4 stages, namely the formation of fuzzy sets, application of implication functions, rule composition, defuzzification. This research uses a simulation method of calculating cholesterol. This research analyzes using fuzzy mamdani and matlab software assistance.

Keywords: Fuzzy mamdani, cholesterol, blood pressure, BMI, matlab software

INTRODUCTION

Cholestrol is a physical property of natural substances in the form of fat which is useful as an essential building material for the body for the synthesis of important substances such as cell membranes and insulation materials around nerve fibers. In addition, it is useful for sex hormones, kidney and bile acids. However, if there is an excessive increase in cholesterol levels in the blood or can be called hypercholesterolemia, it will cause death. Cholesterol can cause several diseases such as atherosclerosis (narrowing of blood vessels), coronary heart disease, stroke, and high blood pressure. Normal total blood cholesterol <200 mg/dl. (Soeharto, 2004)

High cholesterol levels or hypercholesterolemia in the blood trigger hypertension. This is because high cholesterol is the cause of blockages in peripheral blood vessels that reduce blood supply to the heart (Soleha, 2012). The state of high cholesterol levels in the blood increases the risk of atherosclerosis where there will be fat deposits (plaque) in the lining of blood vessels that easily clog blood vessels resulting in increased peripheral resistance of blood vessels, resulting in increased blood pressure. (Ministry of Health RI, 2013) According to data from the 2013 Riskesdas Data, the prevalence rate of hypertension based on the results of measurements in the population aged ≥18 years was 34.1%. Risk factors for hypertension can be divided into factors that cannot be changed and factors that can be changed. One of the risk factors for hypertension that can be changed is hypercholesterolemia. Riskesdas 2013 showed that the proportion of the population >15 years old with total cholesterol levels above normal values was 35.9%.

In line with research conducted by (Maryati, 2017) research conducted in Sidomulyo Hamlet, Rejoagung Village, Ploso Kecataman, Jombang Regency, research was conducted on 24 hypertensive patients, this was done to determine the relationship between cholesterol and blood pressure. The results of the study were mostly (52.9%) respondents had moderate blood cholesterol levels (200 -239 mg/dl) and almost half (41.2%) of respondents suffered from grade 1 hypertension (140 -159/90-99 mmHg) and grade 2 hypertension (160 - 179/100-109 mmHg).

*name of corresponding author

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Research by (Feryad, Sulastri,, & Kadri, 2014)that there is a significant relationship between cholesterol levels and the incidence of hypertension, where respondents who have abnormal cholesterol levels have a 2.09 times greater risk of hypertension than respondents who have normal cholesterol levels in Padang City. Based on the research conducted, it is clear that there is an influence between blood pressure and the risk of developing cholesterol disease. In addition, the cause of cholesterol can come from obesity / overweight, lack of exercise and smoking.

Research conducted by (Listiyana, Mardiana, & Prameswari, 2013)preliminary study on 10 women aged 45-54 years in Plalangan Village, Gunungpati District, Semarang City, obtained the results of 6 women (60%) experiencing central obesity with total blood cholesterol levels ≥ 200 mg/dl as many as 3 women (50%), and total blood cholesterol levels < 200 mg/dl as many as 3 women (50%), while 4 women who did not experience central obesity with total blood cholesterol levels ≥ 200 mg/dl as many as 1 woman (25%) and total blood cholesterol levels < 200 mg/dl as many as 3 women (75%).

This is in line with research conducted by (Nur, Esfandiari , Anggraeni, & Septian, 2020) which shows that the normal IMT category there are 10 people (76.9%) with normal total cholesterol levels and 16 people (37.2%) with excessive total cholesterol levels. While the excess category IMT there are 3 people (23.1%) with normal category total cholesterol levels and 27 people (62.8%) with excessive category total cholesterol levels. The statistical test results obtained a P-value of 0.028 (P-value <0.05). It can be concluded that there is a relationship between body mass index (BMI) and total cholesterol.

Based on these studies, it shows that the influence of obesity (overweight) and blood pressure has a role in the risk of cholesterol disease. But at this time there are still many who do not know and care about this and have difficulty in controlling so that blood pressure remains normal. So it is necessary to have a system to make decisions in preventing cholesterol disease. By detecting early causes of cholesterol disease, faster prevention can be done. Also as a detection of cholesterol patients who have not been detected so that later it can be treated more quickly as a prevention of further complications.

Many methods can be used, one example is Fuzzy. Fuzzy Logic is a decision support system method that is suitable for implementation in the selection of causes of cholesterol. (Adrial, Vitriani, & usna, 2020) Fuzzy logic is widely used in the field of medical informatics both in the form of expert systems and intelligent medical diagnostic systems in determining disease diagnoses to help patients and medical personnel. (Riyadhi & Syukur, 2014).

Research conducted by (David, 2016) The purpose of this research is to produce an application that can measure a man's uric acid, blood sugar and cholesterol levels with fuzzy queries and then display using natural language processing. The results showed that this application was able to produce a level of blood test results. This application can provide a solution that the levels in the blood test results are bad or good or even in a border state so as to determine whether the man is healthy or not.

Research conducted by (Munawar, Marzuki, & Radhiah, 2018) using 3 input variables, namely age, blood pressure, and cholesterol and the output variable is the risk of diabetes. With 20 sample data from Zainoel Abidin Regional General Hospital Banda Aceh. The process for classifying the risk of developing diabetes is by determining the input variables, determining the mamdani fuzzy inference system, then finally applying the rules with the FIS Matlab toolbox. The design of the fuzzy inference system (FIS) is made using a combination of membership functions, namely triangle and trapezoid. The conclusion that can be generated from this research is that the older a person's age with high cholesterol, the greater the chance that someone will get Diabetes. In this research, the fuzzy mamdani method is one of the methods that has proven to have high accuracy due to the complex calculations found in it.

Based on this, researchers conducted research on diagnosing cholesterol disease based on blood pressure and BMI (Body Mass Index) using fuzzy mamdani in detecting the influence between blood pressure and BMI on cholesterol disease so that in the future it can be a reference for preventing cholesterol disease.

.LITERATURE REVIEW

Cholesterol

Cholesterol is one of the most important and widely available sterols in nature. Cholesterol is present in almost all animal and human cells. In the human body, cholesterol is found in the blood, bile, outer adrenal glands and nerve tissue. Cholesterol was first isolated from gallstones because cholesterol is the main component of gallstones. Cholesterol is soluble in fatty solvents such as ether, chloroform, benzene and hot alcohol. When present in high concentrations cholesterol crystallizes in the form of crystals that are colorless, tasteless, odorless and have a melting point of 150o - 151oC. Cholesterol deposits when present in blood vessels can cause narrowing of the blood vessels because the blood vessel walls become thicker. This results in reduced flexibility of blood vessels so that blood flow is disrupted and to overcome this disturbance the heart must pump blood harder.

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A small amount of cholesterol in the body is necessary for certain processes for survival. However, if the amount is excessive, cholesterol will make the blood thicker, more fatty so that it threatens the smooth circulation of blood especially if it sticks to the walls of blood vessels or settles to make blockages in small blood vessels. The ideal total cholesterol level is below 200 mg/dL. (General hospital Singapore) Cholesterol in the human body is found in the blood, bile, outer adrenal glands and nerve tissue. Cholesterol was first isolated from gallstones because cholesterol is the main component of gallstones. Cholesterol is soluble in fatty solvents, such as hexane, ether, chloroform, benzene and hot alcohol. Cholesterol will crystallize in the form of crystals that are colorless, tasteless, odorless and have a melting point of 150^0 -151^0 C. Cholesterol deposits when present in blood vessels can cause narrowing of the blood vessels because the walls of the blood vessels become thicker. This results in reduced flexibility of blood vessels so that blood flow is disturbed and to overcome this disturbance the heart must pump blood harder (Muharrami, 2011)

Fuzzy Logics

The concept of fuzzy logic was first introduced by Professor Lotfi A. Zadeh of the University of California, in June 1965. Fuzzy is linguistically defined as fuzzy or vague. According to (Setiadj, 2009) ,fuzzy is a value that can be true or false simultaneously. But how much the value of truth and error depends on the degree of membership it has.

The degree of membership in fuzzy has a range of values from 0 (zero) to 1 (one). This is different from a firm set which has a value of 1 or 0 (yes or no). Fuzzy logic is used to translate a quantity that is expressed using language (linguistics), for example the amount of vehicle speed expressed by slow, rather fast, fast, and very fast. And fuzzy logic indicates the extent to which a value is true and the extent to which a value is false. Unlike strict logic, a value only has 2 possibilities, namely a member of the set or not. The degree of membership 0 (zero) means that the value is not a member of the set and 1 (one) means that the value is a member of the set.

Metode Fuzzy Mamdani

The fuzzy mamdani method is often known as the min-max method. Where it uses min or minimum in the implication function and max or maximum in the composition between implication functions. In its application, the madani fuzzy method uses 4 stages, namely the formation of fuzzy sets, application of implication functions, rule composition, defuzzification. In this fuzzy mamdani method, both the input or input variables and the output or output variables are in the form of sets, either one or many. The Fuzzy Mamdani method is one part of the Fuzzy Inference System which is useful for drawing conclusions or the best decision in uncertain problems (Bova, 2010). The Mamdani Fuzzy Method was introduced in general by Ebrahim Mamdani in 1975 . (Yulmaini, 2018)

Research by Slamet Riyadhi using input and output variables, namely age, weight, blood pressure, diabetes risk. In this study secondary data from the Dr.H. Soemarno Sostroatmojo Kuala Kapuas Regional General Hospital was used in the form of samples of positive and non-positive pasian data as people with diabetes. This study compares the results that have been calculated using the fuzzy mamdani method and sample data belonging to patients at the Dr.H. Soemarno Sostroatmojo Kuala Kapuas Regional General Hospital. This study produces the following data: from the number of samples used as many as 120 patient data samples, the fuzzy mamdani method has the results of 102 patient data samples whose accuracy is correct and only 18 patient data samples that miss the real results. So it can be calculated what percentage of the accuracy rate of the Mamdani method for diabetes detection with the equation: % Accuracy = (Number of Accurate Data / Total Samples) × 100 = (102/120) × 100 = 85% and 15% error. In analyzing this diabetes inference system Mamdani method, the more variables used as input, the higher the level of accuracy in analyzing the data. (Riyadhi, 2013)

METHOD

This research uses a simulation method of calculating cholesterol. This research is analyzed using fuzzy mamdani and matlab software assistance. In this study, indicators of the patient's age are displayed, namely the teenage age category with Body Mass Index (BMI).

The process of this research is to diagnose cholesterol based on BMI (Body Mass Index) at a teenage age, there are 2 processes, namely:

1. The calculation process by calculating Height & Weight to get the results of Body Mass Index (BMI) in adolescents. Which can be seen in the flowchart:
2. The calculation process by calculating the diagnosis using fuzzy mamadani assisted by Matlab software.

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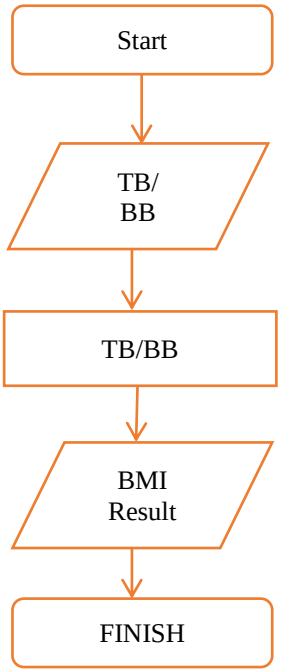

Figure 1. Body Mass Index Flowchart (BMI)

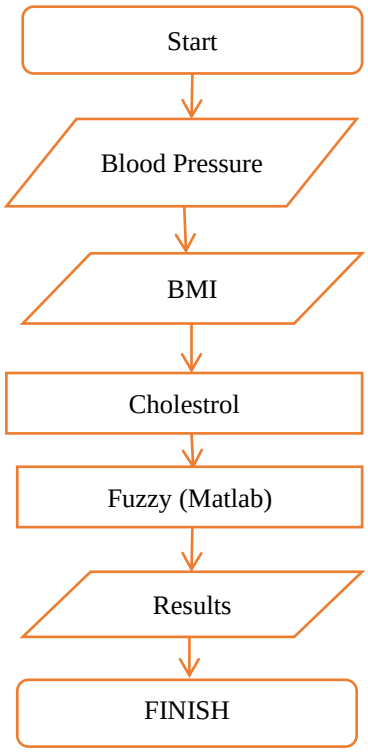

Figure 2. Calculation of diagnoses using Mamdani fuzzy assisted by Matlab software.

Based on the problems described, with the help of technology, namely the use of AI (Artificial Intelligence) which can help predict body cholesterol using fuzzy logic. One of the fuzzy logic methods used is fuzzy mamdani with the help of matlab.

RESULT

Data

This research data is obtained from patient data who conduct health checks at Posbindu PTM which consists of data on Blood Pressure, BMI (Body Mass Index) and Cholesterol Levels can be seen in the following table:

Tablel 1. Blood pressure, BMI and cholesterol data

No	Age	Blood Pressure (BP)	BMI	Cholesterol
1	49	175	27.2	135
2	58	167	30.8	223
3	35	173	35.3	126
4	49	120	28.7	317
5	67	127	15.6	126
6	50	128	27.6	284
7	58	163	29.6	156
8	47	152	24	277
9	45	171	33.8	183
10	50	131	21.5	213
11	36	171	25.2	206
12	38	175	25.5	151
13	45	166	26.6	273
14	57	124	21.5	191
15	64	154	29.6	217
16	35	144	34.2	209
17	58	135	28.2	184
18	62	157	28.2	202

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19	53	233	28.8	144
20	43	135	39.2	225
21	36	100	31.6	134
22	36	109	34	173
23	56	112	25.9	179
24	41	113	23.6	231
25	53	108	32	177

2. Mamdani Method Fuzzy Logic Calculation Process

a. Fuzzy set formation (fuzzification)

By using fuzzy mamdani, the determination of variables is divided into two, namely input and output. Input variables consist of blood pressure data and BMI data, while the output variable is body cholesterol level data. The variable determination can be seen in the following table:

Table 3.Speaker universe for all fuzzy variables

Function	Variable name	Speaker universe
Input	Blood Pressure	[70 - 250]
	BMI	[10 - 45]
output	Cholestrol	[90 - 330]

From the table above, it can be seen that the universe of speech is the minimum and maximum data from variables, both input function variables and output functions. For data that becomes the composition of fuzzy rules, random data obtained from minimum and maximum data. Can be seen in the following table:

Table 3. Minimum and maximum values of random input or output data

Function	Variable name	Speaker universe
Input	Blood Pressure	[100 - 233]
	BMI	[15.6 – 39.2]
output	Cholestrol	[126 - 317]

b. Generating Fuzzy *Rule*

At this stage, the membership value of the blood pressure and BMI sets is based on the fuzzy set membership function based on the data obtained. The formation of fuzzy rules is arranged with the rule IF blood pressure IS ....AND IMT IS....THEN Cholestrol IS....., can be seen in the following table:

Table 4. Fuzzy Rules

No.	Variabel		
	Input		Output
	Blood Pressure	BMI	Cholestrol
1	Low	Skinny	Low
2	Medium	Normal	Normal
3	High	Obese	High

Here is how to get the membership value based on the linguistic variables and numerical variables used:

Membership function of High, Medium, Low fuzzy set of **Blood Pressure** variable

$$\mu[x]\ Lower = \begin{cases} 1 & x \leq 100 \\ \dfrac{167 - x}{167 - 100} & 100 \leq x \leq 167 \\ 0 & x \geq 167 \end{cases}$$

$$\mu[x]\ Normal = \begin{cases} 0 & x \leq 100\ or\ x \geq 233 \\ \dfrac{x - 167}{167 - 100} & 100 \leq x \leq 167 \\ \dfrac{233 - x}{233 - 167} & 167 \leq x \leq 233 \end{cases}$$

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$$\mu[x]\ Higher = \begin{cases} 0 & x \le 167 \\ \dfrac{x-167}{233-167} & 167 \le x \le 233 \\ 1 & x \ge 233 \end{cases}$$

Membership function of Skinny, Normal, Obese fuzzy set of **BMI (Body Mass Index)** variable

$$\mu[x]\ skinny = \begin{cases} 1 & x \le 15.6 \\ \dfrac{28-x}{28-15.6} & 15.6 \le x \le 28 \\ 0 & x \ge 28 \end{cases}$$

$$\mu[x]\ Normal = \begin{cases} 0 & x \le 15.6\ or\ x \ge 39.2 \\ \dfrac{x-28}{28-15.6} & 15.6 \le x \le 28 \\ \dfrac{39.2-x}{39.2-28} & 28 \le x \le 39.2 \end{cases}$$

$$\mu[x]\ Obesitas = \begin{cases} 0 & x \le 28 \\ \dfrac{x-28}{39.2-28} & 28 \le x \le 39.2 \\ 1 & x \ge 39.2 \end{cases}$$

High, Normal, Low fuzzy set membership function of the **Cholestrol** variable

$$\mu[x]\ lower = \begin{cases} 1 & x \le 126 \\ \dfrac{222-x}{222-126} & 126 \le x \le 222 \\ 0 & x \ge 222 \end{cases}$$

$$\mu[x]\ Normal = \begin{cases} 0 & x \le 12\ or\ x \ge 317 \\ \dfrac{x-222}{222-126} & 126 \le x \le 222 \\ \dfrac{317-x}{317-222} & 222 \le x \le 317 \end{cases}$$

$$\mu[x]\ Higher = \begin{cases} 0 & x \le 222 \\ \dfrac{x-222}{317-222} & 222 \le x \le 317 \\ 1 & x \ge 317 \end{cases}$$

3. Program Implementation

The program used in detecting cholesterol disease using the fuzzy mamdani method is MATLAB with the aim of helping to see the effect of blood pressure and BMI on cholesterol levels in order to predict the level of normal cholesterol levels.

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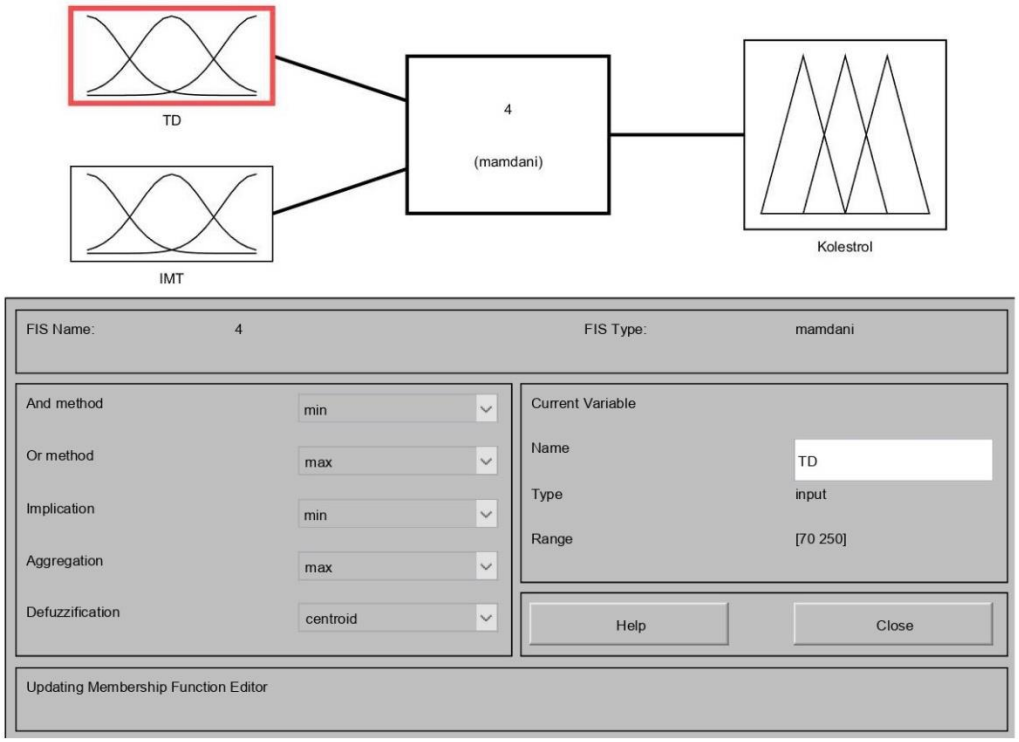

Figure 4. Application of the problem into the Application

In Figure 4, the stage of forming input and output variables. It can be seen in the figure that the yellow inputs are BP (Blood Pressure) and IMT (Body Mass Index) and the green output is cholesterol. the next stage is the formation of a fuzzy set of fuzzy membership functions. The set of fuzzy members is in accordance with the explanation of the previously formed formulation. For details, namely the Blood Pressure variable with membership functions LOW, MEDIUM and HIGH with a range of [70 - 250] for LOW membership with trapmf variable type, MEDIUM membership function with trimf variable type and HIGH membership function with trapmf variable type. Can be seen in the following image:

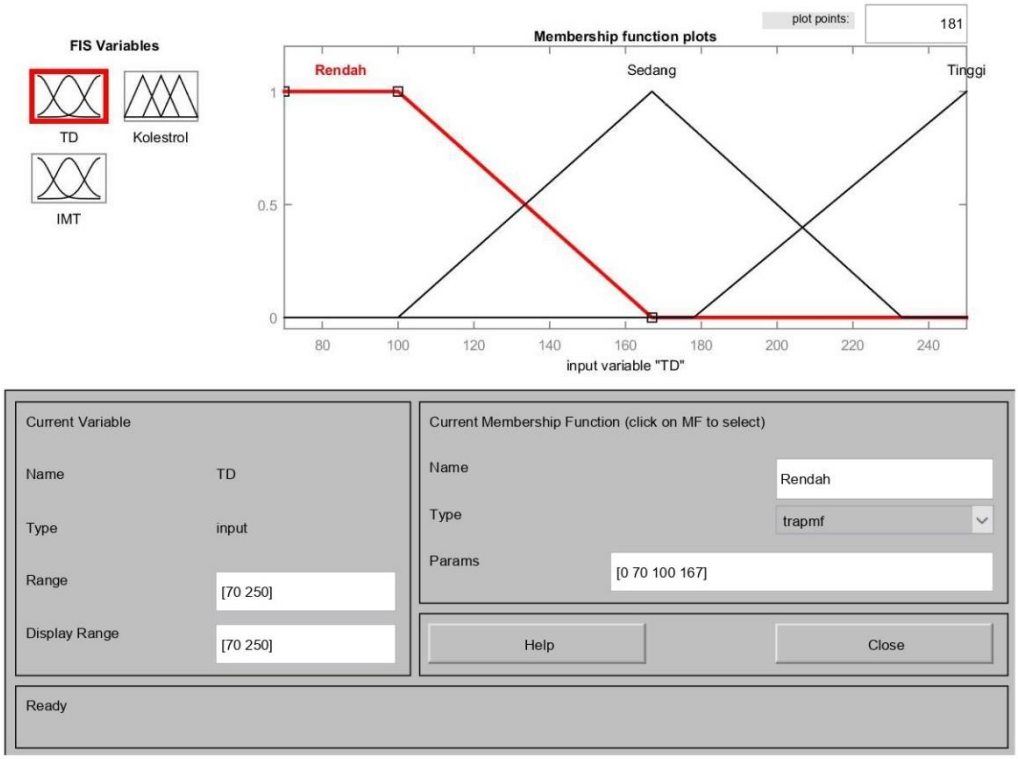

Figure 5. Membership Function of Blood Pressure (BP) Input Variable

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IMT variables with membership functions LESS, NORMAL and OBESITY with the range [10 - 45] for membership LESS with trapmf variable type, NORMAL membership function with trimf variable type and OBESITY membership function with trapmf variable type. Can be seen in the following image:

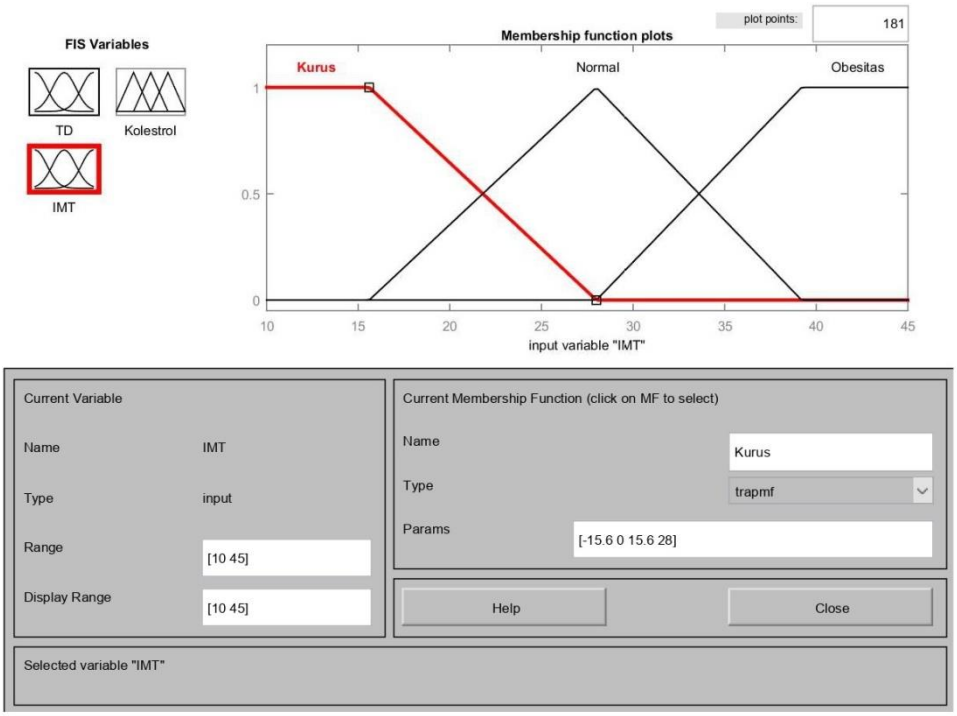

Figure 6. IMT (Body Mass Index) Input Variable Membership Function

Similarly, the output variable is cholesterol with membership functions LOW, NORMAL and HIGH with a range of [90 - 330] for LOW membership with trapmf variable type, NORMAL membership function with trimf variable type and HIGH membership function with trapmf variable type. Can be seen in the following image:

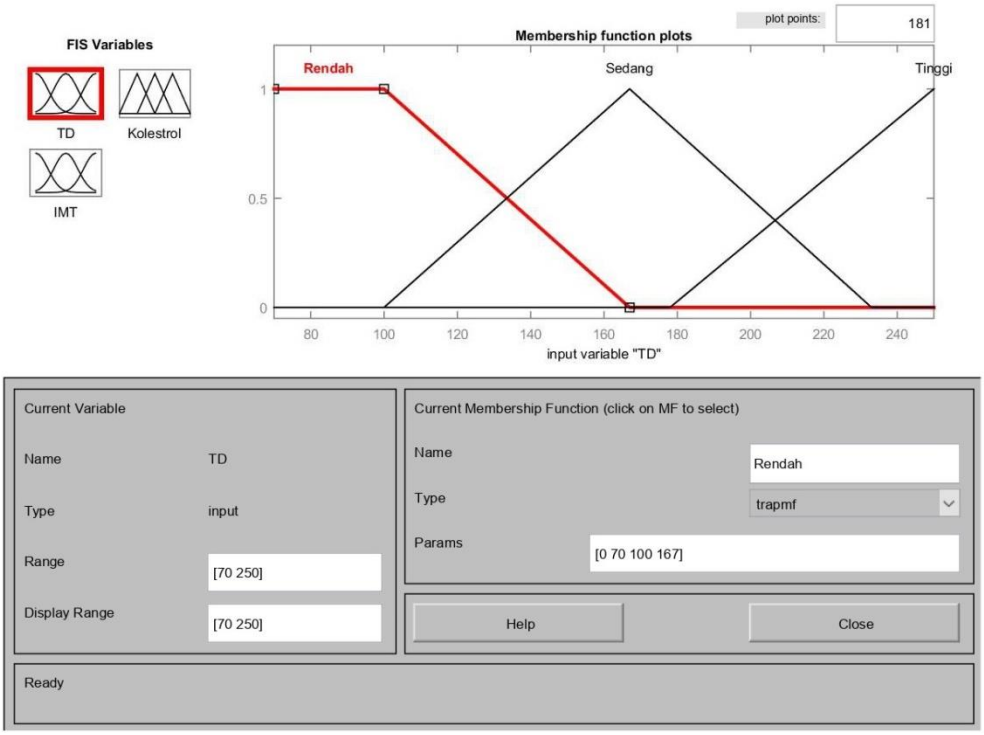

Figure 7. Membership Function of Output Variable Cholestrol

By compiling the Fuzzy rules as in Table 4 into the Matlab tollbox, the result is:

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1. If (TD is Lower) and (IMT is Skinny) then (Cholestrol is Lower) (1)
2. If (TD is Lower) and (IMT is Skinny) then (Cholestrol is Normal) (1)
3. If (TD is Lower) and (IMT is Skinny) then (Cholestrol is Height) (1)
4. If (TD is Lower) and (IMT is Normal) then (Cholestrol is Lower) (1)
5. If (TD is Lower) and (IMT is Normal) then (Cholestrol is Normal) (1)
6. If (TD is Lower) and (IMT is Normal) then (Cholestrol is Height) (1)
7. If (TD is Lower) and (IMT is Obesitas) then (Cholestrol is Lower) (1)
8. If (TD is Lower) and (IMT is Obesitas) then (Cholestrol is Normal) (1)
9. If (TD is Lower) and (IMT is Obesitas) then (Cholestrol is Height) (1)
10. If (TD is Medium) and (IMT is Skinny) then (Cholestrol is Lower) (1)
11. If (TD is Medium) and (IMT is Skinny) then (Cholestrol is Normal) (1)
12. If (TD is Medium) and (IMT is Skinny) then (Cholestrol is Height) (1)
13. If (TD is Medium) and (IMT is Normal) then (Cholestrol is Lower) (1)
14. If (TD is Medium) and (IMT is Normal) then (Cholestrol is Normal) (1)
15. If (TD is Medium) and (IMT is Normal) then (Cholestrol is Height) (1)
16. If (TD is Medium) and (IMT is Obesitas) then (Cholestrol is Lower) (1)
17. If (TD is Medium) and (IMT is Obesitas) then (Cholestrol is Normal) (1)
18. If (TD is Medium) and (IMT is Obesitas) then (Cholestrol is Height) (1)
19. If (TD is Height) and (IMT is Skinny) then (Cholestrol is Lower) (1)
20. If (TD is Height) and (IMT is Skinny) then (Cholestrol is Normal) (1)
21. If (TD is Height) and (IMT is Skinny) then (Cholestrol is Height) (1)
22. If (TD is Height) and (IMT is Normal) then (Cholestrol is Lower) (1)
23. If (TD is Height) and (IMT is Normal) then (Cholestrol is Normal) (1)
24. If (TD is Height) and (IMT is Normal) then (Cholestrol is Height) (1)
25. If (TD is Height) and (IMT is Obesitas) then (Cholestrol is Lower) (1)
26. If (TD is Height) and (IMT is Obesitas) then (Cholestrol is Normal) (1)
27. If (TD is Height) and (IMT is Obesitas) then (Cholestrol is Height) (1)

Based on the fuzzy rules, the rule view can be obtained as the required simulation can be seen in the following figure:

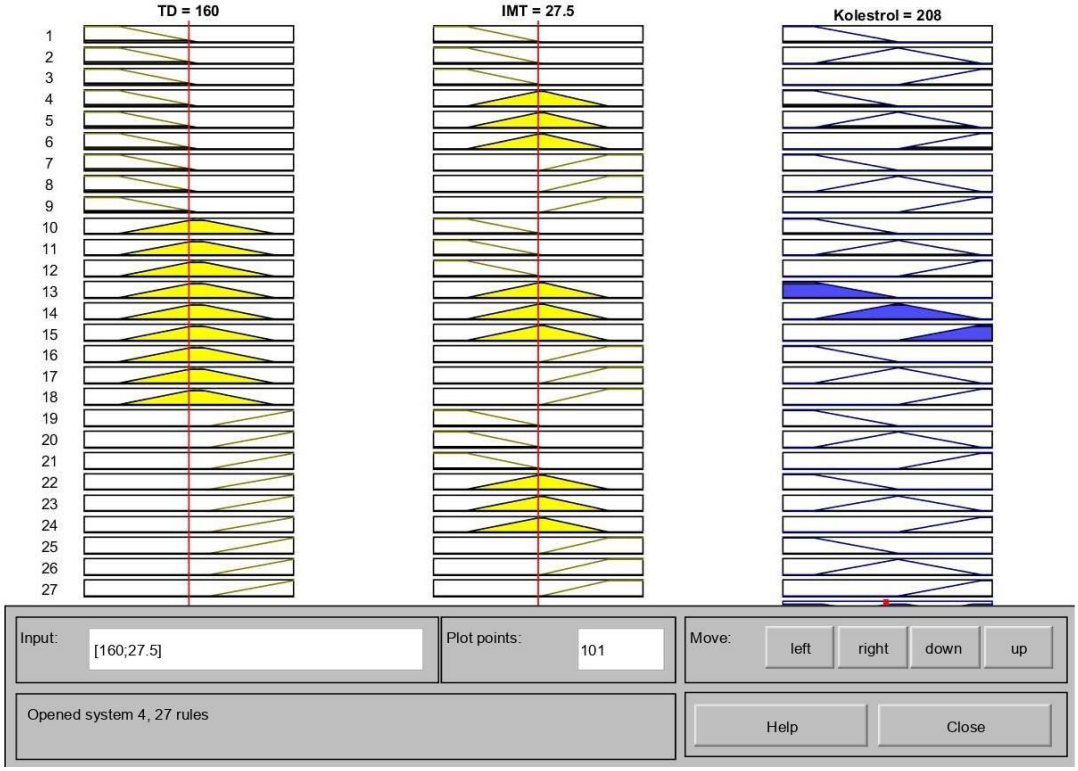

Figure 10. Optimization Results with Blood Pressure 100.6 and BMI 31.8

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Based on the rule view, it can be seen for cholesterol levels of 210 or it can be said that the alert category can be seen for blood pressure of 100.6 and BMI of 31.8. For more details on each patient the fuzzy value can be seen in the following table:

Table 5. Cholestrol levels to watch out for based on patient blood pressure and BMI inputs (Fuzzy Mamdani)

No	Age	Blood Pressure	BMI	Cholestrol	Fuzzy
1	49	175	27.2	135	208
2	58	167	30.8	223	210
3	35	173	35.3	126	210
4	49	120	28.7	317	209
5	67	127	15.6	126	210
6	50	128	27.6	284	210
7	58	163	29.6	156	208
8	47	152	24	277	210
9	45	171	33.8	183	210
10	50	131	21.5	213	210
11	36	171	25.2	206	209
12	38	175	25.5	151	209
13	45	166	26.6	273	208
14	57	124	21.5	191	210
15	64	154	29.6	217	209
16	35	144	34.2	209	210
17	58	135	28.2	184	210
18	62	157	28.2	202	208
19	53	233	28.8	144	209
20	43	135	39.2	225	210
21	36	100	31.6	134	210
22	36	109	34	173	210
23	56	112	25.9	179	209
24	41	113	23.6	231	210
25	53	108	32	177	210

From the results of the application of mamdani fuzzy logic in the Matlab application, the results of the comparison of mamdani fuzzy logic assessment of patient cholesterol levels in Pasbindu PTM, using the average percentage or Mean Percentage Error (MPE) can be seen in the following table:

Tabel 6. MPE calculation

No	Kolestrol Y_t	Fuzzy $\hat{Y}_t$	*Error*	$\left\|\frac{(Y_t - \hat{Y}_t)}{Y_t} \times 100\%\right\|$
1	135	208	-73	54,0740741
2	223	210	13	5,829596413
3	126	210	-84	66,6666667
4	317	209	108	34,06940063
5	126	210	-84	66,6666667
6	284	210	74	26,05633803
7	156	208	-52	33,3333333
8	277	210	67	24,18772563
9	183	210	-27	14,7540984
10	213	210	3	1,408450704
11	206	209	-3	1,45631068
12	151	209	-58	38,410596
13	273	208	65	23,80952381
14	191	210	-19	9,94764398
15	217	209	8	3,686635945
16	209	210	-1	0,4784689
17	184	210	-26	14,1304348
18	202	208	-6	2,97029703
19	144	209	-65	45,1388889

*name of corresponding author

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20	225	210	15	6,666666667
21	134	210	-76	56,7164179
22	173	210	-37	21,3872832
23	179	209	-30	16,7597765
24	231	210	21	9,090909091
25	177	210	-33	18,6440678
			Jumlah	596,3403
			MPE	23,85361
				100-23,85361=76,14639

So that the results of the calculation of the average percentage error of the Fuzzy Logic Mamdani method used are 23.85361 while the truth rate of the calculation results is 76.14639, it can be concluded that the results of the calculation of the Fuzzy Logic Mamdani method used in this system can be used for predicting cholesterol levels in PTM posbindu patients.

DISCUSSIONS

Human diseases in general can be diagnosed with the help of technology in line with the development of the 4.0 revolution era which is growing rapidly, especially the use of technology in the health sector or the field of medicine which is used to increase access to good health services to the community in detecting a disease through symptoms and lifestyle experienced.

And by utilizing the role of technology as access to health services to the community in addition to saving time, the role of this technology will reduce costs to users or patients. It also aims to facilitate performance in the process of detecting diseases suffered by patients. So from this, an expert system is needed to help in terms of detecting a disease through symptoms and lifestyle like an expert.

In line with the research conducted where early detection of cholesterol disease is seen from Blood Pressure and BMI by using technological sophistication, namely by using fuzzy mamdani. This is in line with what other researchers have done, (Br.Kaban, Allwine, Alamsyah, Sianturi, & Tambunan, 2022) from the results of research aimed at designing an expert system to detect the level of risk of disease through symptoms and lifestyle is to determine the level of risk of disease that occurs in sufferers caused by irregular lifestyles. With this, the patient can know the level of risk of the disease that the disease being suffered can cause a small risk or a big risk. The method used in designing this application is the Mamdani fuzzy method.

The expert system application detects the risk level of heart disease to help medical personnel or people with heart disease know the level of risk of heart disease suffered by patients with small risk, medium risk or high risk. The method used is the fuzzy inference method (Mamdani), this is used to determine the level of risk of heart disease suffered and provide information on further actions that must be taken to handle the heart disease (Fiano & Purnomo, 2017).

The healthy life planning expert system is used as an information tool for managing a healthy lifestyle. Through this application we can get information about our daily calorie needs, reduce activity patterns every minute so that the estimated balance of the body's needs by consuming healthy foods that are done every day. Healthy food intake can also be planned through this healthy lifestyle application (P, Sutardji, & Woro, 2011)

An expert system application for diagnosing common human diseases is used as a means of consultation. This expert system application can be used to answer questions. This expert system aims to identify common diseases in humans through the symptoms suffered. The benefit of this expert system application is that sufferers are easier and faster in identifying diseases through the symptoms that arise in sufferers (Ariyawan, 2018)

(Fiano & Purnomo, 2017) said the system is able to help diagnose the risk level of heart disease using the fuzzy inference method (Mamdani). This can make it easier for the public and medical personnel to determine the risk level of heart disease whether heart disease is mild risk, moderate risk or high risk in a study entitled Expert System to Detect the Risk Level of Heart Disease with Fuzzy Inference (Mamdani).

CONCLUSION

Based on the formulation of the problem, the results of research and discussion regarding the determination of cholesterol levels based on blood pressure and BMI, several conclusions can be drawn based on the rule view, it can be seen that the cholesterol level is 210 or can be said to be in the alert category, it can be seen for blood pressure 100.6 and BMI 31.8.

*name of corresponding author

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*name of corresponding author