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PRE-ECLAMPSIA DIAGNOSIS EXPERT SYSTEM USING FUZZY INFERENCE SYSTEM MAMDANI

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Abstract*—Various institutions utilize computer information systems to analyze and process data. An expert system is an information system that is used to help analyze and determine decisions on a problem based on rules determined by experts. This research focuses on creating a prototype expert system for diagnosing pre-eclampsia or pregnancy poisoning in pregnant women based on measuring blood pressure and checking proteinuria. The existing data is then analyzed using the Mamdani system's fuzzy inference method. Supporting theory regarding the fuzzy inference system of Mamdani, pre-eclampsia and its examination indicators will be used as a basis for creating this expert system prototype. The data used were secondary data on preeclampsia patients in the form of medical records of blood pressure measurements, proteinuria examinations and doctor diagnoses of preeclampsia patients at two Regional General Hospitals (RSUD), namely Atambua and Kefamenanu, totaling 20 samples. The interface or user interface of this prototype system is made as simple as possible so that it can be operated by all ordinary people. The programming language used is Visual Basic (VB) with the Visual Studio 2010 developer application. The initial prototype of this system will continue to be developed until it can become a Information systems or real applications used in hospitals. The results of this research are that the expert system for diagnosing preclampsia can be used well and easily by hospital staff and show congruence between the system diagnosis results and the diagnosis results from obstetricians or experts in the 20 processed data.*

Keywords: *diagnosis, expert system, fuzzy inference mamdani system, pre-eclampsia.*

Intisari—Berbagai institusi memanfaatkan sistem informasi komputer untuk menganalisa dan mengolah data. Sistem pakar adalah salah satu sistem informasi yang digunakan untuk membantu menganalisa dan menentukan keputusan suatu masalah berdasarkan aturan yang ditentukan oleh pakar. Penelitian ini fokus pada pembuatan *prototype* sistem pakar diagnosa pre-eklampsia atau keracunan kehamilan pada ibu hamil berdasarkan pengukuran tekanan darah dan pengecekan proteinuria, data yang ada selanjutnya dianalisa menggunakan metode *fuzzy* inferense sistem mamdani. Teori pendukung mengenai *fuzzy* inferense sistem mamdani, pre-eklampsia dan indikator pemeriksaannya akan digunakan menjadi dasar dalam pembuatan *prototype* sistem pakar ini. Data yang digunakan adalah data sekunder pasien pre-eklampsia berupa rekam medis pengukuran tekanan darah, pemeriksaan proteinuria dan diagnosa dokter pasien pre-eklamsia di dua Rumah Sakit Umum Daerah (RSUD) yaitu Atambua dan Kefamenanu sebanyak 20 sampel. Tampilan antarmuka atau *user interface* dari *prototype* sistem ini dibuat sesederhana mungkin agar dapat di operasikan oleh semua orang awam. Bahasa pemrograman yang digunakan adalah visual basic (VB) dengan aplikasi pengembang visual studio 2010. *Prototype* awal dari sistem ini akan terus dikembangkan sehingga dapat menjadi sistem informasi atau aplikasi yang *real* digunakan pada rumah sakit. Hasil dari penelitian ini adalah sistem pakar *diagnose* pre-eklampsia dapat digunakan dengan baik dan mudah doleh petugas rumah sakit dan menunjukan kesesuaian antara hasil diagnosa sistem dengan hasil diagnosa dari dokter kandungan atau pakar di 20 data yang diproses.

Kata Kunci*: diagnosa, sistem pakar, fuzzy inference sistem mamdani, pre-eklampsia.*

INTRODUCTION

Maternal mortality and perinatal mortality rates in Indonesia are still very high. According to the results of the Inter-Census Population Survey (SUPAS) conducted by the Central Bureau of Statistics (BPS) in 2015, the maternal mortality rate was 305 per 100,000 live births. When compared to the target that the government wants to achieve in 2010 of 125/100,000 live births, this figure is still relatively high. Maternal mortality in East Nusa Tenggara in 2017 was 163 per 100,000 live births (Bardja, 2020), the Maternal Mortality Rate (MMR) in North Timor- Tengah District in 2014 was 137 people. The direct causes of death include pre-eclampsia or eclampsia by 5%, bleeding by 50%, infection by 17%, other causes by 28%.

The impact that can be caused by preeclampsia on the mother is premature birth, oliguria, death, while the impact on the baby is stunted fetal growth, poligohydramion, can also increase morbidity and mortality (Nassa, 2018). Pre-eclampsia with seizures, or what is known as eclampsia, which is not properly controlled can lead to permanent disability or even cause death of mother and baby. If eclampsia is not treated quickly there will be loss of consciousness and death due to heart failure, kidney failure, liver failure or brain hemorrhage. Therefore the occurrence of seizures in patients with eclampsia must be avoided. Risk factors for pre-eclampsia are maternal age (less than 16 years or more than 45 years), primigravida, presence of hypertension before pregnancy, multiple pregnancies, molar pregnancies, obesity, history of pre-eclampsia in previous pregnancies (Hanif et al., 2022). By knowing the risk factors, early detection of pre-eclampsia in pregnant women needs to be done so that later it can be treated more quickly as a prevention of further complications.

Several tests will be carried out to detect whether a pregnant woman has pre-eclampsia, namely blood pressure, urinalysis, several other optional screening tests to measure protein levels (PAPP-A) and to measure fetal alpha-fetoprotein (AFP) levels, as well as monitor development baby (Handayani, 2022). This examination is always carried out in hospitals, health centers or other health clinics. With a practical application that can be applied efficiently and effectively for the early diagnosis of pre-eclampsia, ordinary people can make an early diagnosis and can immediately start treatment (Anindita, Pristyanto, Sismoro, Nurmasani, & Nugraha, 2023).

There are several decision-making systems used in diagnosing a disease, one of which is a fuzzy decision-making system or often called the Fuzzy Inference System (FIS). There are 3 FIS methods that can be used in processing decisions, namely the Tsukamoto method, the Mamdani method and the Sugeno method (Surorejo, Chaeriko, & Ananda, 2022)

There are many researchers who have applied FIS in the process of diagnosing diseases, including diagnosing fever in toddlers, diagnosing coronary heart disease, diagnosing diabetes mellitus, diagnosis of ear, nose and eye disease or ENT, detection of lymph node disease, diagnosis of eye disease and risk diagnosis of heart disease. However, detecting pre-eclampsia in pregnant women has never been done (Juwita, Sarjon, & Yuhandri, 2021), (Sitinjak, 2021), (Rizki & Maulana, 2018), (Rizky & Hakim, 2020), (Novianti, Pribadi, & Saputra, 2018), (Dona, Maradona, & Masdewi, 2021), (Anindita et al., 2023), (Ananta, Putra, Purnawan, Purnami, & Putri, 2018), and (Hanif et al., 2022). (Nizar, Shafira, Aufaresa, Awliya, & Athiyah, 2021),diagnosed diabetes using the three FIS methods and obtained the result that the Sugeno method had the highest level of accuracy in analyzing, namely 97.33%, followed by the Mamdani method of 95.33% and the Tsukamoto method had the highest accuracy. smaller than the Mamdani method, for errors in analyzing, the Sugeno method is only 2.67%, the Mamdani method is 4.67% and the Tsukamoto method is 5.78%, for manual calculation time, the Tsukamoto method is the method that requires the least time compared to the Mamdani and Sugeno methods while for calculations, the Mamdani method is the most complicated method.

An expert system is an information system that contains the knowledge of an expert so that it can be used for consultation. An expert's knowledge possessed by this Expert System is used as a basis for answering questions (Supriyono & Fadila, 2022). Expert systems have the ability to recommend a series of actions or user behavior to be able to carry out a correct and accurate correction system. Where, this system also utilizes the capabilities of the reasoning process to be able to reach conclusions based on existing data and facts(Simarmata, 2021)

The use of expert systems in the medical world has been widely used (Dona et al., 2021), but so far expert systems have not been applied to diagnose preeclampsia in pregnant women. Based on the indicators previously explained, the expert system that will be created uses blood pressure and the amount of proteinuria to calculate the level of preclampsia by implementing fuzzy calculations and rules. In processing data using FIS, the help of Matlab software can be used. However, this software only contains the Mamdani method, while the Sugeno method and the Tsukamoto method are

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not available (Athiyah et al., 2021). Furthermore, with the help of Visual Basic development software, a GUI (Graphical User Interface) based prototype of FIS was created so that later the system could be more easily used by medical staff or lay people (Rizky & Hakim, 2020).

This research aims to build a prototype information system for decision making for pre-eclampsia diagnosis in pregnant women based on blood pressure and proteinuria. After system design, the next process is implementing the Mamdani Fuzzy Inference System method in the form of the Visual Basic programming language, and then it will be compared with the diagnosis made by the doctor to check how accurate the system that has been built is.

MATERIALS AND METHODS

This research is a literature study and applied research. A literature study was conducted to find theories about Mamdani's FIS and pre-eclampsia and its examination indicators which would later become the basis for making a diagnostic system. After the system design process, pre-eclampsia case data will be collected from two Regional General Hospitals (RSUD), namely Atambua Hospital and Kefamenanu Hospital.

The data taken is secondary data in the form of medical record data measuring blood pressure, checking proteinuria and doctor's diagnosis of pre-eclampsia patients from 2021 to 2022. The data used is 20 samples, the existing data has received permission from the patient but there are some who do not want their data to be used, so the data used is only limited to the number above. The data is then processed using the Mamdani FIS method with the following steps.

I. Methods Stages

a. Fuzzification

The process of converting input variables with firm values (crips) into linguistic variables (fuzzy) uses the membership functions that have been developed. There are 3 membership function curves that will be used in this study, namely:

Membership function of descending linear representation (parameters (a,b)):

$$\mu(x) = \begin{cases} 1; & x \le a \\ \frac{b-x}{b-a}; & a \le x \le b \\ 0; & x \ge b \end{cases} \quad (1)$$

For more details, the geometric shape of this function can be seen in Figure 1.

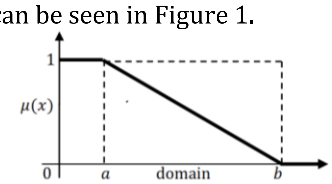

Figure 1. Graph of Descending Linear Functions

Ascending linear representation membership function (parameters (a,b)):

$$\mu(x) = \begin{cases} 0; & x \le a \\ \frac{x-a}{b-a}; & a \le x \le b \\ 1; & x \ge b \end{cases} \quad (2)$$

For more details, the geometric shape of this function can be seen in Figure 2.

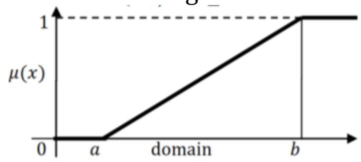

Figure 2. Graph of Increasing Linear Functions

Membership function (parameters (a,b,c)) :

$$\mu(x) = \begin{cases} 0; & x \le a \text{ or } x \ge c \\ \frac{x-a}{b-a}; & a \le x \le b \\ \frac{c-x}{c-b}; & b \le x \le c \\ 1; & x = b \end{cases} \quad (3)$$

For more details, the geometric shape of this function can be seen in Figure 3.

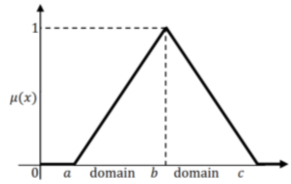

Figure 3. Graph of Triangle Linear Functions

b. Inference

The stage of changing the fuzzy input into fuzzy output by following the IF-AND-THEN rules. Furthermore, at this stage calculations are also carried out for fuzzy decision making. The Mamdani FIS method is often referred to as the Min-Max method because the process of determining the final decision uses the Min operation and the Max operation. The Min operation is performed to determine the membership value as a result of the operation of two or more sets, often referred to as fire strength or α-predicate by using the AND operator with the following equation

$$\boldsymbol{\alpha - predikat_i = \min(\mu_A(x), \mu_B(x))} \quad (4)$$

where i represents the ith rule from a combination of rules formed from any data.

Next, the Max operation is carried out, namely the operation to determine the combination of all existing α-predicates. This operation is carried out using the OR operator with the following equation:

$$\boldsymbol{\mu(x) = [R_1] \cup [R_2] \cup \ldots \cup [R_n]} \quad (5)$$

$$\boldsymbol{= \max\{\alpha - predikat_1, \ldots, \alpha - predikat_n\}}$$

with [R_i],i=1,2,...n stating the number of rules formed from any data.

c. Defuzzification

The process of changing the output with fuzzy values obtained from inference into input with firm values (crips) using a membership function. The FIS Mamdani method defuzzification process in this research uses the Centroid method with the following formula:

$$Z_0 = \frac{\int_a^b z.\mu(z)dz}{\int_a^b \mu(z)dz} \qquad (6)$$

After the system design process is complete, the next step is to compare the diagnosis results based on the processing with the diagnosis system that has been created and the diagnosis based on the experts (doctors) decision to validate how accurate the diagnosis system that has been created.

II. Data Analysis

Determination of the decision to diagnose pre-eclampsia is based on 2 factors, namely blood pressure and proteinuria. These two variables then become input variables for the Mamdani FIS diagnostic system.

a. Blood Pressure Input Variable

The fuzzy set for the input variable blood pressure is divided into 4 sets, namely low blood pressure, normal blood pressure, grade I hypertension and grade II hypertension. The domains of the 4 fuzzy sets can be seen in the membership function graph presented in Figure 4.

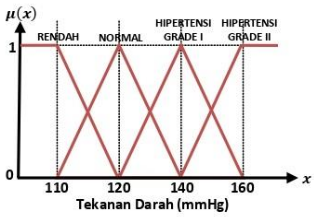

Figure 4. Graph of Blood Pressure Membership Function Graph

Meanwhile, the membership function of the blood pressure variable based on the graph is as follows:

$$\mu_{TD-RENDAH}(x) = \begin{cases} 1 & ; \quad x \le 110 \\ \frac{120-x}{10} & ; \quad 110 \le x \le 120 \\ 0 & ; \quad x \ge 120 \end{cases} \qquad (7)$$

$$\mu_{TD-NORMAL}(x) = \begin{cases} 0 & ; \quad x \le 110 \; atau \; x \ge 140 \\ \frac{x-110}{10} & ; \quad 110 \le x \le 120 \\ \frac{140-x}{20} & ; \quad 120 \le x \le 140 \\ 1 & ; \quad x = 120 \end{cases}$$

$$\mu_{HG-I}(x) = \begin{cases} 0 & ; \quad x \le 120 \; atau \; x \ge 160 \\ \frac{x-120}{20} & ; \quad 120 \le x \le 140 \\ \frac{160-x}{20} & ; \quad 140 \le x \le 160 \\ 1 & ; \quad x = 140 \end{cases}$$

$$\mu_{HG-II}(x) = \begin{cases} 0 & ; \quad x \le 140 \\ \frac{x-140}{20} & ; \quad 140 \le x \le 160 \\ 1 & ; \quad x \ge 160 \end{cases}$$

with TD = Blood Pressure and HG = Grade Hypertension.

b. Proteinuria Input Variable

There are 5 categories to describe the amount of protein in urine (proteinuria). These five indicators are determined based on the protein precipitate test by heating urine until it boils (boiling test). This examination is carried out by inserting 10-15 mL of urine into a tube and heating the top of the tube until it boils and then observing changes in the urine sample in the tube. Interpretations of the five indicators are presented in Table 1.

Table 1. Proteinuria Examination Conditions and Categories

No.	Categories	Conditions
1.	Negatif (-)	No fog
2.	Positif 1 (+1)	Light fog
3.	Positif 2 (+2)	Clear fog
4.	Positif 3 (+3)	White turbidity
5.	Positif 4 (+4)	There are white lumps

From here, a fuzzy set and its domain are then formed as presented by the membership function graph in Figure 5.

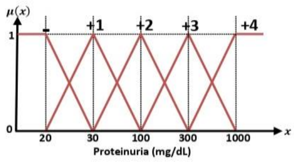

Figure 5. Proteinuria Membership Function Graph

While the membership function of the proteinuria variable based on the graph is as follows on equation (8):

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$$\mu_{P-}(x)=\begin{cases}1 & ; \quad x\le 20\\ \dfrac{30-x}{10} & ; \quad 20\le x\le 30\\ 0 & ; \quad x\ge 30\end{cases}$$

$$\mu_{P+1}(x)=\begin{cases}0 & ; \quad x\le 20 \text{ atau } x\ge 100\\ \dfrac{x-20}{10} & ; \quad 20\le x\le 30\\ \dfrac{100-x}{70} & ; \quad 30\le x\le 100\\ 1 & ; \quad x=30\end{cases} \qquad (8)$$

$$\mu_{P+2}(x)=\begin{cases}0 & ; \quad x\le 30 \text{ atau } x\ge 300\\ \dfrac{x-30}{70} & ; \quad 30\le x\le 100\\ \dfrac{300-x}{200} & ; \quad 100\le x\le 300\\ 1 & ; \quad x=100\end{cases}$$

$$\mu_{P+3}(x)=\begin{cases}0 & ; \quad x\le 100 \text{ atau } x\ge 1000\\ \dfrac{x-100}{200} & ; \quad 100\le x\le 300\\ \dfrac{1000-x}{700} & ; \quad 300\le x\le 1000\\ 1 & ; \quad x=300\end{cases}$$

$$\mu_{P+4}(x)=\begin{cases}0 & ; \quad x\le 300\\ \dfrac{x-300}{700} & ; \quad 300\le x\le 1000\\ 1 & ; \quad x\ge 1000\end{cases}$$

With p-1 = negative proteinuria, p+1 = positive proteinuria 1, and so on.

c. Proteinuria Output Variable

There are 4 fuzzy sets for this output variable, namely non-pre-eclampsia, pre-eclampsia, severe pre-eclampsia type I and severe pre-eclampsia type II. The domain for each fuzzy set can be seen in the membership function graph for pre-eclampsia status which is presented in Figure 6.

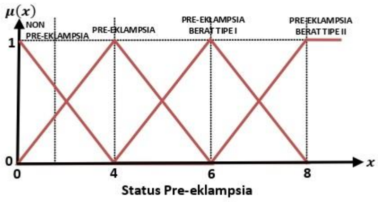

Figure 6. Graph of Membership Function Status of Pre-eclampsia

Meanwhile, the membership function of the pre-eclampsia status variable based on the graph is as follows equation (9).

$$\mu_{NON-PRE}(x)=\begin{cases}1 & ; \quad x\le 0\\ \dfrac{4-x}{4} & ; \quad 0\le x\le 4\\ 0 & ; \quad x\ge 4\end{cases}$$

$$\mu_{PRE}(x)=\begin{cases}0 & ; \quad x\le 0 \text{ atau } x\ge 6\\ \dfrac{x}{4} & ; \quad 0\le x\le 4\\ \dfrac{6-x}{2} & ; \quad 4\le x\le 6\\ 1 & ; \quad x=4\end{cases} \qquad (9)$$

$$\mu_{PRE-BERAT-I}(x)=\begin{cases}0 & ; \quad x\le 4 \text{ atau } x\ge 8\\ \dfrac{x-4}{2} & ; \quad 4\le x\le 6\\ \dfrac{8-x}{2} & ; \quad 6\le x\le 8\\ 1 & ; \quad x=6\end{cases}$$

$$\mu_{PRE-BERAT-II}(x)=\begin{cases}0 & ; \quad x\le 6\\ \dfrac{x-6}{2} & ; \quad 6\le x\le 8\\ 1 & ; \quad x\ge 8\end{cases}$$

With NON-PRE = Negative Pre-eclampsia, PRE = Pre-eclampsia, PRE-SEVERE-I = Severe Pre-eclampsia Type I, PRE-SEVERE-II = Severe Pre-eclampsia Type II.

d. Fuzzy Rule Formulation

The fuzzy rule creation stage uses IF ... AND ... THEN logic. Based on opinions of experts (doctors and nurses), 27 rules were formed as follows.

Table 2. *Fuzzy Rule*

RULE	IF	BLOOD PRESSURE	AND	PROTEINURIA	THEN	PRE-ECLAMSPIA STATUS
[R1]	IF	LOW	AND	-	THEN	NON PRE-ECLAMPSIA
[R2]	IF	LOW	AND	+1	THEN	NON PRE-ECLAMPSIA
[R3]	IF	LOW	AND	+2	THEN	NON PRE-ECLAMPSIA
[R4]	IF	LOW	AND	+3	THEN	NON PRE-ECLAMPSIA
[R5]	IF	LOW	AND	+4	THEN	NON PRE-ECLAMPSIA
[R6]	IF	NORMAL	AND	-	THEN	NON PRE-ECLAMPSIA
[R7]	IF	NORMAL	AND	+1	THEN	NON PRE-ECLAMPSIA
[R8]	IF	NORMAL	AND	+2	THEN	SEVERE PRE-ECLAMPSIA I
[R9]	IF	NORMAL	AND	+3	THEN	SEVERE PRE-ECLAMPSIA I
[R10]	IF	NORMAL	AND	+4	THEN	SEVERE PRE-ECLAMPSIA I
[R11]	IF	NORMAL	AND	-	THEN	PRE-ECLAMPSIA
[R12]	IF	NORMAL	AND	+1	THEN	PRE-ECLAMPSIA

[R13]	IF	HYPERTENSION GRADE I	AND	-	THEN	PRE-ECLAMPSIA
[R14]	IF	HYPERTENSION GRADE I	AND	+1	THEN	PRE-ECLAMPSIA
[R15]	IF	HYPERTENSION GRADE I	AND	+2	THEN	SEVERE PRE-ECLAMPSIA I
[R16]	IF	HYPERTENSION GRADE I	AND	+3	THEN	SEVERE PRE-ECLAMPSIA I
[R17]	IF	HYPERTENSION GRADE I	AND	+4	THEN	SEVERE PRE-ECLAMPSIA I
[R18]	IF	HYPERTENSION GRADE II	AND	-	THEN	SEVERE PRE-ECLAMPSIA II
[R19]	IF	HYPERTENSION GRADE II	AND	-	THEN	PRE-ECLAMPSIA
[R20]	IF	HYPERTENSION GRADE II	AND	+1	THEN	PRE-ECLAMPSIA
[R21]	IF	HYPERTENSION GRADE II	AND	+1	THEN	SEVERE PRE-ECLAMPSIA II
[R22]	IF	HYPERTENSION GRADE II	AND	+2	THEN	SEVERE PRE-EKLAMPSIA I
[R23]	IF	HYPERTENSION GRADE II	AND	+2	THEN	SEVERE PRE-EKLAMPSIA II
[R24]	IF	HYPERTENSION GRADE II	AND	+3	THEN	SEVERE PRE-EKLAMPSIA I
[R25]	IF	HYPERTENSION GRADE II	AND	+3	THEN	SEVERE PRE-EKLAMPSIA II
[R26]	IF	HYPERTENSION GRADE II	AND	+4	THEN	SEVERE PRE-EKLAMPSIA I
[R27]	IF	HYPERTENSION GRADE II	AND	+4	THEN	SEVERE PRE-EKLAMPSIA II

III. System Design

The system design process uses a structured approach where structured design is the activity of transforming the analysis results into a plan to be implemented. A structured approach is equipped with the tools and techniques needed in system development, so that the final result of the developed system will be a system with a well-defined and clear structure. The reasons for using a structured design are that it is relatively simple, easy to understand, commonly known in various industries, and allows for validation between various requirements. The system design in this research uses context diagrams, data flow diagrams, and system usage flowcharts.

a. Context Diagram

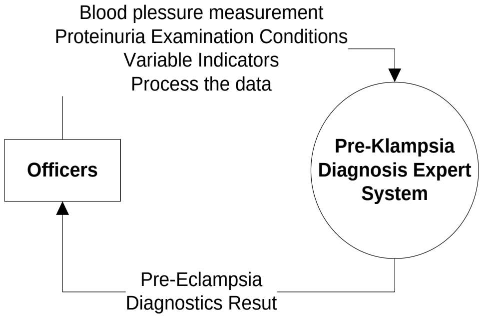

Figure 7. Context Diagram System

The only one user of the system is a medical officers. The officers interacts with the system by providing data in the form of measuring blood pressure and the amount of proteinuria using a keyboard, then the system will process the data and display it on the monitor screen. The results of the system diagnosis will be given to the doctor for further analysis.

b. Data Flow Diagram

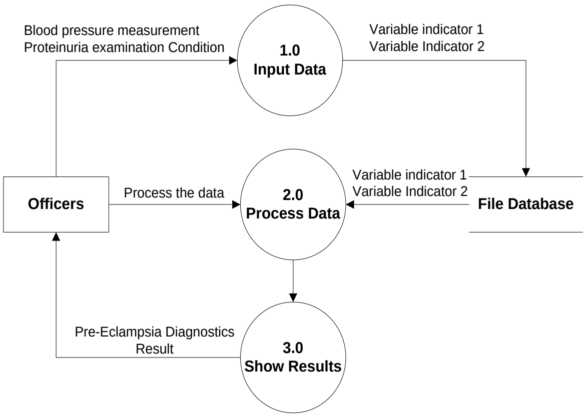

Figure 8. Data Flow Diagram System

Data flow diagrams (DFD) describe the relationships between system, user entities, processes in the system, and databases in system. User enters blood pressure data and the amount of proteinuria through the 1.0 process and then saves it in a database file as variable indicator 1 and variable indicator 2. Data that has been stored is used in process 2.0 and forwarded to process 3.0 to display the results back to the officer.

c. System Usage Flowchart

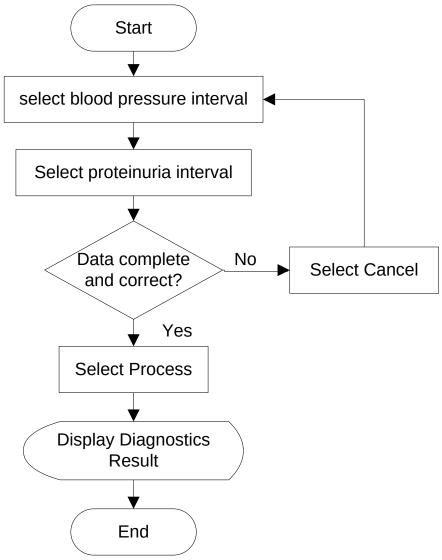

Figure 9. Flowchart Usage System

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User runs the program, starts by selecting the blood pressure value interval, then selecting the proteinuria value interval, if the data correct then the user choose the process, else user can cancel the data. After the diagnostic, process results are displayed on the monitor screen

d. User Interface Design

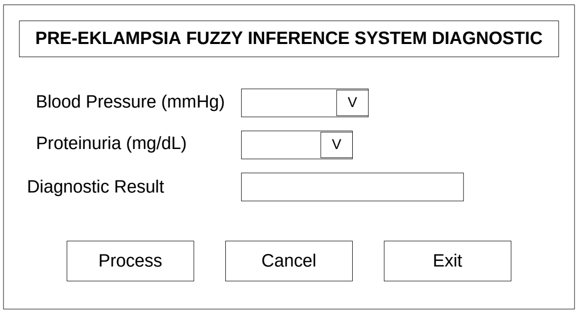

Figure 10. User Interface Design System

The user interface is made as simple as possible to make it easier for users to access the system. There are several components such as labels, combo-box, text-box, and buttons. Data is filled in the combo-box and the command is given by clicking on the button.

RESULTS AND DISCUSSION

Presentation of results using case studies:

It is known that patient a.n. Mrs. V.D.B has a blood pressure of 140/90 mmHg and proteinuria +1. By using the FIS diagnostics that have been developed, the diagnosis status is pre-eclampsia. System demo results are shown in the Figure11.

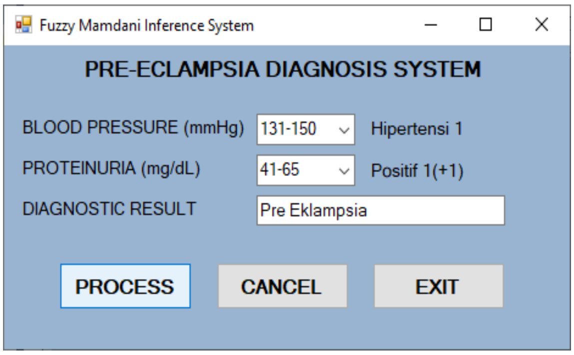

Figure 11. System running results

After the process of implementing the method and making the system prototype is complete, the next step is validation. validation process to compare the suitability between diagnosis results based on expert decisions and FIS calculations. A system is valid when there are more appropriate comparisons than inappropriate ones. The following is a comparison of the results of diagnoses based on experts and systems from data on 20 patients from Atambua Hospital and Kefamenanu Hospital. The comparison is presented in Table 3.

In the medical world, only severe pre-eclampsia is known and there is no division between type I and type II severe pre-eclampsia. This was only created for the purpose of combining rules at the inferencing stage (rule base), so even though in the system diagnosis decision PEB I and PEB II are written, there is no difference between the two, either in follow-up examination or treatment.

Table 3. Comparison of Diagnostic Results between Experts and Systems

No.	Patient	Examination		Diagnosis Result		Validation (Appropriate and inappropriate)
		Blood Pressure (mmHg)	Proteinuria	Expert	System	
1	V. D. B.	140/90	+1	PE	PE	Appropriate
2	R. R.	162/80	-	PEB II	PEB II	Appropriate
3	Yosefina A. N.	155/111	+3	PEB I	PEB I	Appropriate
4	Maria Balok	183/110	+1	PEB II	PEB II	Appropriate
5	Emerencia Merin	150/100	+2	PEB I	PEB I	Appropriate
6	Atriana F. Fahik	156/94	+2	PEB I	PEB I	Appropriate
7	Yustina Abu Leto	141/95	+2	PEB I	PEB I	Appropriate
8	Ermelinda L	200/120	+3	PEB II	PEB II	Appropriate
9	Kristina T	143/83	+3	PEB I	PEB I	Appropriate
10	Marsela W. L.	140/90	+2	PEB I	PEB I	Appropriate
11	Maria T.	156/107	+1	PE	PE	Appropriate
12	Kristina S.	200/140	+2	PEB II	PEB II	Appropriate
13	Oktaviana L. F.	110/70	+2	NPE	NPE	Appropriate
14	Lorensia H.	149/95	+2	PEB I	PEB I	Appropriate
15	Maria A. S.	107/74	-	NPE	NPE	Appropriate
16	Victoria M. A. T.	156/104	+2	PEB I	PEB I	Appropriate
17	Graciana N. Mau	150/100	+2	PEB I	PEB I	Appropriate
18	Ines Da Silva G.	148/106	+2	PEB I	PEB I	Appropriate
19	Maria Hati	165/97	+3	PEB II	PEB II	Appropriate
20	Maria J. Asa	156/95	+2	PEB I	PEB I	Appropriate

Note: NPE = Non-Preeclampsia, PE = Preeclampsia, PEB I = Severe Pre-eclampsia Type I, PEB II = Severe Pre-eclampsia Type II

Patient data serial number 2 with the initials R.R. has two possible diagnoses, namely PEB or NPE. Patients with this condition will be diagnosed with PEB if apart from the results of this screening, there are other symptoms such as headache, vomiting or blurred vision. If the patient does not have the symptoms in question then the patient is diagnosed as NPE. Meanwhile, patient data for serial numbers 13 and 15 are examples of cases that are not pre-eclampsia cases.

Based on Table 3, a comparison of the 20 data shows that the results are an Appropriate between the expert's decision and the decision of the diagnosis system with FIS Mamdani, meaning that the diagnosis system can be used to help the medical team or the lay public in detecting pre-eclampsia as early as possible so that it can prevent pre-eclampsia severe disease and eclampsia which can cause death.

CONCLUSIONS

Based on the results and discussion, there are several conclusions, including: the Mamdani Fuzzy Inference System method with blood pressure indicators and the amount of proteinuria content can be used to process data in a pre-eclampsia diagnosis system in pregnant women. The system's decision results are in accordance with the diagnosis delivered by the expert (doctor), with the level of accuracy of this system reaching 95.62% and therefore this expert system can be trusted to predict pre-eclampsia early so that the death of pregnant women due to pre-eclampsia or eclampsia can be achieved. avoided. This expert system, designed with a Graphical User Interface (GUI) approach, has a simple appearance, this makes it easier for users (officers) to understand the process and how to use the system.

For further research, additional data needs to be added so that the system testing parameters can be more accurate. The 20 data used in this study still cannot represent the characteristics of all patients suffering from pre-eclampsia. It requires a large amount of data to become an accurate parameter. In addition, the system can be developed by considering other factors such as a history of preeclampsia in previous pregnancies, maternal age (less than 16 years or more than 45 years), primigravida, multiple pregnancies, molar pregnancies, and obesity.

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