Optimization of Certainty Factor Method to Detect Preeclampsia in Women Pregnant

Linda Perdana Wanti[1][a], Nur Wachid Adi Prasetya[1][b], Laura Sari[1][c] and Lina Puspitasari[2][d]
[1]*Department of Informatics, Politeknik Negeri Cilacap, Cilacap, Indonesia*
[2]*Department of Midwifery, STIKES Graha Mandiri, Cilacap, Indonesia*

Keywords: Certainty Factor Method, Optimization, Preeclampsia, Pregnant Women, Expert System.

Abstract: Preeclampsia is a hypertensive disorder in pregnant women that significantly affects morbidity and one of the causes of death in pregnant women and fetuses. According to WHO data, the prevalence of preeclampsia is 1.8-18% in developing countries, while in developed countries it is 1.3-6%. This value indicates that in developing countries the case of pregnant women with preeclampsia is higher than in developed countries because preventive treatment for pregnant women with preeclampsia is handled faster in developed countries than in developing countries. In Indonesia alone, the Maternal Mortality Ratio (MMR) for the last 10 years amounted to 459 maternal and fetal deaths from 100,000 births with the frequency of occurrence of preeclampsia around 3% to 10% of the total number of pregnancies. The purpose of this study is the early detection of preeclampsia in pregnant women through diagnosis carried out using the Expert system so that pregnant women get preventive measures as an early prevention of preeclampsia disease that attacks and reduces the MMR rate. Another goal is to provide recommendations for therapy that can be given to pregnant women with preeclampsia. This research uses an optimized certainty factor method so as to provide a certainty value about the Expert's statement through the Expert's confidence level which is symbolized by a number in the range -1 to 1 in diagnosing preeclampsia. The output of this study is the result of expert diagnosis by optimizing the certainty factor method which provides recommendations for preventive actions to be taken to pregnant women with preeclampsia.

1 INTRODUCTION

Maternal Mortality Ratio (MMR) according to the World Health Organization (WHO) is the incidence of death in pregnant women during the period around delivery, which is the period of 42 days after the end of pregnancy, which is caused by all causes related to pregnancy or incorrect handling and is not caused by injury or accident. (Macedo et al., 2020). Maternal Mortality Ratio (MMR) and Infant Mortality Ratio (IMR) are benchmarks for the health and welfare of the people in a country. WHO reports from various sources that the direct cause of maternal death occurs during and after childbirth caused by bleeding, infection or high blood pressure during pregnancy by 75% (Wang et al., 2020). In Indonesia itself as a developing country, the MMR is still quite high, data from the Inter-Census Population Survey (SUPAS) recorded MMR as many as 305 cases during the period 2011 to 2014, which means that there are 305 cases of maternal death caused by pregnancy until delivery. 42 days after delivery per 100,000 live births (Aini, Fajaria Nur; Widyawati, Melyana Nurul, Santor, 2019). In Cilacap Regency, according to data from the Cilacap Regency Health Office, it shows that during the 2019 period of MMR there were 15 cases while for IMR there were 155 cases. As for the maximum target of the Cilacap District Medium-Term Development Plan (RPJMD), MMR is 19 cases and IMR is 139 cases (Tri Budiarti, Dhiah Dwi Kusumawati., Nikmah Nuur Rochmah, 2019).

[a] https://orcid.org/0000-0002-6679-2560
[b] https://orcid.org/0000-0002-4598-4336
[c] https://orcid.org/0000-0002-3495-2558
[d] https://orcid.org/0000-0001-7348-6564

Wanti, L., Prasetya, N., Sari, L. and Puspitasari, L.
Optimization of Certainty Factor Method to Detect Preeclampsia in Women Pregnant.
DOI: 10.5220/0010941400003260
In *Proceedings of the 4th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2021)*, pages 147-155
ISBN: 978-989-758-615-6; ISSN: 2975-8246

Based on this target, the MMR in Cilacap Regency is still quite high even though it is still below the maximum standard set. This has become the concern of relevant institutions in Cilacap Regency to continue to suppress MMR and IMR so that the level of community welfare increases.

MMR can be identified based on the general condition of the mother during a gestation period lasting 40 weeks (Qiao et al., 2020). One of the identifications can be done through the health examination of pregnant women in available health facilities (Gustri et al., 2016). This identification serves to reduce the risk of death of pregnant women and fetuses that can be predicted based on the symptoms experienced by pregnant women during pregnancy through prompt and correct handling in the most dangerous period, namely the period around delivery (Saraswati & Mardina, 2016). An expert system can be interpreted simply as a transfer of knowledge from an expert to a computer through an information system that can be utilized without the time and place restrictions (Mathew et al., 2020). The Expert System asks for facts that will later be used as knowledge inference which is then processed to be able to provide conclusions or decisions that are conical to a result of these facts (Dai et al., 2019). The conclusion is considered as the result of consultation with the Expert, who provides non-expert advice, and explains the possible solutions for the consequences (Zieschang et al., 2019). In research conducted, the Expert system is used to provide recommendations for therapy that can be carried out by pregnant women with preeclampsia during pregnancy as a decision or conclusion based on the symptoms that are inputted into the Expert system which is processed through a knowledge base. The conclusions/decisions given are non-experts, which can later be consulted with real experts if there are doubts about the results given by the Expert system. The therapy recommended by a machine learning-based intelligent system is in the form of an active solution for the decisions/ conclusions given to pregnant women with preeclampsia.

Research on preeclampsia has been conducted by Macedo et al who examined the prevalence of preeclampsia and eclampsia in pregnancy on 291,247 adolescents worldwide since 1969. The results showed 70 studies starting from 1969 to 2019 and consisting of 30 countries with 291,247 adolescents with prevalence rates the overall preeclampsia/eclampsia was 6.7%. Subgroup analysis revealed that the preeclampsia/eclampsia relationship was influenced by country income and the highest prevalence was found in the low- and middle-income countries group with prevalence values of 11.5% and 10.6% (Macedo et al., 2020).

Furthermore, research conducted by Zain et al analyzed the certainty factor method and implemented it into an Expert system for early detection of disease in beef cattle. In this study, the certainty factor method was used to determine the level of confidence in the disease found in beef cattle and the forward chaining method was used to determine the search on the knowledge base that determined the conclusion of the disease in beef cattle. The output of this study is a mobile-based Expert system for early detection of disease in beef cattle so that control measures can be taken quickly and precisely in determining the quality of good beef cattle (Zain & Astutik, 2015).

Further research by Khairina et al applied the certainty factor to the Expert system for diagnosing ENT diseases. The expert in this study is an ENT specialist who provides complete and detailed information about the causes and symptoms experienced by patients who have problems with their ears, nose and throat. The results of this study are a website-based information system that can diagnose ENT diseases by selecting the symptoms experienced by patients and the system provides search results in the form of information about ENT diseases suffered based on the selected symptoms (Setyaputri et al., 2018).

Furthermore, research conducted by Yudia et all which examines the determinants of preeclampsia in RSUP Dr. Moch. Husein Palembang. This research used a case-control study design. The data used secondary data from mothers medical record with preeclampsia and without preeclampsia in the period 1 January 2015-31 December 2015. The number of samples was 85 cases and controls. Analysis of data used univariate, bivariate analysis used chi square test, and multivariate used multiple logistic regression prediction model. Multivariate analysis showed that factors associated with preeclampsia were age> 35 years (OR: 4.120; 95% CI: 1.715 to 9.897) obesity (OR: 2.134; 95% CI: 1.093 to 4.167) and a history of hypertension (OR: 12.143; 95% CI: 1.368 to 107.792). The most dominant factor related to the incidence of preeclampsia in pregnant women is a history of hypertension. The advice can be given that the relevant agencies to improve promotive and preventive efforts by providing socialization of the factors which may be a risk of preeclampsia so that cases of preeclampsia can be prevented at an early

stage (Gustri et al., 2016).

Further research by Retno et al which analyzed the risk factors of severe preeclampsia in pregnant women in RSUD Dr. Moewardi Surakarta. Causes of maternal mortality include hemorrhage, eclampsia, and infection. Pre-eclampsia is a unique disorder that is only found in human pregnancy. Pre-eclampsia usually occurs in the third trimester. Pre-eclampsia at Dr. Moewardi hospital in 2010-2011 had increased. The aim of this study was to determine the risk factors of preeclampsia in pregnant women in Dr.Moewardi hospital. This study was an observational study with case-control design. Technique sampling used was consecutive sampling. The data were analyzed through Chi Square test. The results of this study showed that there were correlations between gestational age (p = 0.001; OR = 16.125, 95% CI = 1.993 to 130.459), occupational status (p = 0.001; OR = 4.173, 95% CI = 1.709 to 10.188) and the incidence of severe preeclampsia in pregnant women, and there was not any relationship between history of diabetes mel- litus (p = 1.000; OR = 1.000, 95% CI = 0.061 to 16.508) and the incidence of severe preeclampsia in pregnant women (Wulandari, 2012).

The novelty of the research carried out with previous research is the optimization of the certainty factor method adapted to provide a confidence value to the results of the Expert system search provided by the Expert. The search results are used to detect early and diagnose symptoms of preeclampsia in pregnant women by providing recommendations for therapy that should be carried out by the family and pregnant women in order to prevent unwanted things such as the death of pregnant women and fetuses. The output of this study is a conclusion of preeclampsia by optimizing the certainty factor method which describes the certainty value of an expert's conclusion on the diagnosis of preeclampsia in pregnant women with details of the stage of preeclampsia and recommendations for therapy that can be taken as a preventive measure to suppress the Maternal Mortality Ratio so that the results of the recommendations can prevent the death of pregnant women as early as possible.

2 RESEARCH METHOD

2.1 Preeclampsia

Preeclampsia is a disease in pregnant women characterized by hypertension, oedema, and proteinuria that arise due to pregnancy (Bracken et al., 2021). Preeclampsia is generally detected in the third trimester of pregnancy or in pregnant women who have a history of hypertension, so this disease can occur in the previous trimester (Aguilar-Cordero et al., 2020). The emergence of hypertension usually precedes other symptoms and in cases of preeclampsia, there are two types of hypertensive disorders, namely systolic and diastolic (Qiao et al., 2020). Excessive accumulation of body fluids in body tissues that can be identified through swelling of certain body parts such as fingers, curries and face and weight gain is called oedema (Macedo et al., 2020). Proteinuria is the level of protein concentration in urine that reaches 0.3 g/liter of urine within 24 hours and usually appears last compared to the other two symptoms (Wang et al., 2020), (Gustri et al., 2016).

For pregnant women with preeclampsia, mild preeclampsia syndrome, and symptoms as above are often missed and not monitored by the pregnant woman and her family, which results in severe preeclampsia and leads to the death of pregnant women (Saraswati & Mardina, 2016). Therefore, early detection of preeclampsia and appropriate therapy as a preventive measure need to be implemented immediately (Wulandari, 2012). Preeclampsia is grouped into 2, namely mild and severe preeclampsia, whigich is shown through the following symptoms (Kurniasari et al., 2015):

a. For mild preeclampsia, an examination every 6 hours showed a systolic blood pressure of 140 mm Hg or an increase of 30 mm Hg and a diastolic blood pressure result of 90 mm Hg or an increase of 15 mm Hg. The weight of pregnant women increased significantly by 1 kg in a period of 1 week continuously and the protein concentration of 0.3 g or more in 1 litre of urine.
b. Severe preeclampsia blood pressure in pregnant women of 160/110 mm Hg or more. The increase in protein concentration reaches 3 g / litre of urine or more. Pregnant women experience pain in the epigastrium, decreased visual function, headaches, decreased conscious function, accumulation of fluid in the lungs and cyanosis. After further examination, the results of the examination showed increased liver enzyme levels accompanied by an increase in bilirubin levels, retinal bleeding occurred, and platelet levels <100,000/mm.

In severe preeclampsia, if these symptoms continue to increase, it will result in maternal death, namely

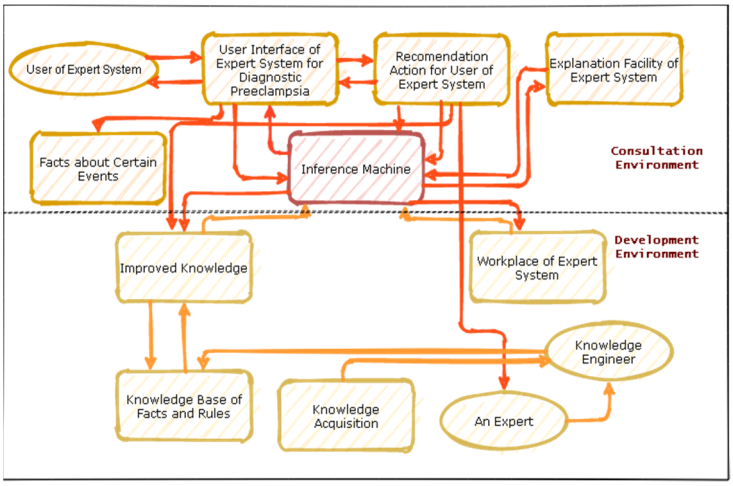

Figure 1: Expert System Environment.

pregnant women and fetuses (Aini, Fajaria Nur; Widyawati, Melyana Nurul, Santor, 2019).

2.2 Expert System

An expert system can be interpreted as a computer program that functions as a problem solver whose use can reach a performance level equivalent to a human expert/expert in a special field to narrow the discussion area and provide decision recommendations/conclusions from the problems encountered (Rada, 2008), (Wanti & Ramadan, 2020). Expert systems require the input of facts that occur to be processed in an inference engine and produce output in the form of a special conclusion (Zieschang et al., 2019). The structure of the Expert system is divided into two groups of environments, namely the development environment which is used for the development of the Expert system from the knowledge base and the needs of both functional and non-functional systems and the consulting environment used by a non-expert or end-user to conduct consultations (Castelli et al., 2017), (Zasada et al., 2017).

The Expert System consists of several components, including:

a. Knowledge base and knowledge acquisition are two different things. The knowledge base contains a collection of knowledge and information from a human expert on a particular skill, while knowledge acquisition is a change in the expertise of an Expert/expert from a knowledge base into a computer system (Zhang et al., 2013).
b. The user interface is used to interact between the intelligent system and the end-user. This component is found in the consulting environment where the inference machine on the system gets input in the form of facts/symptoms from the user, and the system produces output in the form of information on the conclusion of a problem for the user (Liao, 2005).
c. The inference machine is the control centre for a machine learning-based intelligent system in which there is a mechanism for the Expert thinking function and the intelligent system reasoning role used by the expert/Expert and can draw conclusions and control the mechanism of the intelligent system being built (Mathew et al., 2020).
d. Workplace is located in the development environment or can be called an area in computer memory and serves as a database for the process of recording the results of a temporary diagnosis which will later be used as a decision/recommendation on a problem (Ooi & Tan, 2016).
e. Explanation expert system serves to improve the performance of intelligent systems by describing the flow of reasoning carried out to end-users (Liu et al., 2020).
f. Improved knowledge is used by Experts who have the expertise to solve problems through analysis of facts/symptoms that occur and improve the performance of intelligent systems through improving the performance of Expert system performance (Wanti et al., 2019).

The advantage of expert systems compared to conventional systems is that the algorithms in the inference machine are not written in the program source code, only stored as a knowledge base for the intelligent system that was built (Dweiri et al., 2017), (Dai et al., 2019).

2.3 Certainty Factor Method

Certainty theory underlies the use of certainty factors that cover the value of certainty in a problem based on facts/symptoms that occur in the field based on the perception of an expert (Aji et al., 2018). The range of values to describe the level of confidence of an expert is from a negative one (sure it doesn't happen) to one (sure it happens) (Zain & Astutik, 2015). Here is a table of confidence levels to provide a certainty factor value for a fact/symptom:

Table 1: Certainty Factor Uncertain Term.

Uncertain Term	Certainty Factor Value
Definitely Not	0.2
Almost Certainty Not	0.3
Probably Not	0.4
Maybe Not	0.5
Unknown	0.6
Maybe	0.7
Probably	0.8
Almost Certainty	0.9
Definitely	1.0

Users who do not experience symptoms are indicated by a CF value of 0, while for users who experience symptoms it can be predicted according to the selected CF value which shows the percentage for a symptom with a high confidence value experienced by the user (Riadi, 2017). Determination of uncertain terms is based on expert knowledge after consultation to describe each symptom/actual fact that will be given an uncertain term value (Setyaputri et al., 2018). Certainty Factor (CF) accumulates the value of the degree of confidence and the value of the degree of distrust which is denoted by NP(P|E) to describe the confidence value of hypothesis P, evidence E and NK (P|E) to describe the value of distrust of hypothesis P, evidence E, where the sum of the two is not always 1 (Arifin et al., 2017).

The stages of the process on the certainty factor method are as follows:

a. Determining the value of CF

$$CF\ [H,E] = MB\ [H,E] - MD\ [H,E] \quad (1)$$

Information :

CF [H,E] : a measure of the certainty of the hypothesis H that affected by E symptoms

MB [H,E] : a measure of MB's confidence in H affected by E

MD [H,E] : measure of distrust MD to H which is affected by E

b. Determine the value of CF Combination determined by one premise

$$CF\ [H,E] = CF\ [E] * CF\ [RULE] = CF\ [USER] * CF\ [EXPERT] \quad (2)$$

c. Determine the value of CF Combination determined by more than one premise

$$CF\ [X \wedge Y] = Min\ (CF[x], CF[y]) * CF\ [RULE\} \quad (3)$$

$$CF\ [X \vee Y] = Max\ (CF[x], CF[y]) * CF\ [RULE\} \quad (4)$$

d. Determine the CF value for the same conclusion

$$CF\ Combined[CF1, CF2] = CF1 + CF2 * (1 - CF1) \quad (5)$$

The certainty factor method is widely adapted for a machine learning-based intelligent system because the measurement of a definite or uncertain hypothesis, such as early detection of a disease based on the symptoms shown and the calculation for the certainty factor method is only one calculation process and the minimum data that can be obtained processed as much as two data to ensure the accuracy of the results obtained (Aji et al., 2018).

3 RESULT AND ANALYSIS

The data used to diagnose preeclampsia in pregnant women is data on factors that influence the cause of the emergence of preeclampsia obtained from the results of consultations with experts to determine the value of MB (Measure of Believe) and MD (Measure of Disbelieve) which were formulated with developers to build a knowledge base system. Experts. Determination of the classification class to raise the chance of preeclampsia disease which is classified into three categories, namely mild preeclampsia, moderate preeclampsia and severe preeclampsia that attacks pregnant women. The stage begins with collecting data and starting to analyze all the resources needed for the preeclampsia diagnosis process. The parity variable data is shown in table 2 and the data will be used to classify preeclampsia into three categories. The experts in this study were a midwife and an obstetrician specialist.

Table 2: Data on Preeclampsia Causing Factors.

Factor Code	Information	Factor Description
F01	Age	U1, U2, U3
F02	Parity	P1, P2
F03	Pregnancy Distance	JK1, JK2
F04	Multiple Pregnancy	KG1, KG2
F05	History of Preeclampsia	RP1, RP2
F06	History of Hypertension	RH1, RH2
F07	Descendants History	RK1, RK2
F08	History of DM	RD1, RD2
F09	Nutritional status	SG1, SG2
F10	Antenatal Care	AC1, AC2
F11	Family Planning Acceptor History	RA1, RA2
F12	Educational status	SP1, SP2
F13	Knowledge	P1, P2, P3
F14	Economic Status	SE1, SE2
F15	Work	PK1, PK2
F16	Health Service Distance	J1, J2, J3

Table 3: Expert Interpretation.

Factor Description Code	Information	CF User	CF Expert
U1	<= 18 years	0.8	0.8
U2	18 - 38 years	0.6	0.6
U3	>= 38 years	0.8	0.9
P1	First	0.7	0.8
P2	Second/more	0.6	0.6
JK1	< 24 months	0.8	0.9
JK2	>/ 24 months	0.7	0.7
KG1	Double	0.8	0.9
KG2	Single	0.7	0.7
RP1	There is	0.8	0.9
RP2	No	0.7	0.6
RH1	There is	0.8	0.9
RH2	No	0.7	0.6
RK1	There is	0.8	0.9
RK2	No	0.7	0.6
RD1	There is	0.8	0.9
RD2	No	0.7	0.6
SG1	Obesity	0.8	0.9
SG2	No	0.7	0.6
AC1	</= 3 times	0.8	0.9
AC2	> 3 times	0.7	0.6
RA1	There is	0.7	0.6
RA2	No	0.8	0.9
SP1	Elementary/junior high school	0.8	0.8
SP2	Senior High School/ PT	0.7	0.7
P1	Not enough	0.8	0.9
P2	Currently	0.7	0.8
P3	Well	0.7	0.7
SE1	<500k	0.8	0.9
SE2	>/= 500k	0.7	0.6
PK1	Unemployment	0.9	0.9
PK2	Work	0.7	0.6
J1	>1000 meters	0.8	0.9
J2	</= 1000 meters	0.6	0.6

Table 4: Preeclampsia Category Data.

Category Code	Information
P01	Mild Preeclampsia
P02	Moderate Preeclampsia
P03	Severe Preeclampsia

Table 5: Rule.

No	Rule
1	If U1 and P1 and JK2
2	If U2 and RP1 and RH2
3	If U3 and RH1 and RD1
4	If U2 and SG1 and RH1
5	If U3 and SG2 and RD2

An example of the calculation process using the certainty factor method by determining the CF value using equation (1), namely for CF Users and CF Experts is available in table 3. Then determining the CF Combination value determined by one premise using equation (2), is as follows:

Rule : If U3 and RH1 and RD1
CF S1 : CF User * CF Expert
: 0.8 * 0.9
: 0.72
CF S2 : CF User * CF Expert
: 0.8 * 0.9
: 0.72
CF S3 : CF User * CF Expert
: 0.8 * 0.9
: 0.72

The next step is to determine the CF for the same conclusion. Because there is more than one symptom experienced by patient A, we use equation (5), the calculation is as follows:

CF C1 : CF S1 + CF S2 * (1-CF 1)
: 0.72 + 0.72 * (1-0.72)
: 0.72 + 0.72 * 0.28
: 0.72 + 0.2019
: 0.92
CF C2 : CF C1 + CF S3 * (1-CF C1)
: 0.92 + 0.72 * (1-0.92)
: 0.72 + 0.72 * 0.08
: 0.72 + 0.0576
: 0.9776

The CF C2 value of 0.9776 was obtained which is the CF diagnosis of preeclampsia experienced by patient A. Then to determine the percentage of confidence in preeclampsia which is included in the category of severe preeclampsia, using the equation:

Percentage : CF Disease * 100
: 0.9776*100
: 97.76%

Based on the calculation by taking a sample of patient A, the information on the level of confidence based on the final percentage is very possible.

For the second example, the calculation process will be carried out using the certainty factor method by determining the CF value in patient B using equation (1). Values for CF User and CF Expert are available in table 3. The first step is to determine the CF Combination value determined by one premise using equation (2), as follows:

Rule : If U2 and SG1 and RH1

CF S1 : CF User * CF Expert
: 0.6 * 0.6
: 0.36
CF S2 : CF User * CF Expert
: 0.8 * 0.9
: 0.72
CF S3 : CF User * CF Expert
: 0.8 * 0.9
: 0.72

The next step is to determine the CF for the same conclusion. Because there is more than one symptom experienced by patient B, we use equation (5). The calculation is as follows:

CF C1 : CF S1 + CF S2 * (1-CF S1)
: 0.36 + 0.72 * (1-0.36)
: 0.72 + 0.72 * 0.64
: 0.72 + 0.461
: 0.821
CF C2 : CF C1 + CF S3 * (1-CF C1)
: 0.821 + 0.72 * (1-0.821)
: 0.72 + 0.72 * 0.179
: 0.72 + 0.13
: 0.951

The CF C2 value of 0.9776 was obtained which is the CF diagnosis of preeclampsia experienced by patient B. Then to determine the percentage of confidence in preeclampsia which is included in the category of severe preeclampsia, using the equation:

Percentage : CF Disease * 100
: 0.951*100
: 95.1 %

Based on the calculation by taking a sample of patient B, the information on the level of confidence based on the final percentage is very possible.

Therapeutic recommendations that can be done to patient A and patient B who are diagnosed with severe preeclampsia are to periodically check the general condition of the mother and the baby in her womb and monitor the pregnancy process until the birth process to obtain measures that prevent maternal and infant mortality. This process can be carried out by medical personnel either in integrated health services such as Posyandu, Puskesmas or the nearest hospital.

4 CONCLUSIONS

The optimization of the certainty factor method to determine the value of expert certainty on the condition of a patient who has the factors causing preeclampsia has been proven. Based on the calculation simulation using the certainty factor method, the results showed that the percentage of patient A was 97.76%, while patient B was 95.1% and both patients were very likely to be included in the category of severe preeclampsia with each of the causative factors accompanying the two patients. These results can be used by medical personnel and families to determine the most likely preventive action in the process of pregnancy to the birth of a baby to prevent maternally and infant mortality.

REFERENCES

Aguilar-Cordero, M. J., Lasserrot-Cuadrado, A., Mur-Villar, N., León-Ríos, X. A., Rivero-Blanco, T., & Pérez-Castillo, I. M. (2020). Vitamin D, preeclampsia and prematurity: A systematic review and meta-analysis of observational and interventional studies. *Midwifery*, *87*, 102707. https://doi.org/10.1016/j.midw.2020.102707

Aini, Fajaria Nur; Widyawati, Melyana Nurul, Santor, B. (2019). Diagnosa Preeklamsia Pada Ibu Hamil Menggunakan Sistem Informasi Berbasis Web. *Jurnal Keperawatan Silampari*, *2*(2), 18–27.

Aji, A. H., Furqon, M. T., & Widodo, A. W. (2018). Sistem Expert Diagnosa Penyakit Ibu Hamil Menggunakan Metode Certainty Factor (CF). *Jurnal Pengembangan Teknologi Informasi Dan Ilmu Komputer*, *2*(5), 2127–2134. http://j-ptiik.ub.ac.id/index.php/j-ptiik/article/view/1556

Arifin, M., Slamin, S., & Retnani, W. E. Y. (2017). Penerapan Metode Certainty Factor Untuk Sistem Expert Diagnosis Hama Dan Penyakit Pada Tanaman Tembakau. *Berkala Sainstek*, *5*(1), 21. https://doi.org/10.19184/bst.v5i1.5370

Bracken, H., Buhimschi, I. A., Rahman, A., Smith, P. R. S., Pervin, J., Rouf, S., Bousieguez, M., López, L. G., Buhimschi, C. S., Easterling, T., & Winikoff, B. (2021). Congo red test for identification of preeclampsia: Results of a prospective diagnostic case-control study in Bangladesh and Mexico. *EClinicalMedicine*, *31*. https://doi.org/10.1016/j.eclinm.2020.100678

Castelli, M., Manzoni, L., Vanneschi, L., & Popovič, A. (2017). An expert system for extracting knowledge from customers' reviews: The case of Amazon.com, Inc. *Expert Systems with Applications*, *84*, 117–126. https://doi.org/10.1016/j.eswa.2017.05.008

Dai, S., Xu, B., Shi, G., Liu, J., Zhang, Z., Shi, X., & Qiao, Y. (2019). SeDeM expert system for directly compressed tablet formulation: A review and new perspectives. *Powder Technology*, *342*, 517–527. https:// doi.org/10.1016/j.powtec.2018.10.027

Dweiri, F., Kumar, S., Ahmed, S., & Jain, V. (2017). Corrigendum to " Designing an integrate d AHP base d decision support system for supplier selection in automotive industry " Expert Systems. *Expert Systems With Applications*, *72*, 467–468. https://doi.org/ 10.1016/j.eswa.2016.12.025

Gustri, Y., Januar Sitorus, R., & Utama, F. (2016). Determinants Preeclampsia in Pregnancy At Rsup Dr. Mohammad Hoesin Palembang. *Jurnal Ilmu Kesehatan Masyarakat*, *7*(3), 209–217. https://doi.org/10. 26553/jikm.2016.7.3.209-217

Kurniasari, D., JURNAL, F. A.-H., & 2015, undefined. (2015). Hubungan Usia, Paritas Dan Diabetes Mellitus Pada Kehamilan Dengan Kejadian Preeklamsia Pada Ibu Hamil Di Wilayah Kerja Puskesmas Rumbia Kabupaten. *Ejurnalmalahayati.Ac.Id*, *9*(3), 142–150. http://ejurnal malahayati.ac.id/index.php/holistik/article/view/232

Liao, S. H. (2005). Expert system methodologies and applications-a decade review from 1995 to 2004. *Expert Systems with Applications*, *28*(1), 93–103. https://doi. org/10.1016/j.eswa.2004.08.003

Liu, Y., Eckert, C. M., & Earl, C. (2020). A review of fuzzy AHP methods for decision-making with subjective judgements. In *Expert Systems with Applications* (Vol. 161). Elsevier Ltd. https://doi.org/10.1016/j.eswa.2020. 113738

Macedo, T. C. C., Montagna, E., Trevisan, C. M., Zaia, V., de Oliveira, R., Barbosa, C. P., Laganà, A. S., & Bianco, B. (2020). Prevalence of preeclampsia and eclampsia in adolescent pregnancy: A systematic review and meta-analysis of 291,247 adolescents worldwide since 1969. *European Journal of Obstetrics and Gynecology and Reproductive Biology*, *248*(March), 177–186. https:// doi.org/10.1016/j.ejogrb.2020.03.043

Mathew, M., Chakrabortty, R. K., & Ryan, M. J. (2020). A novel approach integrating AHP and TOPSIS under spherical fuzzy sets for advanced manufacturing system selection. *Engineering Applications of Artificial Intelligence*, *96*(October), 103988. https://doi.org/ 10.1016/j.engappai.2020.103988

Ooi, K. B., & Tan, G. W. H. (2016). Mobile technology acceptance model: An investigation using mobile users to explore smartphone credit card. *Expert Systems with Applications*, *59*, 33–46. https://doi.org/10.10 16/j.eswa. 2016.04.015

Qiao, P., Zhao, Y., Jiang, X., Xu, C., Yang, Y., Bao, Y., Xie, H., & Ying, H. (2020). Impact of growth discordance in twins on preeclampsia based on chorionicity. *American Journal of Obstetrics and Gynecology*, *223*(4), 572.e1-572.e8. https://doi.org/ 10.1016/j.ajog.2020.03.024

Rada, R. (2008). Expert systems and evolutionary computing for financial investing: A review. *Expert Systems with Applications*, *34*(4), 2232–2240. https:// doi.org/10.1016/j.eswa.2007.05.012

Riadi, A. (2017). Penerapan Metode Certainty Factor Untuk Sistem Expert Diagnosa Penyakit Diabetes Melitus Pada Rsud Bumi Panua Kabupaten Pohuwato. *ILKOM Jurnal Ilmiah*, *9*(3), 309–316. https://doi.org /10.33096/ilkom.v9i3.162.309-316

Saraswati, N., & Mardina. (2016). Unnes Journal of Public Health Berdasarkan data World Health Organization Berdasarkan laporan Dinas Kesehatan. *Unnes Journal of Public Health*, *5*(2), 90–99.

Setyaputri, K. E., Fadlil, A., & Sunardi, S. (2018). Analisis Metode Certainty Factor pada Sistem Expert Diagnosa Penyakit THT. *Jurnal Teknik Elektro*, *10*(1), 30–35. https://doi.org/10.15294/jte.v10i1.14031

Tri Budiarti, Dhiah Dwi Kusumawati., Nikmah Nuur Rochmah. (2019). Hubungan Berat Bayi Lahir Dengan Kematian Bayi. *Jurnal Kesehatan Al-Irsyad*, *12*(2), 63–70. https://doi.org/10.36746/jka.v12i2.42

Wang, Y., Wang, K., Han, T., Zhang, P., Chen, X., Wu, W., Feng, Y., Yang, H., Li, M., Xie, B., Guo, P., Warren, J. L., Shi, X., Wang, S., & Zhang, Y. (2020). Exposure to multiple metals and prevalence for preeclampsia in Taiyuan, China. *Environment International*, *145* (August), https://doi.org/10.1016/j.envint.2020.106098

Wanti, L. P., Azroha, I. N., & Faiz, M. N. (2019). Implementasi User Centered Design Pada Sistem Expert Diagnosis Gangguan Perkembangan Motorik Kasar Pada Anak Usia Dini. *Media Aplikom*, *11*(1), 1–10.

Wanti, L. P., & Romadlon, S. (2020). Implementasi Forward Chaining Method Pada Sistem Expert Untuk Deteksi Dini Penyakit Ikan. *Infotekmesin*, *11*(02), 74–79. https://doi.org/10.35970/infotekmesin.v11i2.248

Wulandari, R. dan F. A. F. (2012). Faktor Risiko Kejadian Preeklampsia Berat Pada Ibu Hamil di RSUD Dr Moewardi Surakarta. *Jurnal Kesehatan*, *5*(1), 29–35.

Zain, A. A., & Astutik, E. Z. (2015). *ANALISIS METODE Certainty Factor Dalam Sistem Expert Untuk Mendeteksi Penyakit SAPI PEDAGING Kebutuhan konsumsi sapi pedaging di Indonesia sangat tinggi hampir setiap hari masyarakat Indonesia mengkonsumsi daging sapi . Sapi juga merupakan hewan yang banya*.

Zasada, I., Piorr, A., Novo, P., Villanueva, A. J., & Valánszki, I. (2017). What do we know about decision support systems for landscape and environmental management? A review and expert survey within EU research projects. *Environmental Modelling and Software*, *98*, 63–74. https://doi.org/10.1016/j.envsoft. 2017.09.012

Zhang, J., Prater, E. L., & Lipkin, I. (2013). Feedback reviews and bidding in online auctions: An integrated hedonic regression and fuzzy logic expert system approach. *Decision Support Systems*, *55*(4), 894–902. https://doi.org/10.1016/j.dss.2012.12.025

Zieschang, L., Klein, M., Jung, N., Krämer, J., & Windbergs, M. (2019). Formulation development of medicated chewing gum tablets by direct compression using the SeDeM-Diagram-Expert-System. *European Journal of Pharmaceutics and Biopharmaceutics*, *144*(April), 68–78. https://doi.org/10.1016/j.ejpb.2019.09.003