Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 5, Number 1, October, 2020
DOI : https://doi.org/10.33395/sinkron.v5i1.10593
e-ISSN : 2541-2019
p-ISSN : 2541-044X

Expert System for Diagnosing Pregnancy Complaints by Forward Chaining

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Submitted : Aug 27, 2020 | **Accepted** : Oct 3, 2020 | **Published** : Oct 3, 2020

Abstract: Limited time in consulting becomes an obstacle for midwives in diagnosing complaints in pregnant women, especially those who are already in the III trimester and approaching the labor process. Misdiagnosis results in inaccuracies in the provision of solutions and actions. Initial treatment that corresponds to the complaints of pregnant women especially the third trimester is expected to reduce mortality rates in the mother and fetus. Expert System can be a timely solution with not too long so as to improve the quality of examination on midwives. The methods used are identification, primary and secondary data collection, forward chaining data analysis combined with bayesian, and evaluation with the calculation of the percentage of system success. Samples taken by 20 patients and 4 patients were declared unsyed because they had only one complaint. Meanwhile, 16 patients had some complaints that complied with the Rules. A total of 11 out of 16 patients or about 70% had valid results between the diagnosis of experts/midwives with the system. It can be concluded that the system works well to diagnose complaints in patients with a third trimester gestational age so that midwives can provide appropriate initial solutions and treatment in reducing maternal and infant mortality.

Keywords: Diagnose; Complaints; Pregnancy; Midwife; Forward chaining

INTRODUCTION

The immortal rates of child and baby still high, one of the prolems caused by lacked of attention about healty when pregnant or improper handling when certain symptoms appear (B A Sitorus, Aris, Pribowo, & Irawati, 2018). In addition to maintaining the growth and health of the fetus, Pregnancy care is one of the factors that need to be considered to prevent complications and death during childbirth (Widyaningsih & Astutiningsih, 2016). The harmful effects of pregnancy risk factors for the body cannot be underestimated (Umoh & Nyoho, 2015).

Midwives are one of the health care and screening spots for pregnant women. Besides the close distance, also at an affordable cost. But the limited hours of work practice, many patients who queued cause fatigue for pregnant women (Maryani & Haryanto, 2018).

Many expectant mothers who conduct ULTRASOUND examinations make midwives and doctors have difficulty in diagnosing the III trimester of pregnant mothers, so that the solution given is less than optimal. It is unfortunate if the actual symptoms can be addressed early into (Munti & Effindri, 2017).

Proper and smooth delivery process will reduce maternal mortality rate and infant. One methode to lower it is to be helped by professional health workers and perform childbirth in the health facilities (Hasbiyanor & Bahar, 2017).

One of the methods of a system of experts diagnosing complaints in the III Trimester pregnant women is forward chaining. The Expert system (ES) aims to replace human knowledge, such as health experts, agricultural experts, etc (Hatta, Ulfah, Khairina, Hamdani, & Maharan, 2017). Forward chaining is a method of detecting complaints or symptoms first, so it comes to a conclusion. The forward chaining method will be combined with a bayesian method that can calculate the probability percentage, so that midwives and doctors can provide the maximum solution to complaints experienced with limited practice time. This pregnancy complaint expert system will be created with Android OS. Android is a type of Operating System (OS) that makes it easy for customers who want to use (Wati, Istikharoh, & Tuslaela, 2020).

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LITERATURE REVIEW

Expert System

An expert System is also called Knowledge Based System which is a computer application aimed at assisting decision making or problem solving in a specific field (Hayadi & Rukun, 2016).

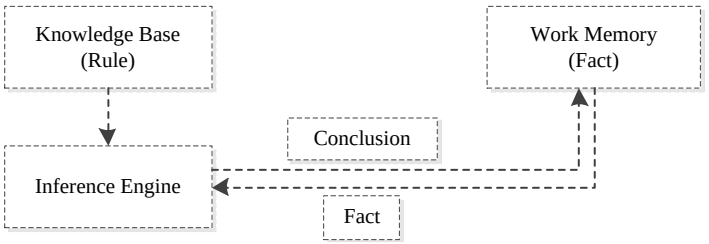
According to Sutojo, the benefits of Expert System in (Hayadi & Rukun, 2016) are:

1. Increase productivity, because expert systems can work faster than humans.
2. Make a human work like an expert.
3. Improve quality by giving consistent advice and reducing errors.
4. Able to capture human expertise and knowledge.
5. Make it easy to access an expert's knowledge
6. Can be used as a supporiting media in training. Novice users who work with expert systems will become more experienced because there is a information facility that works as a teacher.
7. Improve the ability to solve problems because the expert system takes the source of knowledge from many experts.

Forward Chaining

According to Sutejo in (Hayadi & Rukun, 2016), forward chaining is a search technique that starts with known facts, then matches those facts with the IF section of the rules IF_THEN. If there is a fact that matches the IF section, Then the ruleswill executed. When a rule is executed, a new fact (THEN section) is added to the database. Each rule should be executed onlyonce.

A rule-based model known as the forward chaining method can be seen in the following image:



Sumber : (Hayadi & Rukun, 2016)

Fig. 6 Rule-Based Model

Bayesian Method

The Bayesian Method also known as the Bayesian Network (BN) is a probability graphics model that represents a set of variables and relations between these variables (Hasniati, Arianti, & Philip, 2019). Rumus Teorema Bayes (Hasniati et al., 2019) *are :*

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Explanation :

P(A B) = it's also calledposterior probability, which is opportunity A occurs after B.
P(B A) = it's also called likelihood, which is opportunityB occurs after A.
P(A) = it is also called prior, which is opportunity A occurs
P(B) = opportunity B occurs.

For quality filling,the following is the terminology confidence of user's consultation which is given answer choices by each quality (Avrizal, 2019):

- Absolutely Sure : 1.0
- Very Sure : 0.8
- Sure : 0.6
- Less Sure : 0.4
- Abstain : 0.2
- Not Sure : 0

Probability is analyzed by percentage with the following possible values:

0% - 50% Event will not occur
51% - 75% Less event will occur

76% - 84% Event will occur
86% - 100% Very Sure that event will occur

A. State of Art

This research is based on several previous studies with forward chaining methods including :

Table 1
State of Art

Title	Implementation of Expert System to Diagnose Diseases In Pregnancy
Researcher, Year	(Ramanda, 2015)
Generate desktop-based applications with data collection for 12 diseases diagnosed using the forward chaining method. In this study, it will be used as a reference for the diagnosis 5 symptoms.	
Title	Web-Based Expert System Application For Pregnancy Problem Consultation Using Forward Chaining And Production Rule
Researchers, Year	(Widyaningsih & Astutiningsih, 2016)
To Generate web-based applications with data collection of as many as 9 diseases diagnosed using forward chaining methods. In this study, it will be used as a reference for the diagnosis only 1 disease and will be used the advantages of this application is the diagnosis of many questions asked by the program, so that the user only selects a few symptoms listed and will be carried out a search of the nearest possibilities regarding the disease suffered	
Title	Implementation of Expert System to Diagnose Diseases In Pregnancy
Researchers, Year	(Afiana, Hariawan, & Setiyadi, 2017)
To Generate a desktop-based application with data collection of 13 diseases diagnosed using qualitative forward chaining methods. In this study, it will be used as a reference to diagnosis of 2 symptoms.	
Title	Web-Expert System For the Detection Of Early Symptoms Of The Disorder Of Pregnancy Using A Forward Chaining And Bayesian Method
Researcher, Year	(Hatta, Ulfah, Khairina, Hamdani, & Maharan, 2017)
The results of web-based application with the logging for 11 diseases are diagnosed using forward chaining methods (FC) and BNs (bayesian methods or bayes theorems). In this study, it will be used as a reference to diagnosis for 6 diseases. The advantage of this research to be used is its method between forward chaining and bayesian method for probability of giving percent. To access the expert system, users don't need to register if they will be looking for information about pregnancy. This study also proves that abortion has a high system accuracy rate of 82.86% and eclampsia disorder of 97% by comparing the results of expert systems with the diagnosis of the doctors. The comparison between the diagnosis system and the experts will be used for students in the research of budding lecturers	
Title	Expert System in Identifying Infectious Diseases Using Android-Based Forward Chaining Method
Researchers, Year	(Gunawan, Defit, & Sumijan, 2020)
To Generate android-based apps with data collection for 10 diseases diagnosed using forward chaining methods. This research has the result of a level of accuracy of the system, it obtained an accuracy rate of 90% and inaccurate 10% of the 20 test data.	

The state of art table shows more accurate results: liza research with the largest probability of 97% using a comparison between system diagnosis and expert reference will used as a referency.

METHOD

The research method used as a guideline to conduct expert system research on the diagnosis of complaints in pregnant women consists of 4 stages, namely identification, logging, data analysis, and evaluation. Identification stage is the early stage in conducting research to formulate a problem by making observations. The logging phase is the stage that is done after identification and serves to obtain data from the research site or called primary data. In addition, data collection is also done to obtain data from the second source namely journals and e-books called secondary data. The third stage is the analysis of data by summarizing diseases and symptoms according to the data that has been collected from journal sources and midwife interviews. This stage also analyzes some patient complaints according to their weight obtained from the collection of primary data on patients. The last stage is an evaluation conducted by calculating the percentage of success by looking at the comparison between the results of experts / midwives and the results of expert system. An overview of the research methods can be seen below.

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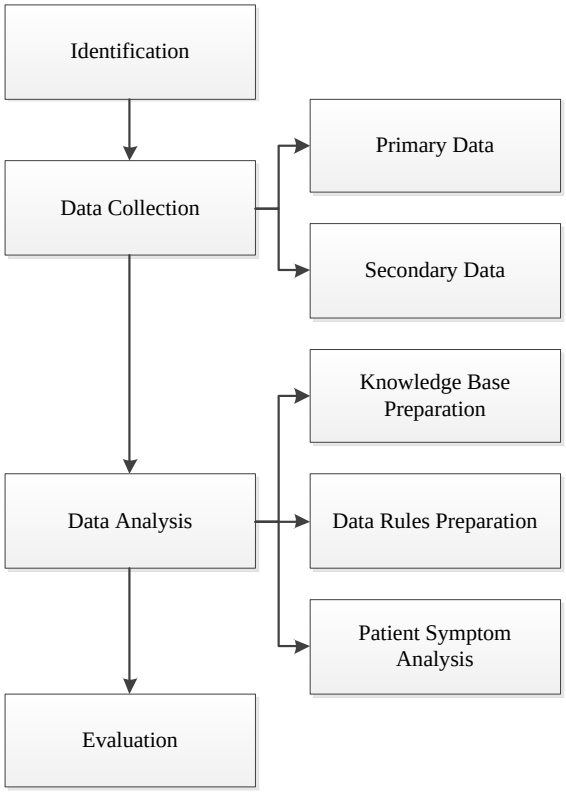

Fig. 2 Method

Identification of Problems

Identification of the problem by direct observation at the checkpoint is Midwife Rosita, by making observations on March 10, 17, and 24, 2020 and April 2 and 7, 2020 on pregnant women who come to do ultrasound examinations and. Samples were taken as many as 4 patients per day who had a gestational life of 7-9 months, up to a total of 20 patients.

Data Collection

The data sources used are :

1. Primary Data: complaint data, disease diagnosis data and solution data from interview results with midwives and pregnant women data from observation results with patients who are still conducting examinations.
2. Secondary Data: complaint data, disease data, diagnosis data and solution data taken from journals

Data Analysis

1. Knowledge Base Preparation

The knowledge base consists of disease data and symptom data which can be seen in the table below. The data from midwife interviews is a disease with codes P01, P06 and P07 as well as symptoms with codes G03, G23, and G25.

Table 2
Disease Data

Source	Code	Disease
(Widyaningsih & Astutiningsih, 2016)	P01	Hyperemesis third trimester
(Hatta et al., 2017)	P02	Hyperemesis gravidarum In Level 1
	P03	Hyperemesis gravidarum In Level 2

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P04	Hyperemesis gravidarum In Level 3
P05	Mild preeclampsia
P06	Preeklampsia
P07	Eklampsia

Table 3
Symptom Data

Source	Code	Symptom
(Widyaningsih & Astutiningsih, 2016) (Ramanda, 2015)	G01	Bleeding in young and old pregnant
(Widyaningsih & Astutiningsih, 2016)	G02	Amniotic water comes out before its time
(Ramanda, 2015)	G03	Excessive nausea or vomiting
	G04	Upper abdominal pain
	G05	Dry and dirty tongue
	G06	Dehydration
	G07	Decreased appetite
(Hatta et al., 2017)	G08	Weight Loss
	G09	Sunken eyes
	G10	Increased pulse rate & lower blood pressure
	G11	Pulse frequency about 100 beats/minute
(Hatta et al., 2017) (Ramanda, 2015) (Afiana et al., 2017)	G12	Looks weak and limp (not fit)
	G13	Yellow eyes
	G14	Difficulty defecating
(Hatta et al., 2017)	G15	Decreased skin elasticity
	G16	The faster the pulse frequency above 100 beats/ minute
	G17	Small pulse as blood volume drops
(Hatta et al., 2017) (Ramanda, 2015)	G18	Increased body heat or fever
	G19	Urine slightly until it does not come out urine
(Hatta et al., 2017)	G20	Vomiting and mixed blood
	G21	Decreased awareness
	G22	Out of sight
(Hatta et al., 2017)	G23	Headache or dizziness
(Ramanda, 2015) (Afiana et al., 2017)	G24	Excess weight or greater weight gain
	G25	Swollen face or other parts of the body
	G26	Blood pressure between 140/90 to 160/110
	G27	Proteinuria +1
(Hatta et al., 2017)	G28	Proteinuria +2
	G29	Proteinuria +3 or more
	G30	Tensions over 160/110
	G31	Heart a pain
	G32	Seizures

2. Data Rules Preparation
Rule data can be seen in the following table and the decision tree can be seen in Fig. 3.

Table 4
Data Rules

Rule	Condition

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Rule 1	IF G01 AND G02 THEN P01
Rule 2	IF G03 AND G04 AND G05 AND G06 AND G07 AND G08 AND G09 AND G10 AND G11 AND G12 THEN P02
Rule 3	IF G03 AND G04 AND G05 AND G08 AND G09 AND G13 AND G14 AND G15 AND G16 AND G17 AND G18 AND G19 AND G20 THEN P03
Rule 4	IF G03 AND G04 AND G05 AND G10 AND G13 AND G14 AND G17 AND G18 AND G19 AND G20 AND G21 AND G22 THEN P04
Rule 5	IF G23 AND G24 AND G25 AND G26 AND G27 THEN P05
Rule 6	IF G13 AND G23 AND G24 AND G25 AND G28 AND G30 THEN P06
Rule 7	IF G13 AND G21 AND G22 AND G23 AND G24 AND G25 AND G29 AND G30 AND G31 AND G32 THEN P07

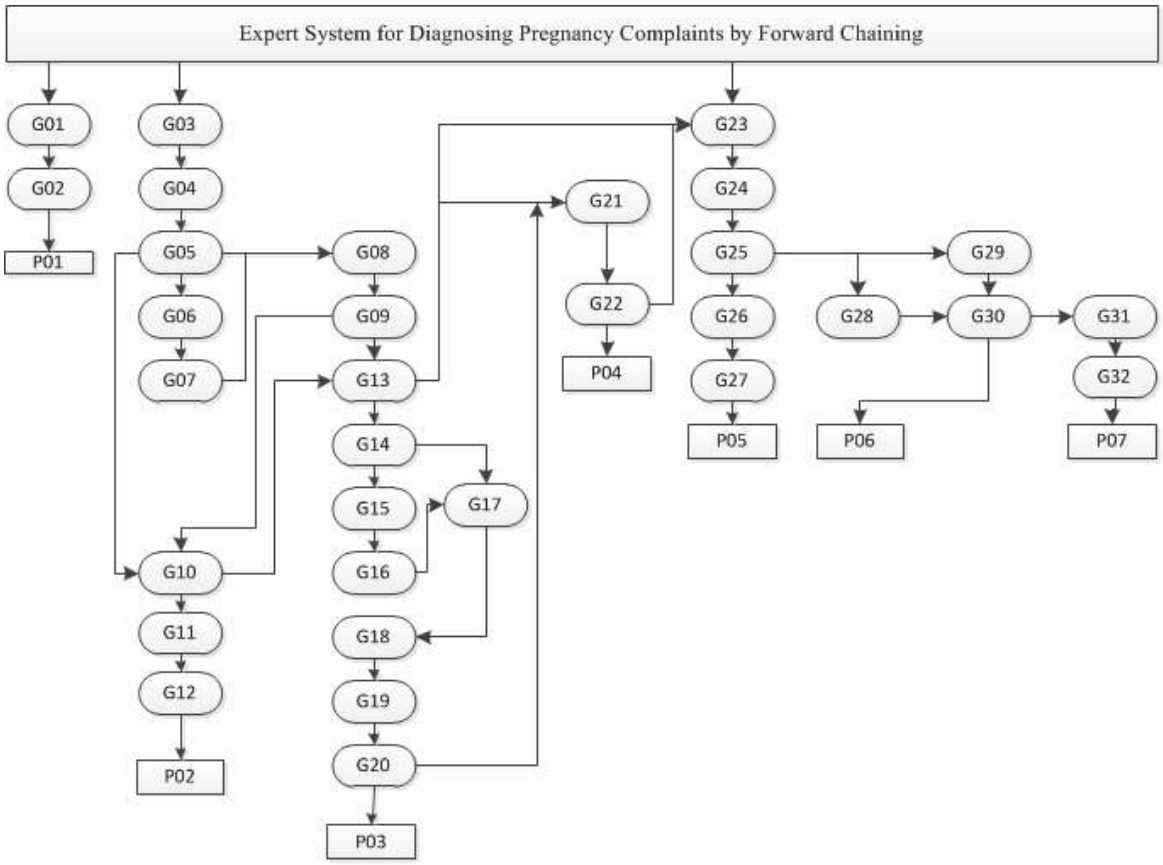

Fig. 3 Decision Tree

3. Patient Symptom Analysis

Twenty patients who have been recorded as samples, then recorded the symptoms and diagnostic results by midwives that can be seen in table 6 of the expert/midwife column. The symptoms complained of by patients were also analyzed with forward chaining and bayesian methods whose results can be seen in table VI of the system column.

Evaluation

The evaluation of the data can be seen at the conclusion.

RESULT

After consulted by testing the system on 20 patients with the age of third trimester pregnancy, the results are obtained in the table below.

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Table 5
Consultation

Patient	Age	Symptom	Weight	Rule
Erlita	26	G24	-	-
Sulis	20	G06, G23, G24, G25, G26, G31	1.0, 0.8, 0.8, 0.8	R5
Dewi	30	G01, G02	1.0, 0.8	R1
Susanti	35	G23, G25, G26, G27	1.0, 1.0, 1.0, 0.6	R5
Mia	37	G03, G04, G05, G06, G07, G08, G09, G13, G14, G15	0.4, 0.8, 1.0, 0.6, 0.8, 0.6, 0.8, 0.8	R2
Cihyanti	28	G23, G24, G25	0.4, 0.6, 0.4	R5
Tri	27	G04, G23	-	-
Wiwi	22	G23, G24, G28, G30	1.0, 0.8, 0.4, 0.6	R6
Iin	27	G04, G23, G24, G25, G26	0.6, 0.6, 0.6, 0.6	R5
Damayanti	37	G03, G04, G05, G07, G10, G11, G24, G26	1.0, 0.6, 0.4, 0.2, 0.4, 1.0	R2
Sifa	28	G04, G10, G13, G14, G15, G17, G20, G21, G22, G24	0.4, 0.6, 0.6, 0.6, 0.8, 0.4, 0.8, 0.4	R4
Andini	24	G01, G03, G24, G26, G27	0.4, 0.6, 0.2	R5
Siti	39	G24	-	-
Maharanisa	21	G02, G04, G07, G14, G23, G24, G25, G26	1.0, 1.0, 1.0, 1.0	R5
Ida	23	G01, G02, G03	1.0, 1.0	R1
Yunita	29	G24, G25, G28, G30	0.6, 1.0, 0.6, 0.2	R6
Rika Rohilia	26	G25, G26, G27, G30	0.6, 0.8, 0.4	R5
Ruqiyah	29	G03, G07, G13, G23, G24, G27, G28, G29	0.8, 0.8, 0.4, 0.6	R6
Osti	36	G04	-	-
Dyah	30	G23, G24, G26, G30	1.0, 0.6, 0.4	R5

The advantage of this system is that in terms of tracing this system does not use questions that sometimes make the user lazy to fill because it has to answer many questions asked by the program, so the user simply selects some of the symptoms that exist and the program will look for the nearest possibilities regarding the disease suffered (Widyaningsih & Astutiningsih, 2016). Then the results on the consultation table will be selected into 16 patients, because 4 patients have only 1 complaint and do not have the potential to have the disease. In this system, it will be detected if the percentage of complaints or symptoms reaches above 60%. Example of calculating the percentage of symptoms or complaints in Ida patients who have 2 symptoms that match rule 1:

$$\frac{\text{number of symptoms detected rule}}{\text{total symptoms rule}} * 100\%$$

$$= \frac{2}{2} * 100\% = 100\%$$

For weight filling, the following consultation user trust terminology is given a choice of answers with each weight (Avrizal, 2019) :
Very Confident: 1.0
Sure : 0.8
Pretty sure : 0.6
A little sure: 0.4
Don't know : 0.2
Not : 0

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Probability is analyzed by percentage with the following possible values (Avrizal, 2019) :

0% - 50% Possibility of not happening
51% - 75% Less likely to happen
76% - 84% Most likely to happen
86% - 100% Very confident it happened

Symptoms in the consultation results table with selected weights can be calculated with bayesian formula (Hatta et al., 2017) like an example in Dewi's patient.

Determination P(E|Hi-n) :

P(E|H1) = 1.0
P(E|H2) = 0.8

Overall weight value:

$$\sum_{k=1}^{10} = G01 + G02$$

$$\sum_{k=1}^{10} = 1.0 + 0.8 = 1.8$$

Count P(Hi) :

$$P(H1) = \frac{H1}{\sum_{k=1}^{10}} = \frac{1.0}{1.8} = 0.56$$

$$P(H2) = \frac{H2}{\sum_{k=1}^{10}} = \frac{0.8}{1.8} = 0.44$$

Next steps :

$$\sum_{k=1}^{n} = P(Hi) * P(E|Hi\text{-}n)$$
$$= (0.55*1.0) + (0.44*0.8)$$
$$= 0.56 + 0.352$$
$$= 0.912$$

Probability value Hi if given evidence E :

$$P(H1|E) = \frac{0.55*1.0}{0.912} = 0.61$$

$$P(H2|E) = \frac{0.44*0.8}{0.912} = 0.39$$

Total bayesian :

$$\sum_{k=1}^{10} = bayesian1 + bayesian2$$

$$= (1.0*0.61) + (0.8*0.39)$$
$$= 0.61 + 0.312$$
$$= 0.92 * 100\ \% = 92\ \%$$

The results of weight calculation in other patients can be seen in the following table:

Table 6
Comparison Result

Name	Expert/MidWife	System	Weight	State
Sulis	Mild preeclampsia	Mild preeclampsia	86%	Valid
Dewi	Hyperemesis third trimester	Hyperemesis third trimester	92%	Valid
Susanti	Mild preeclampsia	Mild preeclampsia	97%	Valid
Mia	Hyperemesis gravidarum In Level 1	Hyperemesis gravidarum In Level 1	90%	Valid
Cihyanti	Preeklampsia	Mild preeclampsia	51%	Invalid
Wiwi	Preeklampsia	Preeklampsia	83%	Valid

Iin	Preeklampsia	Mild preeclampsia	60%	Invalid
Damayanti	Hyperemesis gravidarum In Level 1	Hyperemesis gravidarum In Level 1	87%	Valid
Sifa	Hyperemesis gravidarum In Level 1	Hyperemesis gravidarum In Level 3	66%	Invalid
Andini	Preeklampsia	Mild preeclampsia	51%	Invalid
Maharanisa	Mild preeclampsia	Mild preeclampsia	100%	Valid
Ida	Hyperemesis third trimester	Hyperemesis third trimester	100%	Valid
Yunita	Preeklampsia	Preeklampsia	81%	Valid
Rika	Preeklampsia	Mild preeclampsia	68%	Invalid
Ruqiyah	Preeklampsia	Preeklampsia	77%	Valid
Dyah	Mild preeclampsia	Mild preeclampsia	85%	Valid

After selection, 11 out of 16 patients or about 70% had valid results among experts, namely doctor diagnoda with a calculation system using forward chaining combined with bayesian. The results of the diagnosis with a bayesian calculation (% weight) of less than 70% indicate that the results differ between the system and the expert.

DISCUSSIONS

Results showed that valid patients were about 70%, smaller than the study (Hatta et al., 2017) which was about 82.86%. This is due to the use of different bayesian methods, namely the choice of answers with each weight adopted from the terminology of the consulting user trust (Avrizal, 2019) and calculated with the bayesian formula (Hatta et al., 2017). While in the study (Hatta et al., 2017) gave direct weighting to the symptoms in the absence of a choice of answers displayed after selecting symptoms.

CONCLUSION

The conclusion that can be produced from this study is that the expert system with forward chaining method calculated by bayesian method can work quite well with valid results of about 70% or as many as 11 patients out of 16 patients who have been selected. This can be a means for midwives to see the history of complaints in patients, so as to provide appropriate initial solutions and treatment for the prevention of maternal and infant deaths in the lead up to the delivery process. For further research, it can be done the addition of symptoms and diseases, can also be done with other more up-to-date and accurate methods.

ACKNOWLEDGMENT

Thank you goes to Universitas Bina Sarana Informatika and Ristek Dikti who have given the opportunity to participate in the research of budding lecturers.

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