Contents lists available at IOCS

Science Midwifery

journal homepage: www.midwifery.iocspublisher.org

Expert system for diagnosing female reproductive disorders using forward chaining

Nur Rizky Aulia[1], Laode Mohammad Rasdi Rere[2], Aqwam Rosadi Kardian[3]
[1,2,3]Master of Information Technology, Sekolah Tinggi Manajemen Informatika dan Komputer Jakarta, Indonesia

ARTICLE INFO

Article history:

Received Aug 6, 2025
Revised Aug 21, 2025
Accepted Aug 30, 2025

Keywords:

Expert System
Female Reproductive System
Diseases
Forward Chaining
Fuzzy Mamdani

ABSTRACT

Early diagnosis increases the chances of successful treatment and prevents the disease from worsening. However, not all women feel comfortable consulting a doctor about their condition. This study aims to develop a web-based expert system capable of diagnosing diseases of the female reproductive system with a user-friendly interface and high accuracy. This application enables women to evaluate the likelihood of potential diseases based on their symptoms and consult a doctor for appropriate treatment. This expert system combines the forward chaining and fuzzy Mamdani methods. Forward chaining identifies possible diseases based on selected symptoms, while fuzzy Mamdani confirms the diagnosis. The disease and symptom data used in this study were gathered through interviews with two obstetricians and gynecologists. The final results of this study show a comparative accuracy level of diagnostic results between the system and experts of 88%.

Corresponding Author:

Nur Rizky Aulia,
Master of Information Technology,
Sekolah Tinggi Manajemen Informatika dan Komputer Jakarta,
Jl. Swadarma Raya No. 30, Ulujami, Pesanggrahan, Jakarta Selatan, DKI Jakarta, 12250, Indonesia
Email: nurrizkyaulia@gmail.com

INTRODUCTION

Women's reproductive health is a critical aspect of healthcare that requires significant attention. The female reproductive system is highly susceptible to abnormalities, disorders, and various types of diseases (

Gama, A. W. O., & Wardhiana, I. N. G. A. M. (2023). In Indonesia, approximately 25-50% of deaths among women of childbearing age are attributed to reproductive system diseases (Putra, S. D., Ulum, M. B., & Aryani, D. (2021). Reproductive system diseases that can attack women include vaginal infections, menstrual disorders, cancer in the genital area and endometriosis. Cervical cancer is one of the leading causes of cancer death among women worldwide. In 2018, it was estimated that there were around 570.000 cases and 311.000 deaths from cervical cancer worldwide. In 2020, there was an increase to around 604.127 cases and 341.831 deaths from cervical cancer worldwide (Zhang, S., Xu, H., Zhang, L., & Qiao, Y. (2020)(Guo, M., Xu, J., & Du, J. (2021). Women experiencing reproductive system issues require prompt, accurate, and efficient treatment to prevent the progression of severe conditions. However, many women delay or avoid seeking

medical consultation due to social and psychological barriers, such as embarrassment when discussing intimate health issues, fear of costly medical expenses, cultural stigma surrounding reproductive health, and a lack of awareness regarding early symptoms (
Gama, A. W. O., & Wardhiana, I. N. G. A. M. (2023)(Putra, S. D., Ulum, M. B., & Aryani, D. (2021)(Ramadhani, S., Furqan, M., & Sriani. (2022). These factors highlight the need for alternative, accessible tools that can provide preliminary diagnoses to encourage timely medical intervention.

Handling of disorders of the female reproductive system is not only done with an initial diagnosis, but also requires a thorough examination by a doctor to get the right and appropriate treatment. However, providing a good initial diagnosis will help to decide on the right and targeted treatment. The rapid development of the world of technology can help health workers and patients to make an initial diagnosis quickly, precisely, and accurately (

Gama, A. W. O., & Wardhiana, I. N. G. A. M. (2023). Artificial intelligence is a part of computer science that aims to create a computer-based system that can behave intelligently like humans, this intelligence can imitate human activities such as reasoning, learning and problem solving (Nowak, M., & Szewczyk, J. (2021)(Liu, R., Rong, Y., & Peng, Z. (2020). Artificial intelligence can be used in the decision-making process and improve diagnostic accuracy (Kaul, V., Enslin, S., & Gross, S. A. (2020)(Sulistiani, H., Muludi, K., & Syarif, A. (2021). One area of artificial intelligence that can be used for decision making or diagnosis is an expert system. An expert system is a computer-based system that uses human knowledge (experts), then this knowledge is entered into a computer so that the computer can solve problems that are generally solved by experts in a particular field (Ramadhani, S., Furqan, M., & Sriani. (2022)(Anwar, M. R. (2023). Expert systems can make intelligent decisions and help solve problems and explain the resolution process (Sha, Y., Feng, T., Xiong, X., & Yang, T. (2021)(El-Habibi, M. F., Megdad, M. M. M., Al-Qadi, M. H., AlQatrawi, M. J. A., Sababa, R. Z., & Abu-Naser, S. S. (2022). In the health sector, expert systems can be used because they have strong capabilities in making decisions on diagnosing diseases quickly and accurately (Nowak, M., & Szewczyk, J. (2021)(Liu, R., Rong, Y., & Peng, Z. (2020).

Expert system research for diagnosing diseases in the female reproductive system has been conducted by several researchers, such as that conducted by (El-Habibi, M. F., Megdad, M. M. M., Al-Qadi, M. H., AlQatrawi, M. J. A., Sababa, R. Z., & Abu-Naser, S. S. (2022) by creating expert system for obstetrics & gynecology diseases diagnosis using CLIPS which can diagnose 10 obstetrics & gynecology diseases. Research conducted by (

Gama, A. W. O., & Wardhiana, I. N. G. A. M. (2023) by creating expert system for menstrual disorders diagnosis using naive bayes which can diagnose 10 menstrual disorders diseases with a diagnostic accuracy value of 84%. Research conducted by (Putra, S. D., Ulum, M. B., & Aryani, D. (2021) by creating expert system for diagnosis of uterine myomas using certainty factor with a diagnostic accuracy value of 98.70%. Research conducted by (Rohmawati, E. S., & Sipayung, Y. R. (2022) by creating expert system of early diagnosis of polycystic ovarian syndrome using case based reasoning with a diagnostic accuracy value of 80%. Research conducted by (Ramadhani, S., Furqan, M., & Sriani. (2022) by creating expert system for diagnosis of disorders of women's menstrual cycle using backward chaining which can diagnose 5 disorders of women's menstrual cycle. Research conducted by (Wati, E. F., & Puspitasari, A. (2020) by creating expert system for diagnosing pregnancy complaints using forward chaining and bayesian network with a diagnostic accuracy value of 70%. Based on the review conducted in previous studies, the expert system that has been created only focuses on detecting certain disorders or one disease in the female reproductive system. This study contributes to the literature by combining forward chaining with fuzzy Mamdani inference to develop a more comprehensive diagnostic system for various reproductive health diseases. Forward Chaining is a search method or forward tracking technique that in the process utilizes the information provided and matches it with existing rules to produce a conclusion or goal (Anwar, M. R. (2023)(Wati, E. F., & Puspitasari, A. (2020). Fuzzy Mamdani is a linguistic framework that works to handle uncertainty and inaccuracy in decision making. Fuzzy

Mamdani inference is used to capture expert knowledge, thus allowing expert expertise to be described more intuitively and more expert-like in making decisions (Masmali, I., Ahmad, A., Azeem, M., Koam, A. N. A., & Alharbi, R. (2024)(Zubair, A., Sonalitha, E., Ratih, S., Nurdewanto, B., Yudhistiro, & K., Mujahidin, I. (2020)(Ningrum, R. F., Siregar, R. R. A., & Rusjdi, D. (2021). Unlike previous systems that focus on a single diagnostic method, forward chaining allows systematic tracing of potential diseases based on patient-reported symptoms, while fuzzy Mamdani enhances decision-making under uncertainty by incorporating expert-like reasoning. Thus, this research extends the application of forward chaining in medical diagnosis by integrating it with fuzzy logic to improve adaptability and diagnostic reliability. The purpose of this study is to create a web application for an expert system for diagnosing diseases in the female reproductive system using the forward chaining and fuzzy mamdani methods to make it easier to determine whether a woman is suffering from a disease based on the symptoms or complaints she is experiencing.

RESEARCH METHOD

The implementation of the forward chaining and fuzzy Mamdani methods in an expert system for diagnosing diseases of the female reproductive system can be divided into four main stages:

Data Collection

This study employed interviews as its data collection method. This technique involves a direct question-and-answer process between the data collectors and informants (Mazhar, S. A., Anjum, R., Anwar, A. I., & Khan, A. A. (2021). In this study, data were collected through interviews with two obstetrics and gynecology specialists. Data collected from interviews with two doctors included information on diseases, symptoms, and their prioritization from primary to secondary which can be seen in Table 1.

Table 1. Disease and symptom data

No	Disease Name	Symptom Name	Order
1	Twisted Ovarian Cyst	Sudden pain in the pelvic area	1
		Lower abdominal pain on the left or right side (pelvis)	2
		Irregular menstruation	3
		Palpable lump in the lower abdomen	4
		Having a family history of cysts	5
		Feeling full after eating a small amount of food or bloated	Subjective
		Constipation	Subjective
		Frequent urination	Subjective
2	Endometriosis	Menstruation feels very painful	1
		Irregular menstruation	2
		Dyspareunia	3
		Infertility	4
		Heavy menstrual bleeding	5
		Constipation	6
…	…	…	…
17	Tubo Ovarian Abscess	Lower abdominal pain with moderate or severe intensity	1
		Fever	2
		Excess vaginal discharge and smells	3
		Palpable lump in the lower abdomen	Subjective

Data Analysis

The data analysis stage in this study was carried out to study and process data obtained through interviews. The results of the data analysis will be the basis of knowledge about female reproductive system diseases that will be used in the expert system application that will be created. At this stage, diseases and symptoms will be given codes as identities, and the determination of weights is based on the order from the most identical symptoms to accompanying symptoms. Based on the analysis of the interview results, 17 disease name data were obtained and each disease was given a code as seen in Table 2, and 61 symptom name data and each symptom was given a code as seen in Table 3. Table 4 is the relationship between the order of symptoms and the weights that will be used in fuzzy calculations. Table 5 is a decision table that will be used as a reference in making decision trees and the rules used.

Table 2. Disease data

No	Disease Code	Disease Name
1	P0001	Twisted Ovarian Cyst
2	P0002	Endometriosis
…	…	…
17	P0017	Tubo Ovarian Abscess

Table 3. Symptom data

No	Symptom Code	Symptom Name
1	G0001	Sudden pain in the pelvic area
2	G0002	Lower abdominal pain on the left or right side (pelvis)
3	G0003	Irregular menstruation
4	G0004	Palpable lump in the lower abdomen
5	G0005	Having a family history of cysts
6	G0006	Feeling full after eating a small amount of food or bloated
7	G0007	Constipation
8	G0008	Frequent urination
9	G0009	Menstruation feels very painful
10	G0010	Dyspareunia
11	G0011	Infertility
12	G0012	Heavy menstrual bleeding
13	G0013	Fever
…	…	…
60	G0060	Lower abdominal pain with moderate or severe intensity
61	G0061	Excess vaginal discharge and smells

Table 4. Weight data

No	Order	Weight
1	1	0.9
2	2	0.9
3	3	0.8
4	4	0.8
5	5	0.7
6	6	0.7
7	7	0.6
8	8	0.6
9	9	0.5
10	Subjective	0.5

Table 5. Female reproductive disease decision table

Symptom Code	Disease Code							
	P0001	P0002	P0003	P0004	P0005	…	P0016	P0017
G0001	0.9							
G0002	0.9							
G0003	0.8	0.9						
G0004	0.8							0.5
G0005	0.7							
G0006	0.5							
G0007	0.5	0.7						
G0008	0.5							
G0009		0.9						
G0010		0.8	0.8					
G0011		0.8	0.7	0.6			0.5	
G0012		0.7		0.9				
G0013			0.9					0.9
…								

G0060	0.9
G0061	0.8

Application Development

The expert system application in this study was developed using the System Development Life Cycle (SDLC) method with the Waterfall model. The SDLC consists of several stages: planning, analysis, design, development, testing, and maintenance. Waterfall is a linear system flow model, the output of each stage will be input for the next stage. This model will complete one stage completely before moving on to the next stage (Kristanto, E. B., Andrayana, S., & Benramhman. (2020) . The use of the SDLC method with the Waterfall model in this expert system helps the application development process to be well structured and organized. The System Development Life Cycle (SDLC) with the Waterfall model can be seen in Figure 1.

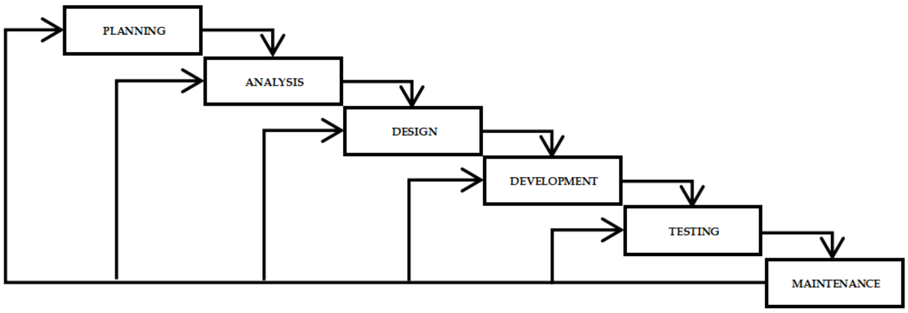

Figure 1. System development life cycle (SDLC) waterfall

Planning is the stage to identify and determine the scope in the system creation process, the main activities at this stage are literature studies and determining the research plan to be carried out. The achievement of this stage is a plan to create an expert system web application, which can diagnose diseases in the female reproductive system using the forward chaining and fuzzy Mamdani methods. Analysis is a stage to conduct a functional system requirements analysis, which includes hardware, software and research data. The hardware used is a Laptop with Windows 11 Operating System and Intel Core i3 Processor. The software used is Visual Studio Code, Navicat, XAMPP Control Panel, Google Chrome, and programming languages using PHP, HTML, JavaScript, CSS and SQL. Research data was obtained through interviews with two obstetrics and gynecology specialists. Design is a plan or specification of the system to be created. In this section, interface design, database design and UML (Unified Modeling Language) design are made, which is a method in visual modeling used as a means of designing object-oriented systems. Development is the stage of software creation, at this stage the database, interface and logic of the expert system program are created based on the analysis and design that have been done in the previous stage. This expert system web application is designed dynamically so that it allows the addition of diseases that can be diagnosed by the system. The application features a data management page for diseases, symptoms, relation, symptom weights, and diagnoses for users. The user interface of the Diagnosis page can be seen in Figure 2 and an overview of the expert system diagnosis process can be seen in Figure 3.

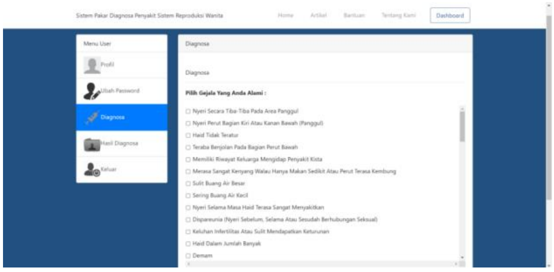

Figure 2. User interface diagnosis

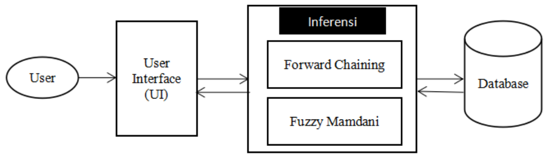

Figure 3. Expert system process

Decision making for diagnosis in the expert system web application for diagnosing female reproductive system diseases will be explained through a case study of a woman who experiences symptoms such as sudden pain in the pelvic area, lower abdominal pain on the left or right side (pelvis), irregular menstruation, palpable lump in the lower abdomen, having a family history of cysts, feeling full after eating a small amount of food or bloated, constipation and frequent urination. Decision making is carried out in two stages, namely looking for possible diseases based on symptoms using the forward chaining method and determining the most dominant disease using the Mamdani fuzzy method. Forward Chaining is used to search for possible diseases based on symptoms. Sudden pain in the pelvic area (G0001) is a symptom of twisted ovarian cyst (P0001). Lower abdominal pain on the left or right side (pelvis) (G0002) is a symptom of twisted ovarian cyst (P0001). Irregular menstruation (G0003) is a symptom of twisted ovarian cyst (P0001) and endometriosis (P0002). Palpable lump in the lower abdomen (G0004) is a symptom of twisted ovarian cyst (P0001) and tubo ovarian abscess (P0017). Having a family history of cysts (G0005) is a symptom of twisted ovarian cyst (P0001). Feeling full after eating a small amount of food or bloated (G0006) are symptoms of twisted ovarian cyst (P0001). Constipation (G0007) is a symptom of twisted ovarian cyst (P0001), endometriosis (P0002) and ovarian cancer (P0015). Frequent urination (G0008) is a symptom of twisted ovarian cyst (P0001). Based on the tracking, it was found that the possible diseases suffered were twisted ovarian cyst (P0001), endometriosis (P0002), ovarian cancer (P0015) and tubo ovarian abscess (P0017). Details of the selected disease codes and symptom codes can be seen in Table 6.

Table 6. Selected disease code and symptom code

No	Disease Code	Symptom Code
1	P0001	G0001, G0002, G0003, G0004, G0005, G0006, G0007, G0008
2	P0002	G0003, G0007
3	P0015	G0007
4	P0017	G0004

Fuzzy Mamdani is used to determine the value of each possible symptom and take the highest value. The structure of the fuzzy inference system consists of 4 components, namely fuzzy knowledge base, fuzzification, inference machine, defuzzification.
Here is the equation for the Fuzzification:

$$\mu uncertain[Tx] = \begin{cases} 0 & x > 0 \\ \dfrac{0,5 - Tx}{0,5}; & 0 < x < 0,5 \\ 1 & x < 0,5 \end{cases} \tag{1}$$

$$\mu certain[Tx] = \begin{cases} 0 & x \geq 0,5 \\ \dfrac{Tx - 0,5}{0,5}; & 0,5 \leq x \leq 1 \\ 1 & x \leq 1 \end{cases} \tag{2}$$

Where x = weight of symptom, Tx = total weight of symptom, μTx = fuzzy value of Tx.

Here is the equation for the Inference Machine:

$$Tx = (x1) + (x2) + (x3) + ...(xn) \quad (3)$$

Where x = weight of symptom, Tx = total weight of symptom. If Tx < 0,5 then use the µuncertain[Tx] equation, whereas if Tx >= 0,5 then use the µcertain[Tx] equation.

Here is the equation for the Defuzzification:

$$Z = \frac{\mu Tx}{Tx} \quad (4)$$

Where Z = average value, Tx = total weight of symptom, µTx = fuzzy value of Tx.

Finding the value of P0001:

$$Tx = G0001 + G0002 + G0003 + G0004 + G0005 + G0006 + G0007 + G0008$$

$$Tx = 0,9 + 0,9 + 0,8 + 0,8 + 0,7 + 0,5 + 0,5 + 0,5 = 5,6$$

$$\mu certain[5,6] = \begin{cases} 0 & x \geq 0,5 \\ \frac{5,6 - 0,5}{0,5}; & 0,5 \leq x \leq 1 = 10,2 \\ 1 & x \leq 1 \end{cases} \qquad Z_{P0001} = \frac{10,2}{5,6} = 1,82$$

Finding the value of P0002:

$$Tx = G0003 + G0007 = 0,9 + 0,7 = 1,6$$

$$\mu certain[1,6] = \begin{cases} 0 & x \geq 0,5 \\ \frac{1,6 - 0,5}{0,5}; & 0,5 \leq x \leq 1 = 2,2 \\ 1 & x \leq 1 \end{cases} \qquad Z_{P0002} = \frac{2,2}{1,6} = 1,37$$

Finding the value of P0015:

$$Tx = G0007 = 0,5$$

$$\mu certain[0,5] = \begin{cases} 0 & x \geq 0,5 \\ \frac{0,5 - 0,5}{0,5}; & 0,5 \leq x \leq 1 = 0 \\ 1 & x \leq 1 \end{cases} \qquad Z_{P0015} = \frac{0}{0,5} = 0$$

Finding the value of P0017:

$$Tx = G0004 = 0,5$$

$$\mu certain[0,5] = \begin{cases} 0 & x \geq 0,5 \\ \frac{0,5 - 0,5}{0,5}; & 0,5 \leq x \leq 1 = 0 \\ 1 & x \leq 1 \end{cases} \qquad Z_{P0017} = \frac{0}{0,5} = 0$$

Finding Max Value:
Max [ZP0001, ZP0002, ZP0015, ZP0017]
Max [1,82, 1,37, 0, 0] = 1,82

Based on the calculations that have been done, it can be concluded that the most dominant disease based on the selected symptoms is the Twisted Ovarian Cyst. Testing is the testing stage on the system to assess whether the expert system that has been created can work according to the expected functionality. If during testing a problem is found, it will be fixed immediately, this process continues until the expert system is completely free from bugs, works stably, and functions as expected. Maintenance is the maintenance stage on the expert system that has been created. At this stage the system operation process begins and makes minor repairs if necessary.

Application Testing

Testing of the expert system for diagnosing female reproductive system diseases was conducted to evaluate its alignment with the intended objectives. The testing consisted of three types: functional testing using black box testing, usability testing, and diagnostic accuracy testing by comparing the system's results with those of experts. Black box testing is carried out by observing execution results using test data to verify software functionality without examining the structure or content of the program code. This method plays an important role in software testing, as it helps validate the overall functionality of the system (Zubair, A., Sonalitha, E., Ratih, S., Nurdewanto, B., Yudhistiro, & K., Mujahidin, I. (2020)(Rambe, B. H., Pane, R., Irmayani, D., Nasution, M., & Munthe, I. R. (2020)(Sholeh, M., Gisfas, I., Cahiman., & Fauzi, M. A. (2021). Usability Testing is a technique for evaluating a product or system by testing it on users who provide direct input on how users use the system. This aims to ensure the system meets user goals and requirements (Kamińska, D., Zwoliński, G., & Laska-Leśniewicz, A. (2022).

RESULTS AND DISCUSSIONS

Black Box Testing

Black box testing is carried out to test the functionality of the system that has been created. The testing was carried out with 18 cases and all cases had a passed status, meaning that the expected results and test results had a conformity percentage of 100%.

Usability Testing

Usability Testing aims to evaluate the UX (user experience) of the expert system. The test was conducted by distributing questionnaires to 100 users, the questionnaire contains 10 statements of usability criteria and 5 likert scale answer choices. The usability criteria statements are presented in Table 7 which contains 10 statements to be answered by the user and the likert scale is presented in Table 8 which contains 5 answer choices to be answered by the user. The distributed questionnaire will be used to calculate the interval value. The interval value categories were defined as follows: a score of 1,00-1,79 indicates Bad, 1,80–2,59 indicates Not Good, 2,60–3,39 indicates Fair Enough, 3,40–4,19 indicates Good, and 4,20–5,00 indicates Very Good.

Table 7. Usability criteria statement

No	Code	Usability Criteria Statement
1	P01	This website is easy to operate (user friendly)
2	P02	This website helps to obtain information and diagnose diseases of the female reproductive system.
3	P03	This website has easy navigation
4	P04	This website makes users satisfied when using it
5	P05	This website uses appropriate background colors and designs
6	P06	This website displays text colors with appropriate backgrounds
7	P07	This website uses the right font size
8	P08	This website has the right button sizes
9	P09	This website has the right component placement
10	P10	You would recommend this website to your friends or others

Table 8. Likert scale

No	Code	Likert Scale	Rating
1	SD	Strongly Disagree	1
2	D	Disagree	2
3	N	Neither agree nor disagree	3
4	A	Agree	4
5	SA	Strongly Agree	5

The questionnaire that has been filled by the user is then processed to get the total score. The total score is presented in Table 9. Here is the equation for the Score:

$$s = (Tsd \times Rsd) + (Td \times Rd) + (Tn \times Rn) + (Ta \times Ra) + (Tsa \times Rsa) \quad (5)$$

Where s = score, Tsd = total of strongly disagree, Rsd = rating of strongly disagree, Td = total of disagree, Rd = rating of disagree, Tn = total of neither agree nor disagree, Rn = rating of neither agree nor disagree, Ta = total of agree, Ra = rating of agree, Tsa = total of strongly agree, Rsa = rating of strongly agree.

Table 9. Score usability testing

No	Usability Criteria Statement	Likert Scale					Score
		SD	D	N	A	SA	
1	P01	0	1	22	53	24	400
2	P02	0	0	10	67	23	413
3	P03	0	1	25	57	17	390
4	P04	0	0	22	55	23	401
5	P05	0	0	33	51	16	383
6	P06	1	1	26	60	12	381
7	P07	0	0	37	50	13	376
8	P08	0	2	34	49	15	377
9	P09	0	1	27	55	17	388
10	P10	0	0	16	61	23	407
Total Score							3916

After getting the total score, the next step is to calculate the interval value. Here is the equation for the Interval Value:

$$\text{Interval Value} = \frac{s}{nr \times np} = \frac{3916}{100 \times 10} = 3{,}916 \quad (6)$$

Where s = total score, nr = number of respondents, number of statements.

The usability testing results indicate that the expert system for diagnosing female reproductive system diseases falls within the 'Good' category, with an interval value of 3,916.

Comparison of Expert Diagnosis and System Diagnosis

Testing is done by finding the level of accuracy of the diagnosis results. This test is done using 50 examples of case data, then comparing the results of the system diagnosis and the results of the expert diagnosis. The system used in this test is divided into 2, namely a system that uses 2 methods (forward chaining and fuzzy Mamdani) and a system that only uses 1 method (forward chaining) with the aim of comparing the results of the level of accuracy of the 2 systems. Determination of the score of each case data is carried out with the following rules: if the results of the system diagnosis and 2 experts match then get a score of 1, if the results of the system diagnosis only match one of the expert diagnoses then get a score of 0,5, if the results of the system diagnosis do not match the results of the diagnosis of 2 experts then get a score of 0. The results of the comparison of the diagnosis between the system and the expert are presented in Table 10. Based on testing 50 examples of case data, the total score of the system using 2 methods was 44, while the system using 1 method was 41. Furthermore, the percentage accuracy value of the comparison of the system and expert diagnosis was calculated using the following equation:

$$\text{Accuracy Value} = \frac{ns}{nc} \times 100\% \quad (7)$$

$$\text{Accuracy Value(2 Methods)} = \frac{44}{50} \times 100\% = 88\% \qquad \text{Accuracy Value(1 Method)} = \frac{41}{50} \times 100\% = 82\%$$

Based on the calculation results, the expert system that used two methods (forward chaining and fuzzy Mamdani) achieved a higher decision-making accuracy of 88%, compared to 82% for the system that used only forward chaining. The accuracy level value with 2 methods is higher than with 1 method because after obtaining the possibility of disease with the forward chaining method, the next step is to look for the highest value of the possibility of the disease suffered with the fuzzy Mamdani method, so that the results of the system diagnosis are closer to the results of the expert diagnosis.

Table 10. Comparison of expert diagnosis and system diagnosis

No	Symptom Code	Expert 1	Expert 2	System (Forward Chaining & Fuzzy Mamdani)	Score (Forward Chaining & Fuzzy Mamdani)	System (Forward Chaining)	Score (Forward Chaining)
1	G0001, G0002, G0003,	P0001	P0001	P0001	1	P0001	1

No	Symptom Code	Expert 1	Expert 2	System (Forward Chaining & Fuzzy Mamdani)	Score (Forward Chaining & Fuzzy Mamdani)	System (Forward Chaining)	Score (Forward Chaining)
	G0004, G0005, G0006, G0007, G0008						
2	G0009, G0003, G0010, G0011, G0012, G0007	P0002	P0002	P0002	1	P0002	1
3	G0013, G0014, G0010, G0015, G0011, G0016, G0017, G0018, G0019	P0003	P0010	P0003	0.5	P0003	0.5
4	G0012, G0020, G0021, G0022, G0023, G0024, G0011, G0025, G0026	P0004	P0004	P0004	1	P0004	1
5	G0027, G0014, G0016, G0028, G0029, G0022, G0025, G0026, G0030	P0005	P0005	P0005	1	P0005	1
6	G0031, G0032, G0033, G0023	P0006	P0006	P0006	1	P0006	1
7	G0031, G0027, G0014, G0010	P0005	P0007	P0007	0.5	P0007	0.5
8	G0034, G0035, G0036, G0037	P0008	P0008	P0008	1	P0008	1
9	G0038, G0010, G0013	P0009	P0009	P0009	1	P0009	1
10	G0039, G0010, G0040, G0014, G0041, G0042	P0010	P0010	P0010	1	P0010	1
11	G0043, G0044, G0045, G0046	P0011	P0011	P0011	1	P0011	1
12	G0043, G0022, G0044	P0012	P0012	P0012	1	P0012	1
13	G0043, G0047, G0044	P0013	P0013	P0013	1	P0013	1
14	G0048, G0049, G0050, G0051	P0014	P0014	P0014	1	P0014	1
15	G0052, G0029, G0022, G0053, G0025, G0026, G0030, G0007, G0054	P0015	P0015	P0015	1	P0015	1
16	G0055, G0056, G0057, G0058, G0059, G0011	P0016	P0016	P0016	1	P0016	1
17	G0060, G0013, G0061, G0004	P0017	P0017	P0017	1	P0017	1
18	G0001, G0002, G0003, G0011	P0002	P0001	P0001	0.5	P0001	0.5
19	G0009, G0003, G0014	P0016	P0003	P0002	0	P0002	0
20	G0014, G0010, G0015, G0025	P0003	P0003	P0003	1	P0007	0
21	G0020, G0021, G0022, G0027	P0004	P0004	P0004	1	P0004	1
22	G0027, G0014, G0016, G0028, G0031	P0005	P0005	P0005	1	P0007	0
23	G0031, G0033, G0023	P0006	P0006	P0006	1	P0006	1
24	G0031, G0027, G0014, G0013	P0017	P0017	P0007	0	P0007	0
25	G0034, G0035, G0014	P0008	P0008	P0008	1	P0008	1
26	G0038, G0010, G0025, G0018	P0009	P0009	P0009	1	P0009	1
27	G0039, G0014, G0041, G0042	P0010	P0010	P0010	1	P0010	1
28	G0043, G0044, G0045	P0011	P0011	P0011	1	P0011	1
29	G0043, G0022, G0044, G0025, G0029	P0012	P0012	P0012	1	P0012	1
30	G0043, G0047, G0044, G0025, G0029	P0013	P0013	P0013	1	P0013	1
31	G0048, G0049, G0029	P0014	P0014	P0014	1	P0014	1
32	G0052, G0029, G0022,	P0015	P0015	P0015	1	P0015	1

No	Symptom Code	Expert 1	Expert 2	System (Forward Chaining & Fuzzy Mamdani)	Score (Forward Chaining & Fuzzy Mamdani)	System (Forward Chaining)	Score (Forward Chaining)
33	G0053, G0003 G0055, G0056, G0058, G0003, G0029	P0016	P0016	P0016	1	P0016	1
34	G0060, G0061, G0004	P0017	P0017	P0017	1	P0017	1
35	G0009, G0003, G0011, G0012, G0033, G0025	P0002	P0004	P0002	0.5	P0002	0.5
36	G0012, G0020, G0021, G0003, G0025	P0004	P0004	P0004	1	P0004	1
37	G0031, G0032, G0023, G0010	P0005	P0006	P0006	0.5	P0006	0.5
38	G0034, G0055, G0036, G0037, G0042	P0008	P0008	P0008	1	P0008	1
39	G0039, G0010, G0014, G0041, G0042, G0009, G0003	P0010	P0010	P0010	1	P0010	1
40	G0043, G0022, G0044, G0060	P0012	P0012	P0012	1	P0012	1
41	G0049, G0050, G0051, G0010	P0014	P0014	P0014	1	P0014	1
42	G0055, G0056, G0057, G0058	P0016	P0016	P0016	1	P0016	1
43	G0001, G0002, G0003, G0004, G0009, G0007	P0001	P0001	P0001	1	P0001	1
44	G0013, G0014, G0010, G0015, G0016, G0009, G0003	P0003	P0003	P0003	1	P0009	0
45	G0027, G0014, G0016, G0029, G0022, G0025, G0028	P0005	P0005	P0005	1	P0005	1
46	G0031, G0027, G0014, G0010, G0048	P0003	P0007	P0007	0.5	P0007	0.5
47	G0038, G0010, G0013, G0041	P0009	P0009	P0009	1	P0009	1
48	G0043, G0044, G0019, G0046, G0029	P0011	P0011	P0011	1	P0011	1
49	G0052, G0029, G0053, G0025, G0054	P0001	P0015	P0015	0.5	P0015	0.5
50	G0060, G0013, G0061, G0004, G0022, G0014	P0003	P0017	P0017	0.5	P0017	0.5
	Total Score				44		41

CONCLUSION

This study demonstrates the effectiveness of the expert system web application in providing early diagnoses of female reproductive system diseases. Black box testing showed a 100% success rate, indicating that the application functions as intended and produces accurate outputs based on user inputs. Usability testing yielded an interval value of 3.916, categorized as Good. In terms of diagnostic accuracy, the system using two methods (forward chaining and fuzzy Mamdani) achieved 88%, compared to 82% for the system using only forward chaining. Thus, the combination of forward chaining and fuzzy Mamdani resulted in higher diagnostic accuracy. For future research, it is recommended to focus on further enhancing the diagnostic accuracy by integrating additional AI techniques, such as machine learning or deep learning, to capture more complex patterns in the data. Additionally, it is advisable to collaborate with a larger group of obstetricians and gynecologists to expand the knowledge base and ensure the system's broader application for various reproductive health conditions. While expert systems, like the one developed in this study, can be helpful in diagnosing reproductive health issues, there are ethical concerns, especially regarding the risk of misdiagnosis. It's important for patients to know that the expert system is just a tool to support doctors, not replace them. The doctor-patient relationship should remain key, with doctors being the ones to interpret results and make final decisions.

ACKNOWLEDGEMENTS

This research was conducted using research funds for a master's thesis from the Ministry of Education, Culture, Research, and Technology with a Decree Number 033/E5/PG.02.00/2022 and an Agreement/Contract Number DIPA-023.17.1.690523/2022; 403/LL3/AK.04/2022; 001/PHB-DIKTI/BP-LP2M/STI&K/VI/2022.

References

Gama, A. W. O., & Wardhiana, I. N. G. A. M. (2023). Naïve bayes on diagnostic expert system for menstrual disorders. *Journal of Intelligent Decision Support System (IDSS)*, 6(2), 66–78.
Putra, S. D., Ulum, M. B., & Aryani, D. (2021). Expert system for diagnosis of uterine myomas using the certainty factor method. *International Journal of Engineering, Science & Information Technology (IJESTY)*, 1(4), 103–108. https://doi.org/10.52088/ijesty.v1i4.177
Zhang, S., Xu, H., Zhang, L., & Qiao, Y. (2020). Cervical cancer: Epidemiology, risk factors and screening. *Chinese Journal of Cancer Research*, 32(6), 720-728.
Guo, M., Xu, J., & Du, J. (2021). Trends in cervical cancer mortality in China from 1989 to 2018: an age-period-cohort study and Joinpoint analysis. *BMC Public Health*, 1-14.
Ramadhani, S., Furqan, M., & Sriani. (2022). Backward chaining method for diagnosis disorders of women's menstrual cycle. *Jurnal Mantik*, 6(3), 3137–3143.
Nowak, M., & Szewczyk, J. (2021). Expert Systems in Medicine. *The Book of Articles National Scientific Conference Science and Young Researchers*, 84-93.
Liu, R., Rong, Y., & Peng, Z. (2020). A review of medical artificial intelligence. *Global Health Journal*, 4(2), 42–47.
Kaul, V., Enslin, S., & Gross, S. A. (2020). History of artificial intelligence in medicine. *Gastrointestinal Endoscopy*, 92(4), 807–812.
Sulistiani, H., Muludi, K., & Syarif, A. (2021). Implementation of various artificial intelligence approach for prediction and recommendation of personality disorder patient. *Journal of Physics: Conference Series*, 1751(1), 012040.
Anwar, M. R. (2023). Analysis of expert system implementation in computer damage diagnosis with forward chaining method. *International Transactions on Artificial Intelligence*, 1(2), 139–155.
Sha, Y., Feng, T., Xiong, X., & Yang, T. (2021). Designing online psychological consultation expert system using human-computer interaction. *Mobile Information Systems*, 2021, Article 6458924.
El-Habibi, M. F., Megdad, M. M. M., Al-Qadi, M. H., AlQatrawi, M. J. A., Sababa, R. Z., & Abu-Naser, S. S. (2022). A proposed expert system for obstetrics & gynecology diseases diagnosis. *International Journal of Academic Multidisciplinary Research*, 6(5), 305–321.
Wati, E. F., & Puspitasari, A. (2020). Expert system for diagnosing pregnancy complaints by forward chaining. *SinkrOn: Jurnal dan Penelitian Teknik Informatika*, 5(1), 7–16.
Rohmawati, E. S., & Sipayung, Y. R. (2022). Application of the case-based reasoning method in the expert system of early diagnosis of polycystic ovarian syndrome. *Asian Journal of Social Science and Management Technology*, 4(4), 176–183.
Masmali, I., Ahmad, A., Azeem, M., Koam, A. N. A., & Alharbi, R. (2024). TOPSIS Method Based on Intuitionistic Fuzzy Soft Set and Its Application to Diagnosis of Ovarian Cancer. *International Journal of Computational Intelligence Systems*, 1-15.
Zubair, A., Sonalitha, E., Ratih, S., Nurdewanto, B., Yudhistiro, & K., Mujahidin, I. (2020). Blackbox Testing Using Fuzzy Clustering Based on Boundary Value Analysis on The Text Opinion Mining Application in Traditional Culture Arts Presentation. *Proceeding on International Conference of Science Management Art Research Technology (IC-SMART)*, 1(1), 10-18.
Ningrum, R. F., Siregar, R. R. A., & Rusjdi, D. (2021). Fuzzy mamdani logic inference model in the loading of distribution substation transformer SCADA system. *IAES International Journal of Artificial Intelligence (IJ-AI)*, 10(2), 298-305.

Mazhar, S. A., Anjum, R., Anwar, A. I., & Khan, A. A. (2021). Methods of Data Collection: A Fundamental Tool of Research. *Journal of Integrated Community Health*, 10(1), 6-10.

Kristanto, E. B., Andrayana, S., & Benramhman. (2020). Application of Waterfall SDLC Method in Designing Student's Web Blog Information System at the National University. *Jurnal Mantik*, 4(1), 472-482.

Rambe, B. H., Pane, R., Irmayani, D., Nasution, M., & Munthe, I. R. (2020). UML Modeling and Black Box Testing Methods in the School Payment Information System. *Jurnal Mantik*, 4(3), 1634-1640.

Sholeh, M., Gisfas, I., Cahiman., & Fauzi, M. A. (2021). Black Box Testing on ukmbantul.com Page with Boundary Value Analysis and Equivalence Partitioning Methods. *Journal of Physics: Conference Series*, 1823(1), 1-8.

Kamińska, D., Zwoliński, G., & Laska-Leśniewicz, A. (2022). Usability testing of virtual reality applications—The pilot study. *Sensors*, 22(4), 1342.