# Expert System Diagnoses Varicochel Disease Using Mamdani's Fuzzy Logic Algorithm Method

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**Abstract**

Varicoceles form when valves in the veins that run along the spermatic cord (the structure that suspends the testicles in the scrotum) prevent blood from flowing properly. Most varicocele cases occur during puberty, from the age of 15 to 25 years. If there are symptoms that are not prolonged, treatment is not necessary. However, if a varicocele causes pain, shrinkage of the testicles, impaired fertility, or swelling, surgery will be performed. Symptoms of this disease are similar to hemorrhoids and bladder stones, so it takes an expert. In the research conducted on the Expert System Application for Diagnosing Hyperthyroid Disease with the Mamdani Fuzzy Logic Inference Method, it can be concluded that the expert system can store expert knowledge from experts in solving problems diagnosing hyperthyroid disease while Mamdani fuzzy inference is used for knowledge processing in order to obtain a more accurate diagnosis conclusion. definitely with accuracy . Making the application is expected to make it easier for people to get information without having to wait for the presence of a doctor/expert for varicocele disease, and is expected to reduce or even solve existing problems.

*Keywords*: *varikokel; varicocele disease*

## 1. Introduction

Varicocele is a disease of the scrotum that causes changes in the veins that do not feel comfortable during activities or feel pain in the scrotum, one of the main causes of male infertility with a typical appearance in the form of dilated scrotal veins resembling worm pockets [1] Varicoceles form when valves in the veins that run along the spermatic cord (the structure that suspends the testicles in the scrotum) prevent blood from flowing properly. Most varicocele cases occur during puberty, from the age of 15 to 25 years. If there are symptoms that are not prolonged, treatment is not necessary. However, if a varicocele causes pain, shrinkage of the testicles, impaired fertility, or swelling, surgery will be required [2] Expert systems can help people and provide specific expert knowledge. Simply put, an expert system is a program that simulates the judgment and behavior of humans who have knowledge and experience in a particular field [3]. One of the expert system methods that can be applied is to use the Mamdani Fuzzy Logic method. This study aims to create a Smart Teleconsulting Expert System for Diagnosing Varicocele Using the Mamdani Fuzzy Logic Method. The expert system that is built is expected to facilitate and automate every work of humans in detecting varicocele disease in the human body. In addition, making the application is expected to make it easier for people to get information without having to wait for the presence of a doctor/expert for varicocele disease, and is expected to reduce or even solve existing problems. [4]

## 2. Methods

The research method is the method used to obtain various data to be processed into more accurate information according to the problem to be studied. The methodology used in the final project research entitled "Expert System for Diagnosing Varicocele Using the Fuzzy Mamdani Method". In the development of an expert system, it is known as the Expert System Development Life Cycle (ESDLC) (Turban and Aronson, 2005). This cycle is used as a reference from stage to stage to develop an expert system so that it is more structured and directed. The following is the ESDLC stage in the expert system shown in Figure 1 :
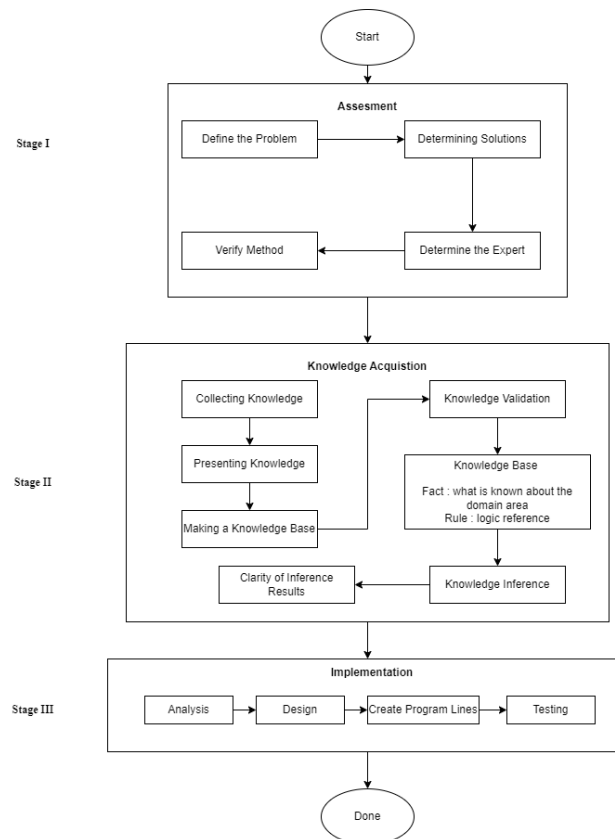


**Figure 1.** Components in an Expert System

### 2.1 Assessments

Stage I is the project initialization stage. In this study consists of four phases.

1.  **The phase defines the problem**
    Detect varicocele disease found in the human body and measure an uncertainty value into a value that can be used to diagnose the disease.
2.  **Phase provides alternative solutions**
    Making the application is expected to make it easier for people to get information without having to wait for the presence of a doctor/expert for varicocele disease, and is expected to reduce or even solve existing problems.
3.  **The phase determines the expert**
    In this phase, interviews with doctors or experts, namely Dr. Multi Soebakti Wisudasari to get information about varicocele disease and get information about the symptoms of varicocele disease. Regarding the interview, there were 6 elements of questions, namely 5 W 1 H regarding varicocele disease, what symptoms are there in varicocele, and the rule basis for determining the diagnosis of varicocele disease.
4.  **The phase of verifying the method**
    Determining the right method for the varicocele expert system is the certainty factor method because the presentation value on this expert system is bigger and more precise.

**2.2 Knowledge Acquisition**

This stage starts from the acquisition or gathering of knowledge, representing knowledge, creating a knowledge base, validating knowledge, inference, and the stage of providing an explanation of the inference results.

1. **Knowledge gathering phase**
   Determine requirements specifications and identify existing problems. This planning stage was carried out based on interviews with experts/doctors who know varicocele disease and conducting valid tests on patients by asking what symptoms are experienced by people with varicocele disease.
2. **Phase of Creating a Knowledge Base**
   The knowledge base is the core of an expert system, namely in the form of knowledge representation from experts and non-formal knowledge, which comes from books, articles, or journals.
3. **Knowledge Validation Phase**
   Knowledge must be valid and tested (eg using test cases) until it is of acceptable quality. The results of test cases are usually shown by experts to test the accuracy of the expert system.
4. **Knowledge Base Phase**
   In this section, the formulation of knowledge that has been obtained is further processed into a form of knowledge in the format IF <antecedent> THEN <consequent>. Consequences are conclusions based on the rules of the knowledge base. In this stage an interface is also designed regarding the interface for inputting data and the interface for the diagnostic process.
5. **Knowledge Inference Phase**
   The inference engine has a role as the brain of an expert system that has a mechanism for thinking functions and placing system reasoning patterns used by an expert.

**2.3 Implementation**

The implementation phase is the process of operating on the platform. This stage is carried out by running the system intensely, making it easier for users to change the data that has been stored. For implementing the user interface, use Gitbash to connect the database to Visual Studio Code.

**2.3.1 Analysis**

At this stage, the authors identify the data needed regarding this varicocele disease in full on how to treat this disease to the veins. Before the development was carried out, it was very difficult for patients to see specialist doctors because there were so many patients piling up in the hospital.

**2.3.2 Design**

Therefore it can be concluded from some of the opinions above, design is taken from the word "designo" (Italian) which means picture, while in English design is taken from the Latin meaning Designare which means to plan or design.

**2.3.3 Program Line**

Designing a display program line is needed in making an expert system website for diagnosing varicocele disease to create an overview of the appearance of the website application that is made.

**2.3.4 Trial**

The trial phase is carried out to find out what has been made has gone well and in accordance with the design. If it is not maximized, then the system will be repaired immediately. The trial phase is divided into 3 stages, namely:
a. Structural trials
   This trial was carried out in order to find out the system in accordance with the existing plans in the design and design.
b. Functional trials
   This is done knowing that the system is functioning according to the design that was made.
c. Trial validation
   This stage is carried out to find out the results of the system that is made are correct without any problems with the system.

**2.4 Fuzzy Logic Mamdani**

The concept of fuzzy logic was introduced by prof.Lotfi Zadeh in 1962. Fuzzy logic is a problem-solving control system methodology, which is suitable for implementation on systems, ranging from simple systems, small systems, PC networks, multi-channel or workstations based on data acquisition and control system. This methodology can be applied to hardware, software, or a combination of both. In classical logic it is stated that everything is binary, which means it only has two possibilities, "Yes or No", "True or False", "Good or Bad". Figure 2
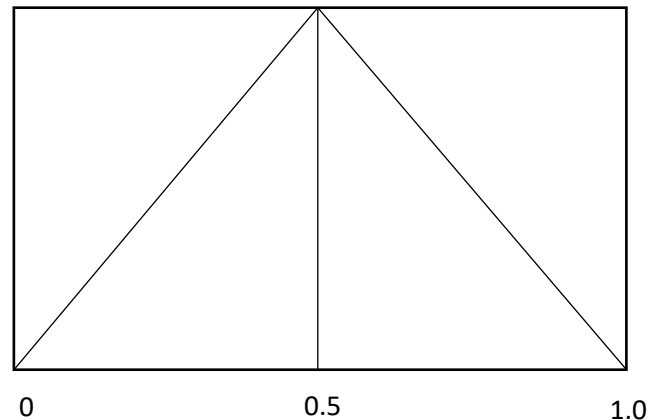


Figure 2 concept of fuzzy logic

Or it can be seen in the formula below:

$$x > 0$$

$$\mu \text{not sure}[x] = \int_1^0 \frac{0.5-x}{0.5} \; ; 0 < x < 0.5 \tag{1}$$

$$x < 0.5$$

$$x \geq 0.5$$

$$\mu \text{not sure}[x] = \int_1^0 \frac{0.5-x}{0.5} \; ; 0 \leq x \leq 1.0 \tag{2}$$

$$x < 1.0$$

The mamdani method is most often used in applications because of its simple structure, which uses MIN-MAX or MAX-PRODUCT operations. To get the output, the following steps are required:

1. Fuzzification
2. Formation of a fuzzy knowledge base (rules in the form of If . . . Then)
3. Application of the implication function using the MIN function and composition between rules using the MAX function (generates a new fuzzy set)
4. Defuzzification using the centroid method.
5. Suppose the following 2 rules are known:
   If (x is A1) and (y is B1) Then (z is C1)
   If (x is A2) and (y is B2) Then (z is C2)

## 5. Result and Discussion
**5.1 Analysis**

At this stage, the authors identify the data needed regarding this varicocele disease in full on how to treat this disease to the veins. Prior to development, it was very difficult for patients to see specialist doctors because of the large number of patients piling up in the hospital, this caused patients to want a quick way to find out what disease they were suffering from.

## 5.2 Knowledge Inference

The system was built to determine the symptoms of varicocele in the community manually, namely by consulting doctors with their patients. Consultation with a doctor or expert is to obtain the symptoms suffered by the patient, then from the symptoms obtained a diagnosis is made in the form of a disease. because the software used must be in accordance with the problem to be solved. Expressing the degree of certainty, Mamdani Fuzzy Logic to assume the degree of certainty of an expert on a data. This concept is then formulated in the basic formula as follows:

The first step, the expert determines Fuzzy Mamdani for each symptom as follows:

**Table 1.** Diagnostic Questions

| | |
|---|---|
| Do you feel enlarged veins in the scrotum? | 0.7 |
| When doing activities for a long time and decreases | 0.2 |
| is there pain when lying down? | 0.4 |
| When having intimate relations, what is production? | 0.5 |
| Is your sperm decreasing? | 0.5 |
| Do you feel blood pooling and pressure? | 0.3 |
| Have you experienced infertility? | 0.2 |
| Is there discomfort in the scrotum? | 0.6 |
| When you stand, do you feel pain for a long time? | 0.6 |

### 5.2.1 Rule Formation

The following are the rules for each disease.
a. If G01 And G02 Then K01
b. If G03 And G04 Then K01
c. If G05 And G06 Then K01
d. If G07, G08 And G09 Then K01

From the rule above, the rules change to the following:
a. If 0.6 And 0.7 Then K01
b. If 0.8 And 0.5 Then K01
c. If 0.6 And 0.6 Then K01
d. If 0.9 , 0.7 And 0.5 Then K01

### 5.2.2 Inference Engine

Determining the level of outcome of contracting vulvovaginitis is represented using fuzzy logic with a value between 0 and 1. If the result of the fuzzy logic calculation is towards 1, then the level of result is higher, this can be seen from the example below:

$$TX = (NG1) + (NG2) + (NG3)\ldots\ldots (NGn)$$

If $TX \leq 50$ then :

$$x \geq 0.5$$

$$\mu \text{not sure}[x] = \int_1^0 \frac{TX - 0.5}{0.5} \; ; \; 50 \leq x \leq 1.0$$
$$x < 1.0$$

Information:

TX  = Total X
NGn = Assess symptoms ke-n
μTX = fuzzy value of TX

1.  if himpunan KG = {G01} then :
     TX     = G01
            = 0.7

so TX x ≥ 0.5 then the fuzzy value is:
$$x \geq 0.5$$
$$\mu TX[0,7] = \int_1^0 \frac{0.7 - 0.5}{0.5} \; ; \quad 50 \leq x \leq 1.0$$
$$x < 1.0$$

  From the results of the calculations above, it can be concluded that the symptoms of G01 (enlarged veins in the scrotum) indicate that the diagnosis is 0.3

2.  if himpunan KG = {G02,G03} then :
     TX     = G01 + G02
            = 0.7 + 0.2
            = 0.9

so TX x ≥ 0.5 then the fuzzy value is:
$$x \geq 0.5$$
$$\mu TX[0,9] = \int_1^0 \frac{0.9 - 0.5}{0.5} \; ; \; 50 \leq x \leq 1.0$$
$$x < 1.0$$

  From the results of the calculations above, it can be concluded that the symptoms of G02,G03 (enlarged veins in the scrotum) indicate that the diagnosis is 0.1

3.  if himpunan KG = {G01,G02,G03} then :
     TX     = G01 + G02 + G03
            = 0.7 + 0.2 + 0.4
            = 1.3

so TX x ≥ 0.5 5 then the fuzzy value is:
$$x \geq 0.5$$
$$\mu TX[1,3] = \int_1^0 \frac{1.3 - 0.5}{0.5} \; ; \; 50 \leq x \leq 1.0$$
$$x < 1.0$$

  From the results of the calculations above, it can be concluded that the symptoms of G01,G02,G03 indicate that the diagnosis is 0.3

4.  if himpunan KG = {G01,G02,G03,G04} then :
     TX     = G01 + G02 + G03 + G04
            = 0.7 + 0.2 + 0.4 + 0.5
            = 1.8

so TX x ≥ 0.5 then the fuzzy value is:
$$x \geq 0.5$$
$$\mu TX[1,8] = \int_1^0 \frac{1.8 - 0.5}{0.5} \; ; \; 50 \leq x \leq 1.0$$
$$x < 1.0$$

  From the results of the calculations above, it can be concluded that the symptoms of G01, G02, G03, G04 indicate that the diagnosis is 0.8

5.  if himpunan KG = {G01,G02,G03,G04,G05} then :
     TX     = G01 + G02 + G03 + G04 + G05
            = 0.7 + 0.2 + 0.4 + 0.5 + 0.5
            = 2.3

so TX x ≥ 0,5 then the fuzzy value is:
$$x \geq 0.5$$

$\mu TX[2.3] = \int_1^0 \frac{2.3 - 0.5}{0.5}$ ; $50 \leq x \leq 1.0$

$x < 1.0$

From the results of the calculations above, it can be concluded that the symptoms of G01, G02, G03, G04, G05 indicate that the diagnosis is 1.3

6.      if himpunan KG   = {G01,G02,G03,G04,G05,G06} then :
           TX                = G01 + G02 + G03 + G04 + G05 + G06
                            = 0.7 + 0.2 + 0.4 + 0.5 + 0.5 + 0.3
                            = 2.6

so TX x ≥ 0.5 then the fuzzy value is:

x ≥ 0.5

$\mu TX[2.6] = \int_1^0 \frac{2.6 - 0.5}{0.5}$ ; $50 \leq x \leq 1.0$

$x < 1.0$

From the results of the calculations above, it can be concluded that the symptoms of G01, G02, G03, G04, G05, G06 indicate that the diagnosis 1.6

7.      if himpunan KG   = {G01,G02,G03,G04,G05,G06,G07} then :
           TX                = G01 + G02 + G03 + G04 + G05 + G06 + G07
                            = 0.7 + 0.2 + 0.4 + 0.5 + 0.5 + 0.3 + 0.2
                            = 2.8

so TX x ≥ 0.5 then the fuzzy value is:

x ≥ 0.5

$\mu TX[2.8] = \int_1^0 \frac{2.8 - 0.5}{0.5}$ ;     $50 \leq x \leq 1.0$

$x < 1.0$

From the results of the calculations above, it can be concluded that the symptoms of G01, G02, G03, G04, G05, G06, G07 indicate that the diagnosis 1.8

8.      if himpunan KG   = {G01,G02,G03,G04,G05,G06,G07,G08} then :
           TX                = G01 + G02 + G03 + G04 + G05 + G06 + G07 + G08
                            = 0.7 + 0.2 + 0.4 + 0.5 + 0.5 + 0.3 + 0.2 + 0.6
                            = 2.9

so TX x ≥ 0.5 then the fuzzy value is:

x ≥ 0.5

$\mu TX[2.9] = \int_1^0 \frac{2.9 - 0.5}{0.5}$ ; $50 \leq x \leq 1.0$

$x < 1.0$

From the results of the calculations above, it can be concluded that the symptoms of G01, G02, G03, G04, G05, G06, G07, G08 indicate that the diagnosis 1,9

9.      if himpunan KG   = {G01,G02,G03,G04,G05,G06,G07,G08,G09} then :
           TX                = G01 + G02 + G03 + G04 + G05 + G06 + G07 + G08 + G09
                            = 0.7 + 0.2 + 0.4 + 0.5 + 0.5 + 0.3 + 0.2 + 0.6 + 0.6
                            = 4

so TX x ≥ 0,5 then the fuzzy value is:

x ≥ 0,5

$\mu TX[4] = \int_1^0 \frac{4 - 0.5}{0.5}$ ;     $50 \leq x \leq 1.0$

$x < 1,0$

From the results of the calculations above, it can be concluded that the symptoms of G01, G02 , G03, G04, G05, G06, G07, G08 indicate that the diagnosis 3

Defuzzyfikasi

$Z = \frac{\Sigma \mu TX}{\Sigma TX}$

$$= \frac{3}{4}$$

$$= 0.75 = 75\%$$

**5.3 Interface Page for Users**

The following is the display result from the Expert System Diagnosing Varicocele website along with an explanation of each page. From the research results, namely by interviewing a doctor (Dr. Multi Soebakti). There are 2 access rights in this system, namely admin and user. Admin is a user operating on the backend of the system in charge of processing master data such as information data, symptom data, disease data, and diagnostic data. Users are users who can see a list of disease information and symptoms that will be input and produce a diagnosis.

**a. Dashboard page**

The Dashboard page is a page that provides varicocele website information and to start the diagnosis shown in Figure 2.



**Figure 2.** Dashboard

**b. Diagnostics Page**

The Diagnosis page is a page that displays patient registration with varicocele disease and provides a choice of symptoms in varicoceles. After selecting varicocele symptoms, the output of the diagnosis will be shown in Figure 3.
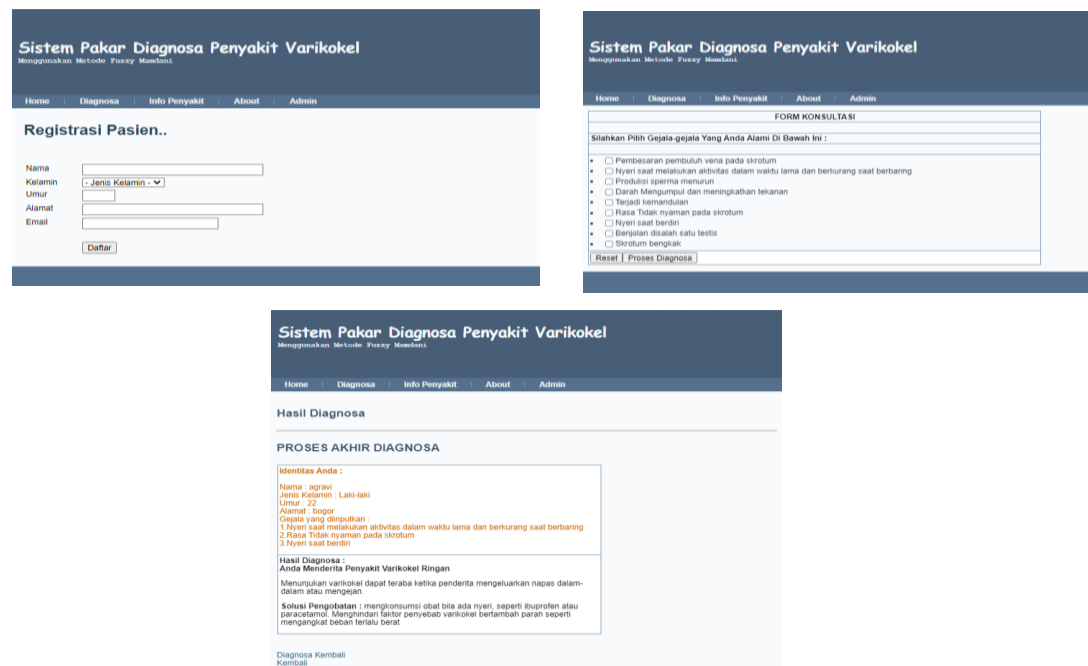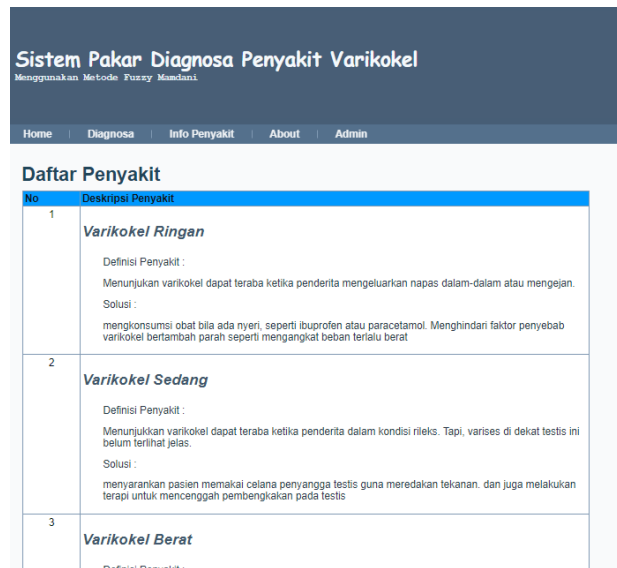


**Figure 3.** Diagnostic Page

**d. Disease Info Page**

The disease info page is a page that displays information about varicocele disease and there are stages of varicocele disease as shown in Figure 4.



**Figure 4.** Disease Information Page

**e. About page**

The about page is a page that displays program information as shown in Figure 5.
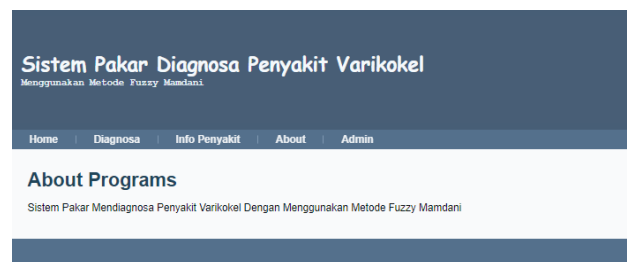


**Figure 5.** About Varicocele

In implementing the web as an information medium for varicocele disease, there are two types of user levels, namely admin and community. This admin level is given access to add, edit, delete information on symptoms and diseases. The public is given access to see a list of information that has been displayed on the Varicocele Disease website. On the main user interface page the patient will be given an explanation of the disease, after the patient has read the details about varicocele the patient will be directed to start the diagnosis, for the diagnosis page the patient must choose what symptoms the patient is feeling, after selecting several symptoms the system will start for calculating the level of confidence and taking the diagnosis level according to the severity of symptoms.

In the Implementation of the Web as an Information Media for varicocele disease, there are two types of user levels, namely the admin and the community. This admin level is given access to be able to add, edit, delete information regarding symptoms and diseases. the public is given access to see a list of information that has been displayed on the Varicocele Disease website.

**6. Conclusions**

Based on research entitled Expert System for Diagnosing Varicocele Using the Mamdani Fuzzy Logic Method, the conclusions obtained are as follows By calculating the Varicocele Disease Diagnosis Expert System using the Fuzzy Mamdani Method, you can get a confidence value from the diagnosis results with an accuracy level of 75%. In varicocele, there are 9 symptoms with 3 levels of diagnosis severity This varicocele

disease website application has two types of user levels, namely admin and community. This admin level is given access to add, edit, delete information on symptoms and diseases. The public is given access to see a list of information that has been displayed on the Varicocele Disease website. Alpha and beta testing is carried out on IT experts, doctors and patients The alpha test results show that the test results are 80% and for the beta test the test results show 67%.

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