Diagnosis of Herpes Zoster Using Bayes Theorem Method

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Abstract

Expert Systems is one branch of Artificial Intelligence (AI) that makes widespread use of knowledge or knowledge specifically for solving expert human-level problems. Kartini Clinic has several health workers such as nurses, midwives to doctors who are ready to serve people who suffer from various diseases, one of which is Herpers Zoster disease. Shingles is an acute inflammation of the skin usually characterized by the appearance of red bubbles like small blisters that cluster on the surface of the skin and watery and accompanied by itching and heat. This disease will appear more if there is irritation, wounds or abrasions and a long healing process. Bayes' theorem is a mathematical equation used in probability and statistics to calculate conditional probabilities.

Keywords: *Expert systems, Disease, Herpes Zoster, Bayes Theorem*

1. Introduction

Kartini Clinic is one of the clinics in Binjai City that handles everyone who needs health services. This clinic has several health workers such as nurses, midwives to doctors who are ready to serve people who suffer from various diseases, one of which is Herpers Zoster disease. Shingles is an acute inflammation of the skin usually characterized by the appearance of red bubbles like small blisters that cluster on the surface of the skin and watery and accompanied by itching and heat. This disease will appear more if there is irritation, wounds or abrasions and a long healing process. If shingles can be diagnosed quickly, you will have more time to get faster treatment that can help the healing process before the disease widens. But not infrequently to see an expert doctor in the field of this disease must take a long time, so most patients are late in the process of handling the disease they suffer.

2. Research methodology

2.1. Expert System

Expert System is a branch of Artificial Intelligence (AI) that makes extensive use of specific knowledge or knowledge for expert human-level problem solving. The Expert System consists of two main parts, namely the development environment and the consulting environment. The developer environment in an expert system is used as an entry point for expert knowledge into the expert system environment, while the consulting environment will be used by users who are not experts in obtaining expert knowledge (Handoko, 2019).

2.2. Bayes Theorem Method

Bayes theorem is a theory of probability conditions that takes into account the probability of an event (hypothesis) depending on other events (proof). Future events can be predicted if previous events have already occurred. Bayes' theorem is a mathematical equation used in probability and statistics to calculate conditional probabilities. In other words, it is used to calculate the probability of an event based on its relationship to other events. This theorem is also known as Bayes law or Bayes rule (Batarius & Tedy, 2017).

Bayes theorem for single proof and single hypothesis The formula is

$$P(H|E) = \frac{P(E|H) * P(H)}{P(E)} \tag{1}$$

Where:

P(H | E)	= probability of hypothesis H if given evidence E
P(E | H)	= the probability of emergence of evidence E if hypothesis H is known
P(H)	= probability H without containing any evidence
P(E)	= evidence E probability

The above equation is used for Bayes Theorem for single proof and single hypothesis.

$$P(H_i|E) = \frac{P(E|H_i)*P(H_i)}{\sum_{k=1}^{n} P(E|H_i)*p(H_k)} \tag{2}$$

$P(H_i \mid E)$	= the probability of the hypothesis H_i if evidence E occurs
$P(E \mid H)$	= the probability of emergence of evidence E if the hypothesis H_i occurs
$P(H)$	= H_i probability without containing any evidence
N	= the number of hypotheses that occur

The above equation is used for Bayes Theorem for single proof and multiple hypothesis.

$$P(H_i|E_1\ E_2 \dots E_m\ ) = \frac{P(E_1|H_i)*P(E_2 H_i)*\dots*P(E_m H_i)*P(H_i)}{\sum_{k=1}^{n} P(E_i|H_k)*p(E_2|H_k)*\dots*p(E_m|H_k)*p(H_k)} \tag{3}$$

$P(H_i \mid E_m)$	= the probability of the hypothesis H_i if evidence E_m occurs
$P(E_i \mid H_i)$	= the probability of emergence of evidence E_i if the hypothesis H_i occurs
$P(E_i \mid H_k)$	= the probability of emergence of evidence E_i if the H_k hypothesis occurs
$P(H_i)$	= H_i probability without containing any evidence
N	= the number of hypotheses that occur

The above equation for Bayes' theorem for double proof and double hypothesis.

3. Flowchart

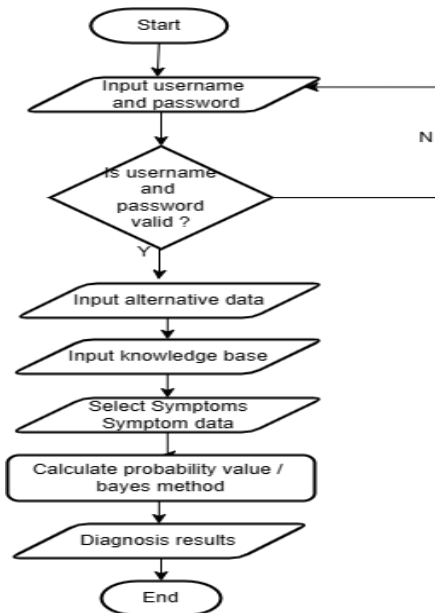A flowchart that describes the steps taken by experts in the design process.

Fig. 1: Flowchart Bayes Theorem

Table 1: Table of symptoms and diseases**.**

Code	Symptom	Disease	
		Herpes Zoster	**Complications of Herpes Zoster**
G01	Fever	√	√
G02	Headache	√	√
G03	Body Pain	√	√
G04	Skin Feels Hot / Burns	√	√
G05	Skin Itching	√	√
G06	Reddish Spots	√	√
G07	Pain on the skin		√
G08	Nauseous		√
G09	Vomit		√
G10	Sore throat		√
G11	Decreased appetite	√	√
G12	Looks pale	√	√
G13	Watery Spots		√
G14	Body Feeling Weak	√	√

Code	Symptom	Disease	
		Herpes Zoster	**Complications of Herpes Zoster**
G15	Skin Rashes	√	√
G16	Swelling in the area of papules/spots		√
G17	Loss of Vision		√
G18	Brain Inflammation		√
G19	Attacking the nerves in the body		√
G20	Attacks the Lungs		√

Table 2: Disease Probability Value.

Disease Code	Disease Name	Amount of data	Probability Value
P01	Herpes Zoster	65	$\frac{65}{115}= 0.57$
P02	Complications of Herpes Zoster	50	$\frac{50}{115}= 0.43$
	Total	**115**	$\frac{65+50}{115}= = 1\frac{115}{115}$

From the table above it can be seen that the probability value of Herpes Zoster disease is 0.57 obtained from a total of 65/115 data and Complicated Herpes Zoster disease, namely 0.43 obtained from a total of 50/115 data.

Table 3: Disease Symptom Probability Value.

Symptom Code	Symptoms of Disease	Disease	
		P01	**P02**
G01	Fever	43	46
G02	Headache	29	24
G03	Body Pain	65	50
G04	Skin Feels Hot / Burns	65	12
G05	Skin Itching	65	50
G06	Reddish Spots	65	31
G07	Pain on the skin	31	47
G08	Nauseous	19	38
G09	Vomit	13	27
G10	Sore throat	34	32
G11	Decreased appetite	36	42
G12	Looks pale	52	49
G13	Watery Spots	49	50
G14	Body Feeling Weak	48	50
G15	Skin Rashes	8	50
G16	Swelling in the area of papules/spots	1	50
G17	Loss of Vision	7	41
G18	Brain Inflammation	1	50
G19	Attacking the nerves in the body	1	50
G20	Attacks the Lungs	1	50

1. Herpes Zoster Disease (P01)

$$P(P01|G01)= \frac{P(G01|P1)*P(P01)}{P(G01|P1)*P(P01)+ P(G01|P2)}$$

$$P(P01|G01)= \frac{(43/65)*(65/115)}{(43/65)*(65/115) + (46/50)*(50/115)} = 0,48$$

$$P(P01|G02)= \frac{(29/65)*(65/115)}{(29/65)*(65/115) + (24/50)*(50/115)} = 0,55$$

$$P(P01|G03)= \frac{(65/65)*(65/115)}{(65/65)*(65/115) + (50/50)*(50/115)} = 0,57$$

$$P(P01|G04)= \frac{(65/65)*(65/115)}{(65/65)*(65/115) + (12/50)*(50/115)} = 0,84$$

$$P(P01|G05)= \frac{(65/65)*(65/115)}{(65/65)*(65/115) + (50/50)*(50/115)} = 0,57$$

$$P(P01|G06)= \frac{(65/65)*(65/115)}{(65/65)*(65/115) + (31/50)*(50/115)} = 0,68$$

$$P(P01|G07)= \frac{(31/65)*(65/115)}{(31/65)*(65/115) + (47/50)*(50/115)} = 0,4$$

$$P(P01|G08)= \frac{(19/65)*(65/115)}{(19/65)*(65/115) + (38/50)*(50/115)} = 0,33$$

$$P(P01|G09)= \frac{(13/65)*(65/115)}{(13/65)*(65/115) + (27/50)*(50/115)} = 0,33$$

$$P(P01|G10)= \frac{(34/65)*(65/115)}{(34/65)*(65/115) + (32/50)*(50/115)} = 0,52$$

$$P(P01|G11)= \frac{(36/65)*(65/115)}{(36/65)*(65/115) + (42/50)*(50/115)} = 0,46$$

$$P(P01|G12) = \frac{(52/65)*(65/115)}{(52/65)*(65/115) + (49/50)*(50/115)} = 0,51$$

$$P(P01|G13) = \frac{(49/65)*(65/115)}{(49/65)*(65/115) + (50/50)*(50/115)} = 0,49$$

$$P(P01|G14) = \frac{(48/65)*(65/115)}{(48/65)*(65/115) + (50/50)*(50/115)} = 0,49$$

$$P(P01|G15) = \frac{(8/65)*(65/115)}{(8/65)*(65/115) + (50/50)*(50/115)} = 0,14$$

$$P(P01|G16) = \frac{(1/65)*(65/115)}{(1/65)*(65/115) + (50/50)*(50/115)} = 0,02$$

$$P(P01|G17) = \frac{(7/65)*(65/115)}{(7/65)*(65/115) + (41/50)*(50/115)} = 0,15$$

$$P(P01|G18) = \frac{(1/65)*(65/115)}{(1/65)*(65/115) + (50/50)*(50/115)} = 0,02$$

$$P(P01|G19) = \frac{(1/65)*(65/115)}{(1/65)*(65/115) + (50/50)*(50/115)} = 0,02$$

$$P(P01|G20) = \frac{(1/65)*(65/115)}{(1/65)*(65/115) + (50/50)*(50/115)} = 0,02$$

2. **Complications Herpes Zoster Disease (P02)**

$$P(P01|G01) = \frac{P(G01|P2)*P(P02)}{P(G01|P1)*P(P01) + P(G01|P2)}$$

$$P(P01|G01) = \frac{(46/50)*(50/115)}{(43/65)*(65/115) + (46/50)*(50/115)} = 0,52$$

$$P(P01|G02) = \frac{(24/50)*(50/115)}{(29/65)*(65/115) + (24/50)*(50/115)} = 0,45$$

$$P(P01|G03) = \frac{(50/50)*(50/115)}{(65/65)*(65/115) + (50/50)*(50/115)} = 0,43$$

$$P(P01|G04) = \frac{(12/50)*(50/115)}{(65/65)*(65/115) + (12/50)*(50/115)} = 0,16$$

$$P(P01|G05) = \frac{(50/50)*(50/115)}{(65/65)*(65/115) + (50/50)*(50/115)} = 0,43$$

$$P(P01|G06) = \frac{(31/50)*(50/115)}{(65/65)*(65/115) + (31/50)*(50/115)} = 0,32$$

$$P(P01|G07) = \frac{(47/50)*(50/115)}{(31/65)*(65/115) + (47/50)*(50/115)} = 0,6$$

$$P(P01|G08) = \frac{(38/50)*(50/115)}{(19/65)*(65/115) + (38/50)*(50/115)} = 0,67$$

$$P(P01|G09) = \frac{(27/50)*(50/115)}{(13/65)*(65/115) + (27/50)*(50/115)} = 0,68$$

$$P(P01|G10) = \frac{(32/50)*(50/115)}{(34/65)*(65/115) + (32/50)*(50/115)} = 0,48$$

$$P(P01|G11) = \frac{(42/50)*(50/115)}{(36/65)*(65/115) + (42/50)*(50/115)} = 0,54$$

$$P(P01|G12) = \frac{(49/50)*(50/115)}{(52/65)*(65/115) + (49/50)*(50/115)} = 0,49$$

$$P(P01|G13) = \frac{(50/50)*(50/115))}{(49/65)*(65/115) + (50/50)*(50/115)} = 0,51$$

$$P(P01|G14) = \frac{(50/50)*(50/115)}{(48/65)*(65/115) + (50/50)*(50/115)} = 0,51$$

$$P(P01|G15) = \frac{(50/50)*(50/115)}{(8/65)*(65/115) + (50/50)*(50/115)} = 0,86$$

$$P(P01|G16) = \frac{(50/50)*(50/115)}{(1/65)*(65/115) + (50/50)*(50/115)} = 0,98$$

$$P(P01|G17) = \frac{(41/50)*(50/115)}{(7/65)*(65/115) + (41/50)*(50/115)} = 0,86$$

$$P(P01|G18) = \frac{(50/50)*(50/115)}{(1/65)*(65/115) + (50/50)*(50/115)} = 0,98$$

$$P(P01|G19) = \frac{(50/50)*(50/115)}{(1/65)*(65/115) + (50/50)*(50/115)} = 0,98$$

$$P(P01|G20) = \frac{(50/50)*(50/115)}{(1/65)*(65/115) + (50/50)*(50/115)} = 0,98$$

Table 4: Probability Value.

Symptom Code	Symptoms of Disease	Disease Weight Value	
		P01	P02
G01	Fever	0.48	0.52
G02	Headache	0.55	0.45
G03	Body Pain	0.57	0.43
G04	Skin Feels Hot / Burns	0.84	0.16
G05	Skin Itching	0.57	0.43
G06	Reddish Spots	0.68	0.32
G07	Pain on the skin	0.4	0.6
G08	Nauseous	0.33	0.67
G09	Vomit	0.33	0.68
G10	Sore throat	0.52	0.48
G11	Decreased appetite	0.46	0.54
G12	Looks pale	0.51	0.49
G13	Watery Spots	0.49	0.51
G14	Body Feeling Weak	0.49	0.51

Symptom Code	Symptoms of Disease	Disease Weight Value	
		P01	P02
G15	Skin Rashes	0.14	0.86
G16	Swelling in the area of papules/spots	0.02	0.98
G17	Loss of Vision	0.15	0.85
G18	Brain Inflammation	0.02	0.98
G19	Attacking the nerves in the body	0.02	0.98
G20	Attacks the Lungs	0.02	0.98

Application of the Bayes Theorem Method

A patient has the following symptoms of Herpes Zoster:
1. Fever
2. Body Pain
3. Skin Feels Hot / Burns
4. Skin Itching
5. Reddish Spots
6. Looks Pale
7. Watery Spots
8. The body feels weak

From the symptoms that have been described, the system will process according to the application of the Bayes method. After the calculation process is complete, it will conclude the identification of the disease experienced by the patient.

Define in advance the probability value of each symptom of the disease.

   a. **Herpes Zoster (P01)**

      G01   =   0,48

      G03   =   0,57

      G04   =   0,84

      G05   =   0,57

      G06   =   0,68

      G12   =   0,51

      G13   =   0,49

      G14   =   0,49

   b. **Complications Herpes Zoster (P02)**

      G01   =   0,52

      G03   =   0,43

      G04   =   0,16

      G05   =   0,43

      G06   =   0,32

      G12   =   0,49

      G13   =   0,51

      G14   =   0,51

Find the probability value of the disease Symptoms.

P(G01|P01)*(P(P01)	=	0,57	*	0,48	= 0,2754
P(G03|P01)*(P(P01)	=	0,57	*	0,57	= 0,3222
P(G04|P01)*(P(P01)	=	0,57	*	0,84	= 0,4812
P(G05|P01)*(P(P01)	=	0,57	*	0,57	= 0,3222
P(G06|P01)*(P(P01)	=	0,57	*	0,68	= 0,3859
P(G12|P01)*(P(P01)	=	0,57	*	0,51	= 0,2935
P(G13|P01)*(P(P01)	=	0,57	*	0,49	= 0,2821
P(G14|P01)*(P(P01)	=	0,57	*	0,49	= 0,2792
P(G01|P02)*(P(P02)	=	0,43	*	0,52	= 0,2222
P(G03|P02)*(P(P02)	=	0,43	*	0,43	= 0,1870
P(G04|P02)*(P(P02)	=	0,43	*	0,16	= 0,0670
P(G05|P02)*(P(P02)	=	0,43	*	0,43	= 0,1870
P(G06|P02)*(P(P02)	=	0,43	*	0,32	= 0,1389
P(G12|P02)*(P(P02)	=	0,43	*	0,49	= 0,2086
P(G13|P02)*(P(P02)	=	0,43	*	0,51	= 0,2172

P(G14|P02)*(P(P02)   =   0,43   *   0,51   =   0,2194

Summing the probability value of each symptom.
PG01 = P(G01|P01) * P(P01) + P(G01|P02) * P(P02)
PG01 = 0,2754 + 0,2222
PG01 = 0,4976
PG03 = P(G03|P01) * P(P01) + P(G03|P02) * P(P02)
PG03 = 0,3222 + 0,1870
PG03 = 0,5091
PG04 = P(G04|P01) * P(P01) + P(G04|P02) * P(P02)
PG04 = 0,4812 + 0,0670
PG04 = 0,5482
PG05 = P(G05|P01) * P(P01) + P(G05|P02) * P(P02)
PG05 = 0,3222 + 0,1870
PG05 = 0,5091
PG06 = P(G06|P01) * P(P01) + P(G06|P02) * P(P02)
PG06 = 0,3859 + 0,1389
PG06 = 0,5248
PG12 = P(G12|P01) * P(P01) + P(G12|P02) * P(P02)
PG12 = 0,2935 + 0,2086
PG12 = 0,5021
PG13 = P(G13|P01) * P(P01) + P(G13|P02) * P(P02)
PG13 = 0,2821 + 0,2172
PG13 = 0,4993
PG14 = P(G14|P01) * P(P01) + P(G14|P02) * P(P02)
PG14 = 0,2792 + 0,2194
PG14 = 0,4986
Calculates the probability value of the disease.
a.   **Herpes Zoster (P01)**
P01 = P(G01|P01) / P(P01) + P(G03|P01) / P(P01) + P(G04|P01) / P(P01) + P(G05|P01) / P(P01) + P(G06|P01) / P(P01) +
       (G12|P01) / P(P01) + (G13|P01) / P(P01) + (G14|P01) / P(P01)
P01 = (0,2754/0,4976) + (0,3222/0,5091)+(0,4812/0,5482) + (0,3222/0,5091) +
       (0,3859/0,5248)+(0,2935/0,5021)+(0,2821/0,4993)+(0,2792/0,4986)
P01 = 0,5534+0,6328+0,8778+0,6328+0,7354+0,5845+0,5650+0,5600
P01 = 5,1417
b.   **Complications Herpes Zoster (P02)**
P02 = P(G01|P02) / P(P02) + P(G03|P02) / P(P02) + P(G04|P02) / P(P02) + P(G05|P02) / P(P02) + P(G06|P02) / P(P02) +
       (G12|P02) / P(P02) + (G13|P02) / P(P02) + (G14|P02) / P(P02)
P02 = (0,2222/0,4976) + (0,1870/0,5091)+(0,0670/0,5482)+(0,1870/0,5091) + (0,1389/0,5248) +
       (0,2086/0,5021)+(0,2172/0,4993)+(0,2194/0,4986)
P02 = 0,4466+0,3672+0,1222+0,3672+0,2646+0,4155+0,4350+0,4400
P02 = 2,8583
Find the Bayes value by adding the probability values of the disease.

$$\sum_{Gn}^{n} = P01 + P02$$

= 5,1417 + 2,8583
= 8
Calculate the percentage of disease.
a.   **Herpes Zoster (P01)**
P01 = 5,1417 / 8
P01 = 0,6427
P01 = 0,6427 * 100 %
P01 = 64,27 %
b.   **Herpes Zoster Komplikasi (P02)**
P02 = 2,8583 / 8
P02 = 0,3573
P02 = 0, 3573 * 100 %
P02 = 35,73%

From the calculation process using the Bayes Theorem method above, it can be seen that the patient is (P01) with a value of 0.6427 or 64.27%.

4. Program Design

The main menu contains menus that can be used by the user, which can facilitate the user in conducting consultations through an expert system for diagnosing Herpes Zoster using Bayes Theorem.
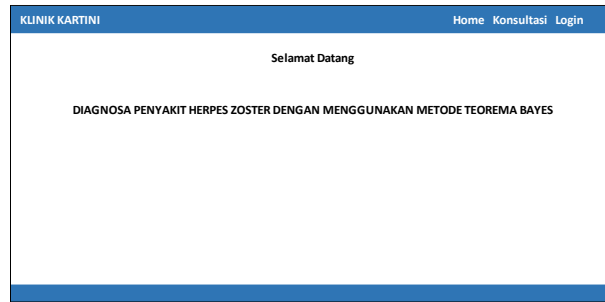
Fig. 2: Main course

The login menu is used by the admin to access all menus on the system, such as the disease menu, symptoms, rules, consultations and passwords which are used to change usernames and passwords.
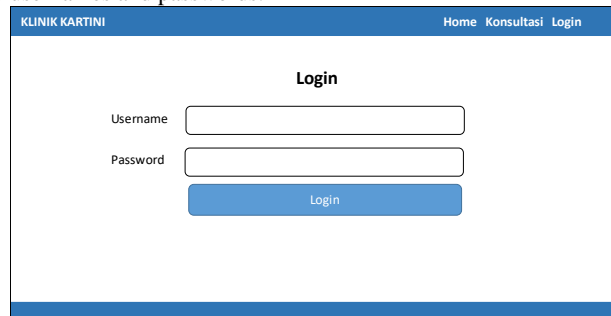

Fig. 3: Login menu

This disease menu is used by the admin to input the type of Herpes Zoster disease.

Fig. 4: Disease menu

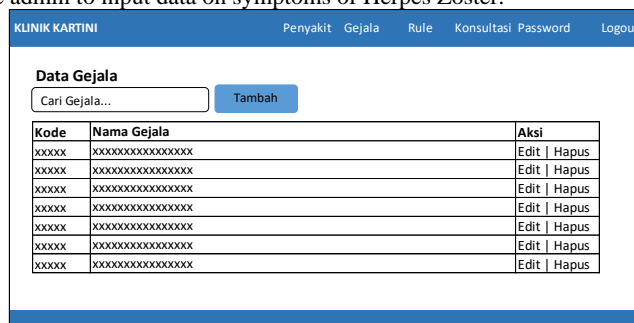The symptoms menu is used by the admin to input data on symptoms of Herpes Zoster.

Fig. 5: Symptom menu

This rule menu is used by the admin to input rules or rules for disease symptoms based on the type of Herpes Zoster disease and the weight value which will later be used to diagnose the type of Herpes Zoster disease.
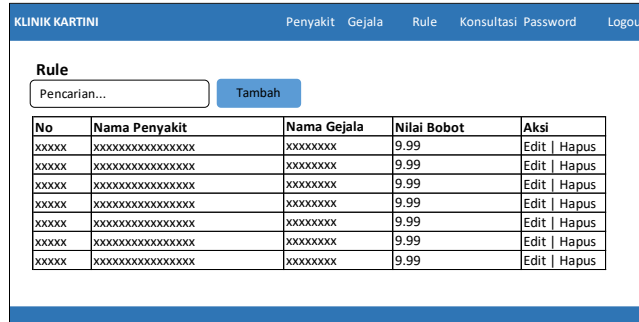
Fig. 6: Rule

This consultation menu is used by both the user and the admin to carry out the process of diagnosing the type of Herpes Zoster disease by entering the user's personal data which then selects the symptoms of the disease that are felt. After all the data has been filled in, you can click Diagnostics.
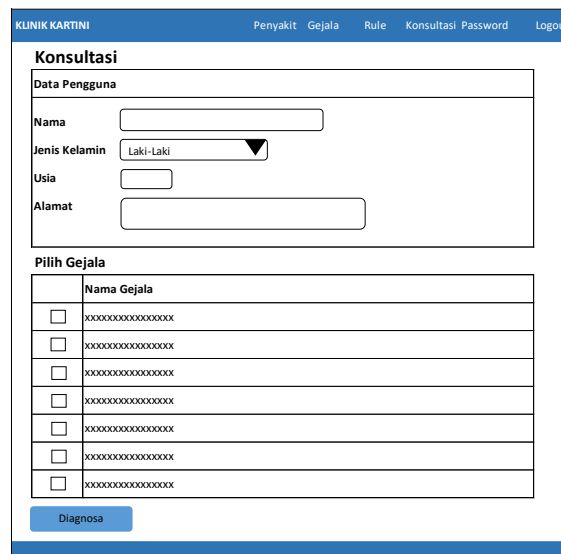

Fig. 7: Consultation

The end result of a consultation through an expert system for diagnosing Herpes Zoster is a report on the results of the consultation. The report on the results of this consultation contains information on which type of Herpes Zoster disease has the highest value based on the symptoms that have been input into the system.
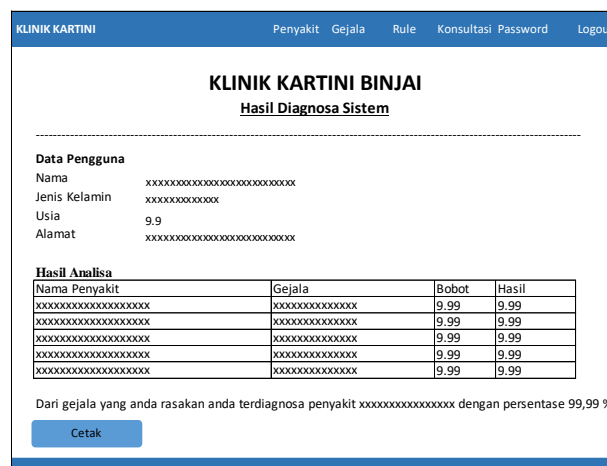

Fig. 8: Diagnostic results

5. Conclusion

Shingles is caused by infection with varicella zoster virus (VVZ) and is classified as a DNA-nucleated virus, this virus measuring 140-200 nm, which belongs to the alpha subfamily herpes viridae. Based on biological properties such as cyclic replication, hosts, cytotoxic properties and latent living cells are identified as 3 subpharmaceutical states, namely alpha, beta and gamma. Shingles is an acute inflammation of the skin usually characterized by the appearance of red bubbles like small blisters that cluster on the surface of the skin and watery and accompanied by itching and heat. This disease will appear more if there is irritation, wounds or abrasions and a long healing process.

Acknowledgement

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