DIAGNOSE OF MENTAL ILLNESS USING FORWARD CHAINING AND CERTAINTY FACTOR

Marcheilla Trecya Anindita[1]; Yoga Pristyanto[2*]; Heri Sismoro[3]; Atik Nurmasani[4]; Anggit Ferdita Nugraha[5]

[1,2,4]Program Studi Sistem Informasi
[3]Program Studi Manajemen Informatika
[5]Program Studi Teknik Komputer
Universitas Amikom Yogyakarta
https://home.amikom.ac.id/
marcheilla.01@students.amikom.ac.id[1], yoga.pristyanto@amikom.ac.id[2*], herisismoro@amikom.ac.id[3], nurmasani@amikom.ac.id[4], anggitferdita@amikom.ac.id[5]

Abstract— *The prevalence of mental disorders in Indonesia is increasingly significant, as seen from the 2018 Riskesdas data. Riskesdas records mental, emotional health problems (depression and anxiety) as much as 9.8%. This shows an increase when compared to the 2013 Riskesdas data of 6%. Based on these data, it can be said that many people still suffer from mental disorders. Meanwhile, the number of medical personnel, medicines and public treatment facilities for people with mental disorders is still limited. In addition, the lack of public awareness, concern and knowledge about mental health causes a lack of public interest in consulting a psychologist, so people tend to self-diagnose. One solution for self-diagnosis is to use an expert system. This study developed an expert system using the forward chaining method and certainty factor. Based on the research conducted, the results are as follows. First, the expert-based system that has been developed can help provide the results of a diagnosis that is carried out before there are complaints and will be detected early by efforts to increase awareness of the prevention of mental illness and reduce the tendency to self-diagnose. Second, applying the forward chaining method and certainty factor to this expert system can produce an accuracy rate of 95.918%. An expert has also validated these results; in this study, the expert was a psychologist at a hospital in Yogyakarta.*

Keywords*: Certainty Factor, Diagnosis, Expert System, Forward Chaining, Mental Illness.*

Intisari—Prevalensi jumlah gangguan jiwa di Indonesia semakin signifikan dilihat dari data Riskesdas tahun 2018. Riskesdas mendata masalah gangguan Kesehatan mental emosional (depresi dan kecemasan) sebanyak 9,8%. Hal ini terlihat peningkatan jika dibandingkan data Riskesdas tahun 2013 sebanyak 6%. Berdasarkan data tersebut dapat dikatakan bahwa masih banyak masyarakat yang menderita gangguan jiwa. Sementara jumlah tenaga medis, obat-obatan dan tempat pengobatan umum bagi penderita gangguan jiwa masih terbatas. Selain itu, kurangnya kesadaran, kepedulian dan pengetahuan masyarakat mengenai Kesehatan mental menyebabkan kurangnya minat masyarakat untuk berkonsultasi dengan psikolog sehingga masyarakat cenderung untuk melakukan selfi-diagnosis. Salah satu solusi untuk self diagnosis ialah dengan menggunakan sistem pakar. Pada penelitian ini sistem pakar yang dikembangkan menggunakan metode forward chaining dan certainty factor. Berdasarkan penelitian yang dilakukan hasilnya sebagai berikut. Pertama sistem Pakar berbasis yang telah dikembangkan dapat membantu memberikan hasil diagnosis yang dilakukan sebelum adanya keluhan dan akan di deteksi dini dengan Upaya meningkatkan kesadaran pencegahan terhadap gangguan jenis mental illness dan mengurangi kecenderungan untuk melakukan self diagnosis. Kedua dengan menerapkan metode forward chaining dan certainty factor pada sistem pakar ini dapat menghasilkan tingkat akurasi sebesar 95,918%. Hasil ini juga telah divalidasi oleg seorang pakar dimana pada penelitian ini pakarnya seorang ahli psikologi pada salah satu Rumah Sakit di Yogyakarta.*

Kata Kunci*: Certainty Factor, Diagnosa, Forward Chaining, Mental Illness, Sistem Pakar.*

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INTRODUCTION

Mental health disorders are conditions in which an individual has difficulty adjusting to the needs around him. The inability to solve a problem causing excessive stress makes the individual's mental health more vulnerable, and eventually is declared to have a mental health disorder (RI, 2020b).

The prevalence of mental disorders in Indonesia is increasingly significant, as seen from the 2018 Riskesdas data. Riskesdas records mental, emotional health problems (depression and anxiety) as much as 9.8%. This condition showed an increase compared to the 2013 Riskesdas data of 6%. The high increase in emotional and mental health problems based on age group, the highest percentage was at the age of 65-75 years and over, as much as 28.6%, followed by the age group 55-64 years, as much as 11%, then the age group 45-54 years and 15-24 years had a higher percentage—the same as 10%. Furthermore, of around 14.5 million people with depression and anxiety, only about 9% are undergoing medical treatment (RI, 2020a).

Furthermore, the prevalence of severe mental disorders, such as schizophrenia, reaches around 400,000 people or as much as 1.7 per 1,000 population. Based on these data, it can be said that many people still suffer from mental disorders. Meanwhile, the number of medical personnel, medicines, and public treatment facilities for people with mental disorders is still limited (Mariyati et al., 2021; Yulianti & Astari, 2020).

The amount of information that is easy to find on the internet and other articles for self-diagnosis is one of the factors behind the increase in mental health disorders. The lack of public awareness, concern, and knowledge about mental health causes a lack of public interest in consulting a psychologist, so people tend to self-diagnose. According to (Borghouts et al., 2021) self-diagnosis or self-diagnosis is an effort to decide that one has a disease or disorder based on available information about knowledge related to perceived experience. With the ease of access to information via the internet and articles when self-diagnosis, it is concluded that self-diagnosis is not recommended because it is detrimental to oneself and can worsen the condition if one does not get appropriate treatment (Marbun & Santoso, 2021; Maskanah, 2022).

Based on the existing problems, a system is needed that can provide information on the results of examinations that were carried out before there were complaints and will be detected early in an effort to increase awareness of the prevention of mental disorders by building an expert system. An expert system is a computer system that is capable of imitating the reasoning of an expert with expertise in computer knowledge which, in principle, works to provide a definite solution like that of an expert (Alshawwa et al., 2019; Hayat et al., 2019). In order to get an accurate diagnosis of a type of mental illness, testing is needed with various methods so that you can find out which method is better. Until now, there is no guarantee that a diagnostic method used is the best method (Alsagheer et al., 2021).

Several studies on expert systems in the health sector have been carried out. Research conducted by Widodo et al. (Widodo & Jaya, 2018) used an expert system to diagnose the level of depression in final-year students using the certainty factor method. The result of this research is to implement the certainty factor method, which can diagnose the level of depression in students, and it can be concluded that the results of the comparison and accuracy are 97%, with these results helping psychologists/experts in diagnosing the level of depression in students. Similar research was also conducted by Sukiakhy et al. (Sukiakhy et al., 2022), who used the certainty factor method to diagnose mental disorders in children and adolescents. With the existence of an expert system, it is hoped that it can provide knowledge and can assist parents in carrying out early self-diagnosis of mental disorders that their children experience independently.

On the other hand, Aldisa (Aldisa, 2022) also conducts research on implementing expert systems for diagnosing mental health conditions. This study used the forward chaining method for the diagnostic process. The results of this study indicate that the resulting system is faster and easier to provide an understanding of the types of mental health conditions; the state of the diagnosis results and the alpha test obtained 51%, so it can be concluded that the system is feasible to use. In addition, Sholeha et al. (Sholeha et al., 2023) conducted a similar study using the forward chaining method. The result is that the resulting expert system can determine the level of depression based on the symptoms the user selects. The level of depression the system generates is normal, mild, moderate and severe. Then the system's accuracy level reaches 86.67% from 15 data owned by experts 13 data is the same as the system.

Based on various studies that have been carried out, in this study an expert system will be proposed using the Forward Chaining method to conduct symptom tracing and apply the Certainty Factor method to diagnose mental illness certainty results. This combination is done to obtain better results in diagnosing. There are two contributions to this research. First, the system built can be used to help make an early diagnosis of mental illness with accurate results. Both of these studies can be a

reference in developing expert systems, especially for diagnosing mental illness.

MATERIALS AND METHODS

This section will discuss materials and methods together with the flow of this research, which is divided into four main stages: Data Acquisition, Knowledge Representation, System Development and System Testing. Following figure 1 is the research workflow.

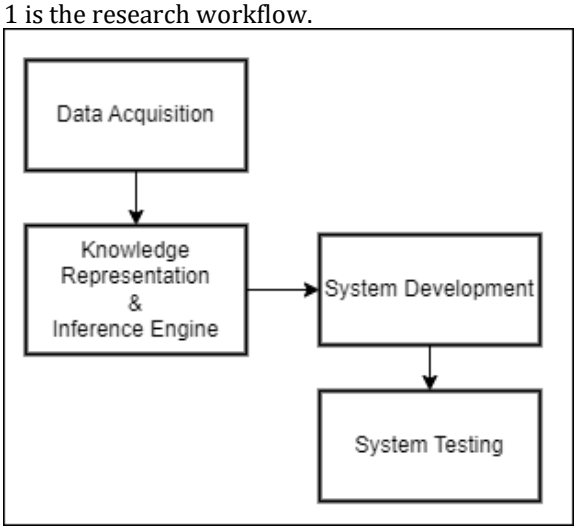

Figure 1. Research Workflow

The following points A to D are an explanation of each stage in this research.

A. *Data Acquisition*

Data acquisition is the stage of data collection to develop this expert system in the form of data on types of mental disorders and supporting symptom data obtained from interviews with a psychologist or psychologist at a hospital in Yogyakarta.

B. *Knowledge Representation and Inference Engine*

Knowledge representation is a technique for representing the knowledge base obtained in a particular scheme or diagram so that the relationship or connection between data and other data can be known. In this study, knowledge representation is a rule table with evidence value from an expert. After that, the next stage is the withdrawal of reasoning using the inference engine. This study uses the Forward Chaining and Certainty Factor as an inference engine. There are two kinds of certainty factors that are used (Alfiah et al., 2019; Pamungkas et al., 2021), the first is the certainty factor which is filled in by the expert along with the rules. The second is the certainty factor given by the user. The process of calculating the percentage of confidence begins with rules that have a single symptom. Then each new rule calculates its CF value using Equation 1 below.

$$CF = CF_{user} * CF_{pakar} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The rules of the Certainty Factor method are as follows (Putra & Yuhandri, 2021; Rahmadhani et al., 2020; Ramadhan & Sitorus Pane, 2018; Sholeha et al., 2023; Sukiakhy et al., 2022).
First, the rules for adding two positive Certainty Factor factors use equation 2.

$$(CF_a CF_b) = CF_a + CF_b * (1 - CF_a) \ldots\ldots\ldots\ldots\ldots (2)$$

The second is rules for adding two negative Certainty Factors use equation 3.

$$(CF_c CF_d) = CF_c + CF_d + (CF_c * CF_d) \ldots\ldots\ldots\ldots\ldots (3)$$

The third is rules for adding positive Certainty Factors and negative certainty factors are more complex using equation 4.

$$(CF_e CF_f) = \frac{CF_e + CF_f}{1 - (|CF_e|, |CF_f|)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

C. *System Development*

In this study, system development uses the System Development Life Cycle method with modelling using use case diagrams in the Unified Modeling Language (UML). In the UML method, use cases are used to describe system requirements and how users can interact with the system. While the Activity diagram describes a series of flows from user activity (users) and the system. Class diagrams describe the types of objects in the system and the various kinds of static relationships between them. Sequence diagrams are used to describe the dynamic behaviour of the system that occurs between objects or entities.

D. *System Testing*

The final stage in the research is to test the system. In this research, system testing is divided into two scenarios. First testing using Black Box Testing is carried out to test the functionality of the features in this expert system. The second is testing the level of accuracy of the expert system that has been developed. Testing the level of accuracy is carried out by conducting several test scenarios to find out the output produced by the expert system following the validation of an expert.

RESULTS AND DISCUSSION

In this section, the overall results obtained from this research will be discussed, especially in terms of the expert system developed based on the stages that have been carried out.

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A. Data Acquisition

The data in this study focused only on the types of disorders most commonly experienced in today's society. The types of mental illness disorders found in this expert system are described in Table 1. In addition, the disease data obtained has also been validated by an expert; in this study, the expert was a psychologist at a hospital in Yogyakarta.

Table 1. List of Mental Illnesses

Code	Mentall Illnes
P01	Anxiety Disorder
P02	Skizofrenia
P03	Mood Disorder
P04	Autism
P05	Attention deficit hyperactivy disorder
P06	Depression

In addition, it is also equipped with data on symptoms of mental illness. The types of mental illness symptoms found in this expert system are described in Table 2. In addition, the symptom data obtained has also been validated by an expert; where in this study, the expert was a psychologist at a hospital in Yogyakarta.

Table 2. List of Mental Illnesses Symptoms

Code	Symptoms
G01	Fear of a specific phobia or fear of an object
G02	Anxiety in every situation
G03	Social anxiety
G04	Obsessive-compulsive disorder
G05	Panic attacks
G06	Feeling worried
G07	Post-traumatic stress disorder
G08	Talking over and over to yourself
G09	Avoiding social contact
G10	Talking and seeing things that are not there
G11	Problems with memory and reasoning
G12	Depression and lack of emotion
G13	Have no attention
G14	Get bored quickly with routine
G15	Very active and cannot stay still
G16	Cannot concentrate or focus
G17	Talking and not listening
G18	Touching and playing with everything
G19	Talking without thinking and acting emotionally
G20	Feeling like being alone
G21	Difficulty in speaking
G22	Strange body movements and patterns
G23	Indifference and lack of emotion towards objects, people and events
G24	Lack of confidence
G25	Difficulty adapting to other people
G26	Loss of energy
G27	Changes in appetite
G28	Sleep disorders
G29	Feeling anxious
G30	Inability to make decisions
G31	Feeling uneasy
G32	Feeling useless
G33	Feeling guilty or hopeless
G34	Thinking about self-harm/suicide

B. Knowledge Representation and Inference Engine

An expert system that applies the certainty factor calculation method takes several rules or rules and the weight of the CF value given by the expert. The rules in this study are made in the form of IF-THEN (if-then) equipped with expert CF values. CF values are required for each symptom in each disorder. Experts provide a CF value scale for each symptom between 0.2 – 1.0 according to the expert's belief in the symptoms of a particular disorder. The rules containing the symptoms and expert CF values for each disorder are shown in Table 3 below.

Table 3. Rules Based of Mental Illnesses

No	Rules	CF Expert
1	*IF is afraid of a specific phobia or object THEN Anxiety Disorder*	0.5
2	*IF anxiety in every situation THEN Anxiety Disorder*	0.5
3	*IF social anxiety THEN Anxiety Disorder*	0.3
4	*IF obsessive-compulsive disorder THEN Anxiety Disorder*	0.3
5	*IF panic attacks THEN Anxiety Disorder*	0.5
6	*IF is worried THEN Anxiety Disorder*	0.4
7	*IF post-traumatic stress disorder THEN Anxiety Disorder*	0.4
8	*IF avoids social contact THEN Anxiety Disorder*	0.4
9	*IF feels like being alone THEN Anxiety Disorder*	0.3
10	*IF lack of self-confidence THEN Anxiety Disorder*	0.2
11	*IF finds it difficult to adapt to other children THEN Anxiety Disorder*	0.6
12	*IF speaks repeatedly for itself THEN Schizophrenia*	0.5
13	*IF avoids social contact THEN Schizophrenia*	0.4
14	*IF speaks and sees things that are not there THEN Schizophrenia*	0.3
15	*IF has problems with memory and reasoning THEN Schizophrenia*	0.2
16	*IF depression and lack of emotion THEN Schizophrenia*	0.3
17	*IF has no concerns THEN Schizophrenia*	0.3
18	*IF has problems with memory and reasoning THEN Mood Disorders*	0.6

No	Rules	CF Expert
19	*IF depression and lack of emotion THEN Mood Disorders*	0.2
20	*IF has no concerns THEN Mood Disorders*	0.5
21	*IF quickly gets bored with routine THEN Mood Disorders*	0.4
22	*IF lack of self-confidence THEN Mood Disorders*	0.3
23	*IF has difficulty adapting to other people THEN Mood Disorders*	0.5
24	*IF speaks without thinking and acts emotionally THEN Autism*	0.5
25	*IF feels like being alone THEN Autism*	0.6
26	*IF has difficulty speaking THEN Autism*	0.3
27	*IF Strange body movements and patterns THEN Autism*	0.2
28	*IF indifference and lack of emotion towards objects, people and events THEN Autism*	0.2
29	*IF lack of self-confidence THEN Autism*	0.5
30	*IF finds it difficult to adapt to other children THEN Autism*	0.4
31	*IF speaks repeatedly for itself THEN ADHD*	0.5
32	*IF speaks and sees things that are not there THEN ADHD*	0.4
33	*IF has problems with memory and reasoning THEN ADHD*	0.5
34	*IF quickly gets bored with activities THEN ADHD*	0.4
35	*IF is very active and can't stay still THEN ADHD*	0.2
36	*IF cannot concentrate or focus THEN ADHD*	0.3
37	*IF talks all the time and can't listen THEN ADHD*	0.4
38	*IF touches and plays with everything THEN ADHD*	0.5
39	*IF speaks without thinking and acts emotionally THEN ADHD*	0.3
40	*IF cannot concentrate or focus THEN Depression*	0.5
41	*IF loses energy THEN Depression*	0.5
42	*IF changes in appetite THEN Depression*	0.4
43	*IF sleep disorders THEN Depression*	0.3
44	*IF feels anxious THEN Depression*	0.2
45	*IF inability to make decisions THEN Depression*	0.2
46	*IF feels uneasy THEN Depression*	0.2
47	*IF feels useless THEN Depression*	0.1
48	*IF feels guilty or hopeless THEN Depression*	0.3
49	*IF thinks about self-harm/suicide THEN Depression*	0.6

After the production rules are made, the next step is to conduct a diagnostic experiment to ensure that the inference engine used works correctly. The inference engine used is Forward Chaining combined with Certainty Factor. To better understand the process of calculating this system, the following is an example of a case in performing manual calculations using the Forward Chaining and Certainty Factor methods.

For example, there has been a man for some time recently who has felt that he has a mental health disorder. The symptoms he is feeling are as follows.

1) Not being able to concentrate and focus is a symptom of ADHD (P05) and Depression (P06)
2) Changes in appetite are a symptom of depression (P06)
3) Feeling uneasy is a symptom of depression (P06)
4) Feeling useless is a symptom of Depression (P06)
5) Feeling guilty or hopeless is a symptom of depression (P06)

So for diagnostic calculations using Forward Chaining and the Certainty Factor is as follows.

1) ADHD (P05)
   Cannot concentrate and focus (G36) [CFexpert = 0.3 || CFuser = 0.6]
   CF(G36) = CFuser * CFexpert = 0.6 * 0.3 = **0.18**

2) Depression (P06)
   Cannot concentrate and focus (G40) [CFexpert = 0.5 || CFUser = 0.6]
   CF(G40) = CFuser * CFexpert = 0.6 * 0.5 = **0.3**
   Changes in appetite (G42) [CFpakar = 0.4 || CFuser = 0.2]
   CF(G42) = CFuser * CFexpert = 0.2 * 0.4 = **0.8**
   Feeling uneasy (G46) [CFexpert = 0.2 || CFuser = 0.6]
   CF(G46) = CFuser * CFexpert = 0.6 * 0.2 = **0.12**
   Feeling useless (G47) [CFexpert = 0.1 || CFuser = 0.6]
   CF(G47) = CFuser * CFexpert = 0.6 * 0.1 = **0.6**
   Feeling guilty or hopeless (G48) [CFexpert = 0.3 || CFuser = 0.2]

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CF(G48) = CFuser * CFexpert = 0.2 * 0.3 = **0.6**
Then calculate it using CF Combination

CF Comb = CFa + CFb * (1 - CFa)
= 0.3 + 0.8 * (1 – 0.3)
= 0.3 + 0.8 * (0.7)
= 0.3 + 0.56
= 0.86
= 0.86 + 0.12 * (1 – 0.86)
= 0.86 + 0.12 * (0.14)
= 0.86 + 0.0168
= 0.8768
= 0.8768 + 0.6 * (1 – 0.8768)
= 0.8768 + 0.6 * (0.1232)
= 0.8768 + 0.07392
= 0.95072
= 0.95072 + 0.6 * (1 – 0.95072)
= 0.95072 + 0.6 * (0.0928)
= 0.95072 + 0.029568
= 0.980288

Based on the above calculations, it can be seen that the results of the diagnosis with the highest level of confidence in the type of mental illness suffered by a man are depression, with a CF value percentage of 98%.

C. *System Development*

In system development, the interface implementation stage is one of the essential stages in meeting user needs in interacting with the system created. Good interface facilities will significantly assist the user in understanding the processes being carried out by the system to improve system performance. In this section, two primary feature interfaces will be displayed on the system that has been built, namely the diagnosis page interface and the diagnostic results page interface.

On the diagnosis interface page containing the selection of symptoms and conditions, the user must select the conditions that match what he is suffering from to carry out system processes. The details of the diagnostic page interface can be seen in Figure 2.

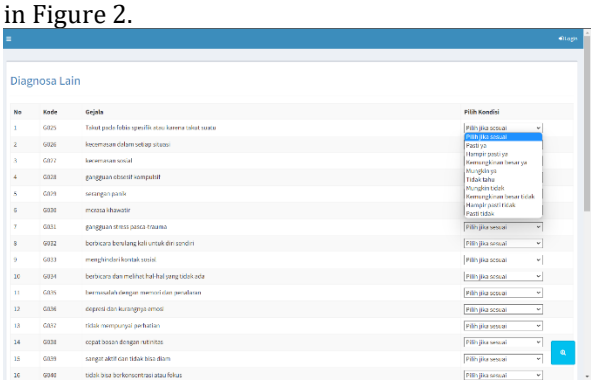

Figure 2. The Diagnostic Page Interface

While the results of the diagnosis display the results of the symptoms that have been selected in the form of CF and % (per cent) values, descriptions, pictures and suggestions for handling the disorder, details of the interface for the diagnosis results page, can be seen in Figure 3.

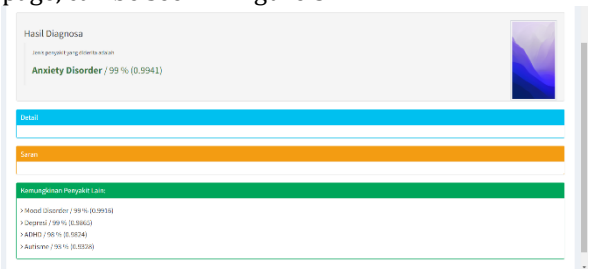

Figure 3. The Diagnostic Results Page Interface

D. *System Testing*

The final stage in the research is system testing. In this work, system testing is divided into two scenarios. First testing using Black Box Testing is carried out to test the functionality of the features in this expert system. Following Table 4 is the results of Black Box testing.

Table 4. Black Box Testing Results

No	Features	Scenarios	Results
1	Admin Login	Enter the registered username and password	Valid.
		Entering an unregistered username and password	Valid.
2	Nuisance Data	Enter fault data	Valid.
		Editing fault data	Valid.
		Delete tampering data	Valid.
3	Symptoms Data	Enter symptom data	Valid.
		Edit symptom data	Valid.
		Delete symptom data	Valid.
4	Knowledge Data	Input knowledge data	Valid.
		Edit knowledge data	Valid.
		Deleting knowledge data	Valid.
5	Admin	Enter admin data	Valid.
		Edit admin data	Valid.
		Delete admin data	Valid.
6	Logout	Pressing the logout button	Valid.
7	Diagnosis	Choose the condition of the symptoms you are experiencing, then click the process button	Valid.

Based on the tests carried out, overall, the features contained in this expert system have been running well. This is shown in Table 3, with no errors in all the test scenarios performed.

The second is testing the level of accuracy of the expert system that has been developed. Testing the

level of accuracy is carried out by conducting several test scenarios to find out the output produced by the expert system following the validation of an expert. The following Table 5 is an example of an expert system accuracy testing scenario that has been developed.

Table 5. Accuracy Testing Scenario

No	Symptoms	System	Expert	Results
1	a. Problems with memory and reasoning b. Depression and lack of emotion c. Has no attention d. Get bored quickly with routine e. Lack of self-confidence f. Difficulty adapting to other children	Mood Disorder 99%	Mood Disorder	Valid
2	a. Speak without thinking and act emotionally b. Feel like you want to be alone c. Difficulty in speaking d. Strange body movements and patterns e. Indifference and lack of emotion towards objects, people and events f. Lack of self-confidence g. Difficulty adapting to other children	Autism 97%	Autism	Valid

Accuracy testing aims to determine the performance of the expert system in providing the results of a diagnosis of a type of mental illness. At this stage, there are 49 cases with various symptoms and diseases to test the accuracy of expert analysis values, which will be compared with the actual expert system results. Based on the tests carried out from a total of 49 cases tested, 47 of them had a concordance between the system diagnosis and the expert diagnosis. Meanwhile, in the other 2 cases, there were still differences between system and expert diagnoses. Then the accuracy value of this expert system can be calculated using the following equation 5.

$$Accuracy = \frac{True\ Diagnosis\ Data}{All\ Diagnosis\ Data} * 100\% \text{.....(5)}$$

$$Accuracy = \frac{47}{49} * 100\%$$

$$Accuracy = 95{,}918\ \%$$

Based on the test results, it can be concluded that the percentage accuracy value from the comparison results of expert systems for diagnosing mental illness types with the forward chaining method and the certainty factor has a value of 95,918%.

CONCLUSION

Based on the research results of the expert system for diagnosing mental illness using Forward Chaining and the Certainty Factor Method, the conclusions are drawn as follows. First, the expert-based system that has been developed can help provide the results of a diagnosis that is carried out before there are complaints and will be detected early by efforts to increase awareness of the prevention of mental illness and reduce the tendency to self-diagnose. Second, applying the forward chaining method and certainty factor to this expert system can produce an accuracy rate of 95.918%. An expert has also validated these results; in this study, the expert was a psychologist at a hospital in Yogyakarta. The suggestion for further research is to form a more accurate knowledge base by adding data on symptoms and disorders from various experts to produce a better diagnosis process.

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