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Comparative Analysis: Accuracy of Certainty Factor and Dempster Shafer Methods in Expert Systems for Tropical Disease Diagnosis

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Abstract.
Purpose: This study aims to diagnose Neglected Tropical Diseases early by applying the concept of an expert system as a tool that works by mimicking the thought patterns of an expert (doctor). The methods applied in this expert system are Certainty Factor and Dempster Shafer. Both methods work by combining a number of pieces of evidence (symptoms) to produce a confidence value for a disease.
Methods: The study began with discussions and interviews with experts to collect information and data about Neglected Tropical Diseases. Conducting a literature review study to enrich knowledge about Neglected Tropical Diseases. Two main inference methods are used to detect diseases based on patient symptoms. The Certainty Factor method uses expert value weighting parameters and patient input value weighting as a basis for knowledge. The Dempster Shafer method only uses expert value weighting in analyzing the probability of symptoms to produce a level of diagnostic accuracy.
Result: The Certainty Factor method works by integrating patient and expert weight values into its calculations. Meanwhile, the Dempster Shafer method considers expert weight values without involving patient weight values. Expert system searches using the Forward Chaining inference engine show that the Certainty Factor method has an accuracy probability value of up to 90%. Meanwhile, the Dempster Shafer method has an accuracy value of 70%.
Novelty: The results of the study show that expert systems can be applied in the health sector, especially in diagnosing Neglected Tropical Diseases. Of the two methods used, the Certainty Factor method shows a high accuracy value, so it can help detect Neglected Tropical Diseases early and provide treatment solutions to improve health.

Keywords: Neglected tropical diseases, Expert system, Certainty factor, Dempster shafer
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INTRODUCTION

The World Health Organisation (WHO) pays special attention to countries with tropical climates in relation to health issues, particularly Neglected Tropical Diseases (NTDs) [1][2]. NTDs are infectious diseases that affect people living in poor conditions [3]. In 2010, there were 17 classifications of diseases, and this number has continued to grow to 21 diseases in 2023 [4].

Indonesia has a tropical and subtropical climate, climates with high humidity and temperature are sources of disease spread and microorganism growth [5]. The transmission of NTDs is caused by environmental, socio-economic, and biological factors [6]. Environmental factors are closely related to the causes of endemic diseases, such as dengue haemorrhagic fever (DHF) [7]. Continued climate change can worsen conditions, often occurring in areas with low socioeconomic levels [8]. High poverty rates are correlated with inadequate access to health services, making them vulnerable to disease, especially in remote areas where communities depend on agriculture. Traditional livelihoods and inadequate public health infrastructure exacerbate health services [9].
Some serious diseases have similar symptoms that require an accurate diagnosis. For example, leprosy, caused by Mycobacterium leprae, is still overlooked [10]. Protozoal infections caused by parasites are widespread due to poor sanitation and hygiene [11]. The prevalence of infections contributes to disease and environmental degradation [12]. Various infectious diseases, such as smallpox, tuberculosis (TB), diphtheria, pertussis, SARS (Severe Acute Respiratory Syndrome), elephantiasis (filariasis), and others, are easily spread [13].

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NTD diagnosis can utilize ES using machine learning algorithms with knowledge-based inference models for fast and accurate decision-making [14]. ES never changes over time [15], and the system continuously collects and loads knowledge-oriented information [16]. Many studies have applied ES to problem-solving [17], using knowledge-based systems that think intelligently like experts [18]. Knowledge is integrated into logical models to generate decisions [19][20].

ES, with its inference engine, can apply CF and DS methods to handle diagnostic uncertainty [21][22]. CF applies rules from experts to measure the level of confidence in a hypothesis [23], applying rule-based ES to health diagnosis [24][25]. This approach has proven effective in the medical field for early detection [26]. Meanwhile, DS is a flexible framework for managing beliefs and handling uncertainty in decision making [27]. The DS approach to disease diagnosis is useful when data and information sources are conflicting and not complex [28], so that DS can provide accurate diagnostic results [29][30]. The role of DS in various fields can help in decision-making [31], especially in health services for prevention and treatment [32].

CF and DS methods have advantages and disadvantages in terms of accuracy, computational complexity, and ability to handle uncertainty. CF is easier to implement and interpret [33], producing numerical outputs in clinical settings [34]. DS tends to provide a more comprehensive analysis by representing levels of confidence and uncertainty [35][36]. Recent studies have shown that both methods play an important role. Integration of the two can leverage their respective strengths. CF provides a rapid initial assessment, while DS can improve decisions based on cumulative evidence [37] in diagnosing NTDs due to their diverse and often uncertain symptoms [38]. This integration simulates expert reasoning and provides contextually and statistically relevant recommendations [39], thereby improving diagnostic accuracy [40], especially for similar symptoms [41].

Based on the background, CF and DS can improve diagnostic accuracy, decision-making efficiency, safety, and quality of healthcare [42]. Therefore, this study conducted an early diagnosis of NTDs by implementing ES as a tool that can mimic a doctor's thought process. The diagnostic results of CF and DS will provide the best accuracy values, optimal methods, and treatment solutions based on the patient's initial symptoms.

METHODS

Figure 1 shows the methodology for diagnosing NTDs using the CF and DS methods.

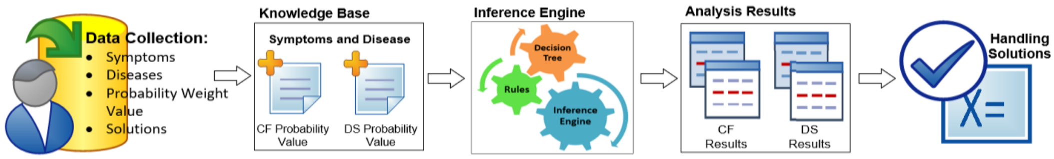

Figure 1. NTDs diagnostic framework

Data collection, knowledge base, and inference engine

Data collection was conducted by interviewing experts (internal medicine specialists) to obtain information related to NTDs based on symptoms, disease names, probability weighting, and treatment solutions. Meanwhile, the knowledge base is the thinking intelligence of experts obtained from experience in handling patient cases.. The knowledge base includes symptoms, disease names, probability weight values, and treatment solutions. An inference engine is an expert's reasoning rules for determining a disease expressed in IF-THEN rules. IF is the existing condition, THEN is the action or response that is triggered.

Certainty factor methods

The first rule of the CF method is to add two positive CF factors. The second rule for adding two negative CF factors, and the third rule for adding positive and negative CF factors [43]. The formulation is as follows:

$$F = CF_{user} * CF_{expert} \quad (1)$$

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

$$(CF_cCF_d = CF_c + CF_d + (CF_c * CF_d) \quad (3)$$

$$(CF_eCF_f) = \frac{CF_e + CF_f}{1 - (/CF_e/, /CF_f/)} \quad (4)$$

Where CF_user is the patient's level of confidence in the symptoms/facts (input from the user). CF_expert is the expert's (doctor's) level of confidence in the relationship between symptoms and disease/hypothesis, and F is the certainty factor value resulting from the combination of user and expert confidence.

Dempster shafer methods

DS mathematically constructs facts through belief functions and logical reasoning, integrating various pieces of information while considering all possibilities of an event [44]. Belief (Bel) defines a cumulative measure of confidence in a set of statements. A Bel = 0 indicates no evidential support, while a Bel = 1 indicates absolute certainty. Where Pl is plausibility (0 - 1), and Bel is belief. DS is the assessment framework concept (θ), which represents the universe of discourse of various possible hypotheses. The combined function m_3, is the result of the combination of m_1 and m_2. Formulate DS as follows:

$$[Belief, Plausibility] \quad (5)$$

$$Pl(s) = 1 - Bel\ (\sim s) \quad (6)$$

$$m_3 = \frac{\Sigma\ X \cap Y = m1\ (X)\ .m2(Y)}{1 - \Sigma\ X\ \cap\ Y = \theta m1\ (X).\ m2(Y)} \quad (7)$$

The explanation is: where m_1 is probability density 1, m_2 is probability density 2, m_3 is probability density 3, X ∩ Y is the disease X slice disease Y, and θ is the frame of discernment.

RESULTS AND DISCUSSIONS

This research requires the expertise of internal medicine specialists (doctors) working in a hospital to accurately diagnose NTDs. It is then supported by a literature review of NTDs. This results in a knowledge base covering symptoms, disease names, probability weights, and treatment solutions.

Expert system knowledge base

This study consists of 38 symptoms and 10 NTDs obtained from interviews with doctors based on diagnoses of patients in the hospital and literature reviews [45]. The names of the diseases in Table 1.

Table 1. Names of NTDs

No	ID_Disease	Disease Name	No	ID_Disease	Disease Name
1	DE01	Dengue Haemorrhagic Fever (DHF)	6	DE06	Pertussis
2	DE02	Malaria	7	DE07	Chikungunya
3	DE03	Elephantiasis	8	DE08	Typhoid Fever
4	DE04	Chickenpox	9	DE09	Diphtheria
5	DE05	Tuberculosis (TBC)	10	DE10	SARS

The next step is to determine the symptom weight values obtained from experts through a comprehensive analysis of patient diagnoses to measure the significance of each clinical symptom. The symptom weight values are shown in Table 2. The results of NTDs symptom weighting according to knowledge base criteria are presented in Table 3.

Table 2. Determination of symptom weight values by experts

No	ID_Symp	Symptom Weight Value	No	ID_Symp	Symptom Weight Value
1	Very confident	1	4	A little sure	0.4
2	Sure	0.8	5	Do not know	0.2
3	Sure enough	0.6	6	No	0

Table 3. Symptom weight values

ID Symp	Symptom Name	Weight	ID Symp	Symptom Name	Weight
SY01	Prolonged fever	0.45	SY20	Blood-tinged phlegm	0.45
SY02	Periodic fever	0.45	SY21	Shortness of breath	0.3
SY03	Red spots	0.4	SY22	Red and watery eyes	0.15
SY04	Nosebleeds	0.15	SY23	High-pitched coughing	0.4
SY05	Upper abdominal pain	0.1	SY24	Weight loss	0.2
SY06	Dehydration	0.05	SY25	Night sweats	0.35
SY07	Chills	0.2	SY26	Red-coloured urine	0.05
SY08	Cold sweats	0.02	SY27	Feeling weak and fatigued	0.25
SY09	Vomiting	0.45	SY28	Headache	0.25
SY10	Excessive sweating	0.35	SY29	Diarrhea	0.1
SY11	Flu	0.4	SY30	Abdominal pain	0.4
SY12	Joint and muscle pain	0.4	SY31	White coating on the middle of the tongue	0.1
SY13	Swollen lymph nodes	0.7	SY32	Difficulty defecating	0.35
SY14	Swelling of the legs, arms, breasts, or testicles	0.6	SY33	Inflamed tonsils	0.45
SY15	Swelling in the legs and armpits	0.75	SY34	Runny nose	0.3
SY16	Red eyes	0.2	SY35	Skin rash	0.15
SY17	Sensitivity to light	0.2	SY36	Joint inflammation	0.35
SY18	Red spots on the body spread to other body parts	0.5	SY37	Muscle stiffness	0.15
SY19	Coughing	0.45	SY38	Pain in the spine and back	0.2

Inference engine

The ES reasoning process applies an FC inference engine. It uses the IF-THEN rule, which is an implicative relationship between two parts. IF is the premise derived from the symptoms, and THEN is the conclusion indicating the name of the disease. Data is converted into reasoning rules in algorithmic syntax. As an illustration, the algorithm below is an example of a simple reasoning rule for the case of Dengue Hemorrhagic Fever (DHF). The search for symptoms to determine the name of the disease is depicted in the inference tree schematic, as shown in Figure 2.

```
IF prolonged fever
     THEN red spots
        IF red spots
        THEN nosebleed
            IF nosebleed
            THEN heartburn
               IF heartburn
               THEN dehydration
                   IF dehydration
                   THEN cold sweat
                       IF cold sweat
                       THEN Dengue Hemorrhagic Fever (DHF)
```

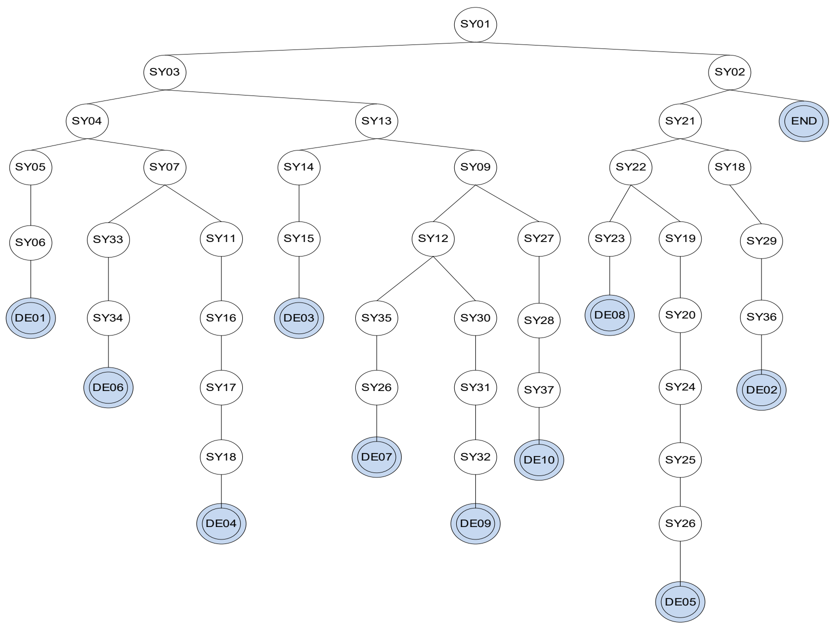

Figure 2. Diagnosis inference tree for NTDs

Analysis of CF and DS methods based on knowledge

For example, consider a case study of a patient with symptoms and symptom weights as shown in Table 4.

Table 4. Names of symptoms and values from experts

No	Symptom Name	Patient Value	No	Symptom Name	Patient Value
1	Prolonged fever	0.6	4	Heartburn	0.8
2	Red spots	0.6	5	Dehydration	0.6
3	Nosebleeds	0.6	6	Cold sweats	0.8

Certainty factor method analysis

The CF method integrates patient input weights with symptom weights according to Table 3. The CF process begins by multiplying the two weights using Equation 1; this is followed by aggregating the CF factor multiplication results. As an illustration, the calculation procedure for a patient with Dengue Haemorrhagic Fever (DHF) using patient input values from Table 4. Results of the multiplication of weight values and the combination rule CF value in Table 5.

Table 5. Multiplication of weight values and combination rule CF value

ID_ Symp	Symptom Name	Expert Weight Value	Value of Patient Possibility	Multiplcation	CF Combination
SY01	Prolonged fever	0.45	0.6	0.27	CFcombine CF[D,S]1.2 = CF[D,S]1 + CF[D,S]2 * (1-CF[D,S]1)
SY03	Red spots	0.4	0.6	0.24	= 0.27 + 0.24 * (1-0.27) = 0.445 (T1)
SY04	Nosebleeds	0.15	0.6	0.09	CFcombine CF[D,S]T1,3 = CF[D,S]T1,3+CF[D,S]3*(1-CF[D,S]T1) = 0.445 + 0.09 * (1-0.445) = 0.494 (T2)
SY05	Heartburn	0.1	0.8	0.8	CFcombine CF[D,S]T2,4 = CF[D,S]T2,4+CF[D,S]4*(1-CF[D,S]T2) = 0.494 + 0.08 * (1 – 0.494) = 0.534 (T3)
SY06	Dehydration	0.05	0.6	0.03	CFcombine CF[D,S]T3,5 = CF[D,S]T3,5+CF[D,S]5*(1-CF[D,S]T3) = 0.534 + 0.03 * (1 – 0.534) = 0.547 (T4)
SY08	Cold sweats	0.02	0.8	0.016	CF(x) > 0 and CF(y) > 0 = 0.547+ 0.016 – (0.547 * 0.016) = 0.555 (T5)

The combined value of the CF rule in Table 5 provides the conclusion that the patient is likely to suffer from Dengue Hemorrhagic Fever (DHF) with a value of 0.555 (T5).

Dempster shafer method analysis

The DS method also applies value weights sourced from experts as listed in Table 4. The computational process begins with calculating the belief and plausibility values for each symptom, taking into account user value weights and expert value weights. In the initial stage, the first symptom obtained a density value of m_1 (G_1) = 0.45 and m1 (θ) = 0.55. The second symptom, recalculating the belief and plausibility values of the symptom with a density value of m_2 (G_2) of 0.4 and a density value of m_2 (θ) of 0.6, as shown in Table 8, displays density values from m_3 to m_6. The results are presented in Table 6.

Table 6. The Density value of m_n (G_n)

ID_Symp	Symptom Name	m_n (G_n)	m_n (θ)
SY01	Prolonged fever	m_1 (G_1) = 0.45	m_1 (θ) = 1 – 0.45 = 0.55
SY03	Red spots	m_2 (G_2) = 0.4	m_2 (θ) = 1 – 0.4 = 0.6
SY04	Nosebleed	m_3 (G_3) = 0.15	m_3 (θ) = 1 – 0.15 = 0.85
SY05	Heartburn	m_4 (G_4) = 0.1	m_4 (θ) = 1 – 0.1 = 0.9
SY06	Dehydration	m_5 (G_5) = 0.05	m_5 (θ) = 1 – 0.05 = 0.95
SY08	Cold sweats	m_6 (G_6) = 0.02	m_6 (θ) = 1 – 0.02 = 0.98

The next step is to use equation 7 to calculate the combination function values from the first symptom to the sixth symptom. The combination function values m_3 for Dengue Haemorrhagic Fever (DHF) in Table 7. The summary of the confidence and plausibility values of the m_3 combination for DHF is in Table 8.

Table 7. Combination function m_3

m_1 (SY01)	m_2 (SY03)	m_2 (Pl) Θ	DS method results for m3
m_1 (SY01) = 0.45	m_3 = 0.18	m_3 = 0.27	m_3 (SY01) = (0.18 + 0.27) / (1-0) = 0.45
m_1(P_l) {Θ} = 0.1	m_3 = 0.04	m_3 {Θ} = 0.06	m_3 (SY03) = (0.04) / (1-0) = 0.04
			m_3 {Θ} = (0.06) / (1-0) = 0.06

Table 8. Density values in m_3 based on symptoms

No	Symptoms	Density (m)	Value
1	Prolonged fever and red spots	m_3 (SY01), m_3 (SY03), m_3 {Θ}	0.45, 0.04, 0.06
2	Nosebleeds	m_5 (SY04), m_5 (SY04), m_5 (DE01), m_5{Θ}	0.45, 0.04, 0.009, 0.051
3	Heartburn	m_7 (SY05), m_7 (SY05), m_7 (DE01), m_7 {Θ}	0.045, 0.04, 0.005, 0.045
4	Dehydration	m_9 (SY06), m_9 (SY06), m_9 (DE01), m_9 {Θ}	0.045, 0.04, 0.007, 0.043
5	Cold sweats	m_{11} (SY08), m_{11} (SY08), m_{11} (DE01), m_{11} {Θ}	0.045, 0.04, 0.007, 0.042

The results of the density assessment (m) in Table 8 indicate that the highest density values are found in m_3 and m_5, with a density probability value of 0.45, indicating the possibility of experiencing DHF.

Comparison of analysis results using the CF method and the DS method

The results of the recapitulation of probability values based on the provisions given by experts, the CF and DS approaches, provide analysis results as presented in Table 9 below.

Table 9. Recapitulation of comparison of expert analysis results, CF and DS

No	Disease Name	Expert	CF Method	DS Method
1	Dengue Haemorrhagic Fever (DHF)	0.58	0.55	0.45
2	Malaria	0.72	0.67	0.45
3	Elephantiasis	0.90	0.92	0.70
4	Chickenpox	0.94	0.90	0.48
5	Tuberculosis (TBC)	0.85	0.91	0.45
6	Pertussis	0.73	0.70	0.45
7	Chikungunya	0.82	0.80	0.56
8	Typhoid Fever	0.82	0.84	0.45
9	Diphtheria	0.74	0.76	0.30
10	SARS	0.70	0.65	0.45

Based on testing using the FC inference engine, Table 9 shows a comparison of the results between expert scores, CF, and DS. The probability value for CF is 0.92, and DS is 0.70, the same as for elephantitis. In the final test, CF obtained a score of 0.65, while DS obtained a score of 0.45. This evaluation appears to be declining, despite having tracked the six initial symptoms. Based on patient symptoms, the ES knowledge base shows a specific and direct relationship to the disease. CF works more effectively in handling linear relationships, while DS is relatively weak and suboptimal in the knowledge base. DS relies heavily on symptom density values. If the density values are imperfect, the DS rule combination process becomes inaccurate. CF is less complex, as it only requires the certainty factor value of each rule from the expert.

Several studies have shown that simple CF can outperform more complex DS methods because it reduces the risk of excessive computation and error accumulation [20].

Therefore, expert confidence values and the values generated by applying CF and DS influence the analysis results. The test performed did not show a relationship between the number of symptoms. ES search using FC provides a clear picture of the relationship between symptoms and disease. This means that the process of searching for symptoms and disease can be accurate in diagnosing NTDs.

Treatment solutions

Table 10 provides solutions for the treatment and prevention of NTDs. These solutions were obtained from interviews with experts and literature reviews. Thus, at the end of the diagnosis, treatment, and prevention, solutions can be provided to patients according to the disease they are suffering from.

Table 10. Solutions for NTDs management

ID_DE	Solutions	
	Treatment	Prevention
DE01	- Give the patient plenty of fluids, such as drinking as much water as possible. - Give fever reducers, and give Ringer's lactate infusion (under medical supervision)	- Perform the 3 methods (cover water storage containers, drain bathtubs, and bury unused items) - Use abate powder in gutters or water reservoirs - Use mosquito-repellent lotion
DE02	- Take the patient to the nearest health facility - Take special malaria medication - Drink plenty of water	- Conduct fumigation or fogging in malaria-endemic areas - Avoid mosquito bites by installing mosquito nets and using mosquito repellent, and do not go out at night.
DE03	- Administering Dicarbamazine (DEC) - Administering Ivermectin (Mectizan) - Administering Albendazole 400 mg single dose - Mass treatment with DEC and albendazole can be administered once a year	- Clean aquatic plants in swamps that are breeding grounds for mosquitoes, fill in, drain, or divert puddles of water. - Go directly to the nearest health agency.
DE04	- Drink plenty of water. - Give antihistamines or anti-itch medication, antiviral acyclovir, or vidarabine, and give multivitamins.	- Isolate patients - Improve nutrition for people living with patients - Carry out immunization
DE05	- Visit the nearest health facility immediately - Drink as much water as possible	- Reduce direct contact with people who have active tuberculosis - Wear a face mask, and do not spit in public places
DE06	- Erythromycin antibiotics - Intravenous fluids are administered if the patient shows signs of dehydration or difficulty eating. - Intensive care in the hospital	- 12 units of pertussis vaccine divided into 3 doses at 8-week intervals - Administration of 1.5 ml of pertussis immunoglobulin intramuscularly to children
DE07	- Simply take symptomatic medication (symptom relievers) such as fever reducers or painkillers.	- Avoid or eliminate mosquitoes that carry the virus.
DE08	- Antibiotics will help kill bacteria and cure the infection - Antitoxins are used to neutralize the diphtheria toxin that has spread throughout the body	- Prevention of diphtheria by joining the DPT vaccine
DE09	- Administration of antibiotics and intensive care in the hospital	- Pay attention to the cleanliness of food and beverages.
DE10	- Antipyretic treatment - Oxygen supplementation and ventilatory support	- Prevent transmission through the air, droplets, or contact - Treatment in an isolation room is recommended

Expert system accuracy testing

The ES diagnosis results for 20 patient cases present a comparative analysis of accuracy between the CF and DS methods. The notation used includes: X (Patient), SY (Symptoms), HC (Certainty Factor results), HD (Dempster Shafer results), and EX (expert diagnosis), which can be seen in Table 11.

Table 11. Expert system accuracy testing

X	SY	HC	HD	EX	CF	DS
X1	(SY01, SY04, SY06, SY08, SY14, SY15, SY17, SY19, SY20, SY21, SY23, SY25, SY27, SY30, SY32, SY34, SY38)	DE03	DE03	DE03	✓	✓
X2	(SY01, SY03, SY04, SY06, SY07, SY09, SY10, SY13, SY15, SY17, SY18, SY21, SY23, SY25, SY27, SY30, SY32, SY34)	DE02	DE04	DE04	x	✓
X3	(SY01, SY02, SY03, SY06, SY08, SY10, SY12, SY13, SY15, SY17, SY19, SY21, SY24, SY26, SY29, SY30, SY32, SY36, SY37)	DE06	DE07	DE06	✓	x
X4	(SY01, SY03, SY04, SY09, SY10, SY11, SY13, SY15, SY17, SY20, SY21, SY23, SY25, SY27, SY28, SY30)	DE07	DE07	DE07	✓	✓
X5	(SY01, SY04, SY06, SY08, SY09, SY11, SY13, SY14, SY15, SY17, SY19, SY20, SY21, SY23, SY25, SY27, SY30, SY32, SY34, SY35, SY38)	DE08	DE04	DE08	✓	x

X	SY	HC	HD	EX	CF	DS
X6	(SY01, SY04, SY06, SY08, SY17, SY19, SY21, SY23, SY25, SY27, SY30, SY32, SY35, SY38)	DE05	DE05	DE05	✓	✓
X7	(SY01, SY02, SY04, SY07, SY09, SY10, SY17, SY19, SY21, SY25, SY27, SY28, SY29)	DE09	DE09	DE09	✓	✓
X8	(SY02, SY03, SY05, SY07, SY09, SY10, SY17, SY19, SY21, SY25, SY27, SY29, SY37)	DE10	DE02	DE10	✓	x
X9	(SY01, SY02, SY03, SY04, SY06, SY08, SY09, SY10, SY12, SY15, SY16, SY18, SY20, SY22, SY25, SY26, SY27)	DE01	DE01	DE01	✓	✓
X10	(SY01, SY02, SY03, SY04, SY06, SY08, SY09, SY10, SY15, SY16, SY20, SY22)	DE01, DE02	DE01, DE02	DE01, DE02	✓	✓

Based on the accuracy testing of the expert system, the CF method showed an accuracy rate of 90% with 9 out of 10 patient cases (X1-X10) providing results consistent with the expert diagnosis, except for patient case X2. Meanwhile, the DS method achieved an accuracy of 70%, with 7 patient cases matching and 3 patient cases (X3, X5, and X8) showing inconsistencies.

CONCLUSION

This study has successfully implemented the CF and DS with a search using the FC inference engine to show the relationship between symptoms and NTDs. The final stage of the study is to conduct a test to compare the results of the diagnosis carried out by experts with the CF and DS. Adopting a disease symptom weighting system that is sourced from expert knowledge as the main reference. The results show that the CF can work by integrating the weight of the patient and expert values in its calculations. While the DS considers the expert's weight value without involving the patient's weight value. The test was conducted on 10 patient samples. The number of samples was limited because obtaining patient data was not easy due to privacy concerns. With the number of samples used in the analysis, the results of validation against expert diagnostic standards through quantitative evaluation showed an accuracy level of 90% for the Certainty Factor and 70% for the Dempster Shafer method. Here, it can be seen that the performance of the Certainty Factor method is more accurate than the Dempster Shafer method.

To produce a high level of accuracy in an ES, the knowledge base plays a very important role. So that the search carried out by the inference motor can work optimally to produce decisions. For further research, analysis can use data mining techniques or big data concepts to optimize rule formation and determine certainty values.

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