Diagnosis Of Respiratory Tract Infections In Toddlers With Expert System Using Variable-Centered Intelligent Rule System And Certainty Factor Method

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ABSTRACT

Expert system can help the experts in diagnose the Respiratory Tract Infection For Toddlers. This research have a purpose to build an expert system for Android with Kotlin language using Variable-Centered Intelligent Rule System and Certainty Factor method, also get the accuracy of it. System's input is a yes or no answer from Yes-No Question with user. This research use 164 patient data of toddlers at UPTD Kenten Laut Banyuasin Health Center and variables which is symptoms that occurs in toddlers such as cough, cold, hard to breathe, fever, and the results of a physical examination conducted by the expert. Based on test result, the system has 95,52% accuracy when diagnose ISPA case, and 100% accuracy when diagnose Pneumonia case. So, it can be concluded that Variable-Centered Intelligent Rule System and Certainty Factor method can be used to diagnose respiratory infections in toddlers.

1. Introduction

Respiratory system is one of the systems that plays a crucial role in the human body, because the human respiratory system can inhale and process oxygen to meet its body's needs. The respiratory tract, namely the nose, larynx, trachea, bronchi, bronchioles, and lungs, is part of the respiratory system which functions as a pathway for oxygen to enter and exit and manage it for the needs of the human body. The respiratory tract can be affected by various diseases that can be caused by viruses, bacteria, and other factors that can become infected and even lead to fatal if not treated immediately.

Toddlers who are still in their early stages of growth can easily contract various diseases, especially respiratory diseases such as acute respiratory infections (ARI) and pneumonia. There are many cases of Acute Respiratory Infections and Pneumonia in Palembang city due to thick smoke in July 2019, there were 3,690 toddlers diagnosed with Acute Respiratory Infections [10]. Cases of this Acute Respiratory Infections continued to the first week of September, with a total of 32,815 cases and 14,702 cases occurring toddlers [2]. Thick smoke still covered Palembang city, even reached its highest point 841 µg / m3 at 06.00 WIB on October 15, 1,189 toddlers have been diagnosed with Acute Respiratory Infections [5]. Based on this information, an application is needed that can help diagnose Acute Respiratory Infections and Pneumonia and reduce the number of sufferers of these diseases.

Expert system created to solve problems that can only be handled by an expert in a field, with the aim of not being a substitute for an expert system but as an assistant or tool that can help experts [4]. Expert systems can be used in the medical field, namely diagnosing diseases by searching based on the rules and symptoms experienced by patients. Variable-Centered Intelligent Rule System method is one of the methods that can be used in developing expert systems, implementing Rule-Based System inference and acquiring Ripple Down Rule knowledge. Overcoming the weaknesses of the Rule-Based System which has weaknesses in Knowledge Acquisition, Knowledge Base Updates, and System Verification must be done by an expert manually who is assisted by a Knowledge Engineer and can take time so Ripple Down Rule is used to overcome these weaknesses with the aim of the expert not always involved manually, and the Rule-Based System is used for better inference than the Ripple Down Rule method [8]. An uncertainty is something that can occur when diagnosing a disease, so a method is needed to overcome it and can confirm the diagnosis. Certainty Factor method can be used to overcome the uncertainty that will occur by using an expert's confidence value as a material to calculate the confidence value of the diagnosis.

The proposal of this research is to make an expert system application to diagnose Acute Respiratory Infections and Pneumonia in toddlers using the Variable-Centered Intelligent Rule System and Certainty Factor method.

2. Related work

Research by Astuti et al., (2018) which developed an expert system to diagnose digestive system diseases in children using a combination of the Forward Chaining and Certainty Factor methods shows that the diagnose results have 100% accuracy in comparison with the results of diagnose by experts with a confidence level of 80.5% so that included in the good category [1].

Research by Hsieh et al., (2012) developed an expert system for the diagnosis of respiratory infections based on fuzzy rules based on doctor's experience and using 50 patient data to test the system that has been created. The research shows that the proposed system produces an accuracy of 94% [3].

Research conducted by Martiano et al., (2019), namely developing an expert system to examine the potential for Lentigo Maligna Melanoma and Nodular Melanoma skin cancer using Variable-Centered Intelligent Rule System and Certainty Factor method with input in form of "yes" or "no" answers given by the user through questions and shows that the expert system has successfully carried out the detection with a confidence value of 80.75% [6].

Research by Setiabudi et al., (2017) which developed an expert system for the diagnosis of diseases in teeth using Certainty Factor has shown that in calculating the accuracy of the system that has been developed using data from 20 patients, there are 19 cases that are suitable and 1 case that is not suitable so that an accuracy of 95% is obtained and included in the good category [7].

Research Syaukani et al., (2017) building a system to diagnose Acute Respiratory Infections that aims to support medical decisions using the Technique for Order of Preference by Similarity to Ideal Solution and Extended Technique for Order of Preference by Similarity to Ideal Solution methods which are then compared. The diseases discussed in the study were Not Pneumonia, Pneumonia, and Severe Pneumonia. This research shows that the Extended Technique for Order of Preference by Similarity to Ideal Solution method produces better output, namely 93% sensitivity value, 96% specificity value, 93% precision value, and 95% accuracy value [9].

3. Research Method

The data used were obtained from UPTD Kenten Laut Banyuasin Health Center in the time range from July to October 2019. The data consisted of toddler patients with Acute respiratory infections and Pneumonia. Other data used in the study is expert knowledge obtained from the interview process, namely dr. Hj. Irta Danillah as Head of Integrated Management Poly for Children with Pain at the UPTD Kenten Laut Banyuasin Health Center and dr. Hj. Virdayati Sp.A as a Pediatrician. List of symptoms and physical examination in patients with Acute Respiratory Infections and pneumonia can be seen in Table 1.

Table 1. Symptoms List of ARI and Pneumonia Patients

No	Symptoms
1	Cough (Dry or Phlegm)
2	Cold

3	Fever
4	Feeling short of breath

While the list of physical examinations in patients with Acute Respiratory Infections and Pneumonia can be seen in Table 2.

Table 2. List of Physical Examination of Patients with ARI and Pneumonia

No	Physical Examination
1	Body Temperature
2	Respiration Rate

Physical examination of body temperature to check if it is above 37.5°C and above, the patient is said to have a fever and Respiration Rate to calculate the patient's breathing rate within one minute. Patients can be said to have rapid breathing based on age and respiration rate which can be seen in Table 3.

Table 3. Criteria for Patient's Rapid Breath

No	Patient Age	Respiration Rate / minute
1	Under 2 months	60
2	2 months to under 12 months	50
3	12 months to under 5 years	40

a. User Answer

The answers given by users based on a list of general and specific symptom questions used to diagnose Acute Respiratory Infections are described in Table 4.

Table 4. List of Patient Diagnosis Questions

ID	Symptom Questions	Expert's CF *Value*
1	Does the child unable to drink or suckle?	0.7
2	Does the child always throw up?	0.7
3	Does the child had seizures?	0.7
4	Does the child appear lethargic or unconscious?	0.7
5	Does the child have coughs?	0.8
6	Does the child consume food that contain oil or preservatives or fast food?	0.3
7	Does the child have a cold?	0.1

8	Does the child have difficulty breathing?	0.8
9	Does the child inhale a lot of smoke?	0.5
10	Is the child's respiration rate a criterion for rapid breathing in their age range?	0.9
11	Does the child have a fever, have a high temperature, or have an unstable body temperature?	0.3
12	Is the child's body temperature 37.5°C and above?	0.3

b. Variable-Centered Intelligent Rule System

The system accepts CF Value (E) input based on answers from the user in the form of 1 for yes and 0 for no on every question that system gives. The form of the Rule Base for Acute Respiratory Infections can be seen in Figure 1.

If Does the child unable to drink or suckle?	**Yes**
If Does the child always throw up?	**Yes**
If Does the child had seizures?	**Yes**
If Does the child appear lethargic or unconscious?	**Yes**
If Does the child have coughs?	**Yes**
If Does the child consume food that contain oil or preservatives or fast food ?	**Yes**
If Does the child have a cold?	**Yes**
If Does the child have difficulty breathing?	**Yes**
If Does the child inhale a lot of smoke?	**Yes**
If Does the child have a fever, have a high temperature, or have an unstable body temperature?	**Yes**
If Is the child's body temperature 37.5°C and above?	**Yes**
Then ARI/ISPA	

Fig.1. Form of Rule Base for ARI Disease

While the form of the Rule Base for Pneumonia can be seen in Figure 2.

If Does the child unable to drink or suckle?	**Yes**
If Does the child always throw up?	**Yes**
If Does the child had seizures?	**Yes**
If Does the child appear lethargic or unconscious?	**Yes**
If Does the child have coughs?	**Yes**
If Does the child consume food that contain oil or preservatives or fast food ?	**Yes**
If Does the child have a cold?	**Yes**
If Does the child have difficulty breathing?	**Yes**
If Does the child inhale a lot of smoke?	**Yes**
If Is the child's respiration rate a criterion for rapid breathing in their age range?	**Yes**
If Does the child have a fever, have a high temperature, or have an unstable body temperature?	**Yes**
If Is the child's body temperature 37.5°C and above?	**Yes**
Then *Pneumonia*	

Fig.2. Forms of Rule Base for Pneumonia Disease

The Variable-Centered Intelligent Rule System method architecture can be seen in Figure 3.

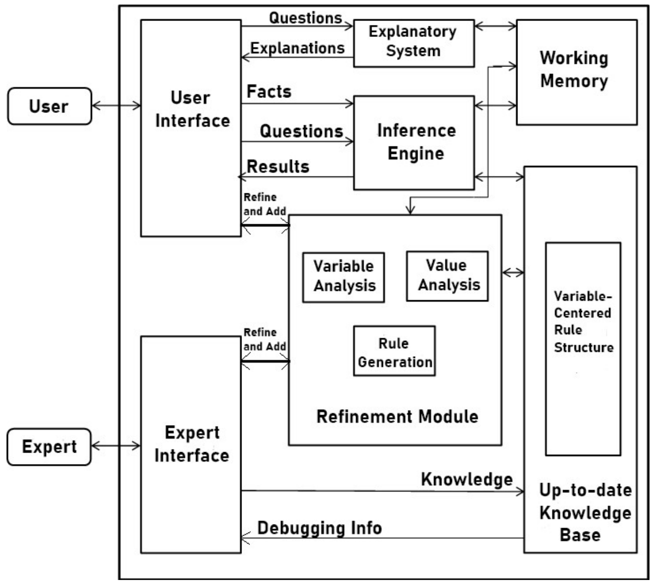

Fig.3. Variable-Centered Intelligent Rule System Architecture (Subakti, 2005)

Through Figure 3, Variable-Centered Intelligent Rule System components such as:

b.1. Variable-Centered Rule Structure, divided into Node Structure and Rule Structure. The shape of the node structure can be seen in Figure 4.

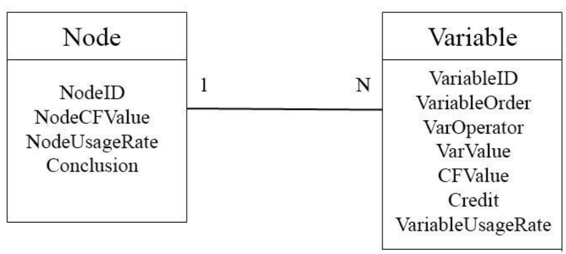

Fig.4. Node Structure Schema (Subakti, 2005)

Through Figure 4, information can be seen:

NodeID: Node identity number is unique

NodeCFValue: Certainty Factor value on the node

NodeUsageRate (NUR): Node usage level value

Conclusion: Conclusion

VariableID: Variable identity number is unique

VariableOrder: Number of sequence variables

VarOperator: Variable operator

VarValue: Variable value (0 to 1)

CFValue: Value of the Certainty Factor in the variable

Credit: Appearance of the variable on the node

VariableUsageRate: Variable usage level value

Rule Structure, The form of the rule structure can be seen in Figure 5.

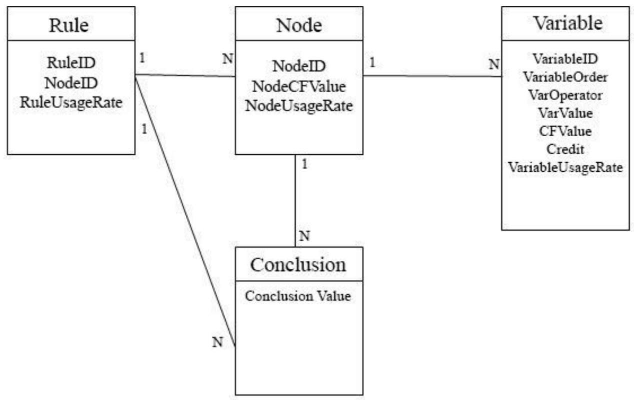

Fig.5. Rule Structure (Subakti, 2005)

Through Figure 5, information can be seen:

RuleID: Rule identity number is unique

RuleUsageRate: Rule usage level value

Conclusion Value: Value of the conclusion

b.2. Refinement Module, there are three main tasks in Variable-Centered Intelligent Rule System namely Variable Analysis, Value Analysis, and Rule Generation. The Variable Analysis function is to analyze nodes with the consideration that nodes are increasingly important when more rules are used, and variables will become more important when used by more nodes. The things that are done in the Value Analysis are the provision of usage values, namely Variable Usage Rate (VUR), Node Usage Rate (NUR), and Rule Usage Rate (RUR). The first degree of use, namely the Variable Usage Rate (VUR) is used to measure the usefulness of the variable in the node being used. Variable Order (VO), Credit (Credit), and Number of nodes (NS) and provide CF Value (H) to each symptom based on the expert are used to calculate the Variable Usage Rate (VUR) value. Variable Usage Rate (VUR) value is used to calculate Node Usage Rate (NUR) value and used to calculate Rule Usage Rate (RUR) value. The value of CD_i can be calculated using equation 1.

$$CD_i = \frac{VO_i}{TV} \quad (1)$$

$Weight_i$ can be calculated using equation 2.

$$Weight_i = NS_i \, x \, CD_i \quad (2)$$

VUR can be calculated using equation 3 .

$$VUR_i = Credit_i \, x \, Weight_i \quad (3)$$

The VUR value obtained will be used to calculate the Node Usage Rate (NUR) value, which is the value used to measure the usefulness of nodes in executing NUR can be calculated using equation 4.

$$NUR_j = \frac{\Sigma_1^N VUR_i}{N_j} \quad (4)$$

The value of *Nj* represents the number of variables at the node and the NUR value obtained will be used to calculate the Rule Usage Rate (RUR) value to measure the usefulness of a rule during its execution. RUR can be calculated using equation 5.

$$RUR_k = \frac{\Sigma_1^N NUR_j}{N_k} \quad (5)$$

Note:
$Credit_i$: The occurrence of variable i in the node

$Weight_i$: Weight / mass variable i in nodes

NS_i (*Number of Node*): Number of nodes (sharing) of variable i-th

CD_i: The value of the variable i rank in the node

VO_i (*Variable Order*): The order of the variable i in the node

TV (*Total Variable*): The Amount of variables in the node

Nj: The amount of variable

N_k: The amount of node

The last function, namely Rule Generation, is the process of generating rules after conducting Variable Analysis and Value Analysis, which is Rule Usage Rate is the output from this method.

c. Certainty Factor

The Certainty Factor method is a parameter value to express trust. This method is one of the methods suitable for dealing with uncertainty in diagnosis. First step of this method is calculating the value of CF Value (H, E), if questions answered "no" by the user, then the CF Value (H, E) will be zero. The next step is to calculate the CFR value of each variable. The final step is to calculate the Total CFR Value using the Certainty Factor method equation for more than two rules so that the final result of the diagnosis is obtained. The total CFR value is the confidence value of the diagnosis.CF Value (H, E) can be calculated using equation 6.

$$CF\ (H,E) = CF\ (H) * CF\ (E) \quad (6)$$

CFR *Value* can be calculated using equation 7.

$$CFR = CF\ (H,E) * RUR \quad (7)$$

CFR *Value* total can be calculated using equation 8.

$$CFR\ (CFR_1,CFR_2) = CFR_1 + CFR_2 * (1 - CFR_1) \quad (8)$$

Note:

CF (H): Certainty Factor value from experts

CF (E): Certainty Factor evidence value from user

CF (H, E): Certainty Factor value

CFR_1: Certainty Factor value from symptoms 1

CFR_2: Certainty Factor value from symptoms 2

CFR: Combined Certainty Factor value from rules

4. Result and Discussion

The results of the calculation from expert system when diagnosing ARI cases can be seen in Figure 6.

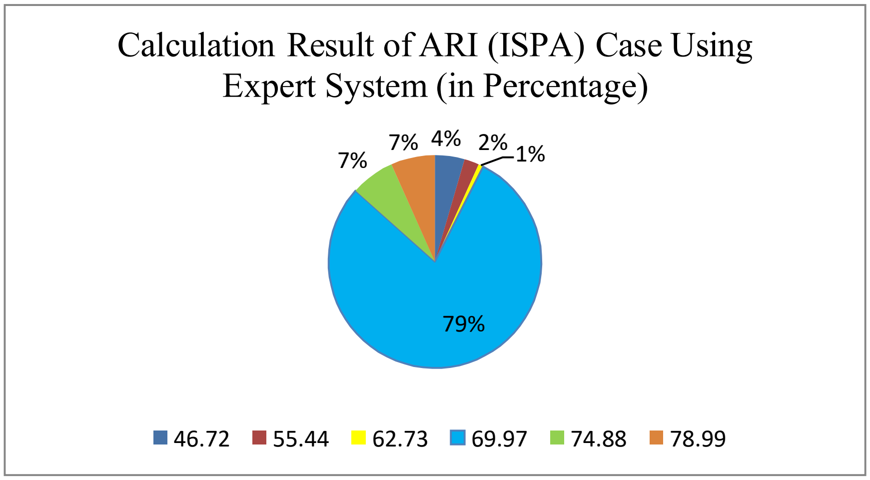

Fig.6. Calculation Result of ARI (ISPA) Case Using Expert System

The graph in Figure 6 is the confidence value obtained using the Variable-Centered Intelligent Rule System and Certainty Factor methods. The results of calculations issued by the expert system depend on the answers given by the user, there is a confidence value of 46.72 as many as 6 data (4% of all ARD patient data) because patients tend not to experience symptoms that lead to ARI disease. There is a confidence value of 55.44 as many as 3 data (2% of all ARI patient data) because these patients experience only mild symptoms such as coughs and colds.

The confidence value of 62.73 is 1 data (1% of all ARI patient data) because these patients have coughs, colds, fever, and the results of physical examinations show body temperature above. 37.5OC. The confidence value is 69.97 as many as 106 data (79% of all ARI patient data) because these patients experience symptoms that lead to ARI such as cough, runny nose, shortness of breath. The confidence value of 74.88 is 9 data (7% of all ARI patient data) because the patient has a cough, runny nose, shortness of breath, plus a fever or fluctuating temperature and the physical examination results show a body temperature below.37.5^{O}C, and the highest confidence value issued by the system when using research data is 78.99 as many as 9 data (7% of all ARI patient data) because the patient has already experienced symptoms as asked by the system so that the expert system is quite sure that the patient contracted ARI. Table The number of ARD diagnosis results that have been carried out by an expert system can be seen in Table 5.

Table 5. Table of Number of ARI Diagnosis Results

The Amount of Data	Confidence Value Below 50%	Confidence Value Above 50%
134	6	128

Based on table V, there are 6 data that have the calculation result of the confidence value below 50%. This is due to various factors, including the following:

1. The patient has a cough, runny nose, feels difficulty breathing but does not experience any other factors that are asked by the system
2. The patient does not feel breathing difficulties, which lowers the system's confidence level in the diagnosis result
3. The results of the examination do not show the factors experienced by the patient, for example the patient feels feverish but when doing a physical examination the patient's body temperature does not show that the patient has a fever (the body temperature limit for fever is 37.50C)

The Variable-Centered Intelligent Rule System and Certainty Factor methods provide more reasonable results when diagnosing the above cases in this research data compared to Rule Base and Certainty Factor. The influencing factor is in the form of a definite input, namely "yes" or "no" so that the RUR value of the Variable-Centered Intelligent Rule System method provides a value that functions to adjust the confidence value (CFR Total) of the system so that it remains reasonable. The accuracy of the expert system for diagnosing ARI cases is calculated using equation III-1.

$$\text{Accuracy} = \frac{128}{134} x\ 100\% = 95{,}52\% \quad (9)$$

Based on the above equation, the expert system has an accuracy of 95.52% when diagnosing ARI cases.

While The results of the calculation from expert system when diagnosing cases of Pneumonia can be seen in Figure 7.

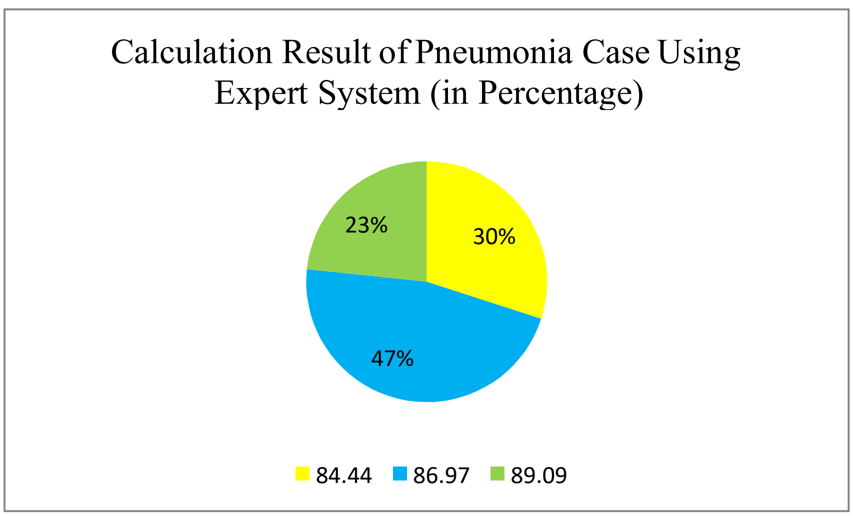

Fig.7. Calculation Result of Pneumonia Case Using Expert System

Based on the graph in Figure 7, the system produce a high confidence value, namely 84.44 for 9 data (30% of Pneumonia patient data), 86.97 for 14 data (47% of data Pneumonia patients), and 89.09 for 7 data (23% of Pneumonia patient data). This is because the symptoms experienced by patients with pneumonia tend to be similar to those of ARI patients. When the patient performs a further physical examination, it turns out that the patient's respiration rate / minute meets the criteria for having pneumonia so that the system is more confident about the diagnosis result. Analyzing Pneumonia cases, expert systems that have been created using the Variable-Centered Intelligent Rule System and Certainty Factor methods do well. Table that contains number of pneumonia diagnosis results that have been carried out by the expert system can be seen in Table 6.

Table 6. Table of Number of Pneumonia Diagnosis Results

The amount of data	Confidence Value Below 50%	Confidence Value Above 50%
30	0	30

Based on table VI, there is no data that has a confidence value calculation result below 50%. This is because when the patient has difficulty breathing and meets the criteria for pneumonia, namely aged under 2 months with a Respiration Rate of 60 / minute or 2 months to <12 months with a Respiration Rate of 50 / minute or 12 months to <5 years with a Respiration Rate of 40 / minute, the patient also experiences other symptoms such as cough, runny nose, and has a fever so that the average calculation results of the expert system using the method *Variable-Centered Intelligent Rule System* and Certainty Factor is above 80%. Expert system accuracy for diagnosing pneumonia cases is calculated using equation III-1.

$$\text{Accuracy} = \frac{30}{30} x\ 100\% = 100\% \tag{10}$$

Based on the above equation, the expert system has 100% accuracy when diagnosing cases of pneumonia.

5. Conclusion

Based on the results of experiments that have been carried out, there are several conclusions as follows:

1. The method used in the research, namely the Variable-Centered Intelligent Rule System and Certainty Factor can be used to diagnose respiratory tract infections in toddlers and can provide a system confidence value for the results of the diagnosis that has been carried out with symptoms experienced such as cough, cold, fever, and the results of several physical examinations conducted by an expert.
2. The system has an accuracy of 95.52% for diagnosing cases of ARI, and 100% for diagnosing cases of pneumonia.

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