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IMPLEMENTATION OF FORWARD CHAINING AND CERTAINTY FACTOR METHODS FOR WEB-BASED DENGUE HEMORRHAGIC FEVER DIAGNOSIS EXPERT SYSTEM (CASE STUDY AT KALIANGET PUBLIC HEALTH CENTER)

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Abstrak

Dengue Hemorrhagic Fever (DHF) remains a significant public health problem in Indonesia, with cases fluctuating substantially over the past five years. In 2024, there was a significant increase with more than 1,400 deaths, while by mid-2025, more than 56,000 cases were recorded. The main challenge in DHF management is the delay in establishing an initial clinical diagnosis, particularly in primary health facilities facing an imbalance between the number of patients and healthcare workers, as well as limited access to diagnostic tools such as NS1 or IgM/IgG testing. This study aims to develop a web-based expert system using Forward Chaining and Certainty Factor inference methods to support the initial screening process for patients with suspected DHF. The system is designed to analyze clinical symptom patterns inputted by healthcare workers, provide a confidence level for each conclusion, and can be accessed in real time. The results provided are indicative and are not intended to replace professional medical diagnosis or laboratory testing. With the implementation of this system, it is hoped that the initial DHF screening process can be carried out more quickly and computerized, thereby optimizing medical service time and improving the quality of primary healthcare services, as exemplified at the Kalianget Community Health Center, Sumenep Regency.

INTRODUCTION

Dengue Hemorrhagic Fever (DHF) is an infectious disease caused by the dengue virus and transmitted through the bite of the *Aedes aegypti mosquito*(Orun et al., 2022). This disease remains a serious health threat worldwide, including in Indonesia, with a high number of cases and the risk of serious complications such as bleeding or shock. Based on data from the Ministry of Health of the Republic of Indonesia, in 2022 there were more than 100,000 cases of dengue fever recorded across the country with a Case *Fatality Rate* (CFR) ranging from 0.5 to 1%. However, an alarming spike in cases occurred in 2024, where the Indonesian Ministry of Health recorded more than 1,400 deaths due to dengue fever throughout the year, making it one

of the years with the highest dengue burden in a decade. Until mid-2025, preliminary data showed that dengue cases remained at an alarming level with more than 56,000 cases and 250 deaths recorded through May. The main challenge in handling dengue fever lies in the process of accurate and rapid initial clinical diagnosis, because delays in identification are often a factor causing the deterioration of the patient's condition to a critical phase requiring intensive care (Tansil et al., 2021). Without reliable *screening tools* in primary healthcare facilities, the risk of delayed treatment remains a structural problem that has not been optimally addressed.

A preliminary study at the Kalianget Community Health Center in Sumenep Regency found that initial dengue fever management efforts were hampered by a high patient-to-health worker ratio. This high workload has the potential to delay the initial identification of patients with dengue-like clinical symptoms. Furthermore, access to sophisticated diagnostic tools such as NS1 or IgM/IgG laboratory tests is not always readily available, particularly in remote areas. This can delay diagnosis and worsen patient outcomes (Pemeriksaan & Nonstruktural, 2024). Similar conditions have been reported in various primary health care facilities in Indonesia, where limited resources and infrastructure remain significant obstacles to effective dengue case management. Furthermore, the lack of a standardized clinical decision support system contributes to inconsistencies in initial patient assessment, further complicating timely intervention efforts.

To address these challenges, an artificial intelligence-based expert system can be an effective solution. This system is an application that simulates the reasoning of medical experts to assist the diagnosis process (Apriliyanto et al., 2024). In this study, *the Forward Chaining inference method* is used to trace premises based on clinical symptoms inputted by the user to produce a disease conclusion. Meanwhile, *the Certainty Factor* is useful for handling uncertainty by assigning a confidence value to each conclusion according to the probability of the symptoms. The combination of these two methods can improve diagnostic accuracy without replacing the role of doctors, but as a decision-making tool. This expert system was developed web-based to ensure easy accessibility for health workers at the Kalianget Community Health Center in *real-time* (Setiawan & Budi, 2023). The selection of the case study location was based on local endemic disease morbidity data, where the geographical conditions of the Kalianget area have a high level of vulnerability to the proliferation of dengue vectors. This system is designed to analyze clinical symptom patterns, match them with medical knowledge stored in the database, and provide initial information regarding potential disease. However, the results provided are indicative and cannot be used as the sole basis for establishing a diagnosis. An accurate diagnosis still requires a thorough evaluation by a doctor or competent health worker.

STUDY NEEDS.

The high incidence of Dengue Hemorrhagic Fever (DHF) in Indonesia, with more than 100,000 cases in 2022 and a surge in deaths reaching more than 1,400 in 2024, has created serious challenges in the early detection system in primary healthcare facilities. The severity of this problem is revealed by the limited availability of accurate and rapid initial clinical diagnostic tools, especially in remote areas such as Sumenep Regency. A preliminary study conducted at the Kalianget Community Health Center (Puskesmas) showed that the imbalanced patient-to-health worker ratio is a major obstacle in the early identification of patients with DHF symptoms. Among all healthcare providers, primary healthcare workers, including nurses and community health center staff, are the ones who most frequently come into contact with suspected DHF patients in the early stages, yet often face limited access to diagnostic tools such as NS1 or IgM/IgG tests.

Healthcare workers' knowledge of dengue fever clinical symptom patterns and their ability to perform initial screening are crucial to improving the speed and accuracy of patient care. However, without a reliable and standardized decision support system, the initial screening process still relies heavily on subjective assessments, which can lead to delays in the identification of critically ill patients. Previous studies have developed expert systems for

dengue diagnosis using inference methods such as Forward Chaining and Certainty Factor. However, most of these systems are still desktop-based or have not been integrated with the specific needs of primary healthcare facilities in endemic areas like Kalianget. Furthermore, the development of web-based systems that can be accessed in real time by healthcare workers at community health centers is still limited, necessitating further study to design and implement expert systems tailored to field conditions. Expert systems that require special attention in their development include the ability to analyze diverse clinical symptom patterns, assign a certainty factor *to* each conclusion, and provide an interface that is easy to use by healthcare workers with varying levels of digital literacy.

3.1 Population and Sample

Kalianget Community Health Center is a primary healthcare facility located in Sumenep Regency, Madura, and serves patients from various surrounding areas. Based on local endemic disease morbidity data, dengue fever is one of the diseases with the highest incidence rates in the Kalianget Community Health Center's working area. This community health center was chosen as the research location due to its geographic location, which has a high level of vulnerability to dengue vector proliferation and limited access to sophisticated diagnostic tools such as NS1 or IgM/IgG tests. Therefore, Kalianget Community Health Center can be considered a research scope that represents the challenges of early dengue diagnosis in primary healthcare facilities in remote areas.

This study includes data from patients with suspected dengue fever recorded at the Kalianget Community Health Center during a specific period. The sample in this study was 133 patient data selected based on inclusion criteria, namely patients who presented with symptoms of fever and other clinical symptoms that indicate the risk of dengue fever, such as headache, muscle pain, rash, or bleeding manifestations. The patient data were collected from medical records and initial screening records conducted by health workers at the Kalianget Community Health Center. This sample selection aims to develop and test an expert system for early dengue diagnosis that can be used by patients and medical personnel to quickly and accurately understand initial screening symptoms during the treatment process. With a sample of 133 data, it is expected that the developed system can provide representative results and be in accordance with field conditions at the Kalianget Community Health Center.

3.2 Data and Data Sources

For this study, primary data was collected from the Kalianget Community Health Center, Sumenep Regency, Madura. The data consisted of medical records of patients with suspected Dengue Hemorrhagic Fever (DHF) registered at the Kalianget Community Health Center during the period of January to December 2025. The collected data included patient clinical symptoms, such as fever, headache, muscle pain, rash, bleeding manifestations, as well as physical examination results and patient status. All data were obtained from medical records and initial screening forms filled out by health workers at the Kalianget Community Health Center. The total number of patient data collected during that period was 133 patient data with suspected DHF. The data was then processed and used as a knowledge base in the development of an expert system for early diagnosis of DHF using the Forward Chaining and Certainty Factor methods.

3.3 Theoretical Framework

This study consists of input and output variables. This study uses a predetermined method for developing an expert system. This study uses clinical symptoms of dengue fever as input variables and the diagnosis results (dengue fever risk level) as output variables. Clinical symptoms were obtained from patient data recorded at the Kalianget Community Health Center and grouped based on the criteria of fever symptoms and dengue fever risk. The dengue fever risk level was calculated using the Certainty Factor method based on the confidence value given

by the expert (Expert CF) and the confidence level given by the patient (User CF) for each symptom experienced. The Forward Chaining method was used as an inference mechanism to trace the rules in the knowledge base based on the symptoms selected by the patient, resulting in a diagnostic conclusion in the form of a dengue fever risk level.

RESEARCH METHODOLOGY

The methodology section outlines the plan and methods for conducting the research. It includes the study population, sample, data and data sources, research variables, and analytical framework. The details are as follows:

3.1 Population and Sample

The population in this study is all patients who underwent examination with symptoms that indicate Dengue Hemorrhagic Fever (DHF) at Kalianget Health Center, Sumenep Regency in 2025. The population also includes symptom data, disease data, and diagnostic rules obtained through interviews with health workers and literature studies as a basis for compiling a knowledge base in an expert system. All of these data are included in the scope of the study because they are used in the process of building a web-based expert system using the *Forward Chaining* and *Certainty Factor methods.*

This study covers patients who have clinical symptoms of Dengue Hemorrhagic Fever (DHF) at Kalianget Community Health Center during 2025. From the total population, 50 patients were selected as research samples using purposive sampling technique, which is a sampling technique based on certain criteria. These criteria include patients who have symptoms that indicate DHF, have complete examination data, and are willing to be research objects. Data from these 50 patients are used as a basis for compiling a rule base, implementing the *Forward Chaining* and *Certainty Factor methods,* and testing the system to determine the ability of the expert system to provide an initial diagnosis based on symptoms entered by the user.

3.2 Data and Data Sources

In this study, the data used consists of primary data and secondary data. Primary data was obtained directly from the Kalianget Community Health Center through interviews with health workers and data collection of patients who have symptoms of Dengue Hemorrhagic Fever (DHF). The data includes symptom data, patient data, and information regarding the initial diagnosis process of DHF which is used as the basis for compiling a knowledge base in the expert system. Meanwhile, secondary data was obtained through literature studies originating from various sources, such as books, scientific journals, research articles, health guidelines, and other references related to Dengue Hemorrhagic Fever (DHF), the *Forward Chaining method, the Certainty Factor method, and the development of a web-based expert system. Secondary data is used to strengthen the theoretical basis, compile inference rules, and determine the Certainty Factor* weight value applied to the system.

The data collection process was carried out at Kalianget Community Health Center during 2025. This study used 50 patient data that met the research criteria as samples. In addition, symptom data, disease data, and diagnostic rules that have been validated by health workers were also used as sources of information in the process of developing, implementing, and testing a web-based Dengue Hemorrhagic Fever (DHF) diagnosis expert system using *the Forward Chaining* and *Certainty Factor methods*.

3.3 Theoretical Framework

The theoretical framework in this study is based on concepts that serve as the foundation for developing an expert system for the early diagnosis of Dengue Hemorrhagic Fever (DHF). This study utilizes the *Forward Chaining method* as an inference mechanism to trace facts in the form of symptoms selected by the user to produce a conclusion in the form of a diagnosis. Furthermore, the *Certainty Factor method* is used to calculate the level of confidence

in the diagnosis results based on the weight of knowledge provided by the expert and the user's level of confidence in the symptoms experienced.

Forward Chaining method is a reasoning technique that uses a *data-driven approach.* The inference process begins with facts obtained through symptoms selected by the user. The system then matches these facts with IF–THEN rules stored in *the* knowledge base to reach a conclusion regarding the possible disease. This approach was chosen because it can systematically search for the relationship between symptoms and disease, making it suitable for application in a dengue fever diagnosis expert system.

The Certainty Factor method is used to address uncertainty in the decision-making process. Each symptom is assigned a weighting value by an expert (*Expert CF*), while the user provides a level of confidence in the symptoms they experience (*User CF*). Both values are calculated using the Certainty Factor formula, resulting in a percentage confidence level for each possible diagnosis. The more symptoms that comply with the rules and have a high confidence value, the higher the Certainty Factor value generated by the system.

The symptom data, diagnostic rules, and Certainty Factor weights used in this study were obtained through interviews with healthcare workers at the Kalianget Community Health Center, literature reviews, and medical references related to Dengue Fever. All of these components were compiled into a knowledge base *that* the inference engine used to automatically perform the diagnosis process.

By combining *the Forward Chaining* and *Certainty Factor methods,* the developed expert system is expected to provide an initial diagnosis of Dengue Fever more quickly, systematically, and with a measurable level of confidence. The diagnostic results are not intended to replace the decisions of medical personnel, but rather serve as a supporting tool to aid the early identification of the disease so that the public can receive earlier treatment.

3.4 Analysis Tools

This section explains the analytical methods used in the study to process the data to produce conclusions. This study employed the *Forward Chaining method* as an inference process to determine a diagnosis of Dengue Hemorrhagic Fever (DHF) based on the symptoms selected by the user. Furthermore, *the Certainty Factor method* was used to calculate the confidence level in the diagnosis results based on the symptom weighting given by the expert and the user's confidence level.

3.4.1 Descriptive Analysis

Descriptive analysis was used to provide an overview of the data used in the study, including symptom data, disease data, rule data, and patient data from the study sample. This analysis aimed to describe the characteristics of the data obtained from Kalianget Community Health Center as a basis for developing a knowledge base for the expert system.

The obtained symptom data and diagnostic rules were then analyzed using the *Forward Chaining method.* This method works by conducting fact-based searches in the form of symptoms selected by the user, then matching them with the IF–THEN rules contained in the knowledge base to produce a disease diagnosis. After the inference process is complete, the Certainty Factor method is used to calculate the confidence level value for each diagnosis result. This value is obtained from the multiplication of the expert's confidence weight and the user's confidence level in the selected symptoms, then combined to produce a final confidence percentage. The results of this analysis are used as a basis for evaluating the ability of *the Forward Chaining* and *Certainty Factor methods* in producing an initial diagnosis of Dengue Hemorrhagic Fever (DHF).

3.4.2 Application of Forward Chaining and Certainty Factor Methods

After the process of collecting and compiling symptom data, disease data, and the rule base *is* complete, the next step is to apply *the Forward Chaining* and *Certainty Factor methods* as the primary methods in the Dengue Hemorrhagic Fever (DHF) diagnosis process. The

Forward Chaining method functions as an inference mechanism that performs searches based on facts or symptoms selected by the user. Each entered symptom will be compared with IF–THEN rules stored in the knowledge base until a diagnosis is obtained that matches the user's condition.

The diagnosis generated through the inference process is then processed using the *Certainty Factor method* to determine the level of confidence in the diagnosis. This method aims to accommodate the uncertainty that often arises in the diagnostic process, allowing the system to not only generate disease types but also provide a confidence level for the results.

The Certainty Factor value is obtained by combining the confidence value provided by the expert (Expert CF) and the user's level of confidence in the symptoms experienced (*User CF*). The calculation begins by determining the CF value for each symptom by multiplying the *Expert CF* and *User CF.* Next, all obtained CF values are combined in stages using the *Certainty Factor combination formula* to produce a final confidence value in percentage form.

By applying these two methods, the system is able to systematically perform the diagnosis process, starting with symptom tracing using the *Forward Chaining method* and then calculating the confidence level using the *Certainty Factor method.* Thus, the resulting diagnosis not only indicates the likelihood of Dengue Hemorrhagic Fever (DHF) but also provides a confidence level for the diagnosis based on the symptoms selected by the user.

3.4.2.1 Forward Chaining Method Model

In the first stage, the system performs an inference process using the *Forward Chaining method.* This method works by utilizing facts in the form of symptoms selected by the user as initial data. Each entered symptom is compared against IF–THEN rules *developed* based on expert knowledge. The search process is carried out in stages until all selected symptoms match the available rules and produce a conclusion in the form of a disease diagnosis.

The Forward Chaining model is a *data-driven* reasoning method, enabling the solution-finding process to move from facts to conclusions. In this study, the user's selected symptoms are treated as initial facts, while diagnostic rules serve as the basis for decision-making. If all conditions in a rule are met, the system will generate a diagnosis of Dengue Hemorrhagic Fever (DHF) that aligns with the rule.

The diagnostic results obtained from the inference process using *the Forward Chaining method* then become input for the calculation process using the *Certainty Factor method* to determine the level of confidence in the resulting diagnosis.

3.4.2.2 Certainty Factor Method Model

After the inference process using the *Forward Chaining method* produces a diagnosis, the next step is to calculate the confidence level of the diagnosis using the *Certainty Factor method.* This method is used to accommodate the uncertainty that arises in the diagnostic process by utilizing the confidence value from the expert (Expert CF) and the confidence value given by the user (*User CF*) for the selected symptoms.

The calculation begins by determining *the Certainty Factor value* for each symptom by multiplying the Expert CF value and the User CF value. The values obtained for each symptom are then combined in stages using the *Certainty Factor combination formula* to produce a final value that indicates the level of confidence in the diagnosis.

Certainty Factor value is expressed as a percentage, reflecting the system's confidence level in the diagnosis of Dengue Hemorrhagic Fever (DHF). The higher the percentage value, the greater the system's confidence that the user has the disease as determined by the diagnosis.

$$CF(1,2) = CF1 + CF2\ x\ (1 - CF1)$$

$$CF(1,2,3) = CF(1,2) + CF3x\big(1 - CF(1,2)\big)$$

$$CF(1,2,3,4) = CF(1,2,3) + CF4\ x\ (1 - CF(1,2,3))$$

3.4.3 Comparison of Methods

The next stage of this research is to analyze the application of *the Forward Chaining* and *Certainty Factor methods* to determine the contribution of each method to the diagnosis of Dengue Hemorrhagic Fever (DHF). The analysis was conducted by observing the working stages of each method and its role in generating appropriate diagnostic decisions based on the symptom data entered by the user.

The Forward Chaining method acts as an inference mechanism used to explore the relationship between symptoms and rules *contained* in the knowledge base. Through this matching process, the system can determine the likelihood of a disease based on the facts provided by the user. Meanwhile, the *Certainty Factor method* is used after the inference process is complete to calculate the confidence level of the obtained diagnosis. The calculation is performed using the expert's confidence value and the user's confidence value for each selected symptom.

The analysis results show that the two methods have different but complementary functions. The *Forward Chaining method* is used to determine the diagnosis based on predetermined rules, while the *Certainty Factor method* provides a percentage value indicating the level of confidence in the diagnosis. By combining these two methods, the system is not only able to produce an initial diagnosis of Dengue Hemorrhagic Fever (DHF) but also provides information regarding the level of confidence in the resulting diagnosis.

Based on the application of these two methods, it can be concluded that the integration of *the Forward Chaining* and *Certainty Factor methods* can support a more systematic and measurable diagnostic process. The combination of the two methods provides more informative results because, in addition to generating diagnostic conclusions, the system also provides confidence values that can be used as considerations in the initial disease identification process.

3.4.3.1 Integration of Forward Chaining and Certainty Factor Methods

In this study, the *Forward Chaining* and *Certainty Factor methods* were integrated into the diagnosis of Dengue Hemorrhagic Fever (DHF). Both methods serve distinct purposes, but they complement each other in producing more accurate diagnostic decisions. The *Forward Chaining method* is used to perform inference based on the symptoms selected by the user, while *the Certainty Factor method* is used to calculate the confidence level in the diagnostic results obtained from the inference process.

The diagnostic process begins by matching the user's selected symptoms to the rules *stored* in the knowledge base using the *Forward Chaining method.* After obtaining the diagnosis, the system continues the calculation process using the *Certainty Factor method,* combining the expert's confidence level with the user's confidence level for each selected symptom. The final result is a disease diagnosis along with a percentage value of the confidence level.

The integrated application of both methods aims to produce a more systematic and measurable diagnostic process. The *Forward Chaining method* plays a role in determining the likelihood of a disease based on established rules, while the *Certainty Factor method* provides a quantitative measure of confidence in the diagnosis. Thus, the combination of these two methods can provide more comprehensive information to support the initial diagnosis of Dengue Hemorrhagic Fever (DHF).

3.4.3.2 Calculation of Certainty Factor Value

The next step in this research is to calculate the confidence level of the diagnosis results using the *Certainty Factor method.* This method is used to address the uncertainty that often arises in the disease diagnosis process, so that the system not only produces a conclusion regarding the type of disease but also provides a level of confidence in the diagnostic results obtained.

The calculation process begins by determining *the Certainty Factor value* for each symptom

selected by the user. This value is obtained by multiplying the confidence value assigned by the expert (Expert CF) by the user's confidence level (User CF) for the selected symptom. The calculated results for each symptom are then used as the basis for obtaining the diagnostic confidence value.
The equation used to calculate **the Certainty Factor value** for each symptom is as follows.

$$CF[h,e] = CF[e] * CF[rule] = CF[user] * CF[pakar]$$

Information:

- CF(H,E) = Certainty Factor value for the hypothesis based on evidence (symptoms).
- Expert CF = confidence weight value given by the expert.
- CF User = user's level of confidence in the selected symptom.

If a diagnosis is supported by more than one symptom, then *the Certainty Factor value* for each symptom will be combined using the *Certainty Factor combination formula* as follows.

$$CF(kombinasi) = CF1 + CF2\ x\ (1 - CF1)$$

Information:

- CF_1 = Certainty Factor value from previous calculations.
- CF_2 = Certainty Factor value of the next symptom.

The final value obtained from this combination process is then converted into a percentage to indicate the system's confidence level in the diagnosis. A higher percentage indicates a greater level of confidence in the system's likelihood of a diagnosed disease. Conversely, a lower percentage indicates a relatively low level of confidence in the diagnosis based on the symptoms selected by the user.

IV. RESULTS AND DISCUSSION

4.1 Results of Research Data Analysis

This study used 50 patient data obtained from Kalianget Community Health Center in 2025. The data consisted of patient identity, symptoms experienced, diagnosis results based on expert knowledge, and confidence values used in the calculation process using the *Forward Chaining* and *Certainty Factor methods.* All data were used as the basis for the analysis process to determine the method's ability to produce an initial diagnosis of Dengue Hemorrhagic Fever (DHF).

The analysis results show that each patient has a different combination of symptoms, resulting in a different inference process. The *Forward Chaining method* searches for the user's selected symptoms by matching them to a rule *base* developed based on expert knowledge. Next, the *Certainty Factor method* is used to calculate the confidence level in the diagnosis results by utilizing the expert's weighting values and the user's confidence level in each selected symptom.
A summary of the research data can be presented in Table 4.1 below.

Table 4.1 Research Data

Information	Amount
Number of Patient Data	50
Number of Symptom Data	15
Number of Types of Disease	1
Number of Rules	15
Inference Method	Forward Chaining
Calculation Method	Certainty Factor

Based on Table 4.1, this study used 50 patient data as samples. The data was processed using the *Forward Chaining method* to determine the diagnosis based on predetermined rules. Next, the diagnosis results were calculated using the *Certainty Factor method* to obtain a confidence level for the diagnosed disease.

CONCLUSION

The author expresses his gratitude to God Almighty for all His grace and gifts so that the research entitled "Application of Forward Chaining and Certainty Factor Methods for Web-Based Dengue Hemorrhagic Fever Diagnosis Expert System (Case Study at Kalianget Community Health Center)" can be completed well.

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The preferred spelling for the word " acknowledgment " in America is without the " e " after the " g. " Avoid the awkward phrase, " One of us (RBG) thanks... ". Instead, try " RBG thanks. " Include acknowledgments to applicable sponsors here; DO NOT put them on the first page of your paper or as a footnote.

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