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Design of a Web-Based Expert System Using Certainty Factors for Internal Disease Diagnosis

Juniana Husna[a,1,*], Sanusi[b,2], Kasyfunnur[c,3]

[a,c]*Information System Department, Abulyatama University, Aceh Besar, 23372, Indonesia*
[b]*Information Technology Department, Teuku Umar University, Meulaboh, 23615, Indonesia*
[1]*juniana@abulyatama.ac.id*,* [2]*sanusi@utu.ac.id,* [3]*kasyfunnur20@gmail.com*

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ABSTRACT

Diseases are classified into different types based on the symptoms, causes, and disturbances they cause to the human body. Among the disease categories that have a wide range of sub-specialties and branches is internal medicine. Early disease detection is difficult because many diseases exhibit similar symptoms. To diagnose the disease, medical specialists will conduct a series of physical and laboratory tests. However, before going to the doctor, the patient should learn about the disease and begin treatment so that it does not worsen and become dangerous. As a result, we require a system that can assist patients in receiving information and detecting their disease early. An expert system was developed in this study to help people obtain complete and precise information about their disease. It is hoped that by using this system, people will be able to obtain preliminary information before visiting a doctor, thereby reducing the risk. An expert system is a type of artificial intelligence application that is a computer program designed on knowledge and rules that could act similarly to or as well as an expert. Expert systems must be able to function in the presence of uncertainty. A number of theories have been developed to deal with uncertainties, one of which is the certainty factor method, which is ideal for analyzing uncertain data. This technique provides a solution by calculating the values of certainty and uncertainty. This study concentrated on three types of internal medicine and 27 symptoms to be diagnosed; the end result was a diagnosis of the type of internal medicine encountered and the percentage of confidence, along with treatment recommendations.

I. Introduction

One of the most important aspects of human life is one's health. However, as technology advances, diseases are increasingly threatening humans of all ages. Diseases come in a variety of forms and cause a wide range of health issues in humans. The most common ones are internal diseases, with a variety of indications and symptoms [1]. Internal medicine is a branch of medicine that focuses on the diagnosis of non-surgical treatment on adult patients' internal organs. The American Board of Internal Medicine recognizes several internal medicine sub-specialties, including immunology, cardiology, gastroenterology, hematology, oncology, endocrinology, nephrology, rheumatology, pulmonology, geriatrics, tropical-infectious diseases, and others [2][3]. The disease's sub-specialties are then further elaborated based on the type of disease, symptoms, causes, and prevention, to facilitate further treatment, action, and prevention management.

The disease must be handled by an expert who has extensive knowledge in that field. A doctor serves as an expert in this case by diagnosing and informing patients about their illness [4]. Without expert knowledge, a wrong diagnosis can endanger the patient and cause death. Because there are so many different types of diseases and their symptoms, an expert must examine patients' symptoms in greater depth to determine what disease they are suffering from and avoid misdiagnosis [5]. Before delivering the results of the diagnosis, a doctor will usually perform several examinations such as

physical checks, laboratory tests, blood, urine tests and so on. However, the high cost of medical consultations, as well as the numerous diseases with similar symptoms, make early detection of illnesses become difficult [6]. In fact, its rapidity and reliability with which patients can obtain disease information is extremely beneficial in terms of disease prevention and early intervention before consulting a doctor [7]. As a result, an expert system is required to assist patients in obtaining the necessary information; this system is expected to assist patients in resolving health problems prior to seeking a specialist.

An expert system is a type of artificial intelligence application in which a computer program is designed based on rules and knowledge and is capable of acting similarly to or in the same way as an expert [8]. Expert systems can be designed to meet specific needs in a variety of fields [9], but they require a special building tool, namely a knowledge base, which can be sourced from an expert as well as obtained from other sources such as big data [10]. The following expert system development process involves transferring an expert's expertise into a computer system using artificial intelligence methods [11]. Forward and backward chaining, breadth first search, fuzzy methods, certainty factors, classical probability, bayes probability, and other methods can be used to build expert systems [12].

Several studies have been conducted to diagnose specific diseases using expert systems. However, the different methods used and the knowledge base derived from various sources can result in diagnoses with varying degrees of accuracy [13][14]. Furthermore, developing applications on different platforms can affect the convenience and the level of user satisfaction [15][16]. As a result, research on expert systems using various methods, as well as an accurate and comprehensive knowledge base, is still required [17]. In this case, the accuracy and precision of the diagnostic results can be calculated by comparing the system's diagnostic results to the results of medical records from doctors or hospitals.

In this study, we employ the certainty factor method to construct an expert system for internal medical diagnosis. The method was chosen because it is appropriate for dealing with problems involving uncertainty. This study will concentrate on diagnosing three types of diseases that are within the purview of internal medicine, namely [18]: To begin, dengue hemorrhagic fever is a viral infectious disease caused by the Aedes aegypti mosquito species. Second, salmonella typhi bacteria cause typhoid fever or typhus. Finally, malaria is a parasitic infection caused by the plasmodium parasite, which is transmitted by female Anopheles mosquitos. However, the database design and user interface are flexible enough to allow for future development for diagnostics in other areas of internal medicine.

The goal of this study is to design and build an expert system that can quickly and accurately diagnose internal medicine based on symptoms experienced by patients. This expert system's output is the type of disease, as well as the results of the diagnosis and treatment. This system was created using the PHP and MySql programming languages, and it is hoped that this research will be able to produce expert system applications with fast, precise, easy, and convenient diagnoses for users to use.

II. Method

A. Data collection

The first stage of this research was to collect data as a knowledge base, which included disease definitions, symptoms, and probabilities, as well as methods of treatment and management of the disease. The information was provided by an expert, a doctor at Zainal Abidin Regional General Hospital in Banda Aceh. The collected data is then generated by a specific code to aid in data processing using the expert system method, as follows:

Table 1. Definition of Disease

Disease code	Disease name	Description
KP 001	Dengue fever	A Potentially fatal viral infection transmitted by the aedes aegypti mosquito.
KP 002	Typhoid fever	An infectious disease caused by the bacterium Salmonella thypi.
KP 003	Malaria	Caused by the Plasmodium parasite (Spread by the female Anopheles mosquito).

Table 2. Disease Symptoms

Symptom Code	Symptom Description
KG 001	High fever that fluctuates dramatically.
KG 002	Rumpel Leede+
KG 003	Spots of bleeding on the inner eyelids.
KG 004	There is bleeding in the nose and gums.
KG 005	Mucus and bloody diarrhea
KG 006	Vomiting and nausea.
KG 007	Appetite suppression
KG 008	Convulsions throughout the body, unconsciousness
KG 009	Headache
KG 010	Aches and pains in joints
KG 011	The appearance of red spots on the skin as a result of blood vessel rupture
KG 012	A swollen liver (hepatomegaly)
KG 013	The blood pressure is too low.
KG 013	The presence of a drop in platelets below 150,000/mm3
KG 014	Feeling sluggish and physically weakened
KG015	soiled tongue
KG 016	Bloated
KG 017	Weak pulse
KG 018	Full stomach
KG 019	Throat irritation and dryness
KG 020	Widal analysis greater than 1/100
KG 021	The face appears pale or anemic.
KG 022	High fever followed by chills
KG 023	Live or have lived in a malaria endemic area
KG 024	Black pee
KG 025	Whole body convulsions, but conscious
KG 026	Plasmodium dark field microscopy was positive
KG 027	High fever that lasts a long time, usually felt at night accompanied by sweat.

Table 3. Disease Treatment

The Disease's Name.	Treatment Type.
Dengue fever	1) Get plenty of sleep. 2) Stay hydrated by drinking plenty of water (especially to replace body fluids that are wasted due to symptoms of high fever and vomiting). 3) Take paracetamol and acetaminophen to relieve fever and pain. 4) Take a break from activities for a while until your body has fully recovered.
Typhoid fever	1) Get adequate rest. 2) Eat frequently; instead of eating large portions three times a day, eat as frequently as possible in small amounts. 3) Drink plenty of water. 4) Wash your hands with soap and warm water on a regular basis to reduce the spread of infection.
Malaria	1) Chloroquine is the most effective drug for treating malaria infections caused by the parasites Plasmodium Ovale or Plasmodium Malauriae. 2) Coartem is a combination of the drugs artemether and lumefanterine. This medication is used to treat P. falciparum malaria.

Table 4. Certainty Value

Disease name	Symptom name	MB value	MD value
Dengue fever	1. There are bleeds on the inner eyelids.	0.4	0.6
	2. Rapidly rising and falling fever	0.9	0.1
	3. Diarrhea associated with mucus and blood.	0.5	0.5
	4. Unconscious convulsions throughout the body	0.4	0.6
	5. Vomiting and nausea	0.5	0.5
	6. The appearance of red spots on the skin caused by blood vessel rupture	0.5	0.5
	7. Loss of appetite	0.5	0.5
	8. Joint pain or discomfort	0.4	0.6
	9. Nasal and gingival bleeding	0.4	0.6
	10. Rumple Leede+.	0.9	0.1
	11. Headaches.	0.7	0.3
	12. Low blood pressure	0.6	0.4
	13. An enlarged liver occurs	0.8	0.2
	14. Platelets fell below 150,000/mm3.	0.9	0.1
Typhoid fever	1. Weak pulse	0.9	0.1
	2. soiled tongue	0.8	0.2
	3. Constantly high temperatures	0.9	0.1
	4. Flatulence	0.8	0.2
	5. stuffed stomach	0.8	0.2
	6. Tiredness and physical weakness	0.5	0.5
	7. Dry and inflamed throat	0.5	0.5
	8. Liver enlargement occurs	0.8	0.2
	9. The face appears pale or anemic.	0.4	0.4
Malaria	1. High fever with chills	0.9	0.1
	2. Conscious convulsions of the entire body	0.5	0.5
	3. Dark urine	0.5	0.5
	4. Live or have lived in a malaria-endemic area.	0.9	0.1

B. Use of the certainty factor

The following formula is used to calculate the certainty value, which is based on the MB and MD of each symptom selected by the user. The disease with the highest CF value will then be chosen as the result of this expert system diagnosis [19]:

$$cf(h,e) = mb(h,e) - md(h,e)$$

Where:

- CF(H,E): Certainty Factor from hypothesis H that is influenced by evidence E. The magnitude of CF ranges from -1 (absolute distrust) to 1 (absolute trust).
- MB(H,E): a measure of the increase in confidence in the hypothesis H that is affected by symptom E.
- MD(H,E): A measure of disbelief in hypothesis H that is influenced by symptom E.

C. System design

System design begins with the creation of context diagrams to describe system interactions with outside entities such as users or expert system managers, as shown in the figure below:

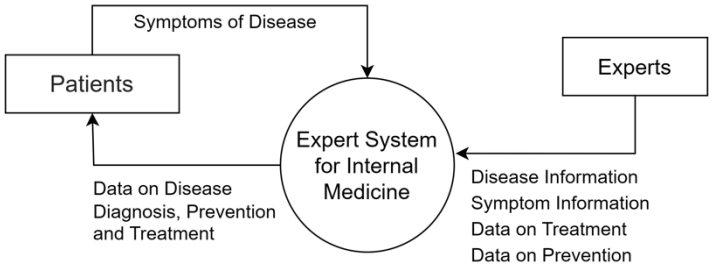

Fig 1. The context diagram for system design.

According to the illustration above, the expert system for internal medicine analysis has two external entities: the patient and the administrator. Admin has the authority to manage data, whereas patients have access to information on the results of disease diagnoses and how to handle them based on the symptoms entered. Furthermore, the context diagram can be reduced into a data flow diagram to detail the flow of data into and out of the processes that occur in a system. During the system design stage, an application interface design is created to describe what features will be included in the expert system application.

D. Database design and Entity relationship diagram

The database contains tables, which are locations for storing information from data flow in a system. ERD, on the other hand, describes the relationship between tables in a database. When processing data, the tables in the database must be linked to avoid overlapping data. This expert system's ERD is as follows:

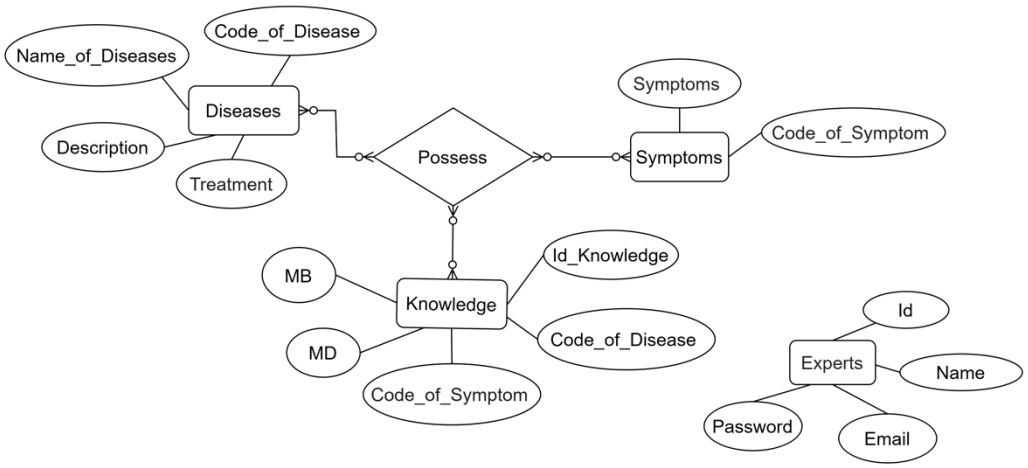

Fig 2. Expert System's Entity Relationship Diagram.

III. Results and Discussion

A. Application of Expert System

The expert system is designed based on a website so that it can be used across devices. In this case, the appearance is made responsive to various gadget widths so that the user can use it comfortably. The following are the features of the expert system website for internal medicine diagnosis:

1) Login feature: As a component of the system safeguards against abuse of access rights, the administrator is prompted to enter an email address and password before proceeding to the next page, as shown in the image below.

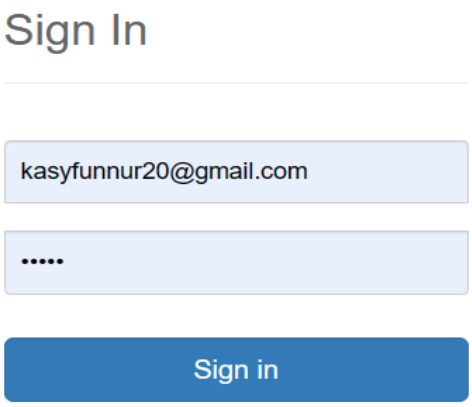

Fig 3. The Login Form

2) Disease Menu Page: This is where the administrator enters disease information. When adding new data, the administrator must enter the disease code and name.

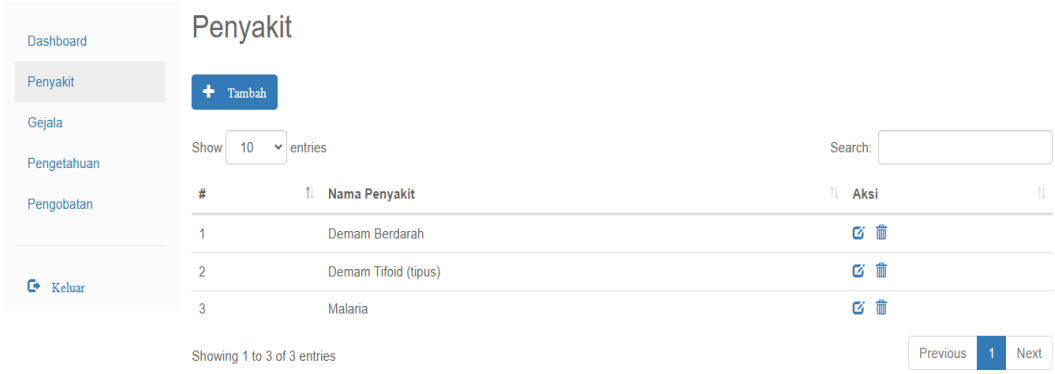

Fig 4. Page of Diseases

3) Disease Symptoms feature: used by the administrator to populate all symptoms based on the type of disease previously entered.

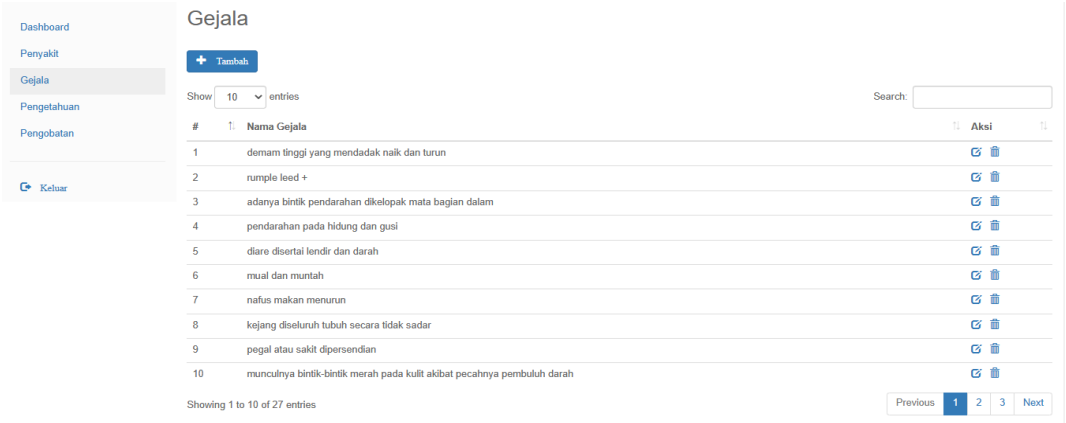

Fig 5. Disease symptom features

4) Certainty Factor Menu: This page displays information about the relationship between symptoms and disease, as well as MB and MD values.

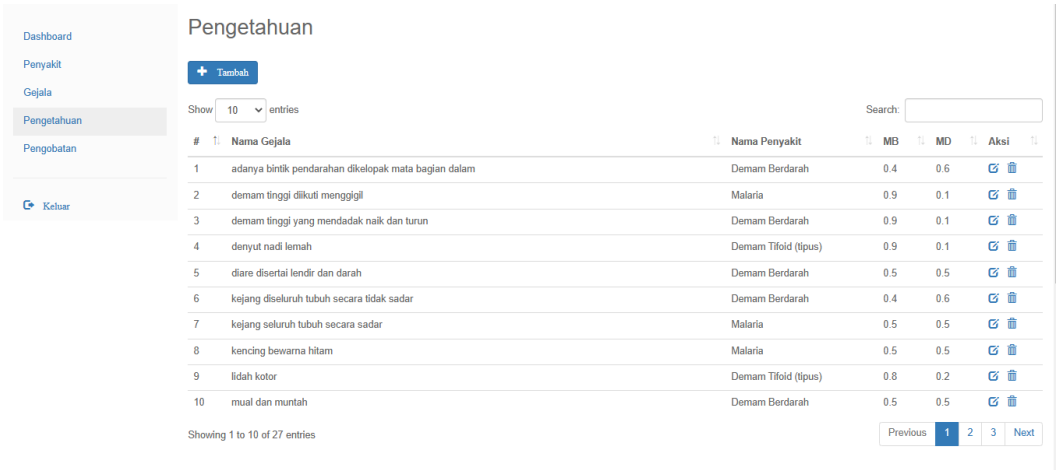

Fig 6. Certainty Factor Data

5) User Menu: In this feature, the user can view and read several questions about the symptoms of the disease they are experiencing. The user then goes through a checklist or selects the disease's symptoms before pressing the process button.

#	Pertanyaan Gejala Peyakit Yang Dialami	Aksi
1	adanya bintik pendarahan dikelopak mata bagian dalam	☐
2	demam tinggi diikuti menggigil	☐
3	demam tinggi yang mendadak naik dan turun	☐
4	denyut nadi lemah	☐
5	diare disertai lendir dan darah	☐
6	emeriksaan mikroskopik lapang gelap plasmadium positif	☐
7	kejang diseluruh tubuh secara tidak sadar	☐
8	kejang seluruh tubuh secara sadar	☐
9	kencing bewarna hitam	☐
10	lidah kotor	☐

Fig 7. User Page

6) The system will display the calculation process based on the symptoms selected by the patient on the following page.

Fig 8. Process of Calculation

7) The results of disease diagnosis will be displayed on the following tab based on the certainty factor value, where the disease with the highest CF value being the final result of this expert system's diagnosis.

Fig 9. Calculation Outcomes

B. Testing the Expert System Diagnostic Results

In this section, we will compare the results of an expert system's diagnosis to the results of a doctor's diagnosis. If it produces the same results, the expert system is functioning properly. Consequently, the user can use the system as a tool to collect information and detect early diseases. If the results of the two diagnoses differ, the system's operation should be improved by expanding the knowledge base or reviewing the methods employed.

Table 9. Expert system diagnoses versus doctor diagnoses.

Case	Symptoms	System analysis results	Doctor's Diagnostic
Case 1	Black pee Soiled tongue Nausea and vomiting	Dengue Fever (CF = 0.5) Typhoid Fever (CF = 0.6)	Typhoid fever
Case 2	Bleeding of the gums and nose Full stomach Headache	Dengue Fever (CF = 0.6) Typhoid fever (CF = 0.4)	Typhoid fever Malaria
Case 3	Low blood pressure Dry and inflamed throat Enlarged liver (hepatomegaly)	Dengue Fever (CF = 0.4) Typhoid Fever (CF = 0.6)	Typhoid fever Malaria
Case 4	High fever fluctuates abruptly Inner eyelid bleeding Nausea and vomiting	Dengue Fever (CF = 0.8)	Dengue fever
Case 5	Lazy and physically weak High fever with chills The face appears pale or anemic	Dengue Fever (CF = 0.5) Typhoid fever CF = 0.4	Dengue fever

When the results of the expert system analysis were compared to the results of the doctor's diagnosis, good results were obtained. Only one case did not match out of the five that were compared. This is not due to an incorrect diagnosis, but rather to the user's selection of symptoms being too small.

IV. Conclusion

Based on the results of this research, the authors can draw several conclusions, namely:

1. The accuracy of diagnosis using an expert system and the certainty factor method produced reliable and precise results. This is shown by comparing system diagnosis results to doctor diagnosis results.
2. Users can rely on this expert system for early disease detection and information before consulting a doctor.
3. Because the application was built using a responsive web method, the user can use it easily and comfortably.

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