Journal of Sisfotek Global
ISSN (Online): 2721 - 3161, ISSN (Print): 2088 – 1762
DOI: http://dx.doi.org/10.38101/sisfotek.v12i1.475
Vol. 12, No. 1, March 2022, pp. 24-31

Expert System for Diagnosing Early Symptoms of COVID-19 Using the Certainty Factor Method

M. Ramaddan Julianti[1], Nunung Nurmaesah[2] & Wisnu Prayogo[3]

[1,2,3]Institut Teknologi dan Bisnis Bina Sarana Global, Tangerang, Indonesia, 14113
E-mail: [1]m.ramaddan.julianti@gmail.com, [2]nunung@gmail.com, [3]prayogowisnu098@gmail.com

ARTICLE HISTORY

Received : 7 March, 2022
Revised : 21 March, 2022
Accepted : 23 March, 2022

KEYWORDS

Expert System
Covid-19
Certainty Factor
Diagnosing

ABSTRACT

Coronavirus Disease 2019 (Covid-19) is a pathogenic virus that is the main cause of respiratory tract diseases that can cause respiratory problems such as lung infections and can cause death. Based on data from the health department, the city of Tangerang said that the level of transmission of Covid-19 in the Tangerang Raya area was included in the red zone category, where the spread of Covid-19 averaged 130 additional cases per day. The main problem found is the difficulty of detecting early symptoms that arise as an indication of being infected with Covid-19 and tools to assist in detecting early symptoms felt by the general public. In this study, a rule-based knowledge representation process for the initial clinical symptoms of Covid-19 infection was carried out using an expert system with the certainty factor method, which aims to measure the level of certainty that has been confirmed by Covid-19 against the initial clinical symptoms felt by the user and makes it easier for users to detect the early symptoms of Covid-19 and helps the government, in this case, the health service center through the availability of the expert system application. Based on the results and discussions that have been carried out in this study, it can be concluded that the results of experiments to detect early clinical symptoms that were implemented using an expert system with the certainty factor method showed empirical calculations in the range of 81-85% confidence level on the results given by the system in initial clinical symptoms entered by the user. The results of the research above were obtained through a process of validating the suitability of initial clinical symptoms to the level of Covid-19 infection by using the forward chaining method and then measuring the level of confidence in the results that have been given based on the established rules. The expert system application with the proposed certainty factor method is the basis for developing mobile-based applications that can be used easily for the wider community

1. Introduction

An expert system is an application that is used to provide problem-solving solutions that usually require human intelligence and use human knowledge [1]. Coronavirus 2019 (Covid-19) better known as a severe acute respiratory syndrome can pose a significant danger to human life in all countries [2]. Covid-19 is divided into four types of infection including 1) mild, 2) moderate, 3) severe and 4) critical. The spread of Covid-19 infection globally is greater through transmission from people who do not show symptoms but can transmit the virus to other people [3].

The implementation of an expert system in the medical world has been carried out with the aim of supporting the doctor's diagnosis process and also giving consideration to the diagnosis results in accordance with the clinical symptoms that appear based on what has been determined [4].

Knowledge of a problem in the medical field by an expert in diagnosing a disease is always associated with uncertainty, so to overcome this, a classification process is carried out with the aim of knowing the group of symptoms that are in accordance with the disease that arises [5].

An expert system is an application that is equipped with a knowledge base for a particular domain and the use of a certain reasoning inference model that can adopt the ability of an expert to solve problems and find solutions so that every ordinary user can solve a particular problem with the help of an expert in their field [6].

The implementation of expert systems in the medical world has provided various benefits, one of which is the ability of expert systems to assist experts in the medical field to be able to assist in overcoming various problems. One of them is an expert system to detect early clinical symptoms of Covid-19 infection and help the public to understand the symptoms and impacts caused by the coronavirus. This research is more focused on measuring the level of certainty of the user's confidence to find out the level of infection that arises due to the initial perceived clinical symptoms and also as a basis for officers at the sub-district health service in conducting tracing with the aim of breaking the chain of Covid-19 spread. Based on the description above, the authors are interested in developing an expert system in detecting early clinical symptoms of Covid-19 infection in the Tangerang area by utilizing datasets originating from community health service centers at the sub-district level.

2. Theoretical Background

Expert system is one of the fields of artificial intelligence, which is known as a knowledge-based system that utilizes computers as a medium to implement various rules and contains knowledge and analysis performed by humans in solving certain problems[7].

An expert system is an application designed to be able to adapt and imitate human knowledge to be implemented in computers through programming languages so that applications in computers can be used to solve problems as experts do [8].

An expert system is a computer-based application that utilizes knowledge, facts, and rules of reasoning techniques as a basic reference in solving problems that are usually solved by experts in a particular field, and also tries to represent and duplicate certain functions and procedures so as to be able to solve problems like an expert in a particular field[9].

Certainty Factor is a theory to determine a certainty in the final decision, which is used to solve the problem of the uncertainty of an object[10]. The certainty factor for CF is a value to measure the confidence of an expert in a given fact [11].

An expert system is an application that is a breakthrough in the development of information technology to be developed in the use of the medical world with the aim of being able to acquire and imitate the abilities possessed by an expert in diagnosing a disease [12].

Certainty theory is a framework for representing and measuring the level of certainty or trust in a solution modeled in the form of a percentage of truth in a knowledge-based system, also representing the level of confidence in a pact or hypothesis based on the data or evidence provided[13]. Still according to [13] that, the CF value is between -1 (definitely wrong) and +1 (definitely true) to measure the level of confidence (positive number) and uncertainty (negative number) of the conclusions generated by the system. To measure the certainty factor according to[13], that the equation as below is carried out:

$$CF[h,e] = MB[h,e] - MD[h,e] \quad (1)$$

Noted:

CF[h,e] = Certainty Factor

MB[h,e] = Size of trust/confidence level of hypothesis h, if given/influenced evidence e (between 0 and 1)

MD[h,e] = Size of distrust/uncertainty level of hypothesis h, if given/influenced evidence e (between 0 and 1)

Expert systems that are designed and implemented require a basic knowledge identification process, where the basic knowledge possessed by experts will be adopted into the system systematically and integrated with the rules and acquisition of knowledge possessed by experts[14].

The expert system is one of the software that stores expert knowledge about a particular domain which is represented by the IF-THEN rule as part of the problem solving process, besides that the expert system has 3 main components including:

1) Knowledge Base is the main component in charge of solving problems. defines all knowledge about the main domain of a problem,
2) Inference Engine is a component that is used to select the right rules and facts to be applied when carrying out the problem solving process,
3) User Interface is a component that is used to bridge the interaction between the user and the system and then displays result of the interaction process that occurs [15].

3. Methodology

This chapter provides information about the research method which consists of several stages, namely: the research framework, the research method to be used, the development of the model, and the research plan to be carried out.

a. Research Method

This study uses the Design Science Research method as depicted in Figure 1, where the stages have several processes, namely

1. Goal-Based Solution Detection (Literature Study), The process of collecting various references such as supporting theories taken through various sources such as books, journals, and previous research, which are included in the bibliography.

2. Problem Identification and Motivation, the stages used to collect and identify the main problems in the research, and collect various facts behind the problem, so that research is important to do.
3. Determination of Research Objectives, The research objective is one of the processes to describe the impact of the results of the research conducted, it is also a description of the problem solving process that underlies the implementation of research in achieving the stated goals.
4. Solution Design and Development, This stage is a process to design and implement the research results that have determined the direction. is described in the form of a UML diagram. This stage is also used to define the minimum requirements for software and hardware as a reference for implementing research results.
5. Demo, This process is carried out to find out the performance of each feature in the application that has been designed and also to find out what features are still having obstacles to support the research results.
6. Testing, is a stage carried out to test the performance of the system that has been designed and evaluate the performance of the system against bugs and errors found in the implementation process. The testing process is also carried out at this stage.
7. Discussion, This stage is used to determine the performance of the system to the response generated by user interaction with the application and also to perform maintenance on features that experience process failure when the application is implemented.
8. Conclusion, The conclusion stage is used to conclude a result from the research obtained from the discussion stage.

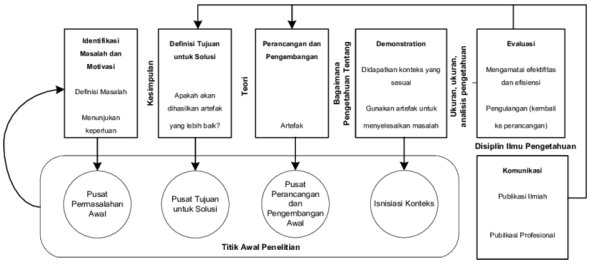

Figure 1 *Design Science Research Method*

c. Research Plan

The research process to be carried out is an experimental research model using the *Design Science Research Methodology* (*DSRM*) method which is divided into 6 stages, as shown in Figure 2. The stages include.

1. Problem Identification & Motivation, this process is carried out to identify the main problems in research, identify data sources and research locations, and determine rules and knowledge bases as a reference in providing diagnostic results to users. The data collection process was carried out by interviewing experts and observing data at the location of the health service center.
2. Definition of Goals for Solutions, this process is carried out to describe the objectives to be achieved in the research, using the certainty factor method which is implemented in the expert system application.
3. Design & Development, This stage is carried out to design the model to be proposed along with the features that have been previously determined and the testing process scheme to support the implementation of the expert system that will be proposed as a solution in solving problems.
4. Demo or Implementation, at this stage, the design that has been made will be implemented which is then carried out with a validation test process and a testing process for all the features that have been developed, including the mechanism for the application performance test process.
5. Evaluation, The evaluation process is a mechanism to see whether the system is running well or not, it is also carried out to see the failure of every process carried out by the user. The results of the evaluation are used as a reference to carry out the maintenance process on the system.
6. Communication, at this stage, the results of the research are published in the process of publication as a form of contribution in the field of research.

Figure 2 *Research Plan*

d. System Design

System design is part of a defined research methodology at the solution design and development stage, where the researcher will describe the stages in determining the results of the expert system application with the certainty factor method, including 1) the diagnostic system flow as shown in Figure 2, this process describes the mechanisms and stages involved. Passed in the process of determining the results in the application of expert systems.

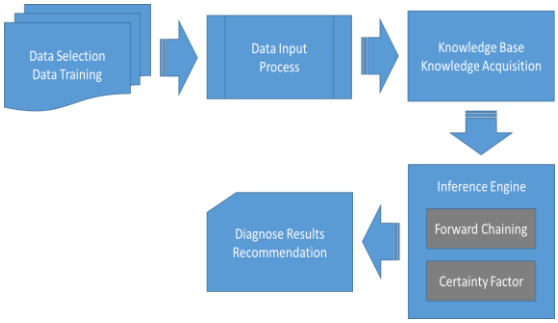

Figure 3 *Certainty Factor Process*

The process that occurs involves two main components, namely the knowledge base and the inference engine. The inference engine component involves 2 methods, namely forward chaining and certainty factors to support the results to be given. And then, 2) the process of determining the final result using the certainty factor method represented in Figure 4, it can be explained that the process begins with determining the weight of the symptoms as an initial identification process to determine the value of CF, then forming a rule base and then calculating the probability obtained in the process of determining the value. The end of the CF, and the last is finding the maximum value of each rule base.

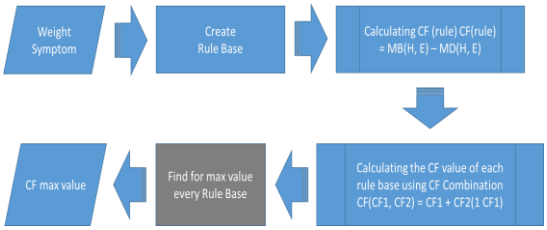

Figure 4 *Certainty Factor Create Values*

5. Result and Discussion

At this stage, information will be conveyed about the initial process in determining the goals and solutions to the main problems and research so that an application design is obtained that is in accordance with the needs of the community as part of the process of breaking the chain of spread of COVID-19. These stages include:

a. Problem Identification

Infection with the Covid-19 virus has caused great concern for people's lives, where they cannot know when they are infected or not. The lack of understanding about infection and symptoms of the conid-19 virus makes people not care and feel no need to check on available health services. . The problems faced are

1) The spread of COVID-19 infection is not followed by an increase in health workers, health facility service systems and the ability to trace users who are detected to have the opportunity to carry the Covid-19 virus.

2) Lack of public attention to the negative impact of covid-19 so that they don't feel the need to carry out an initial detection of symptoms that arise due to covid-19 infection. 3) Lack of availability of applications that can be reached by the public when visiting health facility services to know for sure the initial clinical symptoms that appear when infected with COVID-19. So we need an expert system that can detect early clinical symptoms that appear in patients infected with COVID-19.

b. User Requirement

In designing information systems, user requirements are needed which are then implemented as part of the features contained in the system design. These features will be used to assist users in implementing the system as a whole. The user requirements include:

Table I. User Requirement

Functional	
Needs Analysis	
1	Show main page
2	Displays the user login form
3	Provide user registration form
4	Displays the consultation menu
5	Show case data menu
6	Display history menu can print and delete consultation history
7	Displays the user profile menu
8	Displays the administrator login form
9	Displays the admin dashboard menu
10	Provides a form for adding, deleting, and changing symptom data
11	Provide form add case, delete, and change case data
12	Provide forms add knowledge, delete, and modify knowledge data
13	Provide data search form, print and delete diagnostic data
14	Provide a form to add admin, change, and delete admin data
15	Provide a form to delete user data
Non Functional	
I want the system to get:	
1	Administrator has the right to access all data contained in the application
2	Users must register so they can consult and manage their data in the form of user profiles and diagnostic history
3	Easy to use and understand by users
4	Save and print disease diagnosis results

c. Alternative Solution

Based on the results of problem identification, it was found that the need for a system that makes it easier for the public to access the system to find out the early symptoms of being infected with COVID-19, including 1) Designing an expert system application to find out the types of early clinical symptoms of COVID-19 infection. 2) Create an expert system application that is able to assist the community in identifying COVID-19.

d. Provide Solution

Based on the results of the analysis on the point alternative solution, it can be formulated goals and solutions that are offered. The intended solution is an expert system application design that can facilitate the user in conducting the consultation process for the initial symptoms that arise. The solution design is described in the form of a UML model consisting of use cases, activity diagrams and relational databases.

The proposed design can be seen below:

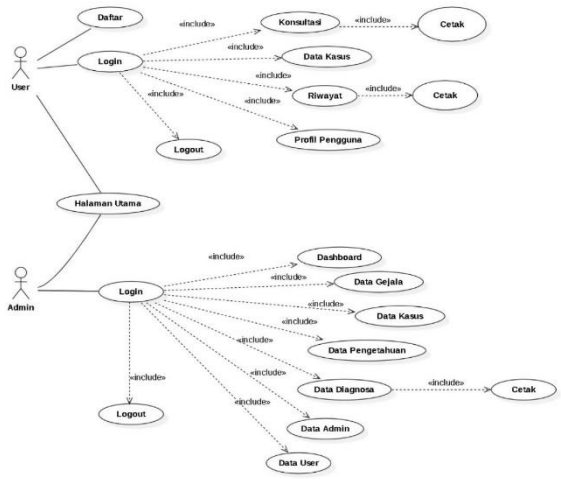

Figure 3 Use Case Diagram

In Figure 3 it is explained that the features that will be used in the proposed expert system application have several features. Where these features are represented in the form of a use case that will be implemented into the system as a whole

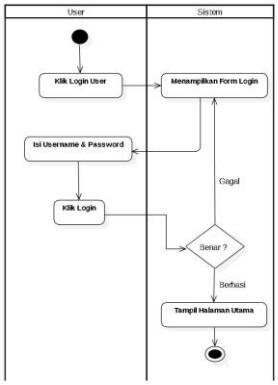

Figure 4 Activity Diagram

Activity diagram is the process of interaction between the system and the user, which describes the flow of information as a form of response between the user and the system

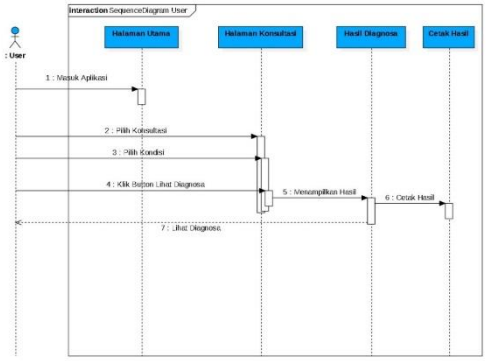

Figure 5 Sequence Diagram

Sequence diagram is a schematic that describes the flow of processes that occur in the system. Sequence diagrams also show the communication of the system to the sub-systems that are in it.

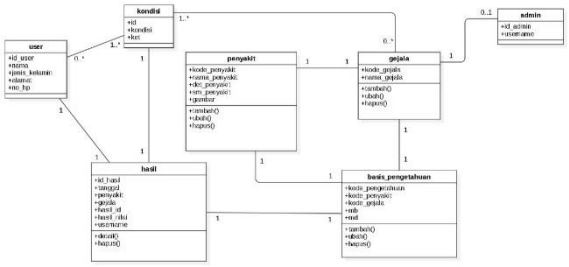

Figure 6 Database Relational

A relational database is a form of representation of a causal relationship between tables in the database. This relationship describes the relationship between data and information that can be processed in an expert system

e. Expert System Design Model

The design of the expert system model is a representation of the user requirements for the application to be designed. The model designed is an interpretation of the community's need for the presence of a system capable of detecting early clinical symptoms of COVID-19 infection.

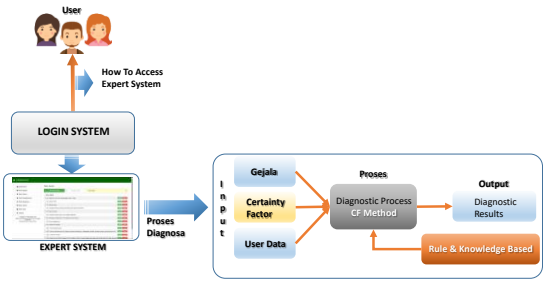

Figure 7 Expert System Model

Figure 7 above explains that the expert system application model designed is a representation of the decision-making process or determination of diagnosis results based on symptom input data performed by the user. The model above explains that the determination of the results is based on the established rule base and knowledge base. The knowledge-based tables include:

Table II. Rule Based

No	Rule
1	IF G1 (0.4) AND G2 (0.4) AND G3(0.4) AND G5 (0.4) AND G10 (0.4) AND G12 (0.4) AND G13 (0.6) THEN P1
2	IF G1 (0.4) AND G4 (0.4) AND G6 (0.6) AND G7 (0.6) AND G8 (0.2) THEN P2
3	IF G15 (0.8) AND G11 (0.8) AND G9 (0.2) AND G14 (0.2) THEN P3

Table III. Knowledge Base

No	Knowledge
G1	Fever body temperature 38 degrees Celsius / more
G2	Out of breath
G3	dry cough
G4	Nasal congestion (stuffy nose, mucus buildup)
G5	sneeze
G6	Loss of the ability to taste (ageusia)
G7	Loss of sense of smell (anosmia)
G8	Sore throat
G9	Fatigue
G10	Headache/dizziness
G11	Have had direct physical contact (such as shaking hands, holding hands) with a confirmed or probable person.
G12	Nausea and vomiting
G13	In the last 14 days before symptoms appeared, had a history of living or working in a high risk place for transmission
G14	Have a loss of consciousness
G15	Has provided direct care to cases that have a possibility or are confirmed without using PPE (Personal Protective Equipment)

6. Testing & Implementation Phase

The implementation of the design results that have been carried out and the coding process using the PHP and MySQL programming languages are executed at this stage, where all the features that have been defined are tested through the testing process. The implementation stage is the stage where the application begins to be used according to the function that has been defined. The results of implementation and testing can be seen below:

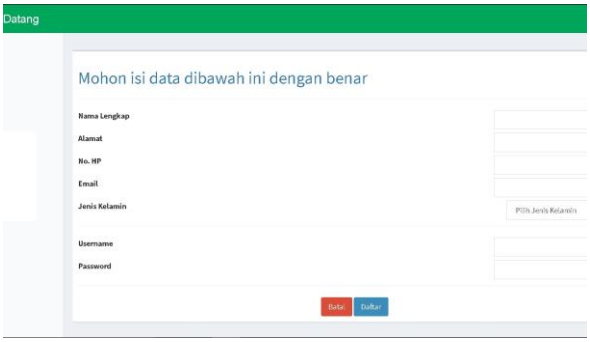

Figure 8 Register Page

In Figure 8, space is given for the user to register first in accessing the system. The purpose of this registration process is to maintain the confidentiality of patient test results information on the level of infection in covid-19.

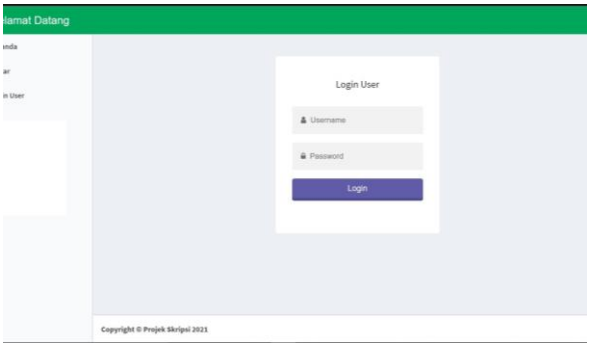

Figure 9 Login Page

In figure 9, the login process is carried out by each user and admin who will access the system, the purpose of this form is to maintain the security of information and data in the database that has been provided.

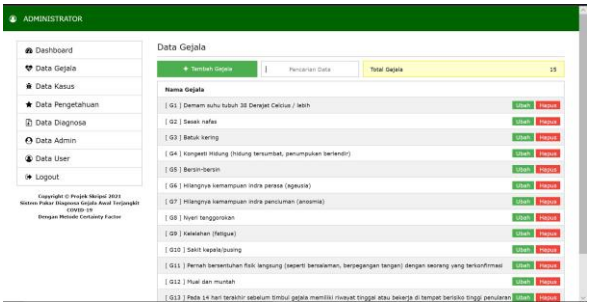

Figure 10 Consultation Process

In figure 10, the consultation process carried out by the user can be accessed in real time, where the user can determine the symptoms that may arise as well as other symptoms felt by the patient. This stage also provides accurate results based on the symptom data that has been inputted. The results of the diagnosis displayed refer to the rule base and knowledge base that have been programmed in this application, so that the results are given in the form of a confidence percentage.

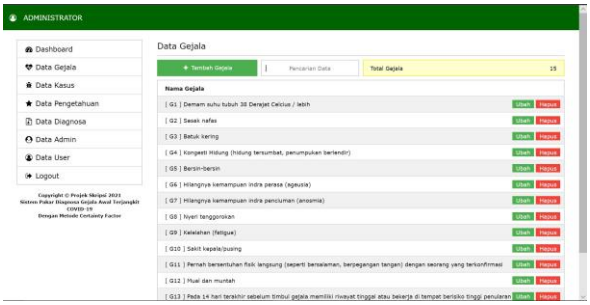

Figure 11 Symptom Page

In figure 11, various symptom data can be managed by the admin, with the aim of enriching information about early symptoms that may arise in various conditions.

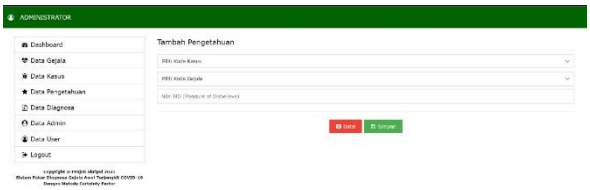

Figure 12 Data Management Page

In Figure 12 it is explained that the data management process consisting of symptom data, disease data, user data and diagnostic data and knowledge based data is managed by the admin with the aim of maintaining data integrity and protecting data from inappropriate use of the application.

7. Conclusions

The expert system is an application designed with the aim of making it easy for the public to accurately identify mild clinical symptoms that are felt based on data and emerging facts so that the transmission process does not spread quickly in the community. By using the PHP and MySQL programming languages, the expert system application using the certainty factor method is expected to assist the hospital in providing access to the public to find out the early clinical symptoms of being infected with COVID-19. The expert system application is also designed based on rules and knowledge adopted from expert knowledge so that the results of the diagnosis received can provide a decision that is in accordance with the established infection level. In addition, the expert system application designed is also expected to facilitate the process of delivering information on the results of the COVID-19 consultation conducted by the community and the results can be printed as a consultation history document.

References

[1] S. A. Pasaribu, P. Sihombing, and S. Suherman, “Expert System for Diagnosing Dental and Mouth Diseases with a Website-Based Certainty Factor (CF) Method,” *Mecn. 2020 - Int. Conf. Mech. Electron. Comput. Ind. Technol.*, pp. 218–221, 2020, doi: 10.1109/MECnIT48290.2020.9166635.

[2] Z. Gao *et al.*, “A systematic review of asymptomatic infections with COVID-19,” *J. Microbiol. Immunol. Infect.*, vol. 54, no. 1, pp. 12–16, 2021, doi: 10.1016/j.jmii.2020.05.001.

[3] J. Yang *et al.*, “Prevalence of comorbidities and its effects in coronavirus disease 2019 patients: A systematic review and meta-analysis,” *Int. J. Infect. Dis.*, vol. 94, pp. 91–95, 2020, doi: 10.1016/j.ijid.2020.03.017.

[4] F. M. Salman and S. S. Abu-Naser, “International Journal of Engineering and Information Systems (IJEAIS) Expert System for Castor Diseases and Diagnosis,” vol. 3, no. 3, pp. 1–10, 2019, [Online]. Available: https://ssrn.com/abstract=3369046.

[5] D. I. G. Hutasuhut, D. Adhar, Nurhayati, E. Ginting, and A. Syahputra, “Expert System Detect Stroke with Dempster Shafer Method,” *2018 6th Int. Conf. Cyber IT Serv. Manag. CITSM 2018*, no. Citsm, pp. 1–4, 2019, doi: 10.1109/CITSM.2018.8674053.

[6] D. A. Prambudi, C. E. Widodo, and A. P. Widodo, “Expert System Application of Forward Chaining and Certainty Factors Method for the Decision of Contraception Tools,” *E3S Web Conf.*, vol. 31, pp. 1–6, 2018, doi: 10.1051/e3sconf/20183110009.

[7] I. Astuti, H. Sutarno, and Rasim, “The expert system of children’s digestive tract diseases diagnostic using combination of forward chaining and certainty factor methods,” *Proceeding - 2017 3rd Int. Conf. Sci. Inf. Technol. Theory Appl. IT Educ. Ind. Soc. Big Data Era, ICSITech 2017*, vol. 2018-Janua, pp. 608–612, 2017, doi: 10.1109/ICSITech.2017.8257185.

[8] K. P. Tripathi, “A Review on Knowledge-based Expert System : Concept and Architecture,” *Artif. Intell. Tech. - Nov. Approaches Pract. Appl.*, vol. 4, no. 4, pp. 19–23, 2011.

[9] F. Rumaisa and D. Junaedi, “Expert system for early diagnosis of meningitis disease using certainty factor method,” *2016 Int. Conf. Inf. Technol. Syst. Innov. ICITSI 2016 - Proc.*, pp. 1–3, 2017, doi: 10.1109/ICITSI.2016.7858202.

[10] W. U. Setiabudi, E. Sugiharti, and F. Y. Arini, “Expert System Diagnosis Dental Disease Using Certainty Factor Method,” *Sci. J. Informatics*, vol. 4, no. 1, pp. 43–50, 2017, doi: 10.15294/sji.v4i1.8463.

[11] H. Fahmi, A. A. Nababan, M. Jannah, M. Khairani, Y. F. A. Lubis, and S. Fahri, “Analysis of Certainty Factor Methods to Determine Skills in Generation y,” *Mecn. 2020 - Int. Conf. Mech. Electron. Comput. Ind. Technol.*, pp. 222–225, 2020, doi: 10.1109/MECnIT48290.2020.9166646.

[12] E. P. Gunawan and R. Wardoyo, “An Expert System Using Certainty Factor for Determining Insomnia Acupoint,” *IJCCS (Indonesian J. Comput. Cybern. Syst.*, vol. 12, no. 2, p. 119, 2018, doi: 10.22146/ijccs.26328.

[13] A. Andriani, A. Meyliana, Sardiarinto, W. E. Susanto, and Supriyanta, “Certainty Factors in Expert System to Diagnose Disease of Chili Plants,” *2018 6th Int. Conf. Cyber IT Serv. Manag. CITSM 2018*, no. Citsm, pp. 1–6, 2019, doi: 10.1109/CITSM.2018.8674264.

[14] Sumiati, H. Saragih, T. K. A. Rahman, and A. Triayudi, “Expert system for heart disease based on electrocardiogram data using certainty factor with multiple rule,” *IAES Int. J. Artif. Intell.*, vol. 10, no. 1, pp. 43–50, 2021, doi: 10.11591/ijai.v10.i1.pp43-50.

[15] H. Saleem, A. R. Khan, and T. A. Jilani, “Expert System for Diagnosing Mobile and Immobile Nutrients Deficiency of Plants,” *Int. J. Acad. Inf. Syst. Res.*, vol. 4, no. 8, pp. 10–15, 2020.