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The Expert System of Determining the Type of Malaria by using Dempster-Shafer Method

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Abstrak- Malaria merupakan penyakit yang paling sering muncul di daerah Asia dan Afrika dan dapat menjadi penyakit yang mengancam jiwa penderitanya. Jenis-jenis malaria seperti Plasmodium Vivax, Plasmodium Ovale, Plasmodium Malariae, dan Plasmodium Falciparum merupakan jenis-jenis malaria yang paling banyak menginfeksi orang di seluruh dunia. Jenis-jenis malaria ini memiliki gejala-gejala tertentu yang menimbulkan beberapa pasien kesulitan untuk memastikan jenis malaria yang dideritanya. Pengujian klinis dan penilaian diagnostik medis dapat dilakukan untuk menentukan jenis malaria, tetapi memanfaatkan sistem juga membawa beberapa manfaat bagi daerah pedesaan yang kekurangan fasilitas medis. Penelitian ini mengembangkan sebuah sistem dengan mengimplementasikan metode Dempster Shafer untuk menentukan jenis malaria. Penelitian ini mengumpulkan pengetahuan dari para ahli berupa 18 kemungkinan gejala beserta nilai densitasnya. Penelitian ini menyajikan 5 kasus penderita dan memberikan hasil sistem berupa kemungkinan jenis malaria. Hasilnya menunjukkan berbagai persentase jenis malaria yang mungkin menginfeksi pasien.

Kata Kunci: Dempster Shafer; Sistem Pakar; Malaria; Jenis-jenis Malaria; Penyakit.

Abstract- Malaria is the most dominant disease in Asia and Africa and may become a life-threatening disease for it suffers. The types of malaria such as Plasmodium Vivax, Plasmodium Ovale, Plasmodium Malariae, and Plasmodium Falciparum are mostly infected people around the world. These types of malaria have certain symptoms that drives difficulties for some patients to confirm which malaria that their infected. A clinical testing and medical diagnostic assessments may be performed to determine the types of malaria, but utilizing a system also brings some benefits for rural areas which lack of medical facilities. The study develops a system by implementing the Dempster Shafer method to determine types of malaria. We collected the knowledge from the experts including 18 possible symptoms along with the density value. This paper present 5 cases of sufferers and provide the system result with the possibilities of malaria types. The result pointed out a various percentage of malaria types that may infected to the patients.

Keywords: Dempster Shafer; Expert System; Malaria; Types of Malaria; Disease.

1. INTRODUCTION

Malaria is kind of disease that has been spread all over the world, especially on the Africa and Asia. Malaria is also a disease that is quite dangerous and can result in death for its sufferers [1]. Based on the report from the World Malaria Report by WHO, the number of sufferers of this disease has reached 247 million people in 2021 with a total death of 619,000 fatalities. Hence, it was indicate an increase in the number of sufferers compared to the number of sufferers in 2020 which has reached 245 million sufferers and 625,000 deaths. [2]. Malaroa is an infectious disease that is usually caused by parasites in the form of *sporozoites* of the genus *Plasmodium* and is usually transmitted to humans through the bite of an infected female *Anopheles* mosquito with the parasite. [3]. The disease transmission occurs when an infected mosquito bites a person, then injects the malaria parasite into their bloodstream Then, the parasite attacks and destroys red blood cells causing the characteristic symptoms of malaria. This mode of transmission is a significant public health concern, particularly in areas where malaria is endemic [4]. the symptoms commonly experienced by sufferers of this disease are fever, chills, dizziness, and nausea. Furthermore, if it is not treated immediately it will be fatal which can cause severe anemia, kidney failure and even death [5].

There are various types of malaria spread throughout the world, including *Plasmodium Vivax, Plasmodium Ovale, Plasmodium Malariae, Plasmodium Falciparum*. These types of malaria have different symptoms and so does the impact of the disease [6], [7]. *Plasmodium Vivax, Plasmodium Ovale,* and *Plasmodium Malariae* are types of malaria that are quite harmless for human health. In other words, it has a small possibility of having an impact on death, but proper management is necessary to avoiding the chronic malaria [8]. On the other hand, *Plasmodium Falciparum* is the most dangerous and life-threatening type of malaria which results in the death of most sufferers. [9]. Moreover, the *Plasmodium vivax* and *Plasmodium falciparum* are types of malaria that is most frequently found in Indonesia [10].

These various types of malaria drive a proper method to determine which type of malaria a person suffers from. Ensuring the patient receives the most effective medication and care is of utmost importance, as it significantly enhances the likelihood of a successful recovery. Additionally, the precise identification of the malaria strain plays a pivotal role in preventing the spread of the disease. Determining the type of malaria and evaluating its impact are usually conducted clinical testing and medical diagnostic assessments. However, there are such mathematical calculations that are useful for understanding and managing malaria which can later be applied to systems, such as expert systems. This mathematical calculation can be used for various purposes, including inference, decision making, handling, uncertainty, and knowledge representation [11]. As one of mathematical analysis, the Dempster-Shafer (DS) method can be used for reasoning under uncertainty and combining evidence from multiple sources. This method usually provides a way to model and measure the level of confidence or uncertainty in a systematic way [12]. Dempster's combination rule is used to combine the belief function, namely by calculating a new belief function by considering the intersection and overlap of the belief function

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related to various sources of evidence. This resulting combined belief function provides a more comprehensive representation of the overall beliefs or uncertainties about the probable outcomes [13].
The DS method has been widely used in various fields, including artificial intelligence, decision support systems, and expert systems. This method can assist in solving problems related to information that is uncertain or conflicting. Thus, enabling better decision making and inference under uncertainty [14]. The DS method is usually also widely applied to expert systems related to the diagnosis of human diseases [15]–[17] as well as plants diseases [18]–[20], and many other fields. The DS method is widely recognized as the most commonly employed approach in expert systems across diverse domains. The present investigation endeavors to ascertain the specific type of malaria afflicting an individual through the utilization of the DS method. The types of malaria that used are *Plasmodium Vivax*, *Plasmodium Ovale*, *Plasmodium Malariae*, and *Plasmodium Falciparum*, with reference to the symptoms experienced. The research conducted also involved the creation of an expert system that effectively incorporated the DS methodology.

2. RESEARCH METHODOLOGY

2.1 Research Steps

A structured research phase is set to ensure the research is run properly. The implementation of the research will be conducted in a sequential manner, following each of the outlined stages. These stages have been visually represented in Figure 1 for clarity and ease of reference. The study will adhere to a structured approach to ensure the accuracy and reliability of the results. The sequential implementation of the research stages will enable a comprehensive analysis of the data collected, leading to a thorough understanding of the research topic.

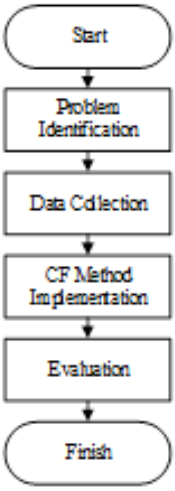

Figure 1. Research Steps

Based on Figure 1, there are several stages involved in carrying out this research. The first stage is identifying the problem, which is the process of defining the problem to be investigated which is useful for establishing fundamental aspects of research [21]. In this study, the problem identified was how to determine the type of malaria suffered by some patients using the DS method and implemented it on an expert system. The second stage is data collection, namely the stage of collecting relevant data to answer research objectives from various sources [22]. Subsequently, the third stage of the project will entail the integration of the DS method into an expert system, which will be followed by a comprehensive evaluation of the outcomes achieved through the application of the method.

2.2 Data Collection

In this study, the data collection step is performed using the interview method, which is explores and understands the perspectives and beliefs of the informants in depth. This method is used to investigate more detailed responses and clarify ambiguous or unclear points [22]. The interviews were conducted with doctors as resource persons, then the results of the interviews will be used as input in the form of knowledge. The data obtained from informants included the types of malaria, its symptoms and their beliefs, and the rule base to describe the type of malaria. Table 1 portrays the types of malaria studied along with the symptoms. Furthermore, Table 2 explains the density value of each possible symptom experienced by malaria sufferers.

Table 1. Types of Malaria and the Symptoms

Disease Code	Disease	Symptoms
P01	*Plasmodium Vivax*	Fever Pale Shivers

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P02	*Plasmodium Ovale*	No Appetite Knee Pain Headache Weak Nauseous Blushing Eyes Dehydration Sweating Profusely
P03	*Plasmodium Falciparum*	Throws up Shivers Hard to breathe Blood Pressure Drop Rapid pulse Headache
P04	*Plasmodium Malariae*	Sore Red Face Diarrhea

Table 2. Symptoms dan Density Value

Code	Symptoms	Density Value
G01	Fever	0.4
G02	Headache	0.4
G03	Weak	0.6
G04	Sweating Profusely	0.8
G05	Sore	0.2
G06	Pale	0.6
G07	Nauseous	0.4
G08	Throws up	0.6
G09	Red Face	0.8
G10	Shivers	0.8
G11	Blushing Eyes	0.8
G12	No Appetite	0.6
G13	Hard to breathe	0.6
G14	Diarrhea	0.6
G15	Dehydration	0.8
G16	Blood Pressure Drop	0.8
G17	Rapid pulse	0.6
G18	Knee Pain	0.6

2.3 Dempster Shafer Method

Dempster Shafer (DS) is a method that carries a measure of the strength of evidence in supporting a set of propositions called as *belief* (*bel*). This belief function lies in a value of 1 or 0, which is a value of 0 indicates that there is no confidence in the evidence, and 1 indicates certainty in the *evidence* [23]. The DS method uses *plausibility* (*Pls*) as a parameter of the uncertainty value over an evidence which will affect the level of confidence of the evidence. For example, if there is a belief in something (X), then the value of *bel(X)* is 1, so the value of *Pls(X)* will be 0. Equations (1) and (2) below are used to calculate the value of *bel* and *Pls* [15].

$$bel(X) = \Sigma_{Y \subseteq X}\, m_1(X) \tag{1}$$

$$Pls(X) = 1 - bel(X) \tag{2}$$

The DS method also carries a universal set of hypotheses that are summarized in an environment called a *frame of discernment* (θ), in this θ there are elements in the form of possible answers and there is also the possibility of one required answer or what is commonly called the *probability function density/mass function* (*m*). If *X* and *Y* are subsets of θ, with m_1 as the density function of *X* and m_2 as the density function *Y*, then m_3 can be formed as a combined function of m_1 and m_2 which is formulated as in Equation (3).

$$m_3(Z) = \frac{\Sigma_{X \cap Y = Z}\, m_1(X) m_2(Y)}{1 - \Sigma_{X \cap Y = \emptyset}\, m_1(X) m_2(Y)} \tag{3}$$

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2.4 Evaluation of Results

The last stage in this research is to evaluate the results obtained from the methods. Comparisons were made by presenting 5 cases of patients suffering from malaria and looking at the accuracy of the results of determining the type of malaria suffered. In this study, the density value of each symptom used the value in Table 2. After analyzing 5 cases of malaria patients, this study will look at the percentage of the results of the calculation method. Hence, it can be proven how good the DS method is in dealing with this problem.

3. RESULTS AND DISCUSSION

This research conducted an assessment of the accuracy of two distinct methods by analyzing five patient cases. Table 3 presents the symptoms encountered by several malaria patients from the case. Subsequently, the DS method was employed to perform calculations utilizing the information provided in the table.

Table 3. Cases and the symptoms

Number of Cases	Symptoms	Code
1	Diarrhea	G14
	Nauseous	G07
	Fever	G01
2	Sweat a lot	G04
	Shivers	G10
	Weak	G03
3	Diarrhea	G14
	Hard to breathe	G13
	Nauseous	G07
	Fever	G01
	Sore	G05
4	Hard to breathe	G13
	Sore	G05
	Pain in the knee	G18
5	Dehydration	G15
	Shivers	G10
	Headache	G02
	Throws up	G08

3.1 System Implementation

The expert system that was built has several menus including Login Page, Home Page, Diseases Page, Symptoms Page, Diagnostics Page, Information Page and others. The menu displays that have been built are separated between admin and user view. The Login Page is used by admin to enter the system by inserting certain username and password that will be filled in by the system's admin. Figure 2 illustrates the system's Login Page interface. Moreover, The Home Page is used to display all menus in the system. Users are able to select the pages to jump to another page. The Home Page is depicted in Figure 3.

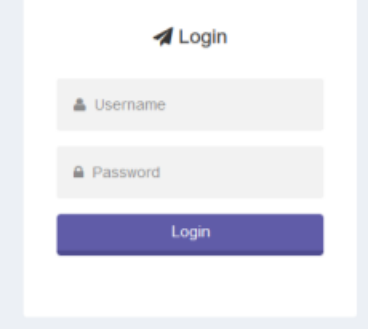

Figure 2. Login Page Interface

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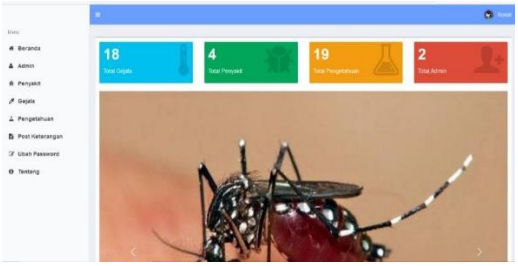

Figure 3. Home Page Interface

Furthermore, the system also presents the Disease Page, which is used to process disease information in the system. The information processed is the name of the disease, disease details and disease advice. Figure 4 shows the interface of Disease Page from the system.

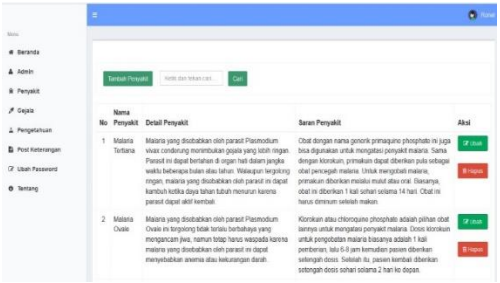

Figure 4. Disease Page Interface

Then, there is a Knowledge Page that used in the system as a rule base for malaria. The page is quite important due to its function to determines the diagnosis result. The data processed by Admin in this menu is the value of trust and distrust given by experts. Knowledge Page interface is displayed in Figure 5. Moreover, the system also has the Diagnosis Page that used to determine the type of disease according to the symptoms experienced by the user. In this page, the user will select the symptoms and select the conditions experienced, after selecting the symptoms and conditions the user must select the search button. Then, the system will display the next menu which is the Diagnostic Results Page. Figure 6 portrays the interface of Diagnosis Page of the system.

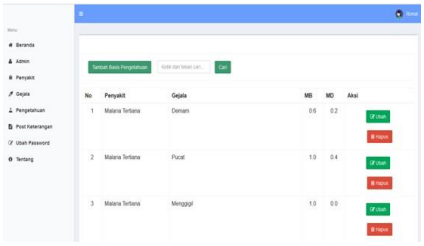

Figure 5. Knowledge Page Interface

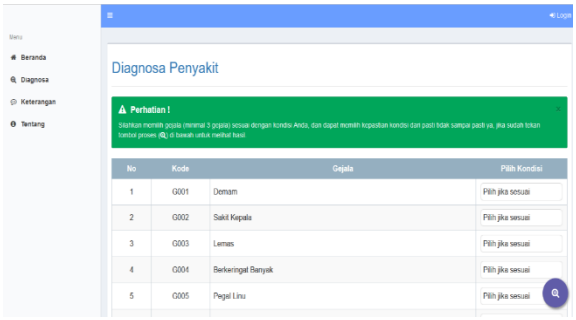

Figure 6. Diagnosis Page Interface

The Diagnostic Results Page shows the diagnostic results that have been input by the user. Users can get the disease experienced, the percentage of the disease, details and suggestions for the disease. The results of this diagnosis can be saved by the user by selecting the print button on the system. The print out of the diagnosis form is the final report on the diagnosis of malaria which can be printed out. Figure 7 displays the interface of Diagnostic Results Page.

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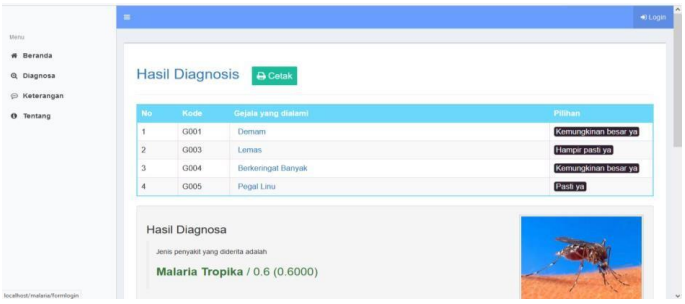

Figure 7. Diagnosis Results Page Interface

3.2 System Result Evaluation

The system is used to determine patients type of malaria according to the symptoms that listed in Table 3. Firstly, we input all the symptoms into the system of each case. The system will do the calculation by using DS method including Equation (1), (2), and (3) that have been implemented on it. Then, we collect the result based on the system output, which is clarifying which types of malaria that suffered by the patient. Table 4 shows the result of system output.

Table 3. Cases and the symptoms

Number of Case	Density Value	Percentage	Malaria Types
1	0,731	73%	*Plasmodium Tertiana*
2	0,817	81%	*Plasmodium Ovale*
3	0,918	91%	*Plasmodium Tropika*
4	0,565	56%	*Plasmodium Malariae*
5	0,91	91%	*Plasmodium Tertiana*

Based on Table 4, there are various percentages of malaria are produced by the system from the cases. Patient number 1 and 5 are infected with the *Plasmodium Tertiana* with the possibility percentage of 73% and 91%. Moreover, patient number 2 is suffered of *Plasmodium Ovale* with the possibility percentage about 81%, then patient number 3 is may exposed to *Plasmodium Tropika* with the possibility percentage of 91%. Last but least, patient number 4 has low possibility of *Plasmodium Malariae* with the percentage of 56%.

4. CONCLUSION

Malaria is one of harmful disease which spread all over the world. Malaria is become a pernicious disease that has a global reach. It manifests in a multitude of symptoms and requires a range of treatments depending on its various types. The disease is caused by the Plasmodium parasite, which is transmitted through the bite of infected Anopheles mosquitoes. The World Health Organization has implemented various strategies to combat the disease, including the distribution of insecticide-treated bed nets and the use of antimalarial drugs. This disease has numerous symptoms and various handling according to it types. Hence, a system is necessary to help patient getting information regarding types of malaria that may infected to them. This research endeavors to create an expert system that can accurately identify the various types of malaria that may afflict patients. The system is designed to utilize Dempster Shafer method to analyze patient data and provide accurate diagnoses. By leveraging the latest technological advancements in the field of medical diagnosis, this study aims to improve the accuracy and efficiency of malaria diagnosis, ultimately leading to better patient outcomes. The expert system developed in this research has the potential to revolutionize the way malaria is diagnosed and treated, providing a valuable tool for healthcare. The system allows users to input the symptoms that their experienced into several forms, then the system presents the malaria type that may possibly occur. The Dempster Shafer is used as the method of system and the study also tested the system with 5 cases of patients and resulting various outcome. The research expect that other methods could be implemented to compare or optimizing the result, such as Fuzzy Logic or Genetic Algorithm.

REFERENCES

[1] J. Talapko, I. Škrlec, T. Alebić, M. Jukić, and A. Včev, "Malaria: the past and the present," *Microorganisms*, vol. 7, no. 6, p. 179, 2019.
[2] World Health Organization, *World Malaria Report 2022*. World Health Organization, 2022.
[3] S. Dhiman, "Are malaria elimination efforts on right track? An analysis of gains achieved and challenges ahead," *Infect. Dis. poverty*, vol. 8, pp. 1–19, 2019.
[4] A. Kamau *et al.*, "Malaria infection, disease and mortality among children and adults on the coast of Kenya," *Malar. J.*, vol. 19, no. 1, pp. 1–12, 2020.
[5] Y. P. Bria, C.-H. Yeh, and S. Bedingfield, "Significant symptoms and nonsymptom-related factors for malaria

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https://journal.fkpt.org/index.php/BIT

diagnosis in endemic regions of Indonesia," *Int. J. Infect. Dis.*, vol. 103, pp. 194–200, 2021.
[6] S. Kho *et al.*, "Diagnostic performance of a 5-plex malaria immunoassay in regions co-endemic for Plasmodium falciparum, P. vivax, P. knowlesi, P. malariae and P. ovale," *Sci. Rep.*, vol. 12, no. 1, p. 7286, 2022.
[7] J. Hawadak, R. R. Dongang Nana, and V. Singh, "Global trend of Plasmodium malariae and Plasmodium ovale spp. malaria infections in the last two decades (2000--2020): a systematic review and meta-analysis," *Parasites \& vectors*, vol. 14, no. 1, p. 297, 2021.
[8] Y. Cui, L. Zhang, Z. Xia, H. Zhou, and F. Huang, "Epidemiological characterization of imported recurrent Plasmodium vivax and Plasmodium ovale in China, 2013--2020," *Infect. Dis. Poverty*, vol. 10, no. 1, pp. 1–10, 2021.
[9] N. Y. Savera, "Stages and Levels of Plasmodium Falciparum Parasitemia in Malaria Blood Preparations," *Jar. Lab. Medis*, vol. 1, no. 1, pp. 22–26, 2019.
[10] P. B. S. Asih *et al.*, "Efficacy and safety of dihydroartemisinin--piperaquine for the treatment of uncomplicated Plasmodium falciparum and Plasmodium vivax malaria in Papua and Sumatra, Indonesia," *Malar. J.*, vol. 21, no. 1, p. 95, 2022.
[11] S. Dick, "Artificial intelligence," *Harvard Data Sci. Rev.*, vol. 1, no. 1, pp. 1–8, 2019.
[12] K. Zhao, L. Li, Z. Chen, R. Sun, G. Yuan, and J. Li, "A survey: Optimization and applications of evidence fusion algorithm based on Dempster-Shafer theory," *Appl. Soft Comput.*, p. 109075, 2022.
[13] Y. Yunitasari, A. Voutama, and N. Sulistiyowati, "Perbandingan Metode Certainty Factor dan Dempster Shafer untuk Sistem Pakar Depresi Pasca Melahirkan," *Techno. Com*, vol. 20, no. 3, pp. 362–371, 2021.
[14] N. A. Hasibuan and A. Fau, "Sistem Pakar Kombinasi Metode Certainty Factor dan Dempster Shafer," *J. Inf. Syst. Res.*, vol. 3, no. 2, pp. 85–90, 2022.
[15] A. R. MZ, I. G. P. S. Wijaya, and F. Bimantoro, "Sistem pakar diagnosa penyakit kulit pada manusia dengan metode dempster shafer," *J. Comput. Sci. Informatics Eng.*, vol. 4, no. 2, pp. 129–138, 2020.
[16] Y. Wiguna, F. Taufik, and A. H. Nasyuha, "Sistem Pakar Mendiagnosa Penyakit Batu Karang Menggunakan Metode Dempster Shafer," *J. Teknol. Sist. Inf. dan Sist. Komput. TGD*, vol. 5, no. 1, pp. 66–75, 2022.
[17] F. Nugroho and A. U. Bani, "Penerapan metode dempster shafer pada sistem pakar diagnosa penyakit usus halus," *J. Media Inform. Budidarma*, vol. 6, no. 1, pp. 243–250, 2022.
[18] O. Yuliardi, I. Zufria, and M. D. Irawan, "Sistem Pakar Mendiagnosis Nutrisi Tanaman Hidroponik Menggunakan Metode Dempster Shafer," *J. Sist. Inf. Triguna Dharma (JURSI TGD)*, vol. 2, no. 3, pp. 425–432, 2023.
[19] D. S. Lumbanbatu, B. Anwar, and M. Dahria, "Sistem Pakar Mendiagnosa Penyakit Tanaman Solanum Betaccum Menggunakan Metode Dempster Shafer," *J. Sist. Inf. Triguna Dharma (JURSI TGD)*, vol. 1, no. 1, pp. 1–9, 2022.
[20] T. E. Togatorop, A. Azlan, and I. Mariami, "Sistem Pakar Mendiagnosa Penyakit Pada Tanaman Kopi Robusta Menggunakan Metode Dempster Shafer," *J. SAINTIKOM (Jurnal Sains Manaj. Inform. dan Komputer)*, vol. 21, no. 1, pp. 32–39, 2022.
[21] S. B. Mishra and S. Alok, "Handbook of research methodology." Educreation publishing, 2022.
[22] N. Walliman, *Research methods: The basics*. Routledge, 2021.
[23] E. Sagala, J. Hutagalung, S. Kusnasari, and Z. Lubis, "Penerapan Sistem Pakar Dalam Mendiagnosis penyakit Tanaman Carica Papaya di UPTD. Perlindungan Tanaman Pangan dan Hortikultura Menggunakan Metode Dempster Shafer," *J. Cyber Tech*, vol. 1, no. 1, 2021.

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