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The Application of the FMADM Electre Algorithm in Diagnosing the Level of Drug Addiction in Adolescents

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ABSTRACT

Drug abuse among adolescents was difficult to identify early without official examinations, while manual methods were often inaccurate. The process of determining rehabilitation also faced challenges due to the lack of technology-based support systems capable of effectively analyzing addiction levels and types of drugs, resulting in rehabilitation efforts that were often poorly targeted. To address this issue, an algorithm was employed to diagnose drug addiction in adolescents by providing scores or rankings indicating addiction levels: scores of 1 and 2 represented mild addiction, 3 and 4 indicated moderate addiction, and 5 or higher signified severe addiction. The FMADM-ELECTRE algorithm recommended various rehabilitation measures for recovery. It offered precise evaluation ranges and scores, simplifying the classification and determination of appropriate detoxification steps for each type of drug-addicted adolescent. The system classified three levels of drug addiction among adolescents, corresponding to three stages of rehabilitation for drug addicts: non-medical (social) rehabilitation, medical rehabilitation (detoxification), and aftercare (post-rehabilitation). Furthermore, the web-based support system was designed to be accessible through various devices, including laptops, computers, tablets, and smartphones, enabling quicker and more efficient decision-making for relevant institutions. This approach also integrated multi-criteria methods to ensure fairness and accuracy in analysis, supporting a comprehensive rehabilitation process. The research produced a web-based system that not only displayed addiction level data but also provided rehabilitation recommendations based on the corresponding addiction categories.

Keywords: FMADM Electre Algorithm, Drugs, Teenagers.

INTRODUCTION

The healthcare sector was influenced by advancements in information and communication technology[1]. Healthcare workers promoted and optimized health by utilizing this technology[2]. The overarching goal of the penitentiary system was drug rehabilitation, which aimed to transform inmates into individuals who could be reintegrated into society and live responsibly as good and accountable citizens[3]. Moreover, this aligned with Indonesia's current penal objectives, which combined absolute and relative theories, incorporating elements of both rehabilitation and deterrence, rather than merely serving as retribution[4].

Drug abuse among adolescents in Indonesia continued to show a concerning trend. In 2018, 3.2% or 2.29 million students in 13 provincial capitals were found to be abusing drugs. By 2021, the prevalence of drug abuse increased from 1.80% to 1.95%, and in 2023, it reached 1.73%, with a significant rise in the 15-24 age group. This data indicated that adolescents were a highly vulnerable group to drug abuse. The dangers of drug abuse among adolescents became increasingly alarming, given the difficulty of early

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identification of users based solely on their characteristics and behaviors before undergoing official examinations by authorized institutions[5]. Identification processes, such as urine, saliva, or hair screening, required strict monitoring to prevent errors in results. Meanwhile, existing manual methods often failed to yield optimal outcomes. Furthermore, determining appropriate rehabilitation types based on the level of addiction and the type of drug used remained a significant challenge, highlighting the need for accurate multi-criteria analysis[6]. Additionally, the lack of technology-based support systems capable of analyzing addiction levels and drug types resulted in slow and inefficient decision-making, often leading to misdirected rehabilitation efforts. Another challenge was the determination of appropriate rehabilitation methods based on addiction levels and drug types, which, if not correctly addressed, could worsen the addicts' condition and hinder their recovery process.

To address these issues, the authors aimed to implement the FMADM-ELECTRE algorithm to enhance confidence and improve accuracy in determining suitable rehabilitation types for drug addicts based on the type of drug and the level of addiction. This processing incorporated weighted values for each available criterion, ultimately producing rehabilitation recommendations tailored to the addicts' characteristics and actions.

The FMADM-ELECTRE algorithm was chosen for its ability to effectively analyze multi-criteria decisions by comparing alternatives based on relevant criteria such as drug type, addiction level, and required rehabilitation. By integrating weighted values, the algorithm produced accurate, data-driven evaluations, enhancing efficiency and precision in determining rehabilitation measures. This approach proved effective in decision support system applications, enabling faster and more targeted decision-making in drug rehabilitation.

The dangers and impacts of drugs on life became increasingly concerning, as noted in a 2020 study by Wildan Fahriza and Sulindawaty[7]. Their research involved applying the simple additive weighting method in a decision support system to identify villages likely to experience drug abuse. This method was used to find ideal solutions among several options based on specific criteria, utilizing data from call centers, recovered addicts, drug crime suspects, nightlife establishments, coffee shops, and poverty data. Village C achieved the highest score with a final value of 0.94684.

Another study by Nur Hasanah Daulay, Surya Darma Nasution, and Fadlina, titled *Decision Support System for Selecting Human Resource Support Personnel Using the ELECTRE Method (Case Study: Sibuhuan Health Services)*[8], highlighted the use of the ELECTRE method based on the outranking concept. This multi-criteria decision-making technique employed pairwise comparisons of alternatives for each criterion, encompassing five attributes: capability, experience, education, creativity, and discipline. By analyzing five sample names through the V matrix comparison, the best outcome was identified, with A3 (NIK: 003) corresponding to Ilmah Wahda Dly.

LITERATURE REVIEW

Various studies had utilized multi-criteria methods to support decision-making in different fields. In the study conducted by Nur Hasanah Daulay, Surya Darma Nasution, and Fadlina, it was explained that the use of the Electre method required the determination of criteria and weights as the basis for calculation and consideration (Case Study: Sibuhuan Health Office). Meanwhile, the study titled "Effective Promotion Decisions Using the Oreste Fuzzy Multiple Attribute Decision Making (FMADM) Method in UMKM Gosimplywedding Sukabumi" by Dicki Prayudi, Renny Oktapian, and Achmad Andika Gunawan revealed that the FMADM method was used to select several tools to determine the best decision[9]. Furthermore, the research by Mahmudi, Kusrini, and Henderi emphasized that the system consisted of interdependent elements to effectively perform input processes through the application of the AHP and Electre methods in employee selection at PT. Gawih Jaya Banjarmasin[10].

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Unlike the previous studies, this research specifically focused on developing a decision support system based on the FMADM-ELECTRE algorithm to address the issues of identifying the level of drug addiction in adolescents and determining the appropriate rehabilitation type. The study by Nur Hasanah Daulay, Surya Darma Nasution, and Fadlina used the ELECTRE method for selecting health support personnel based on criteria such as skills, experience, and creativity. Meanwhile, the research by Dicki Prayudi and colleagues applied the FMADM method to select the best tools for decision-making in promoting UMKM, and the study by Mahmudi and colleagues combined the AHP and ELECTRE methods for employee selection in a company.

The main innovation offered in this study was the application of the FMADM-ELECTRE algorithm in the context of drug rehabilitation. This system was designed to provide scores and rankings based on the level of addiction and the type of drug used, which then led to recommendations for appropriate rehabilitation actions, such as social rehabilitation, medical detoxification, and aftercare. Furthermore, the proposed web-based system allowed access from various devices, facilitating faster and more efficient decision-making. By integrating multi-criteria analysis more specifically focused on drug addiction issues, this study provided more targeted and relevant solutions compared to previous approaches.

METHOD

This study aimed to develop a decision-making system to determine the level of drug addiction in adolescents using FMADM ELECTRE. The planning for this research was presented in the image below.

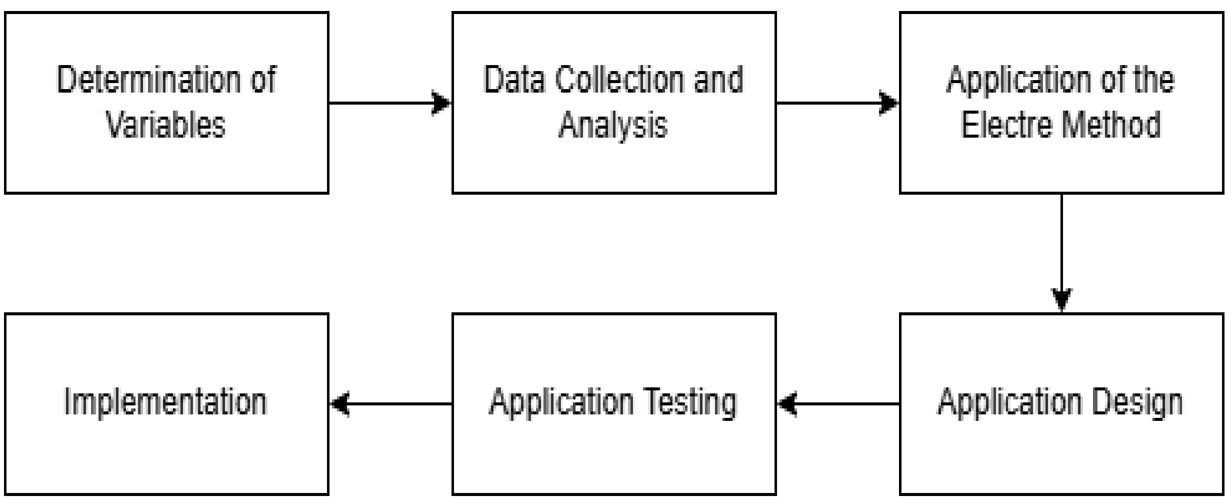

Fig. 1 Planning Process Stages

* Corresponding author

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Determination of Variables

In this study, the determination of variables was based on the type of drug used, the symptoms exhibited by the addict, and the level of addiction, which was determined by ranking. The drug types included Cannabis, Opium, Morphine, Heroin, and Cocaine. The criteria for symptoms used to diagnose the level of addiction were C1 (Red Eyes), C2 (Apathy), C3 (Dry Mouth), C4 (Strong Heart Palpitations), and C5 (Shortness of Breath). Based on the assessment of the drug type and the symptoms, three types of rehabilitation were selected according to the level of addiction.

Non-Medical Rehabilitation (Social) was provided if the ranking of the alternatives was 1 or 2, where the addict participated in rehabilitation programs such as Therapeutic Communities (TC), the Twelve-Step Program, and religious approaches. Medical Rehabilitation (Detoxification) was provided if the ranking of the alternatives was 3, 4, or 5, where the addict underwent a physical and mental health examination by trained doctors, who then decided whether the addict needed medication to alleviate withdrawal symptoms. Lastly, Aftercare (Post-Rehabilitation) was provided if the ranking of the alternatives was greater than 5, where the addict was given activities in line with their interests and talents but remained under supervision to ensure the continuation of their recovery process.

Data Collection Techniques

The data collection techniques in this study were conducted through observation, interviews, and literature review. Observation was carried out by collecting data provided by the Ministry of Law and Human Rights, North Sumatra Regional Office, in the legal field as a direct component of the research. Interviews were conducted with the relevant authorities to obtain information regarding the level of drug addiction among adolescents and the reasons behind their drug use. Additionally, a literature review was conducted by examining relevant literature, including theories and concepts related to this research, such as fuzzy multiple attribute decision-making using the ELECTRE method, as well as theories on drugs and their types. Books, online scientific journals, and websites were used as references in this study.

Requirements Analysis

Before designing the desktop-based software system, a requirements analysis was conducted to determine the type of rehabilitation appropriate for the level of drug addiction in adolescents. This analysis used UML and flowchart modeling. The flowchart illustrates the input and output processes, while UML details the relationships between the users and the system. Formally, the application was designed according to the requirements to determine and document patient data, while informally, the application's interface was simplified for ease of understanding by the users.

Design

In this study, two modeling techniques were used: Unified Modeling Language (UML) and flowchart. The flowchart was used to show the input and output processes, making it easier to understand the steps to be taken[11]. UML was used to design the scope of the system, focusing on the relationship between the users and the system[12]. The following flowchart image shows the designed application:

* Corresponding author

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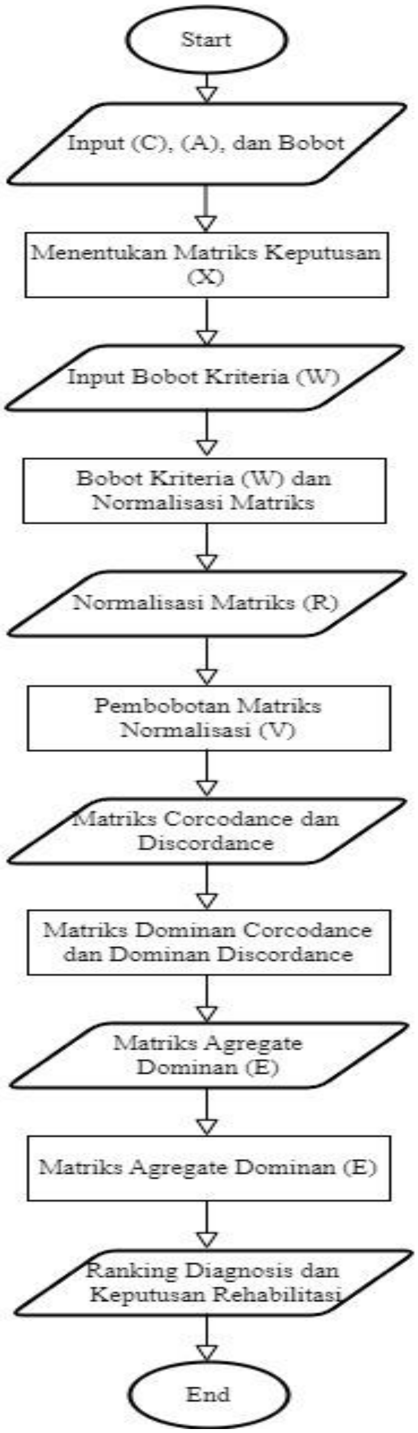

Fig. 2 FMADM-Electre Algorithm Flowchart

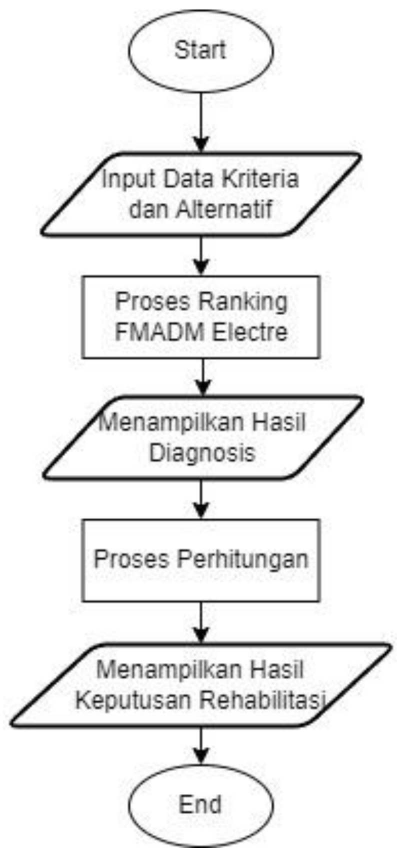

Fig. 3 System Flowchart

The following is an explanation of the Flowchart for the Implementation of the FMADM Electre Algorithm: The process of implementing the FMADM Electre algorithm began with inputting the data for criteria and alternatives, as well as assigning weights to each. Next, a decision matrix was formed to make decisions

* Corresponding author

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based on the alternative data. This matrix was normalized and weighted according to the predefined criteria. Subsequently, the concordance and discordance matrices were calculated to determine the suitability and inconsistency between alternatives. The dominant concordance and discordance matrices were constructed using threshold values, followed by the calculation of the dominant aggregate matrix to rank the alternatives. Finally, the Electre algorithm generated rankings and determined the appropriate rehabilitation type based on the diagnosis of the adolescent's drug addiction.

Here is the explanation of the system's flowchart:
The process begins with the input of data by the user, which includes the criteria data such as the criteria code, name, weight, and evaluation method, as well as the alternative data which contains the alternative code, name, and the weight for each relevant criterion. The system then processes the input data by calculating the rankings using the FMADM Electre algorithm to determine the best alternative. Once the ranking calculation is complete, the system displays the diagnosis results by sorting the alternatives (adolescents) based on their level of drug addiction, from the most addicted to the least. Additionally, the system will present the decision results, showing the rehabilitation action that corresponds to the ranking level of each alternative (adolescent) with drug addiction.

Testing
The testing phase was conducted using the black box method, aiming to determine whether the designed system functions as intended[13]. The testing was carried out based on the characteristics of drug users, where data was input according to the weighted values assigned to each characteristic and attribute.

Implementation
The implementation took place after the design process of the FMADM-ELECTRE application, in order to assess the level of addiction in patients and to determine the subsequent actions that should be taken for the patients.

RESULT

In this study, a system was designed and developed to diagnose the level of drug addiction among teenagers and to provide recommendations for the appropriate type of rehabilitation based on the diagnostic rankings. To diagnose and determine the level of addiction, the system utilized the FMADM Electre algorithm.

System Analysis
The process diagram for diagnosing the level of drug addiction in teenagers involved several steps. First, the addiction level was diagnosed using the FMADM Electre algorithm, which required predetermined symptom criteria for specific types of drugs. Subsequently, the personal data of teenagers were collected and input into the system. Once all necessary data were gathered, the system processed the data by ranking alternative values. It then generated results identifying teenagers affected by drug addiction and provided recommendations for suitable rehabilitation measures based on their ranking values.

Research Data Analysis
To diagnose the level of drug addiction in teenagers using the FMADM Electre algorithm, the data used included types of drugs, criteria for symptoms, and data on teenagers suspected of drug use. The researcher conducted a study at the Ministry of Law and Human Rights (KEMENKUMHAM) of North Sumatra and the Class I Medan Juvenile Rehabilitation Center (LPKA). Below is a detailed analysis of the research data collected.

* Corresponding author

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Types of Drugs

Table 1. Types of Drugs

No.	Type of Drug
1	Marijuana
2	Opium
3	Morphine
4	Heroin
5	Cocaine

Criteria for Symptom Types

Table 2. Criteria for Symptom Types

No.	**Drug Type**	**Criteria Code**	**Symptom Type**	**No.**	**Drug Type**	**Criteria Code**	**Symptom Type**
1	Marijuana	C1	Red Eyes	2	Opium	C1	Malnutrition
		C2	Apathetic			C2	Lung Issues
		C3	Dry Mouth			C3	Liver Issues
		C4	Rapid Heartbeat			C4	Kidney Issues
		C5	Shortness of Breath			C5	Complication Diseases
3	Morphine	C1	Drowsiness	4	Heroin	C1	Withdrawal Symptoms
		C2	Fever			C2	Fever
		C3	Depression			C3	Increased Blood Pressure
		C4	Dry Mouth			C4	Diarrhea
		C5	Lack of Concentration			C5	Piloerection
5	Cocaine	C1	Stimulation				
		C2	Excessive Energy				
		C3	Overconfidence				
		C4	Poisoning				
		C5	Hallucinations and Delusions				

Alternative Adolescent Samples

Table 3. Alternative Adolescent Samples

No.	**No. Institution Reg. Code**	**Alternative Code**	**Adolescent Name**
1	BI. 11/19/Anak	A1	Initials S
2	BI. 14/22	A2	Initials SMP
3	BI. 06/21	A3	Initials BN
4	BI. 08/21	A4	Initials Sr
5	BI. 17/22 (P)	A5	Initials AT
6	BI. 28/22 (P)	A6	Initials RP
7	BI. 27/22 (P)	A7	Initials MI
8	BI. 51/20	A8	Initials PH
9	BI. 01/21 ANAK	A9	Initials AR
10	BI. 04/22	A10	Initials PP

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Implementation of the FMADM Electre Algorithm

This study employed the FMADM Electre algorithm to rank and determine the best alternative through pairwise comparisons of alternatives based on each criterion. The algorithm addressed outranking relationships, where an alternative that did not quantitatively dominate another could still be considered if it was almost certainly better. An alternative was considered dominated if another alternative outperformed it in one or more criteria and was equal in the remaining criteria.

The data required for analysis using the FMADM Electre algorithm included:

1. Assigning suitability weights to each alternative based on criteria, using a scale of 1-5: 1 = Very Poor, 2 = Poor, 3 = Fair, 4 = Good, 5 = Very Good.
2. Determining preference weights for criteria with a scale of 1-5: 1 = Very Low, 2 = Low, 3 = Fair, 4 = High, 5 = Very High.

The steps in applying the FMADM Electre algorithm in this system to diagnose the level of drug addiction among adolescents are as follows:

1. Decision Matrix (X)
   A decision matrix is created to make decisions based on alternative data.

$$X = \begin{bmatrix} 1 & 2 & 3 & 4 & 5 \\ 5 & 4 & 3 & 2 & 1 \\ 2 & 3 & 4 & 5 & 1 \\ 3 & 4 & 5 & 2 & 1 \\ 4 & 5 & 1 & 2 & 3 \\ 5 & 1 & 2 & 3 & 4 \\ 2 & 2 & 3 & 4 & 5 \\ 3 & 3 & 3 & 4 & 5 \\ 4 & 4 & 3 & 4 & 5 \\ 5 & 5 & 1 & 2 & 3 \end{bmatrix}$$

The values in the matrix are obtained through alternative data, with their weights already determined based on the following table.

Table 4. Decision Matrix Alternatives

No.	Alternative	Criteria				
		C1	**C2**	**C3**	**C4**	**C5**
1	A1 (Initials S)	1	2	3	4	5
2	A2 (Initials SMP)	5	4	3	2	1
3	A3 (Initials BN)	2	3	4	5	1
4	A4 (Initials Sr)	3	4	5	2	1
5	A5 (Initials AT)	4	5	1	2	3
6	A6 (Initials RT)	5	1	2	3	4
7	A7 (Initials MI)	2	2	3	4	5
8	A8 (Initials PH)	3	3	3	4	5
9	A9 (Initials AR)	4	4	3	4	5
10	A10 (Initials PP)	5	5	1	2	3

2. Criteria Weights (W)

The weight is assigned to each criterion to express its relative importance (W). The criteria weights are provided in the following table.

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Table 5. Criteria Weights (W)

No.	Criteria Name	Weight (W)
1	C1 (Red Eyes)	1
2	C2 (Apathy)	2
3	C3 (Dry Mouth)	3
4	C4 (Strong Heart Palpitations)	4
5	C5 (Shortness of Breath)	5

3. Normalized Matrix (R)

Normalization is performed to eliminate data duplication, reduce complexity, and facilitate data modification, allowing the data to be presented in a table format and analyzed according to specific requirements. The normalization is calculated using the following formula:

$$\boxed{rij = \frac{xij}{\sqrt{\sum_{i=1}^{m} xij^2}}, \text{i} = 1, 2, \text{...m dan j} = 1, 2, \text{...n}}$$

Below is the calculation of the decision matrix elements that have been normalized:

$$|x_1| = \sqrt{1^2 + 5^2 + 2^2 + 3^2 + 4^2 + 5^2 + 2^2 + 3^2 + 4^2 + 5^2} = 11.5758$$

$$r_{11} = \frac{1}{11.5759} = 0.0864 \qquad r_{61} = \frac{5}{11.5759} = 0.4319$$

$$r_{21} = \frac{5}{11.5759} = 0.4319 \qquad r_{71} = \frac{2}{11.5759} = 0.1728$$

$$r_{31} = \frac{2}{11.5759} = 0.1728 \qquad r_{81} = \frac{3}{11.5759} = 0.2592$$

$$r_{41} = \frac{3}{11.5759} = 0.2592 \qquad r_{91} = \frac{4}{11.5759} = 0.3455$$

$$r_{51} = \frac{4}{11.5759} = 0.3455 \qquad r_{101} = \frac{5}{11.5759} = 0.4319$$

The calculation was carried out up to x_5

Thus, the normalized matrix is as follows:

$$R = \begin{bmatrix} 0.0864 & 0.1789 & 0.3128 & 0.3746 & 0.4272 \\ 0.4319 & 0.3578 & 0.3128 & 0.1873 & 0.0854 \\ 0.1728 & 0.2683 & 0.417 & 0.4683 & 0.0854 \\ 0.2592 & 0.3578 & 0.5213 & 0.1873 & 0.0854 \\ 0.3455 & 0.4472 & 0.1043 & 0.1873 & 0.2563 \\ 0.4319 & 0.0894 & 0.2085 & 0.281 & 0.3417 \\ 0.1728 & 0.1789 & 0.3128 & 0.3746 & 0.4272 \\ 0.2592 & 0.2683 & 0.3128 & 0.3746 & 0.4272 \\ 0.3455 & 0.3578 & 0.3128 & 0.3746 & 0.4272 \\ 0.4319 & 0.4472 & 0.1043 & 0.1873 & 0.2563 \end{bmatrix}$$

The weighted normalized matrix (V) is obtained by multiplying each element of the normalized matrix by the criterion weights that have been determined, as follows: $W = [1\ 2\ 3\ 4\ 5]$

The weighting of the normalized matrix is performed using the following formula:

* Corresponding author

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$$V_{ij} = W_j . X_{ij}$$

$$V = \begin{bmatrix} 0.0864 \text{ x } 1 & 0.1789 \text{ x } 2 & 0.3128 \text{ x } 3 & 0.3746 \text{ x } 4 & 0.4272 \text{ x } 5 \\ 0.4319 \text{ x } 1 & 0.3578 \text{ x } 2 & 0.3128 \text{ x } 3 & 0.1873 \text{ x } 4 & 0.0854 \text{ x } 5 \\ 0.1728 \text{ x } 1 & 0.2683 \text{ x } 2 & 0.417 \text{ x } 3 & 0.4683 \text{ x } 4 & 0.0854 \text{ x } 5 \\ 0.2592 \text{ x } 1 & 0.3578 \text{ x } 2 & 0.5213 \text{ x } 3 & 0.1873 \text{ x } 4 & 0.0854 \text{ x } 5 \\ 0.3455 \text{ x } 1 & 0.4472 \text{ x } 2 & 0.1043 \text{ x } 3 & 0.1873 \text{ x } 4 & 0.2563 \text{ x } 5 \\ 0.4319 \text{ x } 1 & 0.0894 \text{ x } 2 & 0.2085 \text{ x } 3 & 0.281 \text{ x } 4 & 0.3417 \text{ x } 5 \\ 0.1728 \text{ x } 1 & 0.1789 \text{ x } 2 & 0.3128 \text{ x } 3 & 0.3746 \text{ x } 4 & 0.4272 \text{ x } 5 \\ 0.2592 \text{ x } 1 & 0.2683 \text{ x } 2 & 0.3128 \text{ x } 3 & 0.3746 \text{ x } 4 & 0.4272 \text{ x } 5 \\ 0.3455 \text{ x } 1 & 0.3578 \text{ x } 2 & 0.3128 \text{ x } 3 & 0.3746 \text{ x } 4 & 0.4272 \text{ x } 5 \\ 0.4319 \text{ x } 1 & 0.4472 \text{ x } 2 & 0.1043 \text{ x } 3 & 0.1873 \text{ x } 4 & 0.2563 \text{ x } 5 \end{bmatrix}$$

The result of the calculations and the form of the weighted normalized matrix:

$$V = \begin{bmatrix} 0.0864 & 0.3578 & 0.9383 & 1.4985 & 2.1359 \\ 0.4319 & 0.7155 & 0.9383 & 0.7493 & 0.4272 \\ 0.1728 & 0.5367 & 1.2511 & 1.8732 & 0.4272 \\ 0.2592 & 0.7155 & 1.5639 & 0.7493 & 0.4272 \\ 0.3455 & 0.8944 & 0.3128 & 0.7493 & 1.2815 \\ 0.4319 & 0.1789 & 0.6255 & 1.1239 & 1.7087 \\ 0.1728 & 0.3578 & 0.9383 & 1.4985 & 2.1359 \\ 0.2592 & 0.5367 & 0.9383 & 1.4985 & 2.1359 \\ 0.3455 & 0.7155 & 0.9383 & 1.4985 & 2.1359 \\ 0.4319 & 0.8944 & 0.3128 & 0.7493 & 1.2815 \end{bmatrix}$$

4. Concordance Matrix

Determining the set of index values for the concordance matrix. A criterion within an alternative is considered concordant if:

$$\boxed{C_{kl} = \sum j \epsilon \; C_{kl} \; W_j}$$

The concordance matrix is calculated by summing as follows:

$C_{12} = W_3 + W_4 + W_5 = 3 + 4 + 5 = 12$
$C_{13} = W_5 = 5$
$C_{14} = W_4 + W_5 = 4 + 5 = 9$
$C_{15} = W_3 + W_4 + W_5 = 3 + 4 + 5 = 12$
$C_{16} = W_2 + W_3 + W_4 + W_5 = 2 + 3 + 4 + 5 = 14$
$C_{17} = W_2 + W_3 + W_4 + W_5 = 2 + 3 + 4 + 5 = 14$
$C_{18} = W_3 + W_4 + W_5 = 3 + 4 + 5 = 12$
$C_{19} = W_3 + W_4 + W_5 = 3 + 4 + 5 = 12$
$C_{110} = W_3 + W_4 + W_5 = 3 + 4 + 5 = 12$

The calculation was carried out up to C_{109}.

The resulting values are presented in the following concordance matrix:

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$$\begin{bmatrix} - & 12 & 5 & 9 & 12 & 14 & 14 & 12 & 12 & 12 \\ 6 & - & 8 & 12 & 8 & 6 & 6 & 6 & 6 & 8 \\ 10 & 12 & - & 9 & 7 & 9 & 10 & 9 & 7 & 7 \\ 6 & 14 & 11 & - & 7 & 5 & 6 & 6 & 5 & 7 \\ 3 & 11 & 8 & 12 & - & 2 & 3 & 3 & 3 & 14 \\ 1 & 10 & 6 & 10 & 13 & - & 1 & 1 & 1 & 13 \\ 15 & 12 & 6 & 9 & 12 & 14 & - & 12 & 12 & 12 \\ 15 & 12 & 8 & 10 & 12 & 14 & 15 & - & 12 & 12 \\ 15 & 14 & 8 & 12 & 13 & 14 & 15 & 15 & - & 12 \\ 3 & 12 & 8 & 12 & 15 & 3 & 3 & 3 & 3 & - \end{bmatrix}$$

5. Discordance Matrix

Determine the set of index values for the discordance matrix. A criterion in an alternative is considered discordant if:

$$dkl = \frac{\max\{|Vkj - Vlj|\} j \epsilon Dkl}{\max\{|Vkj - Vlj|\} \forall j}$$

The calculation to find the discordance matrix is as follows:

$d_{12} = \{1 , 2\}$

$$d_{12} = \frac{\max\{|0.0864-0.4319|;|0.3578-0.7155|\}}{\max\{|0.0864-0.4319|;|0.3578-0.7155|;|0.9383-0.9383|;|1.4985-0.7493|;|2.1359-0.4272|\}}$$

$$d_{12} = \frac{\max\{0.3455;0.3577\}}{\max\{0.3455;0.3577;0;0.7492;1.7087\}}$$

$$d_{12} = \frac{0.3577}{1.7087}$$

$d_{12} = 0.2094$

This calculation was performed up to d_{110}

The resulting values are presented in the following discordance matrix:

$$\begin{bmatrix} - & 0.2094 & 0.2192 & 0.3661 & 0.6281 & 0.8089 & 1 & 1 & 1 & 0.6281 \\ 1 & - & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0.2306 & - & 0.2783 & 0.7602 & 1 & 1 & 1 & 1 & 0.7602 \\ 1 & 0.2762 & 1 & - & 0.6829 & 1 & 1 & 1 & 1 & 0.6829 \\ 1 & 0.7322 & 1 & 1 & - & 0.597 & 1 & 1 & 1 & 1 \\ 1 & 0.4188 & 0.5847 & 0.7322 & 1 & - & 1 & 1 & 1 & 1 \\ 0 & 0.2094 & 0.2192 & 0.3661 & 0.6281 & 0.6067 & - & 1 & 1 & 0.6281 \\ 0 & 0.1047 & 0.2192 & 0.3661 & 0.4188 & 0.4045 & 0 & - & 1 & 0.4188 \\ 0 & 0.0506 & 0.2192 & 0.3661 & 0.2094 & 0.161 & 0 & 0 & - & 0.2094 \\ 1 & 0.7322 & 1 & 1 & 0 & 0.597 & 1 & 1 & 1 & - \end{bmatrix}$$

6. Dominant Concordance Matrix

The elements of the dominant concordance matrix (F) are constructed using a threshold value by comparing each element of the concordance matrix with its threshold value.

$$\underline{C} = \frac{\sum_{k=1}^{m}\sum_{l=1}^{m} ckl}{m(m-1)}$$

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Journal of Computer Networks, Architecture and High Performance Computing
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The following is the calculation using the above formula to determine the threshold value of the concordance matrix:
Concordance A1 = 12+5+9+12+14+14+12+12+12 = 102
Concordance A2 = 6+8+12+8+6+6+6+6+8 = 66
Concordance A3 = 10+12+9+7+9+10+9+7+7 = 80
Concordance A4 = 6+14+11+7+5+6+6+5+7 = 67
Concordance A5 = 3+11+8+12+2+3+3+3+14 = 59
Concordance A6 = 1+10+6+10+13+1+1+1+13 = 56
Concordance A7 = 15+12+6+9+12+14+12+12+12 = 104
Concordance A8 = 15+12+8+10+12+14+15+12+12 = 110
Concordance A9 = 15+14+8+12+13+14+15+15+12 = 118
Concordance A10 = 3+12+8+12+15+3+3+3+3 = 62

$$\underline{C} = \frac{102+66+80+67+59+56+104+110+118+62}{10(10-1)}$$

$$\underline{C} = \frac{824}{90}$$

$$\underline{C} = 9.1556$$

The threshold value is 9.1556.
The elements of the dominant concordance matrix F are determined as follows:

$$f_{kl} = \begin{cases} 1, \text{jika } C_{kl} \geq c \\ 0, \text{jika } C_{kl} < c \end{cases}$$

Thus, the dominant concordance matrix is:

$$f_{kl} = \begin{bmatrix} - & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & - & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & - & 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & - & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & - & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & - & 0 & 0 & 0 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & - & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & 1 & - & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & - & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & - \end{bmatrix}$$

7. Dominant Discordance Matrix
The elements of the dominant discordance matrix (G) can be obtained using the threshold value.

$$\underline{d} = \frac{\sum_{k=1}^{m}\sum_{l=1}^{m} dkl}{m(m-1)}$$

The following is the calculation using the above formula to determine the threshold value of the discordance matrix:
Discordance A1 = 0.2094+0.2192+0.3661+0.6281+0.8089+1+1+1+0.6281 = 28.601
Discordance A2 = 1+1+1+1+1+1+1+1+1= 9
Discordance A3 = 1+0.2306+0.2783+0.7602+1+1+1+1+0.7602 = 20.298
Discordance A4 = 1+0.2762+1+0.6829+1+1+1+1+0.6829 = 16.426

* Corresponding author

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Discordance A5 = 1+0.7322+1+1+0.597+1+1+1+1 = 7.926
Discordance A6 = 1+0.4188+0.5847+0.7322+1+1+1+1+1 = 17.363
Discordance A7 = 0+0.2094+0.2192+0.3661+0.6281+0.6067+1+1+0.6281 = 26.578
Discordance A8 = 0+0.1047+0.2192+0.3661+0.4188+0.4045+0+1+0.4188 = 19.322
Discordance A9 = 0+0.0506+0.2192+0.3661+0.2094+0.161+0+0+0.2094 = 10.708
Discordance A10 = 1+0.7322+1+1+0+0.597+1+1+1 = 7.925

$\underline{d} = \frac{61.7304}{10(10-1)}$

$\underline{d} = \frac{61.7304}{90}$

$\underline{d}$ = 0.6859

Therefore, the threshold value is: 0.6859.
The elements of matrix G are determined as follows:

$$g_{kl} = \begin{cases} 1, \text{jika } d_{kl} \geq d \\ 0, \text{jika } d_{kl} < d \end{cases}$$

Thus, the dominant discordance matrix is:

$$g_{kl} = \begin{bmatrix} - & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & - & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & - & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & - & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & - & 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 & - & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & - & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & - & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & - & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & - \end{bmatrix}$$

8. Aggregate Dominance Matrix

After obtaining the concordance matrix and discordance matrix, the next step is to multiply both matrices to obtain the aggregate dominant matrix as follows.

Table. 6. Aggregate Dominance Matrix

E_{kl}	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total Weight
A1	-	0	0	0	1	1	1	1	1	1	6
A2	0	-	0	1	0	0	0	0	0	0	1
A3	1	0	-	0	0	1	1	1	0	0	4
A4	0	0	1	-	0	0	0	0	0	0	1
A5	0	1	0	1	-	0	0	0	0	1	3
A6	0	0	0	1	1	-	0	0	0	1	3
A7	0	0	0	0	1	0	-	1	1	1	4
A8	0	0	0	0	0	0	0	-	1	0	1
A9	0	0	0	0	0	0	0	0	-	0	0
A10	0	1	0	1	0	0	0	0	0	-	2

* Corresponding author

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The elimination of less favorable alternatives from the aggregate dominance matrix provided a ranking of each alternative. This means that the row in the aggregate dominance matrix with the least total weight could be eliminated. Therefore, the best alternative was the one that dominated the others.
The final result of the calculation using the Electre algorithm was the aggregate dominance matrix. From the result, it could be seen that the matrix with a value of 1 was the value recommended by the system. Based on the obtained aggregate dominance matrix, the teenager with the highest likelihood of having the most severe addiction was alternative A1, as it had a total weight of 6, where the total weight was the sum of all the 1 values in the aggregate dominance matrix.

System Modeling

System modeling is the process of representing real-world objects or reality as graphical equations or diagrams to make them easily understood by relevant stakeholders[14]. System modeling deals with the details of specifications that explain how the parts of the system will be realized. The outcome of system modeling includes models such as Use Case Diagrams.

Use Case Diagram

A use case diagram is a type of diagram in UML (Unified Modeling Language) used to depict the interaction between a system (usually software or a system) and external actors that interact with the system[15]. Below is the use case diagram for the system used to diagnose the level of drug addiction in adolescents:

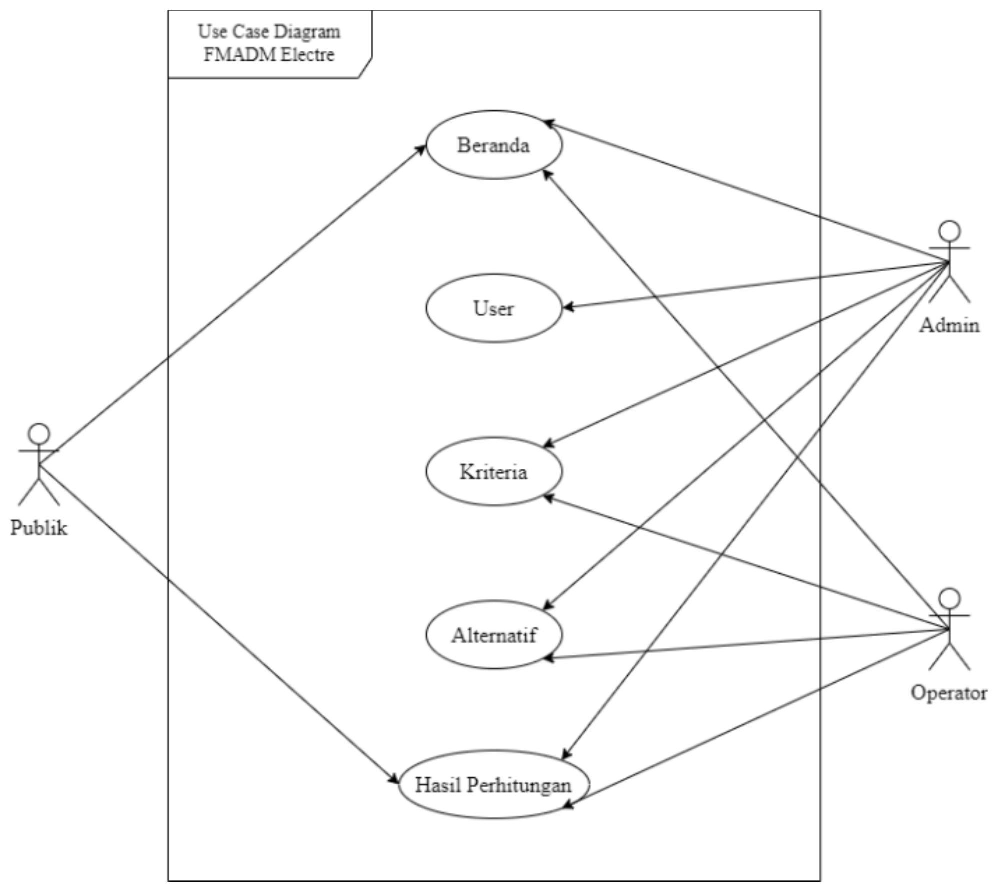

Fig. 4 Use case diagram

* Corresponding author

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Results of the Testing

After conducting testing on a sample of 10 adolescent data (alternatives) out of a total of 223 data obtained from the Ministry of Law and Human Rights (KEMENKUMHAM) of North Sumatra and the Class I Special Child Development Institute (LPKA) Medan, the next step was to rank or assign a ranking to diagnose the level of drug addiction in adolescents by determining the dominant aggregate matrix (E) using the following formula:

$$\boxed{e_{kl} = f_{kl} * g_{kl}}$$

$$f_{kl} = \begin{bmatrix} - & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & - & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & - & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & - & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & - & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 1 & - & 0 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 & 1 & 1 & - & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & 1 & - & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & - & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & - \end{bmatrix} \quad g_{kl} = \begin{bmatrix} - & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \\ 1 & - & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & - & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & - & 0 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & - & 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 & - & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & - & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & - & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & - & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & - \end{bmatrix}$$

Therefore, the resulting dominant aggregate matrix is:

$$e_{kl} = \begin{bmatrix} - & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & - & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & - & 0 & 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & - & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & - & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & - & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & - & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & - & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & - & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & - \end{bmatrix}$$

Here is the table of the dominant aggregate matrix:

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Total Ekl
A1	-------	0	0	0	1	1	1	1	1	1	6
A2	0	-------	0	1	0	0	0	0	0	0	1
A3	1	0	-------	0	0	1	1	1	0	0	4
A4	0	0	1	-------	0	0	0	0	0	0	1
A5	0	1	0	1	-------	0	0	0	0	1	3
A6	0	0	0	1	1	-------	0	0	0	1	3
A7	0	0	0	0	1	0	-------	1	1	1	4
A8	0	0	0	0	0	0	0	-------	1	0	1
A9	0	0	0	0	0	0	0	0	-------	0	0
A10	0	1	0	1	0	0	0	0	0	-------	2

Fig. 5 Dominant Aggregate Matrix Table

* Corresponding author

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After obtaining the Ekl values from the dominant aggregate matrix, the next step is to combine these Ekl values and rank each alternative. The final step of the testing process is to determine the decision for rehabilitation actions based on the ranking of the drug addiction diagnosis level.

No	Alternatif	Nilai Akhir	Hasil Keputusan
1	A1 (Initial S)	6	Bina Lanjut (After Care)
2	A3 (Initial BN)	4	Rehabilitasi Medis (Detoksifikasi)
3	A7 (Initial MI)	4	Rehabilitasi Medis (Detoksifikasi)
4	A6 (Initial RP)	3	Rehabilitasi Medis (Detoksifikasi)
5	A5 (Initial AT)	3	Rehabilitasi Medis (Detoksifikasi)
6	A10 (Initial PP)	2	Rehabilitasi Non-Medis (Sosial)
7	A8 (Intial PH)	1	Rehabilitasi Non-Medis (Sosial)
8	A2 (Initial SMP)	1	Rehabilitasi Non-Medis (Sosial)
9	A4 (Initial Sr)	1	Rehabilitasi Non-Medis (Sosial)
10	A9 (Initial AR)	0	Tidak Terindikasi

Fig. 6 Rehabilitation Decision Results Table

There are 3 types of rehabilitation, which are:

1. Non-Medical Rehabilitation (Social)
   This decision is given if the ranking of the alternative is 1 or 2. The addict will join a rehabilitation program. At this rehabilitation center, the addict undergoes various programs, including therapeutic communities (TC), twelve-step programs, religious approaches, and others.
2. Medical Rehabilitation (Detoxification)
   This decision is given if the ranking of the alternative is 3, 4, or 5. The addict's health, both physical and mental, is examined by trained doctors. The doctor will determine whether the addict requires specific medication to alleviate withdrawal symptoms.
3. After Care
   This decision is given if the ranking of the alternative is above 5. The addict is provided with activities based on their interests and talents to fill their daily routine, and must remain under supervision.

DISCUSSIONS

Based on the results of the research using the FMADM Electre algorithm, this method was applied to diagnose the level of drug addiction in adolescents by assigning rankings or scores. Values of 1 and 2 indicated mild addiction, values of 3 and 4 indicated moderate addiction, while values of 5 or more represented severe addiction. In this study, samples were taken from several adolescents, and the analysis and calculations were conducted using the FMADM Electre algorithm. This method proved to facilitate the grouping process and decision-making for determining appropriate rehabilitation actions based on the level of addiction and type of drug users among adolescents. The final calculation results showed the highest value was 6, indicating the need for further action in the form of aftercare. Thus, the use of the FMADM Electre algorithm provided an effective solution to support a more targeted process for determining rehabilitation steps.

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CONCLUSION

Based on the research findings, the FMADM-ELECTRE algorithm was used to diagnose the level of drug addiction among adolescents by providing specific rankings: scores of 1 and 2 indicated mild addiction, scores of 3 and 4 indicated moderate addiction, and scores of 5 or higher indicated severe addiction. This process allowed for more accurate classification and decision-making in determining the appropriate rehabilitation measures based on the level of addiction and type of drug. The developed web-based system not only facilitated user access through various devices but also expedited the analysis and rehabilitation recommendations process by the relevant institutions. By considering multi-criteria data such as the type of drug and the level of addiction, the system produced data-driven evaluations that were more targeted in determining rehabilitation steps. This approach had a long-term impact, including improving the success of rehabilitation programs and reducing the prevalence of drug abuse among adolescents, while also strengthening the capacity of relevant institutions in addressing drug abuse issues.

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