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Applying TOPSIS For Effective Treatment Selection In Advanced Clinical Decision-Making

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Abstract: Selecting the most appropriate treatment for a medical condition is a critical decision faced by healthcare providers and patients. The effectiveness of the chosen treatment significantly influences patient outcomes, quality of life, and healthcare costs. However, the decision-making process is intricate, involving multiple factors such as treatment efficacy, potential side effects, cost implications, patient preferences, and treatment duration. To address these complexities, structured decision-making frameworks, integrating evidence-based medicine and patient-centered care, are essential. In this paper, we explore the application of Multi-Criteria Decision Making (MCDM) techniques in treatment selection. Specifically, we focus on the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), a widely recognized MCDM method. We present a detailed methodology for applying TOPSIS to evaluate and rank treatment options based on multiple criteria. By constructing a decision matrix, normalizing it, applying weights, and calculating separation measures from ideal solutions, we derive the relative closeness of each treatment option to the ideal solution. The results indicate that surgery emerges as the most preferred treatment option, followed by medication, physical therapy, and lifestyle changes.

***Index Terms* – Multi Criteria Decision Making, TOPSIS, Treatment Selection, Clinical Decision-Making.**

I. Introduction

Choosing the most appropriate treatment for a medical condition is a critical decision that healthcare providers and patients face. The effectiveness of treatment directly impacts patient outcomes, quality of life, and healthcare costs. However, the decision-making process is often complex, involving multiple factors such as treatment efficacy, potential side effects, cost implications, patient preferences, and treatment duration. This complexity necessitates a systematic approach to evaluate and select treatments that best align with the unique needs and circumstances of each patient.

Treatment Selection poses a number of challenges that include Diverse Treatment Options, Variability in Patient Response, and Balancing Benefits and Risks. To navigate these complexities effectively, healthcare providers increasingly rely on structured decision-making frameworks. These frameworks integrate evidence-based medicine with patient-centered care principles, ensuring that treatment decisions are informed by scientific data, patient preferences, and clinical expertise.

Advanced decision-making tools, such as Multiple Criteria Decision Making (MCDM) techniques [1] provide systematic approaches to evaluate treatment options across multiple criteria. These tools help quantify and prioritize treatment attributes such as effectiveness, safety, cost-effectiveness, and patient quality of life, facilitating more informed and transparent decision-making processes.

In this paper, we propose a framework for effective treatment selection across different healthcare contexts. We will discuss how TOPSIS can enhance clinical decision-making, improve patient outcomes, and optimize healthcare resource allocation.

II. Literature Review

Several MCDM techniques have been used by researchers and decision-makers over the years. We will briefly introduce some of the widely used and well-known MCDM techniques.

Analytic Hierarchy Process (AHP) [2]: This method was developed by Thomas Saaty and is widely used for decision-making problems with hierarchical structures. It uses pairwise comparisons to determine the relative weights of criteria and alternatives.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [3]: This method determines the ideal and anti-ideal solutions for each criterion and evaluates the distance between each alternative and these solutions to rank the alternatives.

Simple Additive Weighting (SAW) [4]: This method is a simple weighted sum model that assigns weights to each criterion and sums up the scores for each alternative to find the overall score.

Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE) [5]: This method involves comparing alternatives concerning each criterion and using a pairwise comparison method to assign preference functions to each criterion.

Grey Relational Analysis (GRA) [6]: This method is used for decision-making problems with a limited amount of data. It compares each alternative to a reference alternative to determine their similarity and ranks them based on their closeness to the reference.

III. Methodology

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision-making method that ranks alternatives based on their relative closeness to an ideal solution. TOPSIS is chosen because of the four advantages it has over other techniques as pointed out by Kim et. al. [7]. Here's how we have applied TOPSIS to the problem of treatment selection:

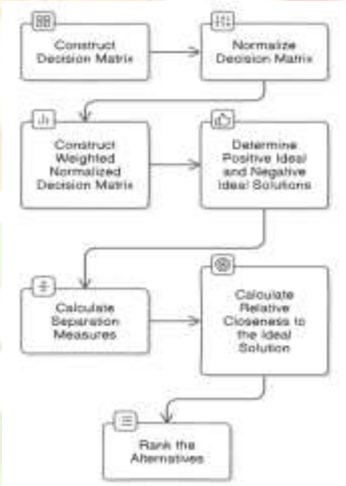

Fig. 1: Process of Decision Making in Treatment Selection using TOPSIS

First, we construct the Decision Matrix by listing the treatment options (alternatives) and the evaluation criteria. The decision matrix is populated with performance ratings for each alternative against each criterion. Then, the decision matrix is normalized using the formula:

$$R_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^2}} \qquad (1)$$

Each column of the normalized decision matrix is multiplied by the corresponding weight of the criterion to get the weighted normalized decision matrix. Then the best (positive ideal) and worst (negative ideal) values are identified for each criterion. Then, the Euclidean distance is calculated of each alternative from the positive ideal solution (S+) and the negative ideal solution (S-) using the following equations:

$$S_i^+ = \sqrt{\sum_{j=1}^{m} (V_{ij} - A_j^+)^2} \qquad (2)$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} (V_{ij} - A_j^-)^2} \qquad (3)$$

This is followed by calculating the relative closeness (C*) of each alternative to the ideal solution using the formula:

$$C_i^* = \frac{S_i^-}{S_i^+ + S_i^-} \qquad (4)$$

Finally the alternatives are ranked based on the relative closeness to the ideal solution. The higher the C* value, the better the alternative.

IV. Results and Discussions

The Decision Matrix is constructed as shown in Table 4.1:

Table 4.1: Decision Matrix

Alternatives	Effectiveness	Side Effects	Cost	Quality of Life	Treatment Duration
Surgery	9	3	7	8	5
Medication	7	6	4	6	4
Physical Therapy	6	5	5	7	3
Lifestyle Changes	5	8	3	6	2

Then, the Decision Matrix is normalized using equation (1) as shown in table 4.2:

Table 4.2: Normalized Decision Matrix

Alternatives	Effectiveness	Side Effects	Cost	Quality of Life	Treatment Duration
Surgery	0.652	0.260	0.746	0.678	0.719
Medication	0.507	0.520	0.426	0.508	0.575
Physical Therapy	0.435	0.433	0.533	0.593	0.431
Lifestyle Changes	0.362	0.693	0.320	0.508	0.287

Then each column of the normalized decision matrix is multiplied by the corresponding weight of the criterion. The assumed weights are as follows: Effectiveness (0.576), Side Effects (0.201), Cost (0.104), Quality of Life (0.040), Treatment Duration (0.079). Using these weights, the Weighted Normalized Decision Matrix is constructed as shown in Table 4.3 below:

Table 4.3: Weighted Normalized Decision Matrix

Alternatives	Effectiveness	Side Effects	Cost	Quality of Life	Treatment Duration
Surgery	0.376	0.052	0.078	0.027	0.057
Medication	0.292	0.104	0.044	0.020	0.045
Physical Therapy	0.250	0.087	0.055	0.024	0.034
Lifestyle Changes	0.209	0.139	0.033	0.020	0.023

Positive and Negative Ideal Solutions are determined as follows:

Positive Ideal Solution (A^+): (0.376, 0.052, 0.033, 0.027, 0.023)

Negative Ideal Solution (A^-): (0.209, 0.139, 0.078, 0.020, 0.057)

Then the Separation Measures are calculated using equation (2) and equation (3) as shown in Table 4.4 and Table 4.5 below:

Table 4.4: Separation from Positive Ideal Solution (S^+):

Alternatives	**S^+**
Surgery	0.095
Medication	0.099
Physical Therapy	0.134
Lifestyle Changes	0.199

Table 4.5: Separation from Negative Ideal Solution (S^-)

Alternatives	**S^-**
Surgery	0.172
Medication	0.140
Physical Therapy	0.095
Lifestyle Changes	0.071

Finally, the Relative Closeness to the Ideal Solution (C*) is calculated using equation (4) as shown in Table 4.6 below:

Table 4.6: Relative Closeness to the Ideal Solution (C*)

Alternatives	**C***
Surgery	0.644
Medication	0.586
Physical Therapy	0.415
Lifestyle Changes	0.263

The alternatives are ranked based on the relative closeness to the ideal solution. The higher the C* value, the better the alternative.

So, the final ranks are:

1. **Surgery:** 0.644
2. **Medication:** 0.586
3. **Physical Therapy:** 0.415
4. **Lifestyle Changes:** 0.263

V. CONCLUSION

TOPSIS provides a structured method to evaluate and rank treatment options based on multiple criteria, helping to identify the treatment that most closely aligns with the ideal solution. In this example, Surgery is identified as the most preferred treatment option, followed by Medication, Physical Therapy, and Lifestyle Changes. This method ensures a comprehensive and balanced approach to treatment selection, considering all relevant factors in the decision-making process.

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