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# Quality Evaluation in Hospital Operations Management Using Multi-Criteria Decision-Making with Plithogenic Approach to Address Uncertainty and Enhance Decision-Making Processes

**Meng Zhang [1], Yafang Li[2*]**

[1]Jining Yucai High School, Jining, 272100, Shandong, China

[2]Jining Medical University, Jining, 272100, Shandong, China

*Corresponding author, E-mail: liyafang@mail.jnmc.edu.cn

**Abstract**: Coordination of medical facilities' operations depends on operations management. Hospitals must function effectively to meet the medical demands of their patients, who get critical and emergency treatment. The decision support system for Quality Evaluation in Hospital Operations Management is created in this study. Plithogenic sets and multicriteria decision-making (MCDM) form the foundation of this decision assistance system. The study presents a novel approach to evaluating and rating Hospital Operations Management. Alternatives are ranked using the plithogenic reference-based normalization alternative ranking (RBNAR) technique. Thus, the algorithm for plithogenic-RBNAR is constructed and presented. An analysis of Hospital Operations Management is conducted using the new hybrid decision support model. The plithogenic-RBNAR hybrid method's applicability is supported by the research findings. The case study and sensitivity analysis results support the plithogenic-RBNAR hybrid model's robustness and applicability.

**Keywords**: Uncertainty; Multi-Criteria Decision Making; Hospital Operations Management; Decision making.

## 1. Introduction

The term "hospital operations management" describes the variety of administrative tasks required to maintain hospital operations. Budgeting, staffing, employee issues, services offered, care quality, and hospital policies are all included[1], [2]. To maintain a hospital's operations and guarantee that its patients receive the treatment they require, operations management specialists are crucial. They frequently collaborate to complete the various administrative duties necessary to maintain the hospital's operations[3], [4]. A hospital's operations management department handles a variety of duties pertaining to managing the facility's daily operations. Among their duties are the following: Budget optimization, grant and other funding applications, financial goal-setting, and strategy implementation[5], [6]. Developing regulations that facilitate operations and the delivery of high-quality care-making sure the hospital complies with all legal requirements, including making sure all healthcare professionals participate in professional development and update their licenses on a regular basis Establish collaborations with other nearby medical establishments to offer community care. Managing the hospital's workforce requirements and carrying out duties like hiring, educating, and acclimating new hires Examining processes and revising tactics to increase service effectiveness Quality[7], [8]. Evaluation in Hospital Operations Management is a MCDM issue[9], [10].

### 1.1 Motivation of this study

There are different primary components to the system for Quality Evaluation in Hospital Operations Management that was created in this study. The first section uses plithogenic sets to determine weighting for the efficiency level of experts in the decision-making process. plithogenic sets, which express the membership, non-membership, and indeterminacy degrees of set constituents, offer a useful method for quantifying qualitative evaluations. This makes it possible to lower the level of uncertainty in expert assessments. Additionally, plithogenic sets are excellent for capturing qualitative uncertainties. A novel reference-based normalization alternative ranking (RBNAR) technique is created to rate alternatives[11], [12]. The RBNAR method enables the computation of values based on their separations from the optimal point[13], [14].

### 1.2 Aims of this study

Linguistic expressions used by experts to assess criteria are converted into plithogenic sets for computing the criteria weights. For reference values. The RBNAR approach for ranking the options is introduced in the study. Using both Z-score normalization and Aytekin's reference-based normalization, this approach integrates reference-based normalization procedures. All these techniques are then used in the study to create the plithogenic-RBNAR hybrid methodology.

### 1.3 Contributions of this study

The study adds a new approach to Quality Evaluation in Hospital Operations Management. Based on the research findings, the conclusions for hospital managers are also examined. In the end, this study offers insights into plithogenic sets, introduces the RBNAR method for ranking Hospital Operations Management. All these elements are combined into a hybrid decision support system for evaluating Quality Evaluation in Hospital Operations Management.

This study offers a comprehensive and cutting-edge decision support system that may be used by experts and decision makers.

RBNAR method for ranking alternatives. The creation of the RBNAR system for evaluating and ranking alternatives is a notable contribution. This approach offers a thorough ranking solution by combining two reference-based normalizing techniques: Z-score normalization and Aytekin's reference-based normalization.

Robustness testing: By conducting thorough sensitivity studies on the case study findings and the plithogenic-RBNAR hybrid approach, this study goes beyond theoretical validation. The results of these investigations support the hybrid model's resilience and dependability.

### 1.4 Organization of this study

There are five sections in this study. The approach is described in Section 2, which also includes details on plithogenic sets and the steps and algorithm of the plithogenic-RBNAR hybrid model. In Section 3, the MCDM issue is evaluated through a case study. The sensitivity analysis results are presented in Section 4. Section 5 shows the conclusions of this study.

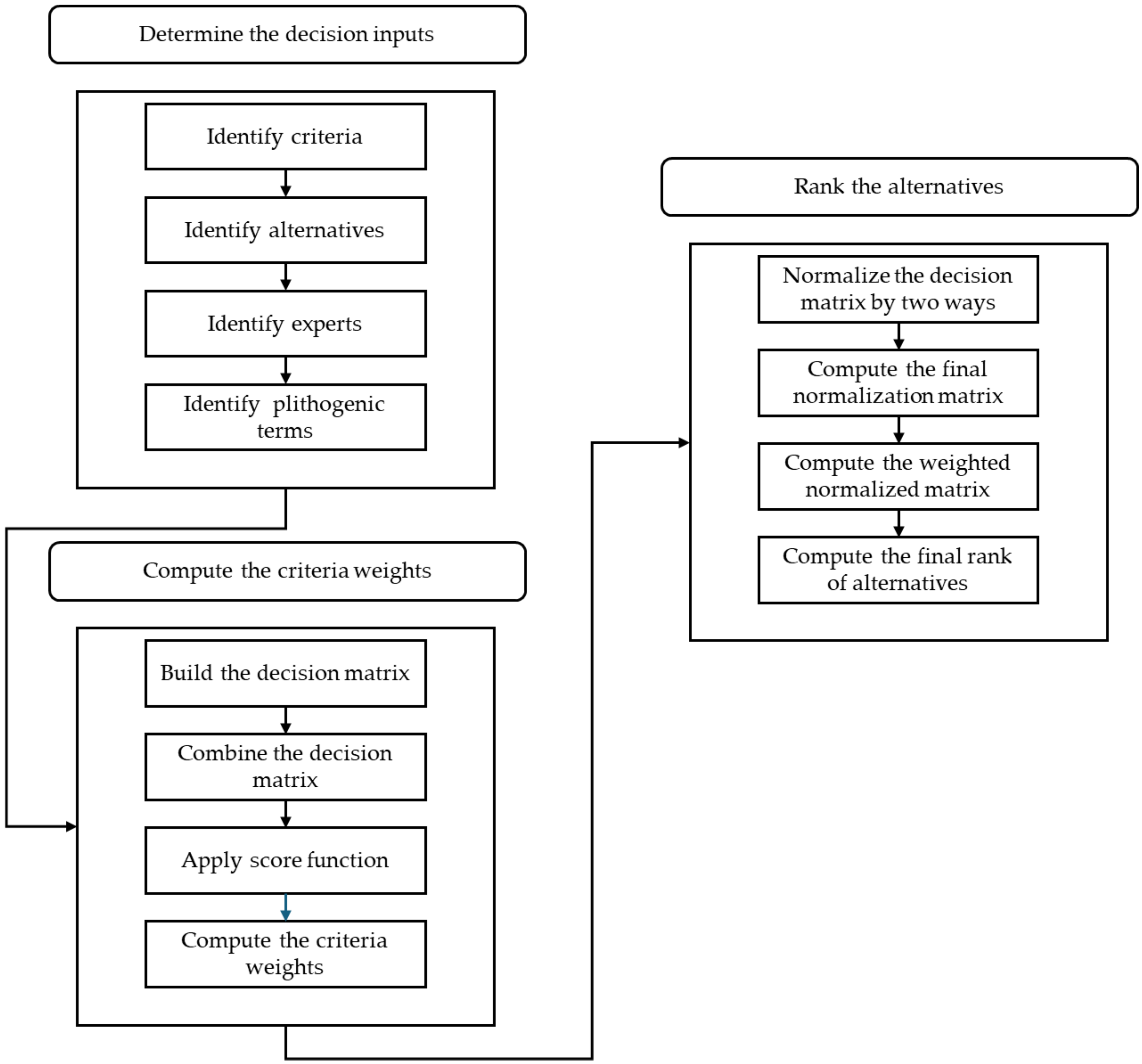


**Figure 1. The steps of the RBNAR approach.**

## 2. Methodology

This section shows the steps of the proposed approach. The RBNAR approach is integrated with the plithogenic sets to deal with uncertainty data[15], [16]. Figure 1 shows the steps of the proposed approach.

Step 1. Build the decision matrix.

Experts use plithogenic terms to evaluate the criteria and alternatives.

Step 2. Combine the decision matrix

The decision matrix is built using the plithogenic numbers between the criteria and the alternatives.

Step 3. Obtain crisp values and compute the criteria weights.

We obtained crisp values from the combined decision matrix. Then we normalize crisp values to obtain the criteria weights.

Step 4. The two distinct normalization methods are used to compute the normalized decision matrix. Among these is the non-monotonic Z-score normalization method. The other is the reference-based normalizing method developed by Aytekin. Normalizing the data using reference values and standard deviations enables a normalization procedure that is based on the presumption of a normal distribution, which is the main reason for using the Z-score normalization technique. However, the ability of Aytekin's reference-based normalization technique to standardize data scales makes it possible to compare datasets with disparate scales. The Heron mean is then used to aggregate two normalized decision matrices.

$$r_{ij} = e^{\left(\frac{\left(x_{ij}-F_j\right)}{-2\left(std_j\right)^2}\right)} \tag{1}$$

Where $F_j$ refers to the reference value and $std_j$ refers to the standard deviation.

$$q_{ij} = 1 - \left(\frac{x_{ij}-F_j}{|F_j|+10^t}\right) \tag{2}$$

Where t>0

Step 5. Compute the final normalization matrix

$$d_{ij} = u\sqrt{r_{ij}q_{ij}} + (1-u)\frac{r_{ij}+q_{ij}}{2} \tag{3}$$

$u \in [0,1]$

Step 6. Compute the weighted normalized matrix.

$$y_{ij} = w_j d_{ij} \tag{4}$$

Step 7. Compute the final rank of alternatives.

$$L_{ij} = \sum_{j=1}^{m} y_{ij} \tag{5}$$


Figure 2. The criteria list.

**3. Case Study**

The evaluation of hospital operational management quality focuses on assessing how effectively a hospital delivers healthcare services while ensuring efficiency, patient satisfaction, and sustainability. It examines the overall performance of hospital systems, including resource allocation, staff coordination, service delivery, and infrastructure utilization. High-quality operational management ensures that hospitals provide timely, safe, and patient-centered care while optimizing costs and maintaining a supportive work environment for healthcare professionals. Effective management also addresses challenges such as patient flow, staff workload, and emergency preparedness to ensure smooth daily operations. Additionally, it emphasizes compliance with healthcare regulations, ethical standards, and the adoption of innovative practices to enhance service quality. By continuously improving operational processes, hospitals can achieve better outcomes for patients, reduce waiting times, and improve resource efficiency. Hospital operational management quality evaluation is essential for identifying gaps, driving improvements, and aligning services with the evolving needs of patients and communities, ultimately contributing to the overall effectiveness and sustainability of healthcare systems. This section evaluates the Hospital Operations Management using the MCDM approach under the uncertainty environment. We collected eight criteria and five alternatives in this study as shown in Figure 2. Four experts have evaluated the criteria and alternatives. Then we used the plithogenic numbers to assess the criteria and alternatives to build the decision matrix as shown in Table 1. Then we used the plithogenic operators to combine the decision matrix. Then we obtained crips values. Then we normalize the decision matrix to obtain the criteria weights as shown in table 2.

Table 1. The decision matrix.

| | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ |
|---|---|---|---|---|---|
| $C_1$ | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) |
| $C_2$ | (0.30, 0.40, 0.80) | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) | (0.30, 0.40, 0.80) |
| $C_3$ | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) |
| $C_4$ | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) |

| | | | | | |
|---|---|---|---|---|---|
| **$C_5$** | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) |
| **$C_6$** | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) | (0.90, 0.10, 0.10) | (0.30, 0.40, 0.80) |
| **$C_7$** | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) | (0.90, 0.10, 0.10) |
| **$C_8$** | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) |
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ |
| **$C_1$** | (0.70, 0.30, 0.10) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) |
| **$C_2$** | (0.70, 0.30, 0.10) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.30, 0.40, 0.80) |
| **$C_3$** | (0.50, 0.40, 0.60) | (0.70, 0.30, 0.10) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) |
| **$C_4$** | (0.70, 0.30, 0.10) | (0.70, 0.30, 0.10) | (0.70, 0.30, 0.10) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) |
| **$C_5$** | (0.90, 0.10, 0.10) | (0.70, 0.30, 0.10) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) | (0.50, 0.40, 0.60) |
| **$C_6$** | (0.70, 0.30, 0.10) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) |
| **$C_7$** | (0.70, 0.30, 0.10) | (0.70, 0.30, 0.10) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) |
| **$C_8$** | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.70, 0.30, 0.10) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) |
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ |
| **$C_1$** | (0.50, 0.40, 0.60) | (0.30, 0.40, 0.80) | (0.30, 0.40, 0.80) | (0.50, 0.40, 0.60) | (0.70, 0.30, 0.10) |
| **$C_2$** | (0.30, 0.40, 0.80) | (0.50, 0.40, 0.60) | (0.30, 0.40, 0.80) | (0.30, 0.40, 0.80) | (0.50, 0.40, 0.60) |
| **$C_3$** | (0.50, 0.40, 0.60) | (0.30, 0.40, 0.80) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) | (0.50, 0.40, 0.60) |
| **$C_4$** | (0.70, 0.30, 0.10) | (0.50, 0.40, 0.60) | (0.30, 0.40, 0.80) | (0.30, 0.40, 0.80) | (0.70, 0.30, 0.10) |
| **$C_5$** | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.50, 0.40, 0.60) | (0.30, 0.40, 0.80) | (0.30, 0.40, 0.80) |
| **$C_6$** | (0.30, 0.40, 0.80) | (0.50, 0.40, 0.60) | (0.30, 0.40, 0.80) | (0.30, 0.40, 0.80) | (0.30, 0.40, 0.80) |
| **$C_7$** | (0.50, 0.40, 0.60) | (0.30, 0.40, 0.80) | (0.30, 0.40, 0.80) | (0.50, 0.40, 0.60) | (0.10, 0.70, 0.80) |
| **$C_8$** | (0.10, 0.70, 0.80) | (0.50, 0.40, 0.60) | (0.30, 0.40, 0.80) | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) |
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ |
| **$C_1$** | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) |
| **$C_2$** | (0.10, 0.70, 0.80) | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.30, 0.40, 0.80) |
| **$C_3$** | (0.50, 0.40, 0.60) | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.90, 0.10, 0.10) |
| **$C_4$** | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) |
| **$C_5$** | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.70, 0.30, 0.10) |
| **$C_6$** | (0.30, 0.40, 0.80) | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.90, 0.10, 0.10) |
| **$C_7$** | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) |
| **$C_8$** | (0.10, 0.70, 0.80) | (0.70, 0.30, 0.10) | (0.90, 0.10, 0.10) | (0.90, 0.10, 0.10) | (0.10, 0.70, 0.80) |

Table 2. The criteria weights.

| | **Weights** | **Rank** |
|---|---|---|
| **$C_1$** | 0.129109 | 6 |
| **$C_2$** | 0.113023 | 2 |
| **$C_3$** | 0.12521 | 4 |
| **$C_4$** | 0.145429 | 8 |
| **$C_5$** | 0.139794 | 7 |
| **$C_6$** | 0.124244 | 3 |
| **$C_7$** | 0.125568 | 5 |
| **$C_8$** | 0.097623 | 1 |

Eq. (1) is used to first normalization decision matrix between the criteria and alternatives.
Then we used Eq. (2) is used to second normalization of decision matrix as shown in Table 3. Then we obtained the final normalized decision matrix by using Eq. (3). We put value of u with 0.5

Table 3. The normalized decision matrix.

| | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ |
|---|---|---|---|---|---|
| $C_1$ | 1.760065 | 1.778128 | 1.778991 | 1.754727 | 1.769856 |
| $C_2$ | 1.778128 | 1.768725 | 1.78456 | 1.76358 | 1.781164 |
| $C_3$ | 1.777716 | 1.769082 | 1.757774 | 1.785468 | 1.760065 |
| $C_4$ | 1.760973 | 1.748623 | 1.76358 | 1.778128 | 1.755575 |
| $C_5$ | 1.735327 | 1.791043 | 1.774249 | 1.76358 | 1.754727 |
| $C_6$ | 1.757774 | 1.79396 | 1.78456 | 1.758101 | 1.757774 |
| $C_7$ | 1.765515 | 1.750706 | 1.772582 | 1.775067 | 1.785468 |
| $C_8$ | 1.812577 | 1.765515 | 1.74583 | 1.772582 | 1.812577 |

Then we obtain weighted decision matrix using Eq. (4). Then we compute the final rank of alternatives using Eq. (5) as shown in Figure 3.

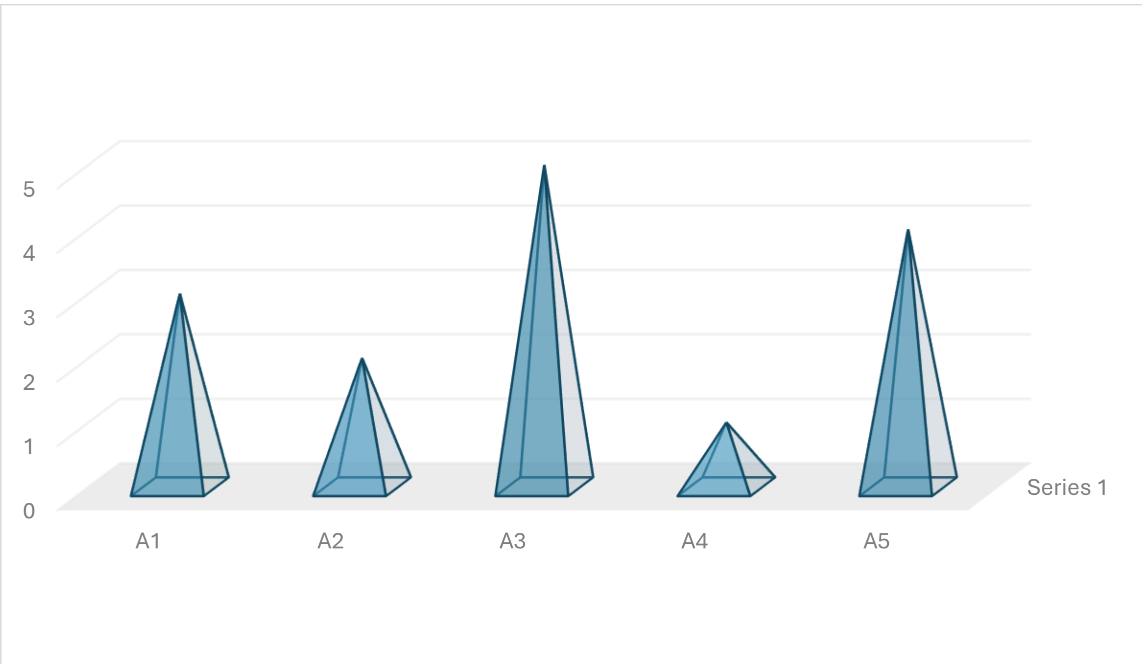


Figure 3. The final rank of alternatives.

## 4. Sensitivity Analysis

This section shows the sensitivity analysis under different cases to show the different ranks of alternatives. We change the value of $u$ between 0 to 1 and then we rank the alternatives under different cases. Table 4 shows different ranks of alternatives.

We show alternative 3 is the best and alternative 1 is the worst. So, our model is effective and stable in the ranks under different ranks.

Table 4. The rank of alternatives under different cases.

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_6$ | $D_7$ | $D_8$ | $D_9$ | $D_{10}$ | $D_{11}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_1$ | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| $A_2$ | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **A3** | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| **A4** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **A5** | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |

In the second case in the sensitivity analysis, we change the criteria weights under different cases, then we rank the alternatives to show the different rank of alternatives. This study proposed nine cases in criteria weights. These cases show the criteria weights can increase with 23% and then decrease with 23% to show different criteria weights. Figure shows the criteria weights under nine cases.

Then we rank the alternatives under these cases. We applied the proposed approach under the new criteria weights to show the different ranks of alternatives. The results show the rank of alternatives is stable under different cases in criteria weights. We show alternative 3 is the highest rank in all cases and alternative 4 is the worst rank in all cases. Figure shows the rank of alternatives. Figure shows the histogram of rank of alternatives.

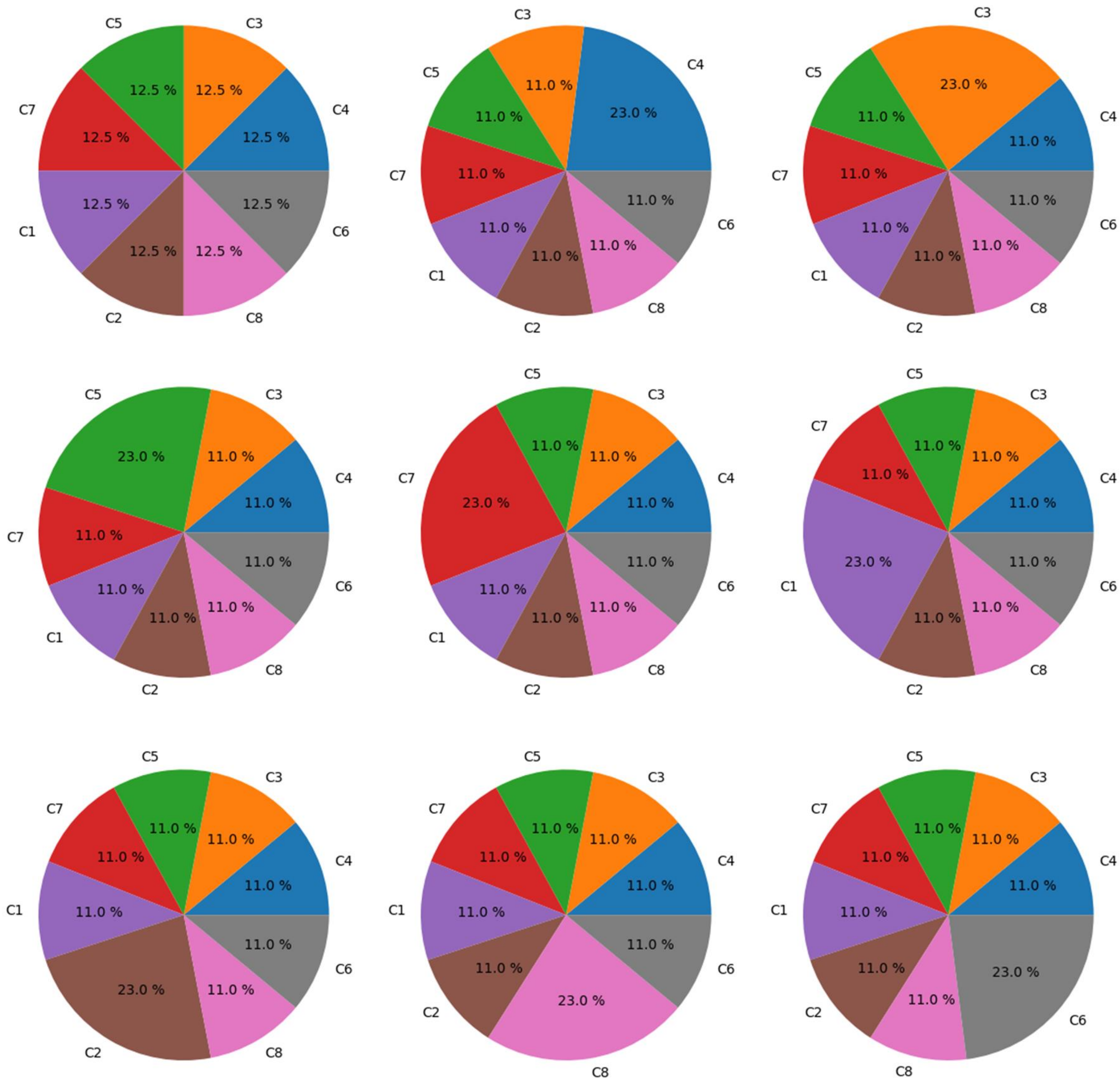


Figure . The different criteria weights.

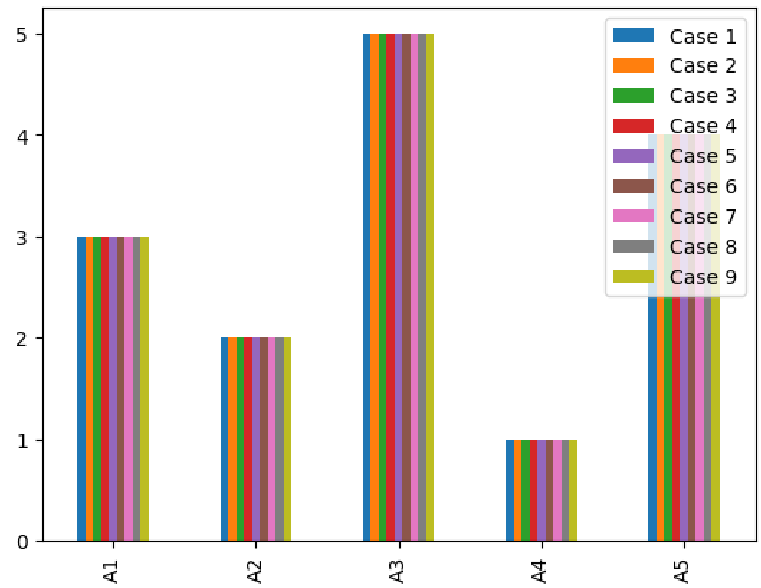


Figure . The rank of alternatives under different criteria weights.

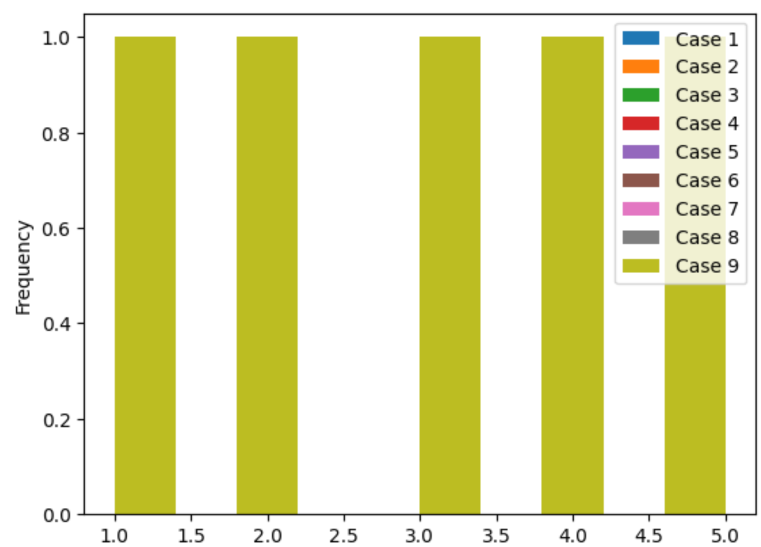


Figure . The histogram of rank of alternatives under different criteria weights.

**Research Implications**

With its novel insights and approaches that add to the body of existing literature, this study has important implications for the field of hospital operations management assessment and decision-making methodologies.

A. Hybrid decision support system – The creation of the plithogenic-RBNAR hybrid method offers a comprehensive decision support system that simultaneously weighs criteria and matrix-based criteria, fostering a more sophisticated and flexible approach to operations management analysis and opening the door for further research and applications.

B. Criterion weighing techniques − This study offers a sophisticated comprehension of criterion weighting. A deeper comprehension of the significance of criteria is provided by the normalization technique, which is under plithogenic environment.
C. Validation of real case studies: The research's practical significance is increased when the created method is applied to a genuine case study involving hospital operations management. When applying comparable approaches, researchers can find inspiration in the case study's design and implementation.

## 5. Conclusions and Future Directions

By creating a unique decision support system for identifying and ranking the Hospital Operations Management, this research made a contribution. Hospital Operations Management was evaluated using MCDM approach. Hospital Operations Management was evaluated and ranked as alternatives using the created RBNAR approach, which enables the ranking of alternatives using reference value-based normalization procedures. By combining these approaches, the hybrid plithogenic-RBNAR method was created, and the paper included a description of its algorithm. The results showed that the alternative one is the best and alternative 4 is the worst.

In the future directions, the proposed algorithm can be applied in different decision-making issues to compute the criteria weights and rank the alternatives. The criteria can be increased to show different directions of the decision making issue. Different decision-making models can be applied to compute the criteria weights and rank the alternatives in this study.

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