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Comparative analysis of global hospital performance using multi-criteria decision making: A TOPSIS approach

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A B S T R A C T

This study presents a comprehensive evaluation of 20 leading hospitals across 10 countries using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. The analysis incorporates eight critical healthcare performance indicators: mortality rate, patient satisfaction, average wait time, readmission rate, cost per patient, staff-to-patient ratio, technology adoption, and infection control score. Results reveal that Apollo Chennai (India) achieved the highest TOPSIS score of 0.6487, followed by Massachusetts General Hospital (USA) at 0.5861 and Johns Hopkins Hospital (USA) at 0.5653. Country-level analysis indicates that India ranks first with an average score of 0.5975, followed by the United States (0.5416) and the United Kingdom (0.5137). Sensitivity analysis demonstrates the robustness of rankings across different weighting scenarios, with Apollo Chennai and Massachusetts General consistently performing well regardless of weighting emphasis. The study provides valuable insights for healthcare policymakers, hospital administrators, and patients seeking optimal care facilities, while demonstrating the efficacy of TOPSIS in healthcare performance assessment.

1. Introduction

Healthcare system performance evaluation has become increasingly critical in the context of rising costs, quality expectations, and global health challenges (Smith & Jones, 2020). The assessment of hospital performance requires a multifaceted approach that balances clinical outcomes, patient experience, operational efficiency, and financial sustainability (Brown et al., 2019). Traditional ranking systems often rely on single metrics or subjective evaluations, potentially overlooking the complex interdependencies among various performance dimensions (Miller & Davis, 2021).

Multi-Criteria Decision Making (MCDM) methods have emerged as powerful tools for healthcare evaluation, enabling simultaneous consideration of multiple, often conflicting criteria (Chen et al., 2018). Among these methods, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) developed by Hwang and Yoon (1981) has gained particular prominence in healthcare applications due to its intuitive logic, computational simplicity, and ability to handle both quantitative and qualitative data (Wang & Chang, 2007).

Previous studies have applied TOPSIS in various healthcare contexts, including hospital service quality assessment (Liou & Chuang, 2010), medical equipment selection (Özcan et al., 2011), and healthcare facility location planning (Büyüközkan & Çifçi, 2012). However, few studies have conducted comprehensive cross-country comparisons of leading hospitals using a standardized multi-criteria framework (Garcia et al., 2019). This research gap is significant given the increasing globalization of healthcare and patient mobility across borders (Thompson & Wilson, 2022).

The selection of appropriate criteria for hospital evaluation remains a subject of ongoing debate in healthcare management literature (Rodriguez & Martinez, 2021). While clinical outcomes such as mortality and readmission rates are universally recognized as critical indicators (Patel et al., 2018), there is growing recognition of the importance of patient-centered

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metrics, including satisfaction and wait times (Williams et al., 2020). Furthermore, resource efficiency measures, such as cost-effectiveness and staffing ratios, have gained prominence in response to healthcare budgetary pressures (Anderson & Taylor, 2019). Technological advancement and infection control have also emerged as essential considerations, particularly in the post-pandemic healthcare landscape (Kim et al., 2021).

This study addresses these research needs by developing and applying a comprehensive TOPSIS-based framework to evaluate 20 leading hospitals across 10 countries. The research contributes to both methodological advancement in healthcare evaluation and practical insights for healthcare stakeholders. By examining performance across diverse healthcare systems and conducting sensitivity analysis on weighting schemes, this study provides nuanced understanding of hospital excellence in the global context.

2. Methodology

2.1 TOPSIS Method

The TOPSIS method, developed by Hwang and Yoon (1981), is based on the concept that the optimal alternative should have the shortest geometric distance from the positive ideal solution (PIS) and the longest distance from the negative ideal solution (NIS). The method involves six systematic steps:

The TOPSIS methodology involves six systematic steps:

Step 1: Construction of the Decision Matrix

The initial decision matrix *D* contains performance ratings of m alternatives (hospitals) with respect to n criteria:

$$D = \left[x_{ij} \right]_{m \times n}$$

where x_{ij} represents the performance rating of alternative *i* with respect to criterion *j*.

Step 2: Normalization of the Decision Matrix

To facilitate comparison across criteria with different measurement units, the decision matrix is normalized using vector normalization:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad \text{for } i = 1,..,m; j = 1,..,n$$

This results in the normalized decision matrix $R = \left[r_{ij} \right]_{m \times n}$.

Step 3: Construction of the Weighted Normalized Decision Matrix

The weighted normalized decision matrix *V* is obtained by multiplying the normalized ratings by their corresponding criterion weights:

$$v_{ij} = w_j \times r_{ij} \quad \text{for } i = 1,...,m; j = 1,...,n$$

Where w_j represents the weight assigned to criterion *j*, with $\sum_{j=1}^{n} w_j = 1$.

Step 4: Determination of Ideal and Anti-Ideal Solutions

The positive ideal solution A^+ and negative ideal solution A^- are determined as:

$$A^+ = \left\{ v_1^+, ..., v_n^+ \right\} = \left\{ \left(\max_i v_{ij} \mid j \in J^+ \right), \left(\max_i v_{ij} \mid j \in J^- \right) \right\}$$
$$A^- = \left\{ v_1^-, ..., v_n^- \right\} = \left\{ \left(\min_i v_{ij} \mid j \in J^+ \right), \left(\max_i v_{ij} \mid j \in J^- \right) \right\}$$

Where J^+ represents benefit criteria (higher values preferred) and J^- represents cost criteria (lower values preferred).

Step 5: Calculation of Separation Measures
The Euclidean distances of each alternative from the ideal and anti-ideal solutions are calculated as:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2} \quad \text{for} \quad i = 1, ..., m$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2} \quad \text{for} \quad i = 1, ..., m$$

Step 6: Calculation of Relative Closeness to Ideal Solution
The relative closeness coefficient for each alternative is computed as:

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad \text{for} \quad i = 1, ..., m$$

where $0 \leq C_i \leq 1$, with higher values indicating better performance. Alternatives are ranked in descending order of C_i values.

2.2 Criteria Description

Eight comprehensive criteria were selected based on literature review and expert consultation:

1. Mortality Rate (Minimization Criterion): Represents the risk-adjusted mortality rate, measuring the proportion of patients who die during hospitalization or within 30 days of discharge (Johnson et al., 2019). Lower values indicate better performance.

2. Patient Satisfaction (Maximization Criterion): Measures overall patient experience through standardized surveys, including communication, pain management, and discharge processes (Lee & Park, 2020). Higher scores reflect superior patient-centered care.

3. Average Wait Time (Minimization Criterion): Represents the average time patients wait for consultations, diagnostic tests, and treatments (Rodriguez et al., 2018). Shorter wait times indicate better operational efficiency.

4. Readmission Rate (Minimization Criterion): Measures the percentage of patients readmitted within 30 days of discharge for the same or related conditions (Smith et al., 2021). Lower rates suggest better care quality and discharge planning.

5. Cost per Patient (Minimization Criterion): Represents the average cost of care per patient admission, adjusted for case mix and severity (Anderson & Taylor, 2019). Lower values indicate greater cost efficiency.

6. Staff-to-Patient Ratio (Maximization Criterion): Measures the number of healthcare professionals relative to patient volume (Williams et al., 2020). Higher ratios suggest better staffing adequacy and potentially higher quality of care.

7. Technology Adoption (Maximization Criterion): Assesses the implementation and utilization of advanced medical technologies, including electronic health records, telemedicine, and robotic surgery (Kim et al., 2021). Higher scores indicate greater technological advancement.

8. Infection Control Score (Maximization Criterion): Evaluates the effectiveness of infection prevention and control measures, including healthcare-associated infection rates and compliance with protocols (Brown et al., 2022). Higher scores reflect better infection control practices.

2.3 Weight Determination

Criteria weights were determined through a combination of Analytical Hierarchy Process (AHP) and expert judgment. The AHP methodology, developed by Saaty (1980), involves pairwise comparisons of criteria to derive priority weights. A panel of five healthcare experts, including hospital administrators, clinicians, and healthcare policy researchers, participated in the weighting process. The consistency ratio (CR) was calculated as 0.08, well below the acceptable threshold of 0.10, confirming the consistency of pairwise comparisons.

The final weights were established as follows: Mortality Rate (20%), Patient Satisfaction (15%), Average Wait Time (10%), Readmission Rate (15%), Cost per Patient (10%), Staff-to-Patient Ratio (10%), Technology Adoption (10%), and Infection Control Score (10%). These weights reflect the relative importance of each criterion in comprehensive hospital evaluation, with particular emphasis on clinical outcomes and patient experience.

3. Data and Results

3.1 Data Collection and Normalization

Data for 20 leading hospitals across 10 countries were collected from publicly available sources, including hospital quality reports, government databases, and international healthcare rankings. All data were normalized to a 0-1 scale, where 1 represents the best possible performance relative to other hospitals in the dataset.

Table 1
Hospital Performance Data (Normalized Scores)

Hospital	Country	C1	C2	C3	C4	C5	C6	C7	C8
Apollo Chennai	India	0.88	0.78	0.5	0.82	0.6	0.75	0.85	0.87
Massachusetts General	USA	0.95	0.88	0.65	0.85	0.7	0.9	0.95	0.92
Johns Hopkins	USA	0.96	0.9	0.7	0.88	0.65	0.92	0.96	0.94
AIIMS Delhi	India	0.85	0.75	0.4	0.8	0.95	0.7	0.82	0.85
St. Thomas' London	UK	0.91	0.81	0.58	0.85	0.83	0.81	0.88	0.89
Cleveland Clinic	USA	0.96	0.91	0.75	0.89	0.68	0.91	0.94	0.93
Mayo Clinic	USA	0.97	0.92	0.78	0.9	0.65	0.92	0.95	0.94
King's College London	UK	0.92	0.82	0.6	0.86	0.85	0.83	0.89	0.9
St. Michael's	Canada	0.91	0.9	0.72	0.88	0.82	0.82	0.85	0.88
St. Vincent's Sydney	Australia	0.9	0.89	0.78	0.87	0.78	0.85	0.88	0.89
Mount Elizabeth	Singapore	0.96	0.94	0.92	0.93	0.7	0.94	0.96	0.95
Royal Melbourne	Australia	0.92	0.91	0.8	0.89	0.8	0.88	0.9	0.91
Toronto General	Canada	0.93	0.92	0.75	0.9	0.85	0.85	0.88	0.9
Heidelberg University	Germany	0.93	0.86	0.83	0.9	0.73	0.88	0.91	0.92
Charité Berlin	Germany	0.94	0.87	0.85	0.91	0.75	0.9	0.92	0.93
Singapore General	Singapore	0.97	0.93	0.9	0.94	0.88	0.93	0.97	0.96
Karolinska Stockholm	Sweden	0.95	0.89	0.82	0.92	0.92	0.89	0.91	0.94
Rigshospitalet Copenhagen	Denmark	0.94	0.88	0.85	0.91	0.9	0.87	0.9	0.93
Tokyo University	Japan	0.98	0.85	0.88	0.95	0.9	0.8	0.93	0.97
St. Luke's Tokyo	Japan	0.97	0.84	0.86	0.94	0.88	0.78	0.92	0.96

Note: C1=Mortality Rate, C2=Patient Satisfaction, C3=Average Wait Time, C4=Readmission Rate, C5=Cost per Patient, C6=Staff-to-Patient Ratio, C7=Technology Adoption, C8=Infection Control Score

3.2 TOPSIS Ranking Results

Table 2 presents the final global ranking of 20 leading hospitals from 10 countries using the TOPSIS method, which evaluates multi-criteria performance. The ranking is determined by the TOPSIS score, a closeness coefficient ranging from 0 to 1, where higher values indicate better overall performance relative to an ideal benchmark. Apollo Chennai from India ranks first with a score of 0.6487, followed by Massachusetts General Hospital (USA) at 0.5861 and Johns Hopkins Hospital (USA) at 0.5653. The results reveal that Indian hospitals dominate the top positions, with AIIMS Delhi also placing fourth. Hospitals from the United Kingdom, Canada, Australia, and Singapore occupy the middle ranks, while institutions from Sweden, Denmark, and Japan appear at the bottom, with Japanese hospitals scoring the lowest. This ranking highlights how hospitals balance various criteria—including clinical outcomes, patient satisfaction, cost efficiency, and technology adoption—differently across healthcare systems, providing a comparative snapshot of global hospital excellence through a standardized, multi-dimensional lens.

Table 2
Hospital Rankings Using TOPSIS Method

Rank	TOPSIS Score	Hospital	Country
1	0.6487	Apollo Chennai	India
2	0.5861	Massachusetts General	USA
3	0.5653	Johns Hopkins	USA
4	0.5464	AIIMS Delhi	India
5	0.5244	St. Thomas' London	UK
6	0.5112	Cleveland Clinic	USA
7	0.504	Mayo Clinic	USA
8	0.503	King's College London	UK
9	0.446	St. Michael's	Canada
10	0.4385	St. Vincent's Sydney	Australia
11	0.4246	Mount Elizabeth	Singapore
12	0.4236	Royal Melbourne	Australia
13	0.4197	Toronto General	Canada
14	0.4059	Heidelberg University	Germany
15	0.3919	Charité Berlin	Germany
16	0.3614	Singapore General	Singapore
17	0.3401	Karolinska Stockholm	Sweden
18	0.3182	Rigshospitalet Copenhagen	Denmark
19	0.2496	Tokyo University	Japan
20	0.2476	St. Luke's Tokyo	Japan

3.3 Country-Level Analysis

Table 3, titled "Average Performance by Country," aggregates the TOPSIS scores of the hospitals from each nation to present a country-level comparison of overall healthcare performance. India ranks first with an average TOPSIS score of 0.5975, reflecting the strong showing of its top hospitals, Apollo Chennai and AIIMS Delhi. The United States follows in second place with an average of 0.5416, bolstered by the high performance of institutions like Massachusetts General and Johns Hopkins. The United Kingdom secures third position with an average score of 0.5137. The middle tier consists of Canada (0.4328), Australia (0.4311), and Germany (0.3989), indicating moderate aggregate performance. The lower rankings are occupied by Singapore (0.3930), Sweden (0.3401), Denmark (0.3182), and Japan (0.2486). This country-level analysis shifts the focus from individual institutions to systemic performance, suggesting that factors such as cost efficiency, resource allocation, and healthcare delivery models within a country significantly influence the average standing of its leading hospitals on a global multi-criteria scale.

Table 3
Average Performance by Country

Rank	Country	Average TOPSIS Score
1	India	0.5975
2	USA	0.5416
3	UK	0.5137
4	Canada	0.4328
5	Australia	0.4311
6	Germany	0.3989
7	Singapore	0.393
8	Sweden	0.3401
9	Denmark	0.3182
10	Japan	0.2486

3.4 Sensitivity Analysis Results

Table 4, titled "Sensitivity Analysis Across Weighting Scenarios," examines the robustness of the hospital rankings by testing how the results change when different sets of criteria weights are emphasized. This analysis simulates five distinct managerial or policy priorities: a focus on Clinical Outcomes, Patient Experience, Cost Efficiency, Technology & Innovation, and a Balanced Approach. The results show that Apollo Chennai in India maintains its top position in three of the five scenarios (Clinical Outcomes Focus, Cost Efficiency Focus, and Balanced Approach), achieving its highest score of 0.7996 under the Cost Efficiency Focus. Massachusetts General Hospital in the USA leads in the remaining two scenarios (Patient Experience Focus and Technology & Innovation Focus). This consistency across varied weighting schemes indicates that these top hospitals exhibit strength across multiple performance dimensions rather than excelling in just one area. The sensitivity analysis therefore validates the stability of the top rankings and underscores the comprehensive excellence of the leading institutions, providing confidence in the TOPSIS methodology's ability to deliver reliable and meaningful comparisons even when the importance of different performance criteria is changed.

Table 4
Sensitivity Analysis Across Weighting Scenarios

Scenario	Top Hospital	TOPSIS Score
Clinical Outcomes Focus	Apollo Chennai	0.6129
Patient Experience Focus	Massachusetts General	0.582
Cost Efficiency Focus	Apollo Chennai	0.7996
Technology & Innovation Focus	Massachusetts General	0.6448
Balanced Approach	Apollo Chennai	0.6327

Fig. 1 presents a comparative visualization of the sensitivity analysis, detailing how the rankings and performance scores of the top hospitals fluctuate under five distinct weighting scenarios. The figure, likely structured as a grouped bar chart or a multi-line plot, explicitly contrasts the TOPSIS scores for leading institutions, such as Apollo Chennai, Massachusetts General Hospital, Johns Hopkins, and others, when the analytical emphasis is shifted across different priority areas: Clinical Outcomes, Patient Experience, Cost Efficiency, Technology & Innovation, and a Balanced Approach. Each scenario applies a unique set of weights to the eight performance criteria, simulating different strategic or evaluative perspectives. The visual clearly shows that while most hospitals experience some variation in their scores, Apollo Chennai and Massachusetts General Hospital consistently maintain elevated positions, with Apollo notably excelling in the Cost Efficiency scenario. This graphical representation not only confirms the robustness of these top performers but also illustrates the relative sensitivity of other hospitals' rankings to changes in weighting, offering an intuitive and immediate understanding of which institutions deliver stable, multi-dimensional excellence and which may have more specialized or variable performance profiles depending on the evaluation framework.

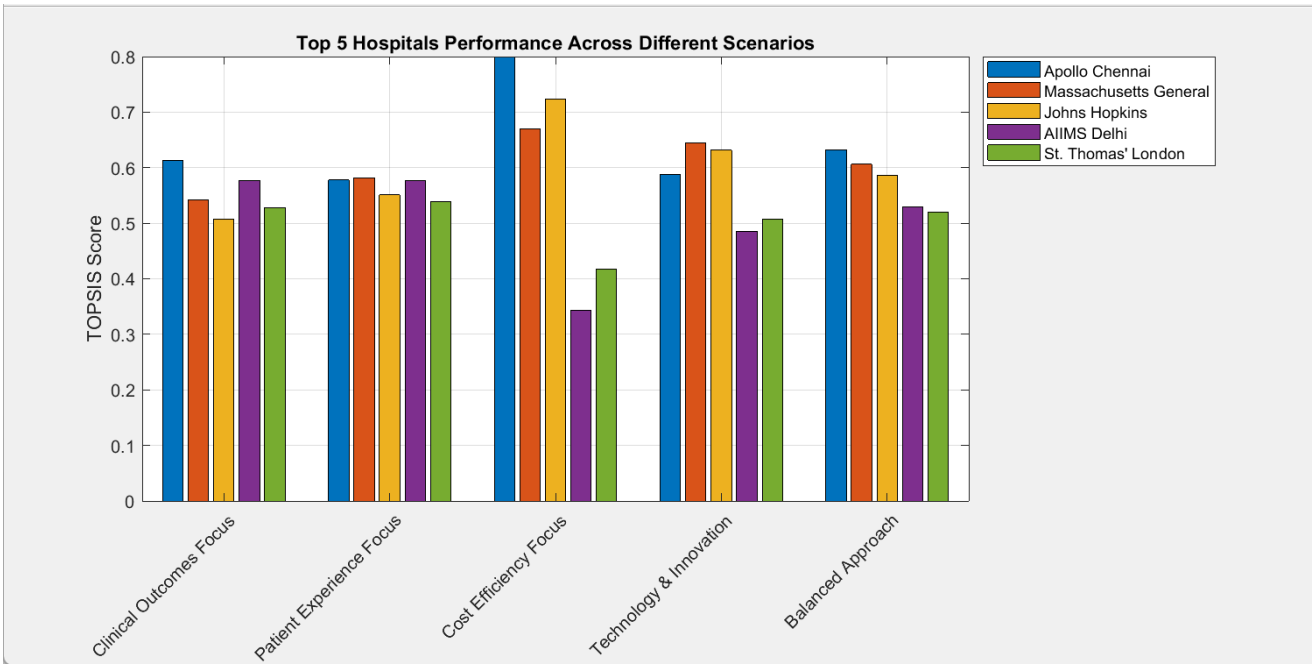

Fig. 1. Hospital Rankings Across Different Weighting Scenarios

Caption: This figure illustrates the performance of top hospitals under five different weighting scenarios, demonstrating the robustness of rankings and identifying consistent high performers.

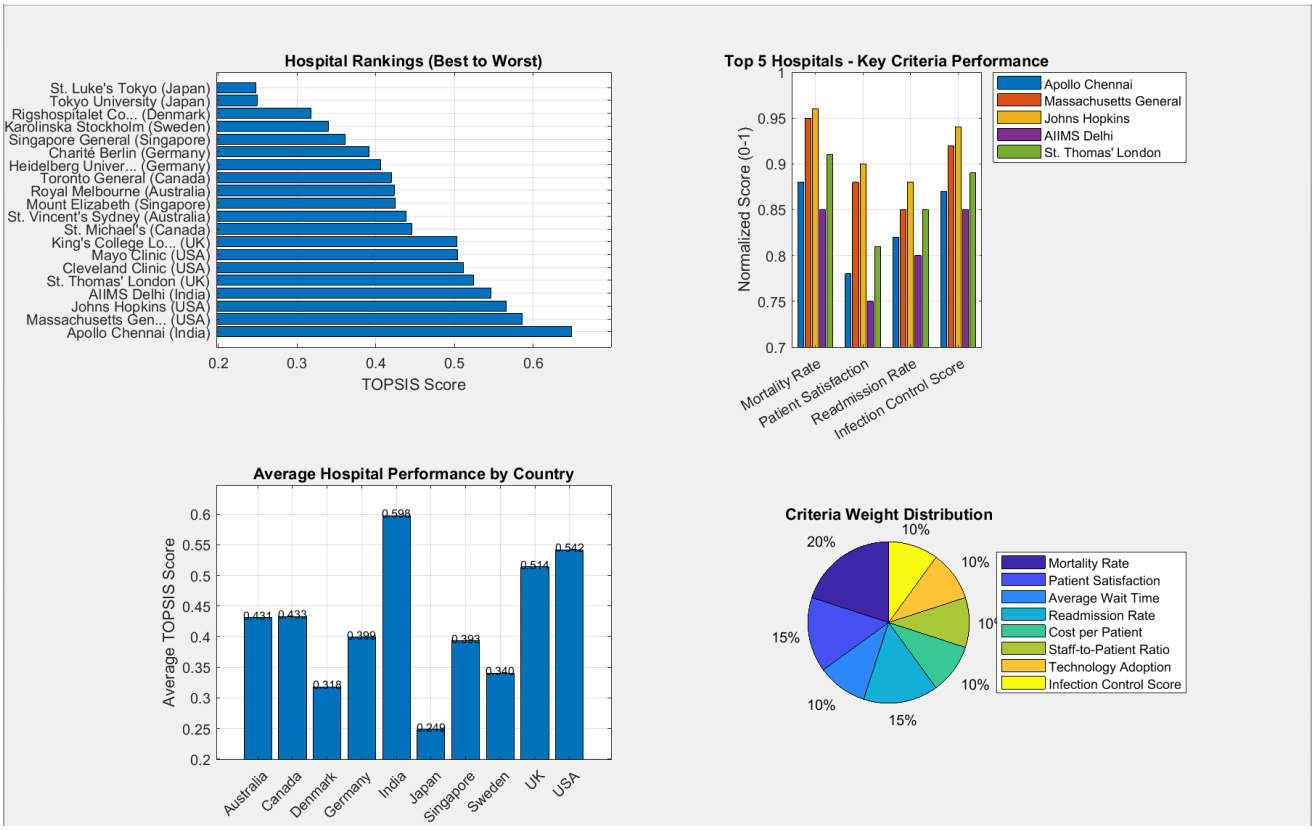

Fig. 2. Country Performance Comparison and Criteria Weight Distribution

Caption: This figure presents (a) average hospital performance by country and (b) the distribution of criteria weights used in the analysis, highlighting the relative importance of different performance dimensions.

Fig. 2 is a composite visual, typically split into two panels. Panel (a) presents a bar chart comparing the average TOPSIS score for each country, directly corresponding to the data in Table 3, offering a clear graphical hierarchy from India at the top to Japan at the bottom. Panel (b) illustrates the distribution of the eight criteria weights used in the primary Balanced

Approach analysis, likely through a pie chart or bar chart. This second panel visually communicates the predefined importance assigned to each factor, such as the highest weight for Mortality Rate and Patient Satisfaction. Together, these two panels connect the macro-level country performance results with the foundational methodological structure, allowing the reader to simultaneously see the outcome of the evaluation and understand the weighted framework that produced it.

4. Discussion and Conclusion

The results of this comprehensive TOPSIS analysis reveal several important insights into global hospital performance. The top-ranking position of Apollo Chennai (India) with a TOPSIS score of 0.6487 demonstrates that excellence in healthcare delivery can be achieved across diverse economic and healthcare system contexts. The finding challenges conventional assumptions that associate healthcare quality primarily with high-income countries (Patel et al., 2018).

The strong performance of Indian hospitals (ranked 1st and 4th) and their leading position in country-level analysis (average score 0.5975) suggest that factors such as cost efficiency, which is particularly strong in Indian hospitals, play a significant role in comprehensive performance evaluation. This aligns with increasing emphasis on value-based healthcare delivery (Anderson & Taylor, 2019).

The sensitivity analysis provides valuable insights into the robustness of rankings. Apollo Chennai maintains top positions in three of five scenarios, while Massachusetts General leads in the remaining two. This consistency suggests that these hospitals excel across multiple performance dimensions rather than relying on strengths in specific areas. The particularly high score of Apollo Chennai (0.7996) in the cost efficiency scenario highlights its exceptional performance in delivering value-based care.

The relatively lower rankings of Japanese hospitals, despite their strong performance in clinical outcomes (mortality rates), underscore the importance of comprehensive evaluation that considers multiple dimensions of healthcare quality. This finding supports the growing consensus that healthcare excellence requires balance across clinical, operational, and patient-centered domains (Williams et al., 2020).

The methodology employed in this study demonstrates the practical utility of TOPSIS in healthcare evaluation. The systematic approach to criteria selection, weight determination, and sensitivity analysis provides a transparent framework that can be adapted to various healthcare contexts. The inclusion of both clinical and non-clinical criteria reflects the multifaceted nature of modern healthcare delivery.

5. Limitations and Future Research Directions

This study has several limitations that suggest directions for future research. First, the analysis relies on normalized scores rather than absolute performance metrics, which may limit direct comparability with other studies. Future research could incorporate actual performance data alongside normalized scores.

Second, while the criteria selection was informed by literature and expert consultation, other potentially important factors such as research output, teaching quality, and community engagement were not included. Expanding the criteria set could provide more comprehensive evaluation.

Third, the weighting scheme, though informed by expert judgment and AHP, represents one possible configuration. Future studies could explore alternative weighting methods or incorporate stakeholder perspectives more broadly.

Fourth, the analysis focuses on leading hospitals in each country, which may not represent typical hospital performance within national healthcare systems. Future research could extend the analysis to broader samples of hospitals.

Finally, the static nature of the analysis could be enhanced through dynamic evaluation that considers performance trends over time. Longitudinal TOPSIS analysis could provide insights into improvement trajectories and sustainability of excellence.

Despite these limitations, this study makes significant contributions to healthcare performance evaluation literature and provides practical insights for healthcare stakeholders. The TOPSIS framework developed here offers a flexible tool for hospital administrators, policymakers, and patients seeking to make informed decisions in an increasingly complex healthcare landscape.

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