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INCISIVE EVALUATION FOR SIX KOLKATA BASED PRIVATE HEALTHCARE PROVIDERS UNDER FUZZY ENVIRONMENT: A DE NOVO APPROACH

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ABSTRACT
Good health is fundamentally essential to maintain a healthy lifestyle. Healthcare is one of the sensitive sector among the available service sector industries. Healthcare is directly related to the health of an individual. This paper presents a comparative approach of multicriteria decision making techniques to identify, evaluate and rank the most reliable private healthcare provider based on its service excellence. A case study taken from Kolkata, India has been carried out to address the pertinent and potential areas related to private healthcare providers and apply the concept of multicriteria decision making techniques in healthcare sector in order to minimise the uncertainity, ambiguity, vagueness and obscurity to develop a holistic decision. TOPSIS, Deng similarity method, PROMETHEE-II and Yager min-max principle approaches are applied to identify, evaluate, compare & rank the private healthcare providers based on its service excellence. The result obtained from the above approaches is integrated and finally compared using copeland method for final ranking. The result reveals that healthcare provider A_4 is ranked top in the list of most reliable healthcare provider based on its service excellence and healthcare provider A_1 is at the bottom of the list. The paper enlightens healthcare administrators with a path to improve their performance for excellent service delivery.

Keywords: Private healthcare providers, service excellence, multicriteria decision making and Copeland.

I. Introduction
The global service market for healthcare is expanding quickly and is fiercely competitive, just like other service sectors. Service quality encompasses consumer views of service performance. Researchers' interest in service quality has escalated substantially in the past few years. An organization's performance is seen to be enhanced by providing high-quality services [1-6]. In service sectors, providing excellent service is essential for sustainability. In the present scenario, organisations must meet consumer expectations. What an organisation values may not be as essential to its customers. The management must fulfil the requirements of their customers to maintain a steady stream of business demands. Quality is now a crucial factor in determining the outcome of investment for any sectors, and it has also substantially lowered costs.[7-8]. In today's cutthroat business world, the performance and perseverance of any organization are largely determined by the quality of its services. In the healthcare industry, quality generates value that benefits both the service supplier about revenues and the service recipient about better health treatment by recognising the feeling of the patients about the services [9]. Healthcare providers with top-notch service have consistently attracted more patients and generated ongoing demand for their services. Healthcare providers have challenges in boosting patients' satisfaction by delivering an excellent care. Doctors are supposed to not only help patients overcome diseases, but also promote healthy lifestyles. Physicians have a significant impact in enlightening people about the value of routine preventive medical check-ups and diagnostics. In healthcare sector, patient opinions are regarded to be the primary determinant of how well a facility is providing its services.[10-11]. A patient's decision to seek medical treatment in their native country or in a hospital overseas is significantly influenced by the standard of medical care provided in hospitals. Continuous assessment of patients' opinions regarding every aspect of services received is necessary to improve the quality of medical care in a given nation. The experiences shared by patients provide a valuable foundation for raising the standard of medical care [12]. Patient satisfaction is a key factor in assessing the standard of a country's health care infrastructure [13]. Recently, improving knowledge

of the variables influencing patient satisfaction has grown to be a top priority for hospital administration.
In India, the private healthcare sector outperforms the public healthcare system in terms of manpower, technology, and customer satisfaction. [14] The middle-class Indian people as well as those living below the poverty level cannot afford medical treatment. The main issues impacting the health service delivery in India include a shortage of diagnostic tools and equipment, delayed patient care, inadequate facilities, and a shortage of physicians, nursing staff and administrative staff. It is essential to consider political, economic, environmental, social and technological factors while choosing the optimal alternative, assessing systems, and seeking methods to uplift the level of services. A comparative performance assessment of service quality criteria analyses the standard to healthcare facilities and assists decision-makers in developing action plans accordingly.
Multicriteria decision making (MCDM) is a rapidly expanding in the field of operation research and a key decision-making tool. The method used to rank and choose one or more options from a pool of options is known as multiple-criteria decision-making or MCDM [15]. Multiple criteria decision making is an effective method for making decisions regarding prioritising and choosing among various options. There is a large selection of MCDA techniques available to assist decision makers in making decisions [16].Researchers studying healthcare have shown an interest in MCDM approaches. Healthcare involves making a lot of decisions, like which medication is best, how to rate hospitals and medical facilities, how to assess performance and what kind of technology is best. For these decisions, several MCDM techniques may be applied.MCDM has dealt with various healthcare decision-making challenges including prioritizing, diagnosing, evaluating treatment plans, allocating resources and assessing technologies.

II. Literature

II. 1. Systematic Review of Literature

According to recent research, MCDM is extensively utilized across numerous fields which include agriculture, finance, transport, supplier selection and supply chain management, environmental sustainability and service quality management [17-31].In addition, the implementation of MCDM in the healthcare sector is expanding; yet, certain research suggests that, in comparison to other sectors, this sector still has a low degree of MCDM adaptability [32-44]. Nevertheless, studies suggests that MCDM is being used more frequently in healthcare [33, 35, 38-39]. Several approaches have been proposed to address the intricacy of MCDM. The most well-known approaches of MCDM in the literature are Goal Programming (GP), Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Elimination and Choice Expressing Reality (ELECTRE), ViseKriterijumskaOptimizacija I Kompromisnoresenje (VIKOR), which stands for multi objective optimization and compromise solution, Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), Data Envelopment Analysis (DEA) and Analytic Network Process (ANP) [45-52]. New approaches for MCDM that are presented in the literature are Weighted Aggregated Sum Product Assessment (WASPAS), Multi Objective Optimization On The Basis Of Ratio Analysis (MOORA), Additive Ratio Assessment (ARAS), Complex Proportional Assessment Method (COPRAS), MOORA plus Full Multiplicative Form (MULTIMOORA), Step Wise Weight Assessment Ratio Analysis (SWARA) and Generalized Regression with Intensities of Preference (GRIP) [53-59]. The majority of research has combined fuzzy set theory with product design, performance assessment, quality measurement and control [60-71].
Hatam and Tourani [72] examined MCDM approaches for assessing hospital performance and contrasted MCDM models with the ratio analysis approach.Hsu and Pan [73] prioritised dental quality parameters using a Monte Carlo AHP technique, which led to greater income, considerable cost reductions, and more self-assured dental clinic management.Lupo [74] developed a novel fuzzy approach to assess the quality of healthcare services by integrating fuzzy triangular numbers with AHP in Sicily.Chui et al. [75] used an electrocardiogram (ECG) identifier that utilised MCDM to

identify cardiac failure.TOPSIS and weighted averaging operators were employed by Ren et al. [76] in a thermodynamic approach to support China's hierarchical healthcare system.Kulak et al. [77] investigated medical imaging risk variables using a novel MCDM technique.Leili et al. [78] used fuzzy MCDM to assess the efficacy of services provided by healthcare facilities in Iran.To improve reliability and accuracy, Zeng et al. [79] implemented an enhanced VIKOR technique for making healthcare decisionsMedical records from hospitals were assessed using MCDM by Ajami and Ktabi [80].Chang [81] proposed a hybrid multi-criteria approach with a fuzzy VIKOR method for rating several healthcare provider. Akdag et al. [82] applied fuzzy TOPSIS, yager min max principle, ordered weighted averaging operator and compensatory AND operator to evaluate the service excellence of private hospitals in Turkey.Chowdhury and Zelenyuk[83] applied DEA approach with bootstrapping & truncated regression to assess the production efficiency of hospital services in Ontario.Vulevic and Dragovic [84] applied PROMETHEE II method to evaluate and rank nine sub watersheds in the Topciderskariver located in Belgrade, Serbia.Bilsel et al. [85] measured the effectiveness of web sites of hospitals in Turkey using a PROMETHEE-based study.

II. 2. Bibliometric Review of Literature

A bibliometric analysis of previous literature was carried out between 2000 and 2024 based on SCOPUS database. The search concentrated largely on multicriteria decision making in healthcare. The search was restricted to journals in source type, articles in document type, English in language and final in publication stage. There were 389 total papers found.

Figure-01- The trend of MCDM applications in healthcare publications from 2000 to 2024

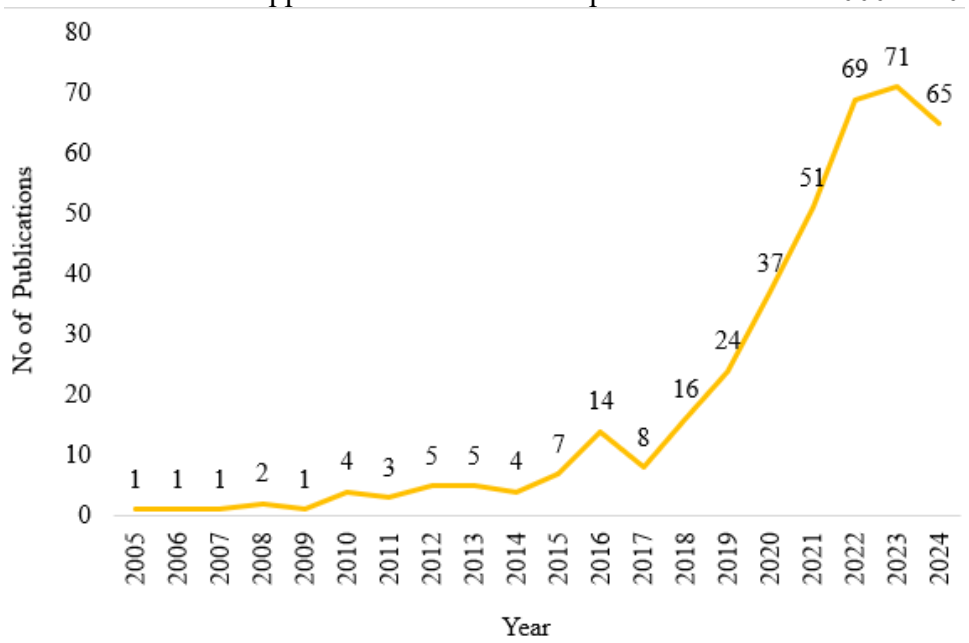

Figure-02- Top ten nations for MCDM research in healthcare from 2000 to 2024

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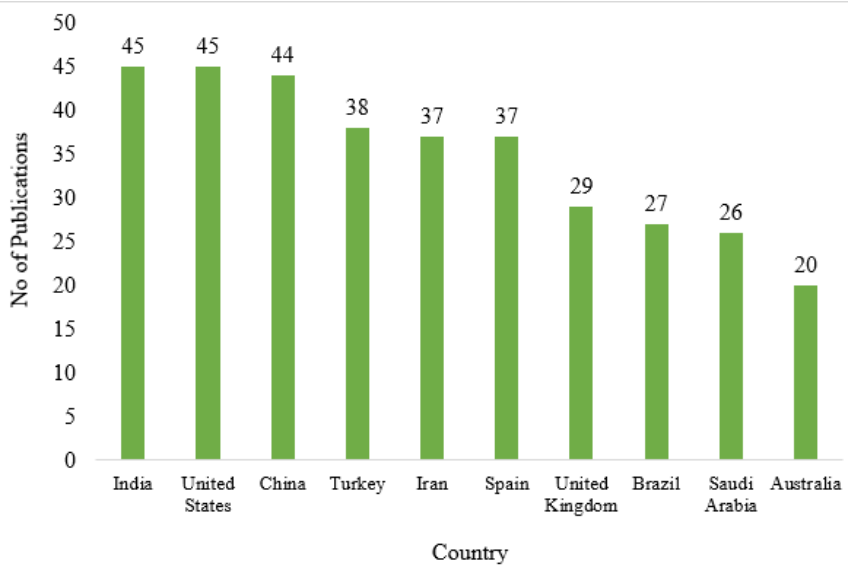

Figure-03- Top ten authors for MCDM research in healthcare from 2000 to 2024

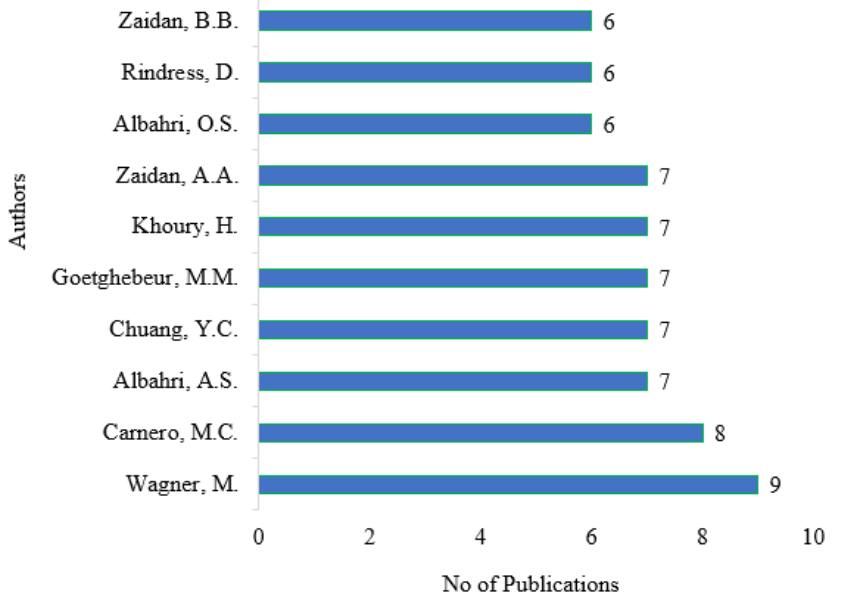

Figure-04- Top ten journals for MCDM research in healthcare from 2000 to 2024

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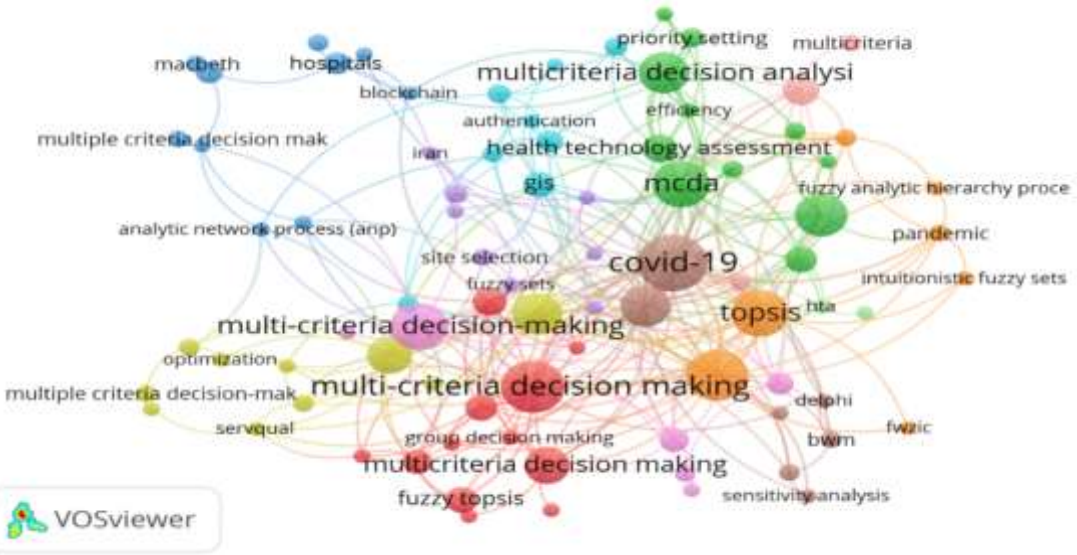
Co- occurrence analysis of author keywords

We use VOSviewer to conduct Co- occurrence analysis of keywords that author have so far utilized in their research. Our findings showed that 1240 keywords were utilized in the articles pertaining to the multicriteria decision making in healthcare. There were 302 links in 11 clusters of all keywords, with a total link strength of 382.

Figure-05:- Co- occurrence analysis of author keywords



III. Research Gap

1. There are few studies on the quality of care rendered by Indian healthcare providers by adapting multicriteria decision making techniques.
2. Different studies used different multicriteria decision making techniques to determine the healthcare providers' level of service
3. Most of the studies adapted preference ranking (TOPSIS) method to rank the service excellence level of healthcare providers.
4. Studies that focus on MCDM strategies based on min max ranking, outranking, and similarity ranking are scarce.
5. The SERVQUAL model is a popular tool in studies on healthcare service providers.
6. The majority of research has been carried out in Western countries, hence it cannot be universally applied to the Indian context.

IV. Objectives of the Study

The present study illustrated following objectives

1. To review existing studies on the use of multicriteria decision making approaches in the field of healthcare and present perspective on the state of Indian healthcare
2. To assess the level of service provided by a private healthcare provider using fuzzy logic.
3. To figure out the crucial and substantial factors that influence a private healthcare providers' service excellence and patient satisfaction
4. To apply TOPSIS, Deng's similarity method, PROMETHEE-II and Yager min-max principle techniques to rank among the private healthcare providers based on their service excellence
5. To propose a final comparison and ranking between the above mentioned techniques of six private healthcare providers by Copeland method.
6. To provide recommendations for improving quality of care in each private healthcare providers.

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V. Research Methodology

An extensive review of the current studies on application of multicriteria decision making techniques in healthcare management is conducted.

Sample

Six private healthcare providers in Kolkata participated in this study, and we categorized them into groups A_1, A_2, A_3, A_4, A_5 and A_6.

Tool

The factors that determine service excellence of private healthcare providers were incorporated into the current study by adapting existing literature. Affordability, accessibility, availability, ambience and satisfaction are considered to couple these factors with service excellence of private healthcare providers in Kolkata. Figure 6 illustrates a research model.

Figure-6:- A research model.

Demographic profile

The demographic profile of the respondents are shown in Table 1

Table-1:- Demographic profile of the respondents

Variable	Types	Frequency	%
Gender	Male	247	51.46
	Female	233	48.54
Age	Less than 20	72	15.00
	20-40	143	29.79
	41-60	210	43.75
	Above 60	55	11.46
Work	Unemployed	83	17.29
	Public sector	71	14.79
	Private sector	156	32.50
	Self employed	90	18.75
	Retired	80	16.67
Income	Less than 1 lakhs	118	24.58
	1-3 lakhs	177	36.86
	Greater than 3 lakhs	185	38.56
Marital status	Married	322	67.08
	Unmarried	158	32.92

Data collection

A survey was conducted by sending 100 questionnaire to six private healthcare providers located in Kolkata. Among 600 questionnaires, 480 were returned with responses of the respondents with response rate of 80%. Linguistic expressions were used to determine respondents' viewpoints on service excellence of six private healthcare providers. The confidentiality of their responses and its application for the purpose of research was assured to the respondents. There are basically two portions of the questionnaire. The first part of the questionnaire consists of demographic profile of the respondents' which includes gender, age, work, income and marital status and the second part consists

of performance scores to assess the service excellence based on five criteria. There are 24 items in the questionnaire, which were arranged in accordance with the five fundamental criteria that is affordability, accessibility, availability, ambience and satisfaction.

Data Analysis

The respondents' opinion were analysed by converting linguistic terms into triangular fuzzy numbers as follows

Poor- (0.0, 0.1, 0.3) Average- (0.1, 0.3, 0.5) Good- (0.3, 0.5, 0.7) Excellent- (0.5, 0.7, 0.9) Outstanding- (0.7, 0.9, 1.0)

Microsoft excel software was used to do the necessary computations and prepare fuzzy performance table as shown in Table 2.

Table- 02:- The fuzzy performance table of each private hospital

	A_1	A_2	A_3	A4	A5	A6
Q_1	(0.345,0.534,0.720)	(0.624,0.805,0.536)	(0.547,0.720,0.971)	(0.521,0.755,0.936)	(0.377,0.572,0.711)	(0.526,0.717,0.932)
Q_2	(0.360,0.568,0.716)	(0.444,0.712,0.365)	(0.746,0.542,0.377)	(0.986,0.571,0.233)	(0.478,0.551,0.810)	(0.621,0.707,0.310)
Q_3	(0.533,0.612,0.311)	(0.603,0.172,0.773)	(0.289,0.451,0.314)	(0.565,0.688,0.713)	(0.595,0.708,0.317)	(0.585,0.632,0.211)
Q_4	(0.289,0.713,0.417)	(0.518,0.714,0.322)	(0.519,0.608,0.121)	(0.774,0.610,0.488)	(0.321,0.577,0.748)	(0.496,0.696,0.869)
Q_5	(0.415,0.348,0.551)	(0.477,0.831,0.112)	(0.558,0.819,0.951)	(0.515,0.333,0.787)	(0.433,0.673,0.319)	(0.433,0.528,0.749)

The fuzzy numbers obtained from fuzzy averaging are transformed into crisp numbers by centre of area technique to formulate the decision matrix. An expert committee consisting of six doctors and four academician were formed to determine the criteria weights by implementing analytical hierarchy process (AHP) using pair wise comparison. The details of the expert committee members are shown in Table-3

Table- 03:- Details of expert committee members

Expert	Age(in Y)	Qualification	Designation	Experience(in Y)
Doctor-1	52	MBBS	Cardiologist	25
Doctor-2	48	MBBS	Nephrologist	23
Doctor-3	45	MBBS	Neurologist	18
Doctor-4	39	MBBS	Gastroenterologist	12
Doctor-5	39	MBBS	Gynaecologist	13
Doctor-6	37	MD	General medicine	10
Academacian-1	58	Post Doctorate	Professor	40
Academacian-2	55	Post Doctorate	Professor	38
Academacian-3	49	Doctorate	Associate Professor	20
Academacian-4	43	Doctorate	Associate Professor	16

The criteria weights attained for each criteria are affordability- 0.2131, accessibility- 0.1270, availability- 0.2085, ambience- 0.2549 and satisfaction-0.1965. TOPSIS for preference ranking, Deng's similarity method for similarity ranking, PROMETHEE-II for outranking and Yager's min max principle for min-max ranking is applied to evaluate, compare and rank the private healthcare providers based on its service excellence. The results obtained from the above mentioned techniques is further compared and analysed using copeland method and a final ranking is presented to minimise the uncertainity, ambiguity, vagueness and obscurity to develop a holistic, eclectic and exotic decision. A conceptual framework of the methodology is illustrated in Figure-7.

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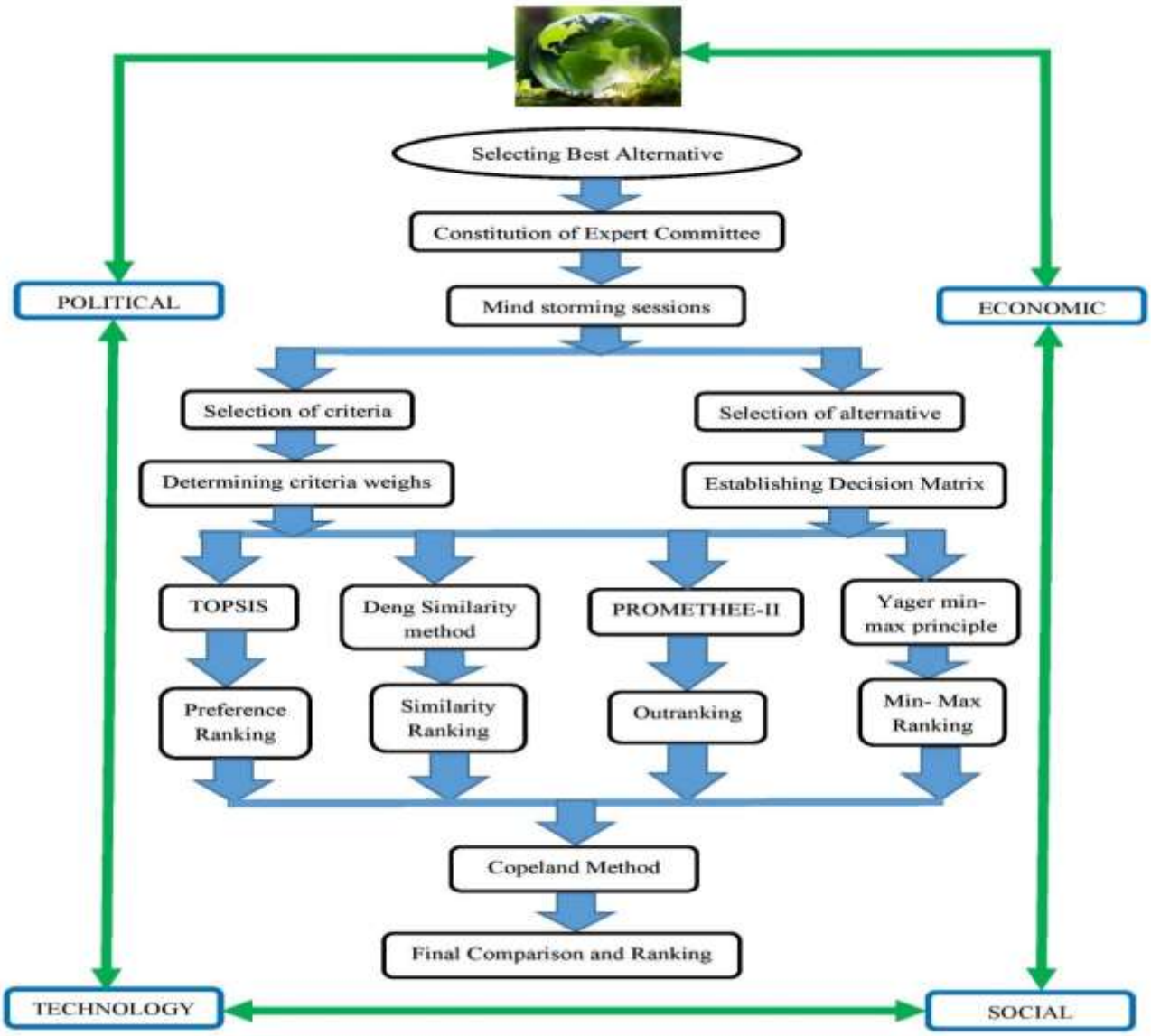
Figure-7:- A conceptual framework of the methodology



VI. Result Analysis

The criteria weights obtained for each aspects are Q_1-0.2131, Q_2-0.1270, Q_3-0.2085, Q_4 -0.2549 and Q_5-0.1965.

Table-04:- The decision matrix of six alternatives according to five criteria

	A_1	A_2	A_3	A_4	A_5	A_6
Q_1	0.533	0.655	0.746	0.737	0.553	0.725
Q_2	0.548	0.507	0.555	0.593	0.613	0.546
Q_3	0.485	0.516	0.351	0.655	0.540	0.476
Q_4	0.473	0.518	0.416	0.624	0.542	0.687
Q_5	0.438	0.473	0.776	0.545	0.475	0.570

Table-05:- Ranking of private healthcare providers according to TOPSIS

Alternatives	S_i	Rank
A_1	0.25	06
A_2	0.3775	05
A_3	0.4375	03
A_4	0.6728	01

A_5	0.4051	04
A_6	0.5992	02

Table-06:- Ranking of private healthcare providers according to Deng Similarity method

Alternatives	Overall performance index	Rank
A_1	0.3821	3
A_2	0.381963	4
A_3	0.380312	6
A_4	0.382844	1
A_5	0.382478	2
A_6	0.381565	5

Table-07:- Ranking of private healthcare providers according to PROMETHEE-II

Alternatives	$\psi^{+}(U)$	$\psi^{-}(U)$	$\psi(U)_{net}$	Rank
A_1	0.18518	0.81482	-0.62964	6
A_2	0.3516	0.6484	-0.2968	5
A_3	0.4858	0.5142	-0.0284	4
A_4	0.8024	0.1976	0.6048	1
A_5	0.56796	0.43204	0.13592	3
A_6	0.60706	0.39294	0.21412	2

Table-08:- Ranking of private healthcare providers according to Yager min-max principle

Alternatives	Value	Rank
A_1	0.3851	05
A_2	0.4324	04
A_3	0.3270	06
A_4	0.5482	01
A_5	0.4581	03
A_6	0.4612	02

Table-09:- Final comparison and ranking by Copeland method

	Wins	Loss	Tied	Difference	Rank
A_1	0	4	1	-4	**6**
A_2	1	3	1	-2	**4**
A_3	0	3	2	-3	**5**
A_4	5	0	0	5	**1**
A_5	3	2	0	1	**3**
A_6	4	1	0	3	**2**

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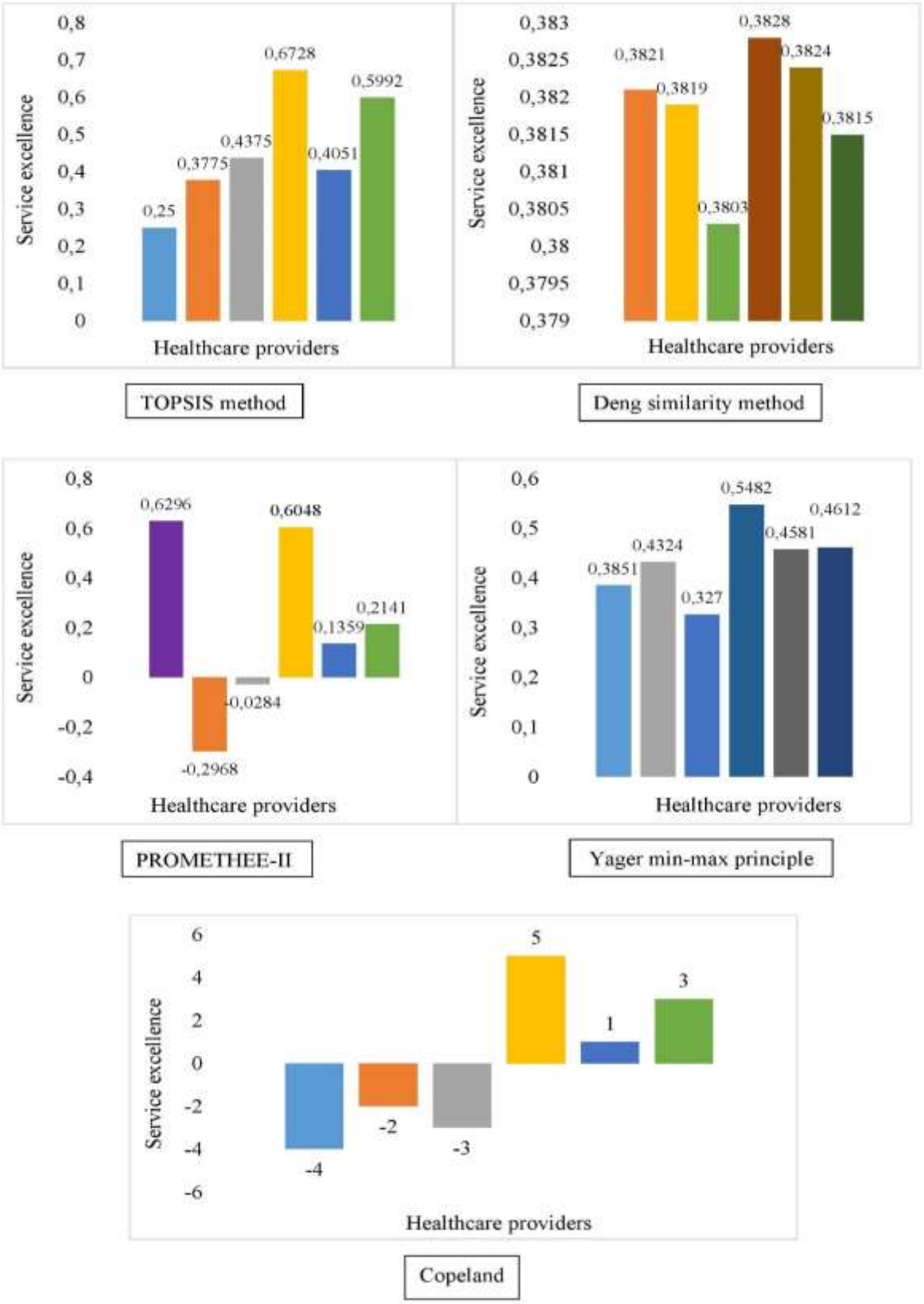
Figure-8:- Graphical representation of service excellence of private healthcare providers by different approaches



VII. Conclusion

We are all aware about the adverse effect of COVID-19 in the past few years globally. Due to the above pandemic, people became more serious about their health. Healthcare providers in India have huge

responsibility in improving the health issues and delivering high quality care to their patients. The quality of care and services provided by healthcare providers are divergent. This paper presents an empirical analysis to evaluate the service excellence of six private healthcare providers located in Kolkata, India from patients' perspective. The proposed approach of this paper considered five criteria which includes affordability, accessibility, availability, ambience and satisfaction and presented an integrated comparison study to select the best healthcare based on its service excellence. Fuzzy numbers were used in order to deal with the uncertainty of decision makers' viewpoints and later transformed into crisp values. Our study applied TOPSIS for preference ranking, Deng's similarity method for similarity ranking, PROMETHEE-II for outranking and Yager min-max principle for min-max ranking to rank the healthcare providers based on its excellence on service delivery. Finally Copeland method is applied for final ranking by comparing the results of the above mentioned technique. Patients will benefit from selecting the greatest and most dependable private healthcare provider because of the ranking based on service excellence. The final result reveals that healthcare provider A_4 ranks top based on its service excellence provided to the patients. Healthcare provider A_6 is in the second position in terms of ranking, healthcare provider A_5 is in the third position and healthcare provider A_1 was in the last position. The findings demonstrate that private healthcare providers with low ranking should prioritize quality of care in order to provide the greatest possible service to their patients. Hospital administration may use these findings to enhance patient services based on patient demands and quality assessment. The quality of the treatment is an essential factor for uplifting a patient's level of satisfaction. It is also concluded that improvements are required on the quality of the treatment delivered to the patients. The healthcare management team should take more administrative measures on the areas that it has lagged behind. The private healthcare providers must understand the patients' needs, increase patients' levels of satisfaction and control costs.

This survey suggests that service excellence appears to be the most significant consideration of private health care providers. We are aware that people have several options for private healthcare providers. If patients are not satisfied with one, they can quickly switch to another provider. As a result, we may predict that there would be intense competition among private healthcare providers. Private health care providers should consider their clients' opinions in order to prosper in this competitive environment. Otherwise, they won't be able to attract new patients and retain their current clientele.
Only six private hospitals in Kolkata were included in the study. As a result, the findings of this study cannot be applied to all parts of India. In future, similar research need to be supervised in many other cities of India to measure the service excellence in different types of hospital. Other MCDM techniques could be used in the future to assess service excellence of private hospitals.

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