PRODUCTION ENGINEERING ARCHIVES 2022, 28(1), 01-11

PRODUCTION ENGINEERING ARCHIVES

ISSN 2353-5156 (print)
ISSN 2353-7779 (online)

Exist since 4th quarter 2013
Available online at https://pea-journal.eu

Hospital selection under Insured Public Health Schemes in the multi-criteria group decision-making environment

Manimay Dev[1], Dinesh Kumar[1,*], Rahul S. Mor[2]

[1] Department of Production and Industrial Engineering, National Institute of Technology Jamshedpur, Jhar-khand, India; manimaydev@yahoo.co.in (M.D.)
[2] Dept. of Food Engineering, National Institute of Food Technology Entrepreneurship and Management, Sonepat - 131028, India; dr.rahulmor@gmail.com (R.S.M.)
*Correspondence: dinesh.prod@nitjsr.ac.in

Article history
Received 01.06.2021
Accepted 12.10.2021
Available online 07.02.2022

Keywords
Healthcare
Multiple criteria decision making (MCDM)
Ayushman Bharat
Intuitionistic Fuzzy-TOPSIS (IF-TOPSIS)
IFWA

Abstract
A thriving healthcare system perfectly reflects economic development and contentment amongst the people of any region. With increasing anxiety concering health and growing medical needs, hospitals worldwide face substantial challenge to provide patients with adequate medical facilities under one roof. With a fragile state of the health industry in a developing country like India, there is a need for the hospitals to opt for international standards and comply with other premier health centers of the country. This paper aims to select the hospitals based on incongruous and conflicting criteria involving group decision-making using the Intuitionistic Fuzzy (IF) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. The criteria used are concomitant to an insured public health scheme named Ayushman Bharat-National Health Protection Scheme (AB-NHPS) of the Government of India. For each alternative Euclidean distance has been used to calculate the positive and negative separation measure from the ideal solution. The relative closeness to the ideal solution has been used to rank the hospitals. The result is a list of hospitals ranked from best to worst based on the laid criteria. It can aid governing bodies in decision-making under an uncertain environment with multiple complex criteria to analyze.

DOI: 10.30657/pea.2022.28.01 JEL: D81, M11

1. Introduction

Economic development is paradoxical without the proportionate sprouting of the healthcare centers. Today, people are more mindful of their health and wholeness. Many developed countries have been spending money on technology assessment for safety, pricing, effectiveness, social and ethical concerns (Bond et al., 1985). For instance, health indicators (IMR, MMR) have shown advancement together with improvement in life expectancy, quality of treatment, and patient safety have shown refinement, transfiguring robotic technology for minimally invasive surgery. As far as hospitals are concerned, patient satisfaction is considered important because it involves a commitment to return in the future and recommendations to others (Becker and Parsons, 2007). Facility management contributes to business expansion and is considered a strategic function (Alexander, 1994). For a favorable conveyance of healthcare services, healthcare facility management is an indispensable factor (Mohamad Nasbi Bin Wan Mohamad and Ali, 2009). The three aspects of facility management embrace policy sponsorship, strategy, and intelligence, including understanding and monitoring along with service management (Williams, 1996). Customer-focused benchmarking could be used as a leading-edge methodology (Hsin and Loosemore, 2001). Even though the healthcare industry is growing rapidly, it is still facing some potential challenges. In affluent countries with the increased use of state-of-the-art technologies, problems like over-prescription, over-hospitalization and misspending of resources are analogical (Roncarolo et al., 2017). However, to a great extent the actual challenge lingers around the developing countries and countries with low Human Development Index (HDI) ratings.

At present, India's healthcare industry is flourishing at 15 percent annually (Acharyulu & Shekbar, 2012). At the same time, medical tourism is also fructifying in India at 30 percent per year and has become USD 1 billion merchandising (Govindarajan and Ramamurti, 2013). A prime determinant driving this growth is the high population, the low cost of treatment, enhanced health insurance infiltration, increased health issues due to an unhealthy lifestyle, and government effort to promote the public-private partnership (PPP) model. Regardless of all these, India's current HDI ranking stood at 130. In recent years, effort has been made to conduct empirical-based studies in healthcare (Ghosh, 2015). Lack of awareness, assessment, quality care, scarcity of workforce, affordability, and accountability are the potential challenges that the Indian healthcare industry is still facing (Kasthuri, 2018). Apart from this, other challenges include lack of infrastructure, the heavy load of patients, and high out-of-pocket expenditure by the patients and their family. In the Indian healthcare industry, the customer's voice is weak. The condition of community health centers (CHCs), primary health centers (PHCs), and sub-centers accounts for this allegory (Kumar, 2018; Kumar and Kumar, 2014, 2018). As per the literature, there is 0.9 beds per 1000 people in India, 10.7 percent of the PHCs are without regular water supply, about 25.5 percent of the sub-centers are without electricity supply. There is a shortfall of 23.4 percent of nursing staff, 18.4 percent of pharmacists, and 43.3 percent of laboratory technicians in various PHCs and CHCs. 34.8 percent of CHCs function without an operation theatre, and only 9.1 percent of first referral units (FRU) have blood storage facilities (Bajpai, 2014). These can be established because yet not all the state government hospitals have got accreditation from National Accreditation Board for Hospitals & Healthcare Providers (NABH), a component of the Quality Council of India (Garg and Aagja, 2010).

The Impact of Covid-19 pandemic on Healthcare

The Covid-19 pandemic has led to an unprecedented demand crisis in the healthcare industry and has led to a severe resource constraint on the healthcare supply chain across the world. As a result, the frontline healthcare workers have been facing a shortage of essential protective equipment while also battling the psychological morbidity and emotional trauma caused due to the pandemic (Tsamakis et al., 2020; Wu et al., 2020; Temsah et al., 2020). Before the emergence of covid-19, the low and middle-income countries accounted for more than 70 percent of global health disease but less than 15 percent of global health spending, and as a consequence, after the arrival of the pandemic, these countries have been witnessing a considerable number of deaths due to inadequate healthcare infrastructure (Okereke et al., 2020; Blumenthal et al., 2020; Hartnett et al., 2020). In countries like Bangladesh and Pakistan, the access to medical facilities for non-covid health issues has decreased, while the cost of healthcare services has risen and the income has dropped (Ahmed et al., 2020). India not being an exception; doctors and medical staff reported mental health problems, with 52.8 percent of health workers reporting pandemic-related burn-out and more than one-third of the health workers who have insomnia (Chatterjee et al., 2021).

On the other hand, the focus on flattening the curve of infections through strict policies like lockdown have led to delay the virus spread and helped to buy time for the healthcare and related manufacturing industries to prepare themselves while adopting lean practices for managing demands (Leite et al., 2020; Walker et al., 2020). In the context of India, lockdown proved effective in checking the virus spread. Still, it had a substantial negative impact on the socio-economic growth and previously gained success in the National health programs (Gopalan and Misra, 2020). It was a significant disruption in the supply chain operations.

In this paper, fifteen criteria, including quantitative (C9-C11) and qualitative (C1-C8, C12-C15), as shown in Table 1, that dominate and propel the hospital industry have been identified to rank the hospitals. These criteria are aligned to the requirements for empanelment of hospitals under the Ayushman Bharat scheme, which was launched in the year 2018 and is aimed to provide healthcare facilities to 100 million low-income families of rural and urban areas in India. Under this scheme, the patients can avail themselves of cashless and paperless treatment in public and empaneled private hospitals. In case of any illness, the expenses incurred before and after the hospitalization are also covered under this scheme. The scheme also covers the transportation cost. It is the largest government-sponsored healthcare scheme in the world. As for selecting alternatives, five hospitals in Jamshedpur (Jharkhand, India) have been taken. These include both public and private hospitals. These alternatives were then ranked based on their relative closeness coefficient obtained after calculating their positive and negative separation measures from the ideal solution. The complete procedure is based on the IF-TOPSIS methodology used in multi-criteria decision-making and analysis. The study provides the decision-making authorities a tool for proper policy drafting regarding the identification of better healthcare centers and resource allocations. This study can be further extended to many hospitals in the region where decision-making is based on multiple criteria under an uncertain environment. This paper is structured in the following sequence: a brief discussion on literature survey has been done in Section 2; details of the methodology used and the steps followed during the research has been given in Section 3; the measures used in the analysis for the study has been given in Section 4; the summary and conclusion has been shown in Section 5; limitations and future scope in Section 6; and followed by References list which offers the details of references cited in the paper.

2. Literature review

The healthcare industry is booming in India, and hospitals' interconnection is growing at a healthy rate. However, this growth also questions their credibility and the quality of service they provide. A gap has been observed from the patient’s stance in assessing healthcare quality by public and private hospitals in India (Manjunath et al., 2007). The hospital services in the less developed countries need both qualitative and quantitative improvements. Factors like the proximity of the hospital from the residence (Propper et al., 2007), the availability of technically advanced equipment and specialist surgeons (Shah et al., 2015), the hospital's size (Gandhi and Sharma, 2018), and the excellent level of the hospital facilities (Swain, 2019) play an essential role in the fabrication of customer base. Factors like the quality of emergency services and the private room availability in the hospital are imperative choice influencers. Also, cleanliness in the hospital premises (C. and B., 2004), accessibility to the elevator (Ahmad, Ahmad, and Papastathopoulos, 2019), officialdom, and response time by the authorities (Ahmad et al., 2019) are the critical choice factors for selecting a hospital. Other factors like the patients' prior clinical experience (Ahmad et al., 2019), hospital reputation (Ahmad et al., 2019), and location, the hospital's security system (Ahmad et al., 2019) play an essential role.

Several methodologies used in multi-criteria decision making (MCDM) include weighted point method, data envelope analysis (DEA), vendor performance matrix approach, analytic network process (ANP), integer linear programming, matrix approach, analytical hierarchy process (AHP), mathematical programming, etc. However, only a few of these address the complexity of present-day decision-making problems adequately. Additionally, in many of such decision-making tools, only quantitative factors are considered without considering the qualitative factors, the degree of uncertainty, and the number of decision-makers involved in consummate decision-making. Therefore, the fuzzy sets and intuitionistic fuzzy sets have been incorporated to select a supplier from a group. Intuitionistic fuzzy set theory was introduced in 1986.

The TOPSIS method used in MCDM follows the fundamental principle that the solution obtained should have the highest proximity to the positive ideal solution (Hwang and Yoon, 1981; Yoon, 1987). At the same time, it should be the farthest away from the perfect negative solution. TOPSIS has been used along with intuitionistic fuzzy (IF) to solve group decision-making (GDM) problems for managers to make more accurate decisions. TOPSIS has also been used in advanced manufacturing technology for effective integration with ergonomic compatibility. An extended intuitionistic fuzzy and TOPSIS methods have been used for credit risk evaluation while dealing with strategic business partners. IF-TOPSIS method has been used for selecting the smartphones amongst different alternatives available in the market, project evaluation and portfolio management information system, green supplier selection, investment selection, organizations ranking based on the distance measure and intuitionistic fuzzy entropy, electricity generation assessment using non-perishable energy resources, rating the sustainability conduct of an alternative passenger automobile wagons for a complete life cycle, packaging machine selection such as vertical form fill and seal (VFFS), used in double square bottom bag (DSBB) machine in food packaging, etc. It has also been used in the knowledge management system (KMS) along with QFD.

Other applications of TOPSIS have been observed along with intuitionistic fuzzy which are interval-valued (IFIV) for solving the partner's selection in virtual enterprise under the incomplete information environment, robots selection, supplier selection by a manufacturing company, improved score function, set pair analysis (SPA) using connection numbers, a comparative study with simple additive weighting (SAW), non-linear programming model, soft computing technique using maximizing consensus, cross-entropy for determining attribute weight, inclusion comparison approach, with Choquet integral operator. Furthermore, TOPSIS has also been used together with ordered weighted averaging (OWA) aggregation operator for ranking and comparison of algorithms, a single-valued neutrosophic environment, and statistical distance in place of Euclidean distance, among many other approaches.

3. Methodology

3.1 Theoretical Background: Intuitionistic Fuzzy Set

An intuitionistic fuzzy set is an extension of classical fuzzy set theory and deals with the uncertainty and vagueness in decision making. Below are some of the basic definitions used in intuitionistic fuzzy set theory.

Let F be the intuitionistic fuzzy set (IFS) defined in a finite set X and is written as:

$$F = \{\langle x, \mu_A(x), \nu_A(x)\rangle | x \in X\} \quad (1)$$

where $X \rightarrow [0,1]$, $\mu_A(x)$ is a membership function and $\nu_A(x)$ is a non-membership function such that

$$0 \leq \mu_A(x) + \nu_A(x) \leq 1 \quad (2)$$

Degree of hesitation or intuitionistic fuzzy index $\pi_A(x)$ which describes the uncertainty whether x belongs to F or not is given as:

$$\pi_A(x) = 1 - \mu_A(x) - \nu_A(x) \quad (3)$$

where $0 \leq \pi_A \leq 1$

For the set X, if A and B are two IFSs, then the multiplication operator gives:

$$A \otimes B = \{\langle \mu_A(x).\mu_B(x), \nu_A(x) + \nu_B(x) - \nu_A(x).\nu_B(x)\rangle | x \in X\} \quad (4)$$

3.2. Intuitionistic Fuzzy-TOPSIS

In this paper, IF-TOPSIS method has been used in the hospital industry for ranking hospitals on the basis of certain criteria that are conflicting in nature. They contradict one another based on the benefit they provide to the patients and the cost associated with it. The criteria selected in this paper are both quantitative and qualitative by nature and are analogous to the criteria under the Ayushman Bharat scheme launched by the government of India for the empanelment of hospitals. A total of fifteen criteria were selected (C1 to C15) and are shown in Table 1. For choosing the alternatives, five hospitals were chosen for the survey in Jamshedpur (Jharkhand, India), and the general managers and medical in-charges were approached through emails and over-the-phone calls. These hospitals are the top-notch hospitals of the city, including both private and public limited hospitals with a high number of patients visiting for treatment every day. These hospitals have high ratings in terms of the services provided by them and have wide varieties of departments for medical treatment compared to the remaining city hospitals. The hospitals with less than the average ratings have been left out of the study.

In order to carry out the study, several meetings with the officials were arranged, followed by formal visits to the hospitals. A questionnaire regarding the availability of basic hospital amenities and facilities was designed, and the responses were recorded. The insights provided by the medical officers were extremely helpful to get a better understanding of the functioning of the hospitals. Some data available in the public domain was collected from the official website and annual reports to avoid recurrence. The hospitals' actual names have not been disclosed as it may have repercussions on their market value, so for convenience, these hospitals have been named as H1, H2, H3, H4, and H5. The total number of steps involved in the evaluation process till the final ranking has been shown in Figure 1. The location of the hospitals under consideration has been shown in Figure 2.

4. Analysis

Different steps involved in the analysis are as follows.

Step 1. Defining the criteria and selecting the alternatives.

Table 1. List of the criteria used for ranking the hospitals

Notation	Criteria
C1	In-House facilities and functioning of Ambulance, Blood Bank, Pharmacy, Kitchen and Laundry
C2	Possibility of getting Online Appointment
C3	Level of integration of services to MIS, SAP and CCTV system at public locations
C4	Availability of ICU, NICU, HDU and Emergency Care
C5	Availability and spectrum of In-house Radiology facility
C6	Level of implementation of PACS (Picture Archiving and Communication System) and Digital Radiology
C7	Availability and spectrum of the In-House Pathology (ISO certified and NABL Accredited)
C8	Level of NABH Accreditation and its ensuing possibility
C9	Distance of the hospital from the nearest Airport (km)
C10	Total number of beds
C11	Number of general duty doctors and specialist surgeons
C12	Availability and functioning of electric sub-stations/ generators, air-conditioned OTs, annual maintenance contract for equipment
C13	Disaster prevention measures for fire, flood and earthquake
C14	OPD with basic amenities like drinking water, clean sanitation, cafeteria, wheel chair, trolley and waiting lounge with real time display of prescription status
C15	Availability and functioning of the Bio-medical waste management facility

[ICU = Intensive Care Unit; NICU = Neonatal Intensive Care Unit; HDU = High Dependency Unit; NABL = National Accreditation Board for Testing and Calibration Laboratories; OT = Operation Theatre; OPD = Out Patient Department]

Step 2. Determining the weights of DMs.

For this work, three decision-makers (DMs) have been approached. They are retired administrative officers and ex-medical practitioners of government hospitals of Jamshedpur. Intuitionistic fuzzy numbers expressed in lingual words used in determining each decision-maker's significance have been shown in Table 2. For rating the kth decision-maker, let $D_k = [\mu_k, \nu_k, \pi_k]$ be the required intuitionistic fuzzy numbers. The weight of kth decision-maker can be obtained as:

$$\lambda_k = \frac{\left(\mu_k + \pi_k\left(\frac{\mu_k}{\mu_k + \nu_k}\right)\right)}{\sum_{k=1}^{l}\left(\mu_k + \pi_k\left(\frac{\mu_k}{\mu_k + \nu_k}\right)\right)} \tag{5}$$

and $\sum_{k=1}^{l} \lambda_k = 1$

Weight of DM$_1$ is given as-

$$\lambda_1 = \frac{0.9 + 0.05\left(\frac{0.9}{0.9+0.05}\right)}{\left\{0.9 + 0.05\left(\frac{0.9}{0.9+0.05}\right)\right\} + \left\{0.7 + 0.1\left(\frac{0.7}{0.7+0.2}\right)\right\} + \left\{0.55 + 0.1\left(\frac{0.55}{0.55+0.35}\right)\right\}}$$

$= 0.406$

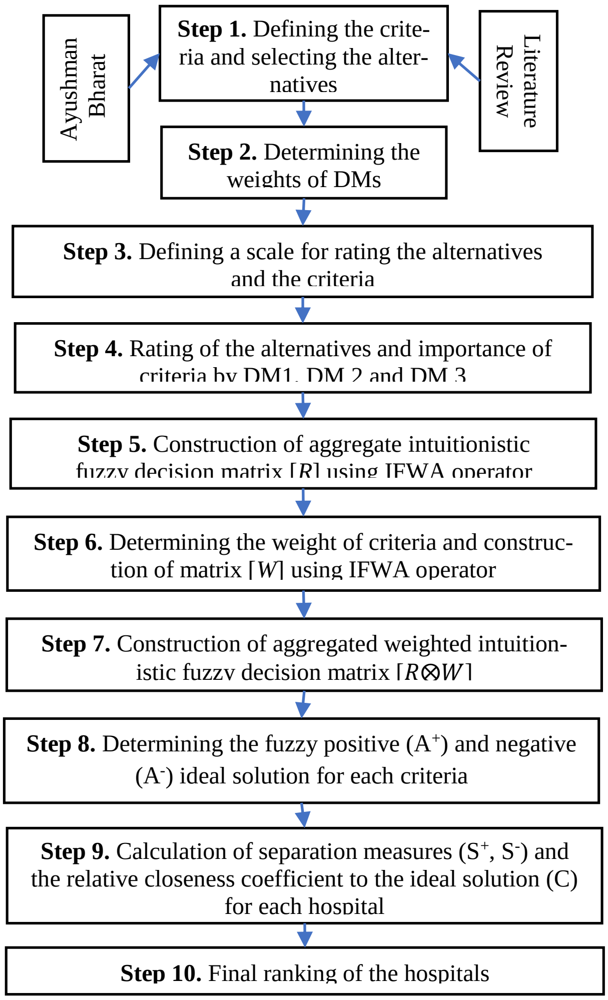

Fig. 1. Steps followed in the ranking of the hospitals using IF-TOPSIS

The weights of all the decision-makers have been exhibited in Table 3.

Step 3. Defining the scale for rating the alternatives and criteria.

The linguistic scale has been shown in Table 4 for rating the alternatives, and the alternatives under the criteria C9, C10 and C11, which are quantitative, have been represented in Table 5.

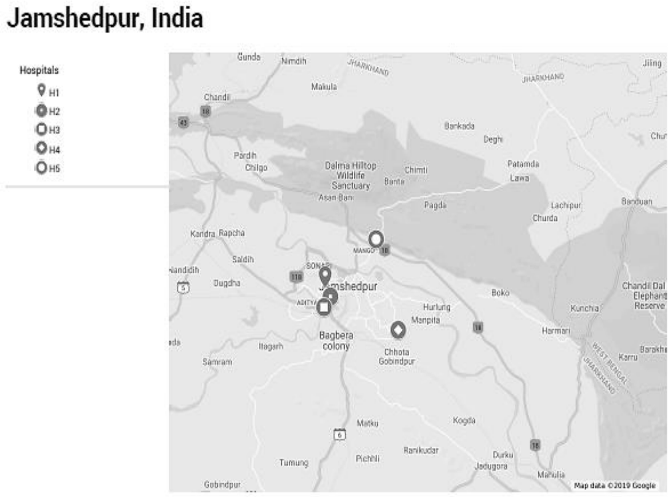

Fig. 2. Location of five alternatives on the map of Jamshedpur (India)

Table 2. Lingual words for designating the significance of DMs and the importance of criteria

Lingual Words	Symbol used	Intuitionistic Fuzzy numbers		
		μ	ν	π
Extremely Crucial	EC	0.9	0.05	0.05
Crucial	C	0.7	0.2	0.1
Moderate	M	0.55	0.35	0.1
Insignificant	I	0.3	0.6	0.1
Very Insignificant	VI	0.15	0.8	0.05

Table 3. Weights of Decision Makers (DMs)

	DM 1	DM 2	DM 3
Lingual Words	Extremely Crucial	Crucial	Moderate
Weight (λ_k)	0.406	0.332	0.262

Table 4. Lingual words for designating the significance of the alternatives

Lingual Words	Intuitionistic Fuzzy numbers		
	μ	ν	π
Exceptionally good (EG)/ Exceptionally high (EH)	0.9	0.08	0.02
Very good (VG)/Very high (VH)	0.8	0.1	0.1
Moderate good (MG)/Moderate High (MH)	0.6	0.3	0.1
Fair (F)/Moderate (M)	0.5	0.4	0.1
Moderate bad (MB)/Moderate low (ML)	0.4	0.5	0.1
Very Bad (VB)/Very low (VL)	0.2	0.65	0.15
Very very bad (VVB)/Very very Low (VVL)	0.1	0.8	0.1

Table 5. Lingual words for rating the alternatives considering quantitative criteria

Lingual Words	C9	C10	C11	Intuitionistic Fuzzy numbers		
				μ	ν	π
Exceptionally high (EH)	≤3.9	≥801	≥100	0.90	0.08	0.02
Very high (VH)	4-7.9	501-800	80-99	0.80	0.10	0.10
Moderately high (MH)	8-11.9	201-500	60-79	0.60	0.30	0.10
Moderate (M)	12-15.9	101-200	40-59	0.50	0.40	0.10
Moderately low (ML)	16-19.9	31-100	20-39	0.40	0.50	0.10
Very low (VL)	20-23.9	11-30	10-19	0.20	0.65	0.15
Very very low (VVL)	≥24	4-10	≤9	0.10	0.80	0.10

Step 4. Rating of the alternative and importance of criteria by DMs.

Based on Table 4 and Table 5, the ratings for the alternatives and criteria were assigned using decision makers' opinions. The ratings assigned by all the three decision-makers in compiled form have been shown in Table 6 and Table 7.

Table 6. Rating of the alternatives by DMs

Criteria	Alternative	Decision Makers		
		DM 1	DM 2	DM 3
C1	H1	EG	VG	EG
	H2	MB	F	MG
	H3	M	MG	VG
	H4	VG	VG	EG
	H5	MG	MB	F
C2	H1	VH	EH	EH
	H2	MH	M	M
	H3	M	ML	MH
	H4	EH	EH	VH
	H5	VVL	VL	ML
C3	H1	EH	EH	VH
	H2	M	MH	M
	H3	MH	M	MH
	H4	VH	VH	EH
	H5	VL	M	ML
C4	H1	VH	EH	VH
	H2	ML	M	M
	H3	MH	MH	VH
	H4	VH	VH	EH
	H5	ML	M	MH

C5	H1	EG	EG	EG
	H2	F	MG	F
	H3	VG	VG	VG
	H4	EG	VG	EG
	H5	VG	EG	VG
C6	H1	VH	EH	EH
	H2	ML	M	M
	H3	MH	M	VH
	H4	EH	EH	VH
	H5	ML	ML	M
C7	H1	VG	VG	EG
	H2	F	MB	MB
	H3	MG	MG	VG
	H4	VG	EG	EG
	H5	MB	F	F
C8	H1	VH	EH	EH
	H2	ML	ML	VL
	H3	M	MH	VH
	H4	MH	VH	VH
	H5	M	VH	MH
C9	H1	EH	EH	EH
	H2	VH	VH	VH
	H3	VH	VH	VH
	H4	M	M	M
	H5	MH	MH	MH
C10	H1	EH	EH	EH
	H2	VL	VL	VL
	H3	MH	MH	MH
	H4	MH	MH	MH
	H5	VH	VH	VH
C11	H1	VH	VH	VH
	H2	VL	VL	VL
	H3	M	M	M
	H4	MH	MH	MH
	H5	VH	VH	VH
C12	H1	EG	VG	EG
	H2	MG	F	MG
	H3	VG	MG	VG
	H4	EG	EG	EG
	H5	MB	F	MB
C13	H1	VH	EH	VH
	H2	M	MH	M
	H3	MH	VH	MH
	H4	MH	EH	VH
	H5	MH	ML	MH
C14	H1	VG	EG	EG
	H2	F	MB	MG
	H3	MG	VG	MG
	H4	VG	VG	EG
	H5	F	MB	F
C15	H1	EG	VG	VG
	H2	MG	MG	F
	H3	VG	VG	MG
	H4	EG	VG	VG
	H5	F	F	MG

Table 7. Importance of weight of criterions

Criteria	**DM 1**	**DM 2**	**DM 3**
C1	EC	EC	EC
C2	EC	EC	EC
C3	M	M	C
C4	I	M	M
C5	EC	EC	EC
C6	C	M	M
C7	EC	EC	EC
C8	EC	C	EC
C9	EC	EC	EC
C10	I	I	M
C11	C	C	EC
C12	M	M	C
C13	VI	I	M
C14	M	M	C
C15	M	C	C

Step 5. Construction of the aggregate intuitionistic fuzzy decision matrix [R] using IFWA operator.

Let an intuitionistic fuzzy decision matrix for each decision-maker be:

$$R^{(k)} = \left(r_{ij}^{(k)}\right)_{mxn}$$

Let the weight of each decision matrix be $\lambda = \{\lambda_1, \lambda_2, \lambda_3, \dots, \lambda_l\}$ such that $\sum_{k=1}^{l} \lambda_k = 1$ and $\lambda_k \in [0,1]$. To construct the aggregate intuitionistic fuzzy decision matrix in a group decision making process, it is required that all the individual opinion has to be aggregated and fused into a group opinion. This is achieved using the Intuitionistic Fuzzy Weighted Averaging (IFWA) operator. One of the most critical aspects of the IFWA operator is that it considers the source of information and computes an aggregated value. From the above equation,

$$r_{ij} = IFWA_\lambda\left(r_{ij}^{(1)}, r_{ij}^{(2)}, \cdots, r_{ij}^{(l)}\right) = \lambda_1 r_{ij}^{(1)} \oplus \lambda_2 r_{ij}^{(2)} \oplus \lambda_3 r_{ij}^{(3)} \oplus \cdots \oplus \lambda_l r_{ij}^{(l)}$$

$$= \left[1 - \prod_{k=1}^{l}\left(1 - \mu_{ij}^{(k)}\right)^{\lambda_k}, \prod_{k=1}^{l}\left(\nu_{ij}^{(k)}\right)^{\lambda_k}, \prod_{k=1}^{l}\left(1 - \mu_{ij}^{(k)}\right)^{\lambda_k} - \prod_{k=1}^{l}\left(\nu_{ij}^{(k)}\right)^{\lambda_k}\right] \quad (6)$$

Here $r_{ij} = \left(\mu_{A_i}(x_j), \nu_{A_i}(x_j), \pi_{A_i}(x_j)\right)$

$where\ (i = 1,2,3, \dots, m; j = 1,2,3, \dots, n)$

The elements of aggregated intuitionistic fuzzy decision matrix [R] can be written in the following order:

$$R = \begin{bmatrix} r_{11} & r_{12} & r_{13} & \cdots & r_{1m} \\ r_{21} & r_{22} & r_{23} & \cdots & r_{2m} \\ r_{31} & r_{32} & r_{33} & \cdots & r_{3m} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & r_{n3} & \cdots & r_{nm} \end{bmatrix}$$

The aggregated intuitionistic fuzzy decision matrix elements have been shown in fragmented form in Table 8.

Table 8. Aggregated Intuitionistic Fuzzy decision matrix $[R]$

	C1			C2			C3		
	μ	ν	π	μ	ν	π	μ	ν	π
H1	0.874	0.086	0.040	0.841	0.093	0.066	0.880	0.085	0.035
H2	0.492	0.406	0.102	0.543	0.356	0.101	0.536	0.364	0.101
H3	0.635	0.253	0.112	0.499	0.399	0.102	0.569	0.330	0.101
H4	0.833	0.094	0.073	0.880	0.085	0.035	0.833	0.094	0.072
H5	0.515	0.383	0.102	0.222	0.660	0.118	0.365	0.516	0.118
	C4			C5			C6		
H1	0.841	0.093	0.066	0.900	0.080	0.020	0.868	0.088	0.045
H2	0.462	0.438	0.101	0.536	0.364	0.101	0.462	0.438	0.100
H3	0.666	0.225	0.109	0.800	0.100	0.100	0.641	0.248	0.112
H4	0.833	0.094	0.072	0.874	0.086	0.040	0.880	0.085	0.035
H5	0.492	0.406	0.102	0.841	0.093	0.066	0.428	0.472	0.100
	C7			C8			C9		
H1	0.833	0.094	0.073	0.868	0.088	0.045	0.900	0.080	0.020
H2	0.443	0.457	0.100	0.353	0.536	0.111	0.800	0.100	0.100
H3	0.666	0.225	0.109	0.635	0.253	0.112	0.800	0.100	0.100
H4	0.868	0.088	0.045	0.735	0.156	0.109	0.500	0.400	0.100
H5	0.462,	0.438	0.101	0.652	0.234	0.114	0.600	0.300	0.100
	C10			C11			C12		
H1	0.900	0.080	0.020	0.800	0.100	0.100	0.874	0.086	0.039
H2	0.200	0.650	0.150	0.200	0.650	0.150	0.569	0.330	0.100
H3	0.600	0.300	0.100	0.500	0.400	0.100	0.748	0.144	0.108
H4	0.600	0.300	0.100	0.600	0.300	0.100	0.900	0.080	0.020
H5	0.800	0.100	0.100	0.800	0.100	0.100	0.435	0.464	0.100
	C13			C14			C15		
H1	0.841	0.093	0.066	0.868	0.088	0.045	0.849	0.091	0.060
H2	0.536	0.364	0.101	0.499	0.399	0.102	0.576	0.324	0.101
H3	0.682	0.208	0.109	0.682	0.208	0.110	0.760	0.133	0.107
H4	0.789	0.145	0.066	0.833	0.094	0.072	0.849	0.091	0.060
H5	0.542	0.356	0.102	0.469	0.431	0.100	0.528	0.371	0.101

Step 6. Determining the weight of criteria and construction of the matrix [W] using IFWA operator.

As each criterion has its importance and may differ in weight compared to other criteria, a set of the grade of importance has been defined in the form of matrix W. The opinion of decision-makers has to fuse to obtain this matrix. To achieve this, we need to assume an intuitionistic fuzzy number (IFN) assigned to each criterion by the individual decision-maker.

For the criterion X_j, let $w_j^{(k)} = [\mu_j^{(k)}, \nu_j^{(k)}, \pi_j^{(k)}]$ be an IFN assigned by the k[th] decision-maker. By using the IFWA operator, the weights of criteria are calculated as follows:

$$w_j = IFWA_\lambda\left(w_j^{(1)}, w_j^{(2)}, \cdots, w_j^{(l)}\right) = \lambda_1 w_j^{(1)} \oplus \lambda_2 w_j^{(2)} \oplus \lambda_3 w_j^{(3)} \oplus \cdots \oplus \lambda_l w_j^{(l)} = \left[1 - \prod_{k=1}^{l}\left(1-\mu_j^{(k)}\right)^{\lambda_k}, \prod_{k=1}^{l}\left(\nu_j^{(k)}\right)^{\lambda_k}, \prod_{k=1}^{l}\left(1-\mu_j^{(k)}\right)^{\lambda_k} - \prod_{k=1}^{l}\left(\nu_j^{(k)}\right)^{\lambda_k}\right] \quad (7)$$

And $W = [w_1, w_2, w_3, \cdots, w_j]^{\mathrm{T}}$

Where $w_j = (\mu_j, \nu_j, \pi_j)(j = 1,2,\cdots,n)$

Hence $W = [(\mu_1, \nu_1, \pi_1), (\mu_2, \nu_2, \pi_2), \cdots (\mu_j, \nu_j, \pi_j)]$

The importance of criteria in the linguistic term has been shown in Table 7. Using Table 7 and the IFWA operator, the aggregate weight of criteria has been shown as a transpose matrix $[W]$.

$$[W] = \begin{bmatrix} (0.792,0.126,0.082) \\ (0.462,0.436,0.103) \\ (0.592,0.306,0.102) \\ (0.900,0.050,0.050) \\ (0.592,0.302,0.102) \\ (0.325,0.586,0.089) \\ (0.657,0.241,0.102) \\ (0.854,0.081,0.065) \\ (0.312,0.608,0.080) \\ (0.374,0.524,0.102) \\ (0.772,0.141,0.087) \\ (0.900,0.050,0.050) \\ (0.646,0.251,0.103) \\ (0.592,0.306,0.102) \\ (0.900,0.050,0.050) \end{bmatrix}^T$$

Step 7. Construction of aggregated weighted intuitionistic fuzzy decision matrix [R⊗W]

After obtaining the aggregated intuitionistic fuzzy decision matrix [R] and matrix $[W]$, the elements of aggregated weighted intuitionistic fuzzy (AWIF) decision matrix $R \otimes W$

are calculated and has been shown in Table 9. It can be obtained using the following equations:

$$R \otimes W = \left\{ \left\langle \begin{matrix} x, \mu_{A_i}(x).\mu_w(x), \nu_{A_i}(x) + \\ \nu_w(x) - \nu_{A_i}(x).\nu_w(x) \end{matrix} \right\rangle \middle| x \in X \right\} \quad (8)$$

And,

$$\pi_{A_i w}(x) = 1 - \nu_{A_i}(x) - \nu_w(x) - \mu_{A_i}(x).\mu_w(x) + \nu_{A_i}(x).\nu_w(x) \quad (9)$$

The aggregated weighted intuitionistic fuzzy decision matrix can be written as:

It can also be written as follows:

$$R' = \begin{bmatrix} r'_{11} & r'_{12} & r'_{13} & \cdots & r'_{1j} \\ r'_{21} & r'_{22} & r'_{23} & \cdots & r'_{2j} \\ r'_{31} & r'_{32} & r'_{33} & \cdots & r'_{3j} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ r'_{i1} & r'_{i2} & r'_{i3} & \cdots & r'_{ij} \end{bmatrix}$$

Here $r'_{ij} = (\mu'_{ij}, \nu'_{ij}, \pi'_{ij}) = \left(\mu_{A_i w}(x_j), \nu_{A_i w}(x_j), \pi_{A_i w}(x_j)\right)$ represents each element AWIF decision matrix R'.

Step 8. Finding the intuitionistic fuzzy positive (IFP) ideal solution, i.e., (A^+) and intuitionistic fuzzy negative (IFN) ideal solution, i.e., (A^-) for each criterion

The fifteen criteria that were initially selected (Table 1) have now been sundered into two broad criteria J1 and J2, representing benefit criteria and cost criteria.

Benefit Criteria

$$J_1 = \{C1, C2, C3, C4, C5, C6, C7, C8, C9\}$$

Cost Criteria

$$J_2 = \{C10, C11, C12, C13, C14, C15\}$$

Table 9. Aggregated Weighted Intuitionistic Fuzzy decision matrix $[R']$

	C1			C2			C3		
	μ	ν	π	μ	ν	π	μ	ν	π
H1	0.692	0.201	0.107	0.389	0.489	0.122	0.521	0.365	0.114
H2	0.390	0.480	0.130	0.251	0.637	0.112	0.317	0.559	0.124
H3	0.503	0.347	0.150	0.231	0.661	0.108	0.337	0.535	0.128
H4	0.660	0.208	0.132	0.407	0.484	0.109	0.493	0.371	0.136
H5	0.408	0.461	0.131	0.103	0.808	0.089	0.216	0.664	0.120
	C4			C5			C6		
H1	0.757	0.138	0.105	0.536	0.358	0.106	0.282	0.622	0.096
H2	0.416	0.466	0.118	0.319	0.556	0.125	0.150	0.767	0.083
H3	0.599	0.264	0.137	0.476	0.372	0.152	0.208	0.689	0.103
H4	0.749	0.139	0.112	0.520	0.362	0.118	0.286	0.621	0.093
H5	0.443	0.436	0.121	0.500	0.367	0.133	0.139	0.781	0.080
	C7			C8			C9		
H1	0.547	0.312	0.141	0.741	0.162	0.097	0.281	0.639	0.080
H2	0.291	0.588	0.121	0.302	0.574	0.124	0.250	0.647	0.103
H3	0.438	0.412	0.150	0.542	0.314	0.144	0.250	0.647	0.103
H4	0.570	0.308	0.122	0.628	0.224	0.148	0.156	0.765	0.079
H5	0.304	0.573	0.123	0.557	0.296	0.147	0.187	0.726	0.087
	C10			C11			C12		
H1	0.337	0.562	0.101	0.618	0.227	0.155	0.787	0.132	0.082
H2	0.075	0.833	0.092	0.154	0.699	0.147	0.512	0.364	0.124
H3	0.224	0.667	0.109	0.386	0.485	0.129	0.673	0.187	0.140
H4	0.224	0.667	0.109	0.463	0.399	0.138	0.810	0.126	0.064
H5	0.299	0.572	0.129	0.618	0.227	0.155	0.392	0.491	0.117
	C13			C14			C15		
H1	0.543	0.321	0.136	0.514	0.367	0.119	0.764	0.137	0.099
H2	0.346	0.524	0.130	0.295	0.583	0.122	0.518	0.358	0.124
H3	0.441	0.407	0.152	0.404	0.540	0.146	0.684	0.176	0.140
H4	0.510	0.360	0.130	0.493	0.371	0.136	0.764	0.137	0.099
H5	0.350	0.518	0.132	0.278	0.605	0.117	0.475	0.402	0.123

Table 10. Intuitionistic fuzzy positive-ideal solution and negative-ideal solution

		A^+			A^-		
		μ	ν	π	μ	ν	π
	C1	0.692	0.201	0.107	0.390	0.480	0.130
	C2	0.407	0.484	0.109	0.103	0.808	0.089
	C3	0.521	0.365	0.114	0.216	0.664	0.120
	C4	0.757	0.138	0.105	0.416	0.466	0.118

J_1	C5	0.536	0.358	0.106	0.319	0.556	0.125
	C6	0.286	0.621	0.093	0.139	0.781	0.080
	C7	0.570	0.308	0.122	0.291	0.588	0.121
	C8	0.741	0.162	0.097	0.302	0.574	0.124
	C9	0.281	0.639	0.080	0.156	0.765	0.079
J_2	C10	0.075	0.833	0.092	0.337	0.562	0.101
	C11	0.154	0.699	0.147	0.618	0.227	0.155
	C12	0.392	0.491	0.117	0.810	0.126	0.064
	C13	0.346	0.524	0.130	0.543	0.321	0.136
	C14	0.278	0.605	0.117	0.514	0.367	0.119
	C15	0.475	0.402	0.123	0.764	0.137	0.099

The IFP and IFN ideal solution (A^{+}) and (A^{-}) respectively can be obtained using the equations given as follows:

$$A^{+} = \left(\mu_{A^{+}W}(x_j), \nu_{A^{+}W}(x_j)\right) \; and \; A^{-} = \left(\mu_{A^{-}W}(x_j), \nu_{A^{-}W}(x_j)\right) \tag{10}$$

Here

$$\mu_{A^{+}W}(x_j) = \left(\left(max_i \mu_{A_iW}(x_j) \middle| j \in J_1\right), \left(min_i \mu_{A_iW}(x_j) \middle| j \in J_2\right)\right) \tag{11}$$

$$\nu_{A^{+}W}(x_j) = \left(\left(min_i \nu_{A_iW}(x_j) \middle| j \in J_1\right), \left(max_i \nu_{A_iW}(x_j) \middle| j \in J_2\right)\right) \tag{12}$$

$$\mu_{A^{-}W}(x_j) = \left(\left(min_i \mu_{A_iW}(x_j) \middle| j \in J_1\right), \left(max_i \mu_{A_iW}(x_j) \middle| j \in J_2\right)\right) \tag{13}$$

$$\nu_{A^{-}W}(x_j) = \left(\left(max_i \nu_{A_iW}(x_j) \middle| j \in J_1\right), \left(min_i \nu_{A_iW}(x_j) \middle| j \in J_2\right)\right) \tag{14}$$

The value of (A^{+}) and (A^{-}) for each criterion has been shown in Table 10.

Step 9. Calculation of separation measures (S^{+}, S^{-}) and the relative closeness coefficient to the ideal solution (C) for each alternative.

Several methods have been proposed to measure the separation distance between intuitionistic fuzzy sets. Using the geometric interpretation of the intuitionistic fuzzy set, distance measures such as the Hamming distance, Euclidean distance, the normalized Hamming distance, and the normalized Euclidean distance can be used. In this paper, normalized Euclidean distance has been used to calculate the separation measures. The separation measures for each alternative from the ideal solution have been determined using equations (15) and (16), as shown in Table 11. The closeness coefficient's value has been obtained using equation (17), and for each of the alternatives, it has been shown in Table 12.

$$S^{+} = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}\left[\begin{array}{c}\left(\mu_{A_iW}(x_j) - \mu_{A^{+}W}(x_j)\right)^2 \\ + \left(\nu_{A_iW}(x_j) - \nu_{A^{+}W}(x_j)\right)^2 \\ + \left(\pi_{A_iW}(x_j) - \pi_{A^{+}W}(x_j)\right)^2\end{array}\right]} \tag{15}$$

$$S^{-} = \sqrt{\frac{1}{2n}\sum_{j=1}^{n}\left[\begin{array}{c}\left(\mu_{A_iW}(x_j) - \mu_{A^{-}W}(x_j)\right)^2 \\ + \left(\nu_{A_iW}(x_j) - \nu_{A^{-}W}(x_j)\right)^2 \\ + \left(\pi_{A_iW}(x_j) - \pi_{A^{-}W}(x_j)\right)^2\end{array}\right]} \tag{16}$$

Here, $\mu_{A_iW}(x_j)$, $\mu_{A^{+}W}(x_j)$ and $\mu_{A^{-}W}(x_j)$ represents the degree of membership of AWIF decision matrix, IFP ideal solution (A^{+}) and IFN ideal solution (A^{-}) respectively.

$\nu_{A_iW}(x_j)$, $\nu_{A^{+}W}(x_j)$ and $\nu_{A^{-}W}(x_j)$ represents the degree of non-membership of AWIF decision matrix, IFP ideal solution (A^{+}) and IFN ideal solution (A^{-}) respectively.

$\pi_{A_iW}(x_j)$, $\pi_{A^{+}W}(x_j)$ and $\pi_{A^{-}W}(x_j)$ represents the degree of uncertainty of AWIF decision matrix, IFP ideal solution (A^{+}) and IFN ideal solution (A^{-}) respectively.

The relative closeness of the alternative to the intuitionistic ideal solution can be calculated as:

$$C_i = \frac{S_{i^{-}}}{S_{i^{+}} + S_{i^{-}}} \qquad where \;\; 0 \le C_i \le 1 \tag{17}$$

Table 11. Value of separation measures

Hospitals	S^{+}	S^{-}
H1	0.201	0.218
H2	0.204	0.193
H3	0.163	0.152
H4	0.175	0.209
H5	0.226	0.171

Table 12. Value of closeness coefficient

Hospitals	C_i
H1	0.520
H2	0.486
H3	0.483
H4	0.544
H5	0.431

Step 10. Final ranking of the hospitals

For the value of relative closeness of each hospital (alternative) from the ideal solution, the final ranking of alternatives can be done in descending order of the value of the relative closeness coefficient. The final ranking obtained for the alternatives are in the order H4 > H1 > H2 > H3 > H5.

5. Summary and Conclusion

This paper aims to identify the best hospital among the five hospitals selected for the study in Jamshedpur (Jharkhand), India. For this, a multi-criteria group decision technique that uses Intuitionistic fuzzy with TOPSIS method has been used. Intuitionistic fuzzy sets contemplate the uncertainty related to decision-making in multi-criteria group decision-making. Fifteen criteria were identified, which are very important from the patient's perspective and are essential from the hospitals' point of view in building its market value and branding purpose. These criteria also reflect the government's minimum standards for the hospitals' empanelment in a centrally sponsored scheme called Ayushman Bharat of Ayushman Bharat Mission under the Ministry of Health and Family Welfare (MoHFW) in India. To achieve this, the hospitals' linguistic rating was done, and the weight assignment of the criteria was carried out using decision-makers' opinions. These weights were characterized by intuitionistic fuzzy numbers (IFNs). In this method, the intuitionistic fuzzy weighted averaging (IFWA) operator was used for aggregating the different stances and opinions of decision-makers who are retired medical officers and healthcare experts in Jamshedpur. The previously selected detrimental criteria were later divided into benefit and cost criteria. The separation measure for each alternative was calculated after the calculation of intuitionistic fuzzy positive (IFP) and intuitionistic fuzzy negative (IFN) ideal solution, i.e., (A^{+}) and (A^{-}) respectively. Towards the end of the paper, the relative closeness coefficient was calculated for each alternative. Based on the relative closeness coefficient's value, the hospitals were ranked in the preference's descending order. Hospital H4 was selected as the best hospital with optimum balance between the benefit and the cost criteria among the five hospitals chosen for analysis. H4 was followed by hospital H1. Hospital H5 was ranked the lowest amongst all the alternatives.

6. Limitations and Future Scope

The present study uses set of criteria specified and laid down by the Government of India. The criteria can vary from country to country and with time. The justification for selecting these criteria as an parameter for empanelment has not been specified by the government. Also, the result is based on specific context of hospital selection in healthcare. When used in some other context, other parameters may be used and the results may vary accordingly. For instance, more number of decision makers can be included to increase robustness of the results and eliminate response bias.

The study provides the model for hospitals' selection and rankings. It can be extended to the large number of hospitals, covering a state for better policy making. The study can be extended in other countries for fuzzy decision making scenarios with multiple criteria. In times of pandemics, as in covid-19, this technique gives a better list of preferences for the administrative authorities in deciding the hierarchy of preferences in decision making in terms of resource allocations and public recommendations.

Reference

Acharyulu, G., Shekbar, B.R., 2012. Role of Value Chain Strategy in Healthcare Supply Chain Management: An Empirical Study in India. The International Journal of Management, 29, 91.

Ahmad, S.Z., Ahmad, N., Papastathopoulos, A., 2019. Measuring service quality and customer satisfaction of the small- and medium-sized hotels (SMSHs) industry: lessons from United Arab Emirates (UAE). Tourism Review, 74(3), 349-370, DOI: 10.1108/TR-10-2017-0160

Ahmed, S.A.K.S., Ajisola, M., Azeem, K., Bakibinga, P., Chen, Y.F., Choudhury, N.N., Fayehun, O., Griffiths, F., Harris, B., Kibe, P., Lilford, R.J., Omigbodun, A., Rizvi, N., Sartori, J., Smith, S., Watson, S.I., Wilson, R., Yeboah, G., Aujla, N., Yusuf, R., 2020. Impact of the societal response to COVID-19 on access to healthcare for non-COVID-19 health issues in slum communities of Bangladesh, Kenya, Nigeria and Pakistan: results of pre-COVID and COVID-19 lockdown stakeholder engagements. BMJ Global Health, 5(8), e003042, DOI: 10.1136/bmjgh-2020-003042

Alexander, K., 1994. A Strategy for Facilities Management. Facilities, 12(11), 6-10, DOI: 10.1108/02632779410070200

Bajpai, V., 2014. The Challenges Confronting Public Hospitals in India, Their Origins, and Possible Solutions. Advances in Public Health, 2014, 898502, DOI: 10.1155/2014/898502

Becker, F., Parsons, K.S., 2007. Hospital facilities and the role of evidence-based design. Journal of Facilities Management, 5(4), 263-274, DOI: 10.1108/1472596071082259

Blumenthal, D., Fowler, E.J., Abrams, M., Collins, S.R., 2020. Covid-19 – Implications for the Health Care System. New England Journal of Medicine, 383(15), 1483-1488, DOI: 10.1056/nejmsb2021088

Bond, E., David, B., Seymour, P., Duncan, N., 1985. Medical Technology Assessment in Developed Countries: Trends and Opportunities for Collaboration - Assessing Medical Technologies - NCBI Bookshelf.

C., B., B., G., 2004. The relationships between service quality, customer satisfaction and buying intentions in the private hospital industry. South African Journal of Business Management, 35(4), 27-37, DOI: 10.10520/EJC22267

Chatterjee, S.S., Chakrabarty, M., Banerjee, D., Grover, S., Chatterjee, S.S., Dan, U., 2021. Stress, Sleep and Psychological Impact in Healthcare Workers During the Early Phase of COVID-19 in India: A Factor Analysis. Frontiers in Psychology, 12, 611314, DOI: 10.3389/fpsyg.2021.611314

Gandhi, A.V., Sharma, D., 2018. Technical efficiency of private sector hospitals in India using data envelopment analysis. Benchmarking: An International Journal, 25(9), 3570-3591, DOI: 10.1108/BIJ-06-2017-0135

Garg, R., Aagja, J.P., 2010,). Measuring perceived service quality for public hospitals (PubHosQual) in the Indian context. International Journal of Pharmaceutical and Healthcare Marketing, 4(1), 60-83, DOI: 10.1108/17506121011036033

Ghosh, M., 2015. An empirical study on hospital selection in India. International Journal of Health Care Quality Assurance, 28(1), 27-39, DOI: 10.1108/IJHCQA-06-2013-0073

Gopalan, H.S., Misra, A., 2020. COVID-19 pandemic and challenges for socio-economic issues, healthcare and National Health Programs in India. In Diabetes and Metabolic Syndrome: Clinical Research and Reviews, Elsevier Ltd, 14(5), 757-759, DOI: 10.1016/j.dsx.2020.05.041

Govindarajan, V., Ramamurti, R., 2013. Delivering World-Class Health Care, Affordably.

Hartnett, K.P., Kite-Powell, A., DeVies, J., Coletta, M.A., Boehmer, T.K., Adjemian, J., Gundlapalli, A.V., 2020. Impact of the COVID-19 Pandemic on Emergency Department Visits – United States, January 1, 2019–May 30, 2020. MMWR. Morbidity and Mortality Weekly Report, 69(23), 699-704, DOI: 10.15585/mmwr.mm6923e1

Hsin, Y.Y., Loosemore, M., 2001. Customer-focused benchmarking for facilities management. Facilities, 19(13/14), 464-476, DOI: 10.1108/EUM0000000006204

Hwang, C.L., Yoon, K., 1981. Multiple Attribute Decision Making: Methods and Applications (1981st ed.). New York: Springer-Verlag.

Kasthuri, A., 2018. Challenges to Healthcare in India - The Five A's. Indian Journal of Community Medicine : Official Publication of Indian Association of Preventive Social Medicine, 43(3), 141-143, DOI: 10.4103/ijcm.IJCM_194_18

Kumar, D., 2018. India's rural healthcare systems: structural modeling. International Journal of Health Care Quality Assurance, 31(7), 757-774, DOI: 10.1108/IJHCQA-02-2017-0020
Kumar, D., Kumar, D., 2014. Modelling rural healthcare supply chain in India using system dynamics. In Procedia Engineering, 97, 2204-2212), DOI: 10.1016/j.proeng.2014.12.464
Kumar, D., Kumar, D., 2018. Managing the essential medicines stock at rural healthcare systems in India. International Journal of Health Care Quality Assurance, 31(8), 950-965, DOI: 10.1108/IJHCQA-12-2016-0186
Leite, H., Lindsay, C., Kumar, M., 2021. COVID-19 outbreak: implications on healthcare operations. TQM Journal, 33(1), 247-256, DOI: 10.1108/TQM-05-2020-0111
Manjunath, U., Metri, B.A., Ramachandran, S., 2007. Quality management in a healthcare organization: a case of South Indian hospital. The TQM Magazine, 19(2), 129-139, DOI: 10.1108/09544780710729971
Mohamad Nasbi Bin Wan Mohamad, W., Ali, M., 2009. Audit assessment of the facilities maintenance management in a public hospital in Malaysia. Journal of Facilities Management, 7(2), 142-158, DOI: 10.1108/14725960910952523
Okereke, M., Ukor, N.A., Adebisi, Y.A., Ogunkola, I.O., Favour Iyagbaye, E., Adiela Owhor, G., Lucero-Prisno, D.E., 2021. Impact of COVID-19 on access to healthcare in low- and middle-income countries: Current evidence and future recommendations. International Journal of Health Planning and Management, 36(1), 13-17, DOI: 10.1002/hpm.3067
Propper, C., Damiani, M., Leckie, G., 2007. Impact of patients' socioeconomic status on the distance travelled for hospital admission in the English National Health Service. Journal of Health Services Research Policy, 12(3), 153-159, DOI: 10.1258/135581907781543049
Roncarolo, F., Boivin, A., Denis, J.L., Hébert, R., Lehoux, P., 2017. What do we know about the needs and challenges of health systems? A scoping review of the international literature. BMC Health Services Research, 17(1), 636, DOI: 10.1186/s12913-017-2585-5
Shah, M.T., Joshipura, M., Singleton, J., LaBarre, P., Desai, H., Sharma, E., Mock, C., 2015. Assessment of the Availability of Technology for Trauma Care in India. World Journal of Surgery, 39(2), 363-372, DOI: 10.1007/s00268-014-2805-7
Swain, S., 2019. Do patients really perceive better quality of service in private hospitals than public hospitals in India? Benchmarking: An International Journal, 26(2), 590-613, DOI: 10.1108/BIJ-03-2018-0055
Temsah, M.H., Al-Sohime, F., Alamro, N., Al-Eyadhy, A., Al-Hasan, K., Jamal, A., Al-Maglouth, I., Aljamaan, F., Al Amri, M., Barry, M., Al-Subaie, S., Somily, A. M., 2020. The psychological impact of COVID-19 pandemic on health care workers in a MERS-CoV endemic country. Journal of Infection and Public Health, 13(6), 877-882, DOI: 10.1016/j.jiph.2020.05.021
Tsamakis, K., Rizos, E., Manolis, A., Chaidou, S., Kympouropoulos, S., Spartalis, E., Spandidos, D., Tsiptsios, D., Triantafyllis, A., 2020. COVID-19 pandemic and its impact on mental health of healthcare professionals. Experimental and Therapeutic Medicine, 19(6), 3451-3453, DOI: 10.3892/etm.2020.8646
Walker, P.G.T., Whittaker, C., Watson, O.J., Baguelin, M., Winskill, P., Hamlet, A., Djafaara, B.A., Cucunubá, Z., Mesa, D.O., Green, W., Thompson, H., Nayagam, S., Ainslie, K.E.C., Bhatia, S., Bhatt, S., Boonyasiri, A., Boyd, O., Brazeau, N.F., Cattarino, L., Ghani, A.C., 2020. The impact of COVID-19 and strategies for mitigation and suppression in low- And middle-income countries. Science, 369(6502), 413-422, DOI: 10.1126/science.abc0035
Williams, B., 1996. Cost-effective facilities management: a practical approach. Facilities, 14(5/6), 26-38, DOI: 10.1108/02632779610117107
Wu, P.E., Styra, R., Gold, W.L., 2020. Mitigating the psychological effects of COVID-19 on health care workers. Canadian Medical Association, CMAJ, 192(17), E459-E460., DOI: 10.1503/cmaj.200519
Yoon, K., 1987. A Reconciliation Among Discrete Compromise Solutions. Journal of the Operational Research Society, 38(3), 277-286, DOI: 10.1057/jors.1987.44

多标准群体决策环境下受保公共卫生计划下的医院选择

關鍵詞
卫生保健
多标准（MCDM）
阿尤什曼·巴拉特
直觉模糊 TOPSIS（IF-TOPSIS）
IFWA

摘要
蓬勃发展的医疗保健系统完美地反映了任何地区人民的经济发展和满足感。随着人们对健康的担忧日益加剧，医疗需求不断增长，世界各地的医院都面临着在一个屋檐下为患者提供充足医疗设施的巨大挑战。由于印度等发展中国家的卫生行业处于脆弱状态，因此医院需要选择国际标准并遵守该国其他主要卫生中心的规定。本文旨在使用直觉模糊（IF）和通过与理想解决方案相似的优先顺序技术（TOPSIS）方法，基于涉及群体决策的不协调和冲突标准来选择医院。所使用的标准与印度政府名为 Ayushman Bharat-National Health Protection Scheme（AB-NHPS）的有保险的公共卫生计划相伴随。对于每个替代的欧几里德距离，已用于计算与理想解的正负分离度量。与理想解决方案的相对接近程度已被用于对医院进行排名。结果是根据既定标准从最佳到最差排名的医院列表。它可以帮助管理机构在具有多个复杂标准进行分析的不确定环境下进行决策。