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Strategic Approaches to Overcome Barriers in Healthcare Service Supply Chains Using Fuzzy MCDM

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ABSTRACT

Objective: This study examines the challenges and strategic approaches to developing and sustaining medical tourism supply chains (MTSC), particularly in developing countries. Medical tourism is one of the fastest-growing sectors within the global tourism industry, generating significant economic impact through the cross-border movement of patients seeking medical care. Despite its growth potential, numerous barriers hinder the effective design and implementation of sustainable MTSCs, especially in emerging economies such as Iran.

Methodology: The study uses the fuzzy Step-wise Weight Assessment Ratio Analysis (SWARA) to quantify the relative importance of various barriers to MTSC development. Subsequently, the fuzzy Weighted Aggregated Sum Product Assessment (WASPAS) method is used to prioritize strategic interventions to overcome the identified barriers. This hybrid fuzzy MCDM approach effectively handles the inherent uncertainty and subjectivity in expert evaluations, thereby providing a robust decision-making framework.

Results: Findings indicate that among the main barriers, the lack of technological support to facilitate supply chain activities constitutes the most critical hurdle faced by Iran's medical tourism industry. The limited adoption and implementation of technological innovations restrict efficient coordination, information sharing, and overall supply chain sustainability. In response to these challenges, the study identifies "economic and incentives-based strategies" as the foremost approach for overcoming barriers in MTSCs. This strategy emphasizes the creation of financial incentives, subsidies, and economic policies to encourage innovation, infrastructure development, and enhanced stakeholder collaboration.

Conclusion: Policy implications suggest that governments and healthcare providers in developing countries should prioritize investments in technology and infrastructure, alongside devising incentive schemes tailored to the medical tourism sector. Collaboration among various stakeholders—including healthcare institutions, tourism agencies, technology providers, and policymakers—is critical to creating resilient supply chains that can adapt to evolving market demands and global health trends.

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Introduction

Iran Tourism, or recreational traveling, is one of the world's leading industries, and it directly affects economic sectors (Trabandt et al., 2024). The tourism industry is also one of the primary sources of foreign exchange proceeds and recruitment opportunities (Aprigliano Fernandes et al., 2021). The majority of governments see this industry as an ideal for the country's development, despite the impact of the considerable tourism revenue (Lv & Jiang, 2023). The foreign currency given by tourists will be spent on local goods and services. Given its economic significance, its role in mitigating the financial crisis, and its importance to the government, tourism is becoming increasingly significant. (Büyüközkan et al., 2021; Godovykh & Ridderstaat, 2020). One type of tourism is health tourism, which has made great strides in recent years. Several reports indicate that 3% to 4% of the world's population will travel abroad for medical treatment (Ile & Țigu, 2017). It is among the fastest-growing segments of the tourism industry. This type of tourism involves short-term movement of patients from the health care system of their country of residence to obtain medical care (Huang et al., 2021; Johnston et al., 2015). All analyses, statistics, and WHO reports, including forecasts, show that global medical tourism is growing rapidly. Various sources estimate that global medical tourism income will be between US$10.5 billion in 2012 and US$32 billion in 2019, and predict that it will reach US$3 trillion by 2025, an exponential increase.

Additionally, the Association of Medical Tourism (AMT) projected that worldwide medical tourism revenue was 100 billion US$ in 2016. Specifically, studies identify and prioritize obstacles to help managers identify the most severe barriers requiring immediate consideration. These studies are deferred and systematically identify and itemize specific methods to defeat these obstacles. Consequently, this study is justified and motivated by the lack of studies that fully identify the obstacles and approaches to overcoming them in establishing medical tourism supply chains in developing nations. Medical tourism organizations from rising economies contribute remarkably to their economies and significantly contribute to the growing issue of global sustainability (Kusi-Sarpong et al., 2019). For instance, nationwide medical tourism formations in Canada constitute around 10-15% of GDP (Kusi-Sarpong et al., 2019; Sarkis et al., 2011). According to current trends, the industry is expected to reach $ 3 trillion.

The sector's expansion involves many factors, including globalization, improved global transportation, increased communication, and patients' efforts to achieve lower costs, higher quality, and shorter waiting lists (de la Hoz-Correa et al., 2018). The expansion of medical tourism has increased revenue, improved services, boosted tourism, generated foreign-exchange income, and improved the trade balance (Suess et al., 2018). Notwithstanding the many advantages of medical tourism, it is not easy to gain a sufficient market share and position in the industry, given

the significant factors that are effective for this new kind of tourism (Rokni et al., 2017). Based on the current medical tourism index, the most important destinations for medical tourism are Japan, Canada, Dubai, Singapore, Israel, Spain, the UK, and Abu Dhabi (Yu et al., 2018). Top nations for medical tourism have eliminated supply chain barriers through coordinated supply chains, adequate tooling, and support from government policymakers (Bulatovic & Iankova, 2021; Ile & Țigu, 2017; Raoofi et al., 2021). Developing countries use substantial human and natural resources across various areas of health. However, the deficiency of MTSC management is reducing productivity and efficiency. (T. J. Lee, Lim, & Kim, 2020; Mathijsen, 2019).

Iran is a developing country located in a specific geographic region. It has medical experts and paramedical assistant teams, stability in political and internal security matters, stem cell knowledge, the best cosmetic procedures, heart operations, spinal cord operations, and infertility treatment. Thus, it gives Iran an advantage in the medical tourism market. Based on the Worldwide Magazine of Medical Travel (Medical Tourism Magazine, 2020), in 2018, Iran received 105,000 medical tourists. The disbursement of medical tourists in this country is about 3600 and 7600 during the 2013-2018 period, as stated by the Iranian Health Ministry (Gholami et al., 2020) and Iran's medical tourism income reached $ 588 million. The Iranian statistical centre said that although Iran has capacity in the tourism and medical sectors, income from medical tourism and its role in the market are inadequate. The leading causes of this interval are weak and poor management, as well as inaccurate policy-making within MTSC. There is a need to implement effective tactics to reduce these barriers.

This commitment is necessary for these nations to recognize the sources of these obstacles and to analyze and propose solutions (Skountridaki, 2017). The latest studies focus on identifying barriers and developing strategies to advance MTSC development. This analysis aims to explore and rate the various obstacles that may affect MTSC outcomes, propose approaches to critical issues, and support the development of health tourism in developing nations. Therefore, to classify the proposed strategies for overcoming critical issues and developing health tourism in developing countries, this research uses the multi-criteria decision-making (MCDM) technique. Furthermore, this research. Use fuzzy step-wise weight assessment ratio (FSWARA) analysis to assign weights to the MTSC, and fuzzy weighted aggregated sum product assessment (FWASPAS) to rate the overcoming strategies for the MTSC. Medical tourism supply chains face several barriers to evolving their systems; however, little research has examined these barriers. These obstacles should be identified within MTSCs to achieve goals such as tourism development in developing countries (Hadian et al., 2021; Mathijsen, 2019; Skountridaki, 2017). In particular, there are relatively few studies on countries such as India and Iran, and those that have been conducted focus on developed economies. As a result, the present study was conducted to identify the obstacles and challenges

facing MTSC in Iran and to propose solutions to overcome them. This analysis also aims to rank these barriers and the strategies related to them. The paper is organized as follows. Section 2 provides an overview of the literature on MTSC and MTSCB. The fuzzy SWARA and the fuzzy WASPAS are presented in part 3. The research plan was cited in section 4. The usage of the suggested association framework is analysed in Section 5. Section 6 discusses the barriers, obstacles, and approaches. Finally, in section 7, the study's conclusions are presented.

Literature Background

Medical Tourism Supply Chain

Supply chains play a central role in the healthcare sector (Kumar et al., 2008). One type of supply chain is MTSCs that organize, deliver, fund, distribute health services, manage related information, and sponsor manufacturers at the point of medical service delivery (Ferrer & Medhekar, 2012). Since the construction of MTSC requires support from different departments to provide products and services to customers, it can be said that, as in other supply chains, there are production and service supply chains that serve as links between business activities (Tapper & Font, 2004).

Expenses of medical treatments, expectations, security, and reliability were also identified as essential factors affecting MTSC (Ferrer & Medhekar, 2012). Regarding medical tourism supply chains, MTSC is complex and multilayered. It comprises various members of the medical tourism industry that provide users with comprehensive medical and vacation services. MTSC leads to cost reductions that benefit society through the consolidated efforts of the healthcare community and industry. Furthermore, it is argued that it can improve efficiencies in service and delivery among providers. MTSC in developing nations is primarily driven by the increasing availability of high-quality, affordable health care, which challenges health systems in these countries (Ferrer & Medhekar, 2012). MTSC participants must understand the factors that support the industry's development. Medical tourists need to consider critical factors such as treatment cost, waiting time, and security. The elements need to be designed as metric selections. The current literature was not sufficient to comprehensively examine the complexity of medical tourism supply chains. Indeed, efficient collaboration among medical tourism chains is needed to support a nation's medical tourism service. Healthcare organizations are adopting MTSC practices to improve their operations and support the industry. If these organizations can maintain these businesses, a country will gain a competitive advantage in being identified as a destination for medical tourism.

Barriers to the medical tourism supply chain

Medical tourism is viewed as an interdisciplinary endeavour that requires further coordination, involving multiple layers with complex administrators. The medical tourism supply chain comprises trustworthy industries across sectors such as tourism, education, culture, medical centres, higher education, and hotels. (Chanin et al., 2015; Majeed et al., 2017). Commonly, the primary impediment to MTSC in developing nations is organizational culture (Ridderstaat et al., 2019). Medical tourism supply chain management is more challenging than conventional supply chain management due to a shortage of skilled logistics personnel, inadequate coordination, and inefficient supply chain processes (Evelyn F Wamboye et al., 2020).

Some of the obstacles of MTSC are as follows. First, violations of SCM laws are a serious obstacle, especially when they occur in government agencies responsible for providing infrastructure and services. (Kim & Lee, 2019). Skill mismatches in the education system, or a deficiency of career paths or advancement. Corruption and fraud within the government and other administrative actions exclude the MTSCM (Chanin et al., 2015), and insufficient monitoring and assessment mechanisms can consequently cause difficulties (including irregular spending) (Drăghici et al., 2016).

Table 1. Barriers to the medical tourism supply chain

Code	Barriers	Study
$B1$	The private sector's unwillingness to invest	(de la Hoz-Correa et al., 2018; Ridderstaat et al., 2019)
$B2$	The inaction of key actors and institutions	(Gabor & Oltean, 2019; Majeed et al., 2017)
$B3$	Lack of transparency of the health tourism authority	(Ridderstaat et al., 2019)
$B4$	Lack of natural attractions	(Armaitiene et al., 2014; de la Hoz-Correa et al., 2018; Mathijsen, 2019)
$B5$	Lack of technology to facilitate activities optimization	(Jovanović et al., 2015; Labanauskaitė et al., 2020)
$B6$	Lack of technical expertise and training	(Loh, 2015)
$B7$	Lack of R&D capabilities	(Szymańska, 2015)
$B8$	Insufficient national and regional branding	(Dryglas & Salamaga, 2018; Labanauskaitė et al., 2020; Momeni et al., 2018)
$B9$	Insufficient facilitating rules related to health tourism development	(Evelyn F et al., 2020)
$B10$	Lack of waste management and recycling facilities	(Masoomi et al., 2024; Moghadam et al., 2022)
$B11$	Lack of capital to carry out innovation activities	(Suess et al., 2018)
$B12$	Cultural incompatibility of developing countries with countries of origin	(Gabor & Oltean, 2019)
$B13$	International sanctions	(Suess et al., 2018)
$B14$	Lack of international standard facilities for the well-being of foreign tourists	(Crush & Chikanda, 2015; Fraiz et al., 2020; Momeni et al., 2018)

Code	Barriers	Study
$B15$	Inconsistency between travel agencies and medical tourism executive agencies	(C. G. Lee, 2010)
$B16$	Lack of precise planning in the medical tourism ecosystem	(Drăghici et al., 2016; Nilashi et al., 2019; Savaşan et al., 2017)
$B17$	International Certification of Physicians	(Kim & Lee, 2019)
$B18$	Poor infrastructure of transport, road, rail, and air in destination countries	(Crush & Chikanda, 2015)
$B19$	Multiple, complex, and changing regulations	(Qureshi et al., 2017)
$B20$	The perception that sustainable services are of low quality	(de la Hoz-Correa et al., 2018)
$B21$	Lack of performance measurement and incentive systems	(Sahebi et al., 2025; Sahebi et al., 2025)
$B22$	Lack of top management commitment	(Fraiz et al., 2020)
$B23$	Unclear customer requirements	(Jovanović et al., 2015)
$B24$	Lack of competitiveness	(Labanauskaitė et al., 2020)
$B25$	Lack of ability to network with outsiders	(Jovanović et al., 2015; C. G. Lee, 2010)
$B26$	Lack of sustainable suppliers	(Kim & Lee, 2019; Langvinienė, 2014; Sayili et al., 2007)
$B27$	Lack of trust in sharing information and forming joint ventures	(Szymańska, 2015)

Additionally, other typically covered barriers include a shortage of company support processes and structures, a shortage of commitment to management, and a lack of trust in traditional accounting procedures. Table 1 presents a list of barriers to achieving MTSC practices.

Materials and Methods

The MTSC analysis needs to consider all actors concerned about hotels, medical centres, and medical education consultants within the medical business enterprise. In this regard, the literature on the subject under investigation was first examined from different perspectives. This analysis identifies 27 MTSCBs and 7 procedures to beat them, based on a thorough literature review and expert study. Moreover, it uses group action and nominal cluster techniques to identify MTSCBs and solution methods to overcome them. Finally, an expert panel deliberated on the research plan and its significance (Table 2).

Table 2. Information of expert's panel

Experts	Stakeholders
Department of Hygiene, Ministry of Health and Medical Education	Governance
Department of Treatment, Ministry of Health and Medical Education Department of Health Tourism, Ministry of Health and Medical Education	International agency/aid agencies
Head	National NGO’s
Academicians Academicians Academicians	Technical experts

Fuzzy step-wise weight assessment ratio analysis

The Step-wise Weight Assessment Ratio Analysis was proposed in 2010 (Keršuliene et al., 2010). Professionals are the primary source for mastering the SWARA procedure. The main advantage of SWARA is its ability to assess expert opinion and estimate the weighting of all criteria (Zolfani & Saparauskas, 2013). A professional makes more effective use of his latent knowledge, experience, and data in the SWARA procedure than in other MCDM procedures (Mardani et al., 2017). The significance of this criterion is usually assigned by precedence weights derived from pairwise comparison matrices (Kou et al., 2016; Kou et al., 2014). The SWARA Act allows free assessment of standards without the use of expert scales. Therefore, the required number of comparisons for SWARA is less than AHP or ANP. In SWARA, the required comparisons are $n-1$ when n criteria are rated by significance in descending order, whereas in AHP, it equals $n(n-1)$ (Mardani et al., 2017). In addition, the SWARA procedure classifies the criteria in descending order; thus, it is not necessary to check the consistency of the judgments. In addition, SWARA is a fast and straightforward MCDM method. The primary feature of SWARA is to assess experts' opinions based on the criteria's significance to obtain criterion weights. SWARA can be easily applied in complex or unusual situations to address inaccurate and ambiguous data using a fuzzy approach. The advantage of the fuzzy approach is that it allows specifying the relative importance of attributes using a fuzzy number rather than an exact one. Fuzzy sets are a versatile tool for numerical and linguistic modelling (Ganesan et al., 2019).

Though fuzzy SWARA is a new procedure, various researchers have applied it to solve MCDM issues, particularly in assessing the political logistics of cities (Tadić et al., 2018), assessment of equipment construction (Keshavarz-Ghorabaee et al., 2018), and selection. Outsourced service providers (Perçin, 2019). Zarbakhshnia et al. (2018) used fuzzy SWARA with ratio analysis-based multi-objective fuzzy optimization (MOORA) in the plastics industry to choose a sustainable 3rd party to reverse logistics service provider. Fuzzy SWARA has been integrated with Fuzzy COPRAS to assess sustainable 3rd party providers of reverse logistics (Keshavarz-Ghorabaee et al., 2018). Mahdiraji et al. (2021) extended SWARA with intuitionistic fuzzy numbers for the formulation of manufacturing strategy in the automotive industry. Ghasemian Sahebi et al. (2020) analyzed the barriers of organizational transformation by using Fuzzy-SWARA. The fuzzy SWARA steps used in this research are as below (Masoomi et al., 2022):

Step 1: The criteria are rated from most essential to least essential based on expert opinion (Zolfani & Saparauskas, 2013). Because decision-making on practical matters always involves uncertainty, language scales provide experts with greater freedom. Therefore, a representative

linguistic scale for a triangular fuzzy number is used to elicit expert opinions on the variables. The fuzzy rating scale is presented in Table 3 (Bouzon et al., 2016).

Step 2: This step begins with a second criterion. Here, for each standard, the expert assigns a linguistic variable for all criteria j, according to the relative importance of the last $(j-1)$ criterion. Additionally, this ratio is essential for comparing averages (Keršuliene et al., 2010).

Step 3: Compute the fuzzy coefficient, $\hat{k}_j$.

$$\hat{k}_j = \begin{cases} 1 & j = 1, \\ \hat{S}_j + 1 & j > 1, \end{cases} \quad (1)$$

Step 4: Compute the recalculated fuzzy weight, $\hat{q}_j$

$$\hat{q}_j = \begin{cases} 1 & j = 1, \\ \dfrac{\hat{q}_{j-1}}{\hat{k}_j} & j > 1, \end{cases} \quad (2)$$

Step 5: Compute the relative fuzzy weights of the evaluation criteria.

$$\hat{w}_j = \frac{\hat{q}_j}{\sum_{k=1}^{n} \hat{q}_k} \quad (3)$$

Where $\hat{wj}$ represents the relative fuzzy weight of the j criterion $n = the\ number\ of\ criterion.$

Step 6: The defuzzification of the relative fuzzy weights of the criterion j is carried out using the center-of-area technique, which is the most straightforward and practical method.

$$w_j = \frac{1}{3}\hat{w}_j = \frac{1}{3}\left(\hat{w}_{j\alpha} + \hat{w}_{j\beta} + \hat{w}_{j\gamma}\right) \quad (4)$$

Where w_j denotes defuzzied relative fuzzy weights of j^{th} criterion.

Fuzzy weighted aggregated sum product assessment

Weighted Sum of Product Evaluation is among the most powerful MCDM methods and was proposed in 2012 (Zavadskas et al., 2012). WSPAS brings together WPM and WSM to develop decision-making. WSPAS works more accurately than other MCDM methods and gives preferable consequences than WSM or WPM (Mardani et al., 2017). WSPAS appraises substitutes against three optimality criteria. First, it estimates multiple alternatives on multiple decision-making criteria utilizing WSM. Second, it appraises the replacements using exponential standards, measured in WPM. Finally, it calculates the weighted aggregation of addition and multiplication

procedures, reflecting a more practical situation. WSPAS allows for to evaluation and ranking of substitutes with great confidence (Mishra & Rani, 2018).

WASPAS is used for several decision-making problems across a variety of fuzzy environments. Lately, fuzzy WASPAS has been working to solve problems in MCDM across various areas, such as site selection for construction (Turskis et al., 2015) and the identification of critical information substructures for sustainable development (Turskis et al., 2019). Zavadskas et al. (2014) extended WASPAS on MCDM issues with IVIF (interval-valued intuitionistic fuzzy) information.

Table 3. Fuzzy evaluation scale (Bouzon et al., 2016)

Linguistic variable	Fuzzy scale
Extremely unimportant	(0,0,1)
Not very important	(0,1,3)
Not important	(1,3,5)
Fair	(3,5,7)
Important	(5,7,9)
Very important	(7,9,10)
Extremely important	(9,10,10)

Ilbahar and Kahraman (2018) suggested WASPAS for MCDM issues according to the IT2FS operators, who applied the Pythagorean fuzzy WASPAS procedure to measure the performance of a retail store. Mishra and Rani (2018) proposed IVIF-WASPAS to assess the optimal management of reservoir flood control. Shaaban et al. (2019) used fuzzy WASPAS integrated with fuzzy decision-making appraisal and examination DEMATEL-ANP procedure to classify combustible gas recovery procedures. Mishra et al. (2019) presented an integrated WASPAS approach with information hesitancy for selecting green suppliers. The appendix steps support the fuzzy WSPAS fuzzy calculation:

Step 1: Make a fuzzy matrix of decisions with fuzzy triangular numbers, as illustrated in Table 3. $\hat{X}_{ij} = \begin{bmatrix} \hat{x}_{11} & \hat{x}_{12} & \cdots & \hat{x}_{1n} \\ \hat{x}_{21} & \hat{x}_{22} & \vdots\vdots & \hat{x}_{2n} \\ \cdots & \cdots & & \cdots \\ \hat{x}_{m1} & \hat{x}_{m2} & \cdots & \hat{x}_{mn} \end{bmatrix}$ (5)

In which n equals the number of appraisal criteria, m equals the number of options, and $\hat{x}_{ij}$ = rating fuzzy value of the i^{th} substitute for the j^{th} criterion of decision.

Step 2: Normalize the fuzzy decision matrix.

The normalized matrix of decision and its element is indicated by $\tilde{\hat{x}}_{ij}$.

If the optimal value is supreme:

$$\tilde{\hat{x}}_{ij} = \frac{\hat{x}_{ij}}{\max \hat{x}_{ij}}, \quad j = 1, \dots \dots, n; \quad i = 1, \dots \dots, m. \tag{6}$$

If the optimum value is minimum:

$$\tilde{\hat{x}}_{ij} = \frac{\min \hat{x}_{ij}}{\hat{x}_{ij}}, \quad j = 1, \dots \dots, n; \quad i = 1, \dots \dots, m. \tag{7}$$

Step 3: Compute fuzzy WASPAS normalized decision-making weighted matrix for the summation part.

$$\tilde{\hat{x}}_{ij}, \ sum = \tilde{\hat{x}}_{ij} w_j, \quad j = 1, \dots \dots, n; \quad i = 1, \dots \dots, m. \tag{8}$$

$$\tilde{\hat{x}}_{ij}, \ sum = \sum_{j=1}^{n} \tilde{\hat{x}}_{ij}, \quad sum \tag{9}$$

Step 4: Compute fuzzy WASPAS normalized decision-making weighted matrix for the multiplication part.

$$\tilde{\hat{x}}_{ij}, \ mult = \tilde{\hat{x}}_{ij} \ w_j, \quad j = 1, \dots \dots, n; \quad i = 1, \dots \dots, m. \tag{10}$$

$$\tilde{\hat{X}}_{ij}, \ mult = \prod_{j=1}^{n} \tilde{\hat{x}}_{ij}, \quad mult \tag{11}$$

Step 5: The fuzzy performance measurement is defuzzified using the centre-of-gravity method, which is the most practical and straightforward approach (Turskis et al., 2019).

$$Q_{i,sum} = \frac{1}{3} \tilde{\hat{X}}_i, \ sum = \frac{1}{3} \left(\tilde{\hat{X}}_i, \ sum, \ \alpha + \tilde{\hat{X}}_i, \ sum, \beta + \tilde{\hat{X}}_i, \ sum, \gamma \right) \tag{12}$$

$$Q_{i,mult} = \frac{1}{3} \tilde{\hat{X}}_i, \ mult = \frac{1}{3} \left(\tilde{\hat{X}}_i, \ mult, \ \alpha + \tilde{\hat{X}}_i, \ mult, \beta + \tilde{\hat{X}}_i, \ mult, \gamma \right) \tag{13}$$

Step 6: Compute Qiweighted aggregation of the summation and multiplication parts.

$$\mathrm{Q_i} = 0.5 \, \mathrm{Q_{i,sum}} + 0.5 \, \mathrm{Q_{i,mult}} \qquad \mathrm{i} = 1, \dots, \mathrm{m} \tag{14}$$

A generalized equation can be developed to evaluate the total relative importance for ranking alternatives, thereby enhancing the effectiveness and accuracy of the decision-making procedure.

$$\mathrm{Q_i^{\lambda}} = \lambda \, \mathrm{Q_{i,sum}} + (1 - \lambda) \, \mathrm{Q_{i,mult}} \qquad \mathrm{i} = 1, \dots, \mathrm{m} \tag{15}$$

The substitutes can be classified based on the Qi values, i.e., the first substitutes with the most incredible Qi value. λ is a parameter of fuzzy WSPAS and can range from 0 to 1. When the value of λ is 0. Fuzzy WSPAS gives WPM, while for λ = 1, WSPAS is converted to WSM.

Results

Applying the proposed framework helps stakeholders recognize the relative importance of MTSCB and rank potential strategies to tackle it, thereby driving adoption. Impressive and efficient medical tourism proceedings, and to improve the proceedings and process. Fuzzy SWARA was used to assess the MTSCB weights and appraise the relative importance of every weight, while fuzzy WASPAS was used to rank the MTSCB crossing strategies. Based on the literature review and expert brainstorming sessions, this analysis presents 27 MTSCBs and 7 approaches to defeat them (Table 3). Here are three framed levels in the decision-making hierarchy for this analysis, representing the strategies' ranks for defeating MTSCB. At the 1st level, the MTSCB hinders the successful implementation of the MTSC at an intermediate level and approaches to overcome the MTSCB at the final grade.

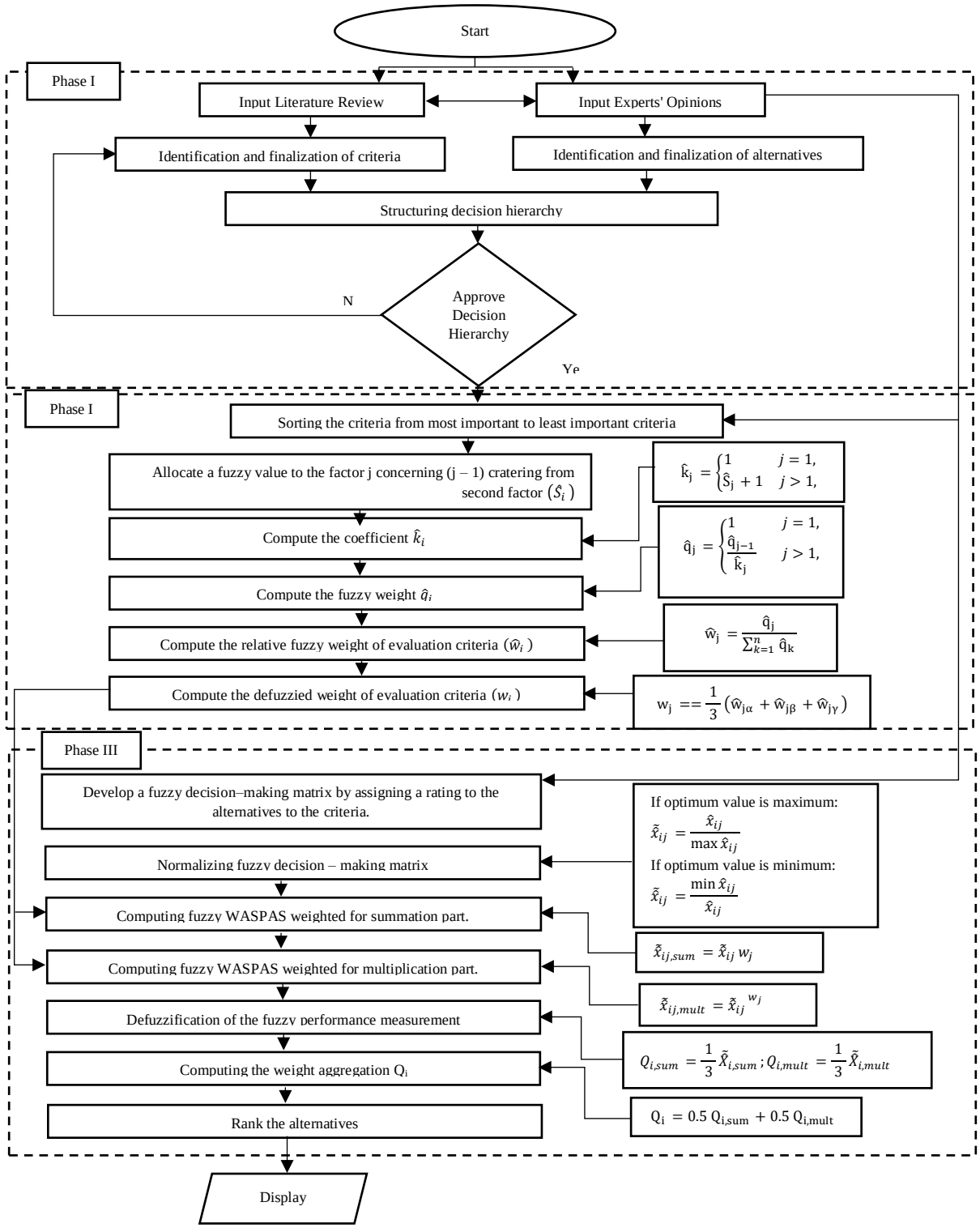

Fig 1. Research flowchart

Result of FSWARA

This section presents the results of fuzzy SWARA weighting for the 27 finalized MTSCBs. Questionnaire/opinion forms were forwarded to experts (Table 1). After a brainstorming session, the expert panel arranges the MTSCBs in decreasing order of significance. The relative importance of the average value, $\hat{S}j$, each MTSCB is evaluated by experts using a fuzzy evaluation scale (Table 3). Eq. (1) is used to calculate the fuzzy coefficient, $\hat{k}j$. Subsequently, Eq. (2) and Eq. (3) compute the recalculated fuzzy weight, $\hat{q}j$, and the relative fuzzy weight, $\hat{w}j$, of MTSCBs, respectively (Table 6). Defuzzification of the relative fuzzy weight, wj, the MTSCB for each MTSCB is computed using the center-of-area method by applying Eq. (4).

Table 4. Results of fuzzy SWARA to weight MTSCBs

MTSCBs	Comparative importance of average value, $\hat{S}j$	Coefficient $\hat{k}_j = Sj + 1$	$\hat{k}_j$ = $\hat{S}_j$ + Recalculated fuzzy weight $q_j = \frac{\hat{q}_{j-1}}{\hat{k}_j}$	Relative fuzzy weight $\hat{w}_j = \frac{\hat{q}_j}{\sum_{k=1}^{n} \hat{q}_k}$	Defuzzified Relative weight wj
$B5$		(1,1,1)	(1.000,1.000,1.000)	(0.162,0.270,0.357)	0.2630
$B12$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.666,0.769,0.909)	(0.108,0.208,0.325)	0.21367
$B6$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.444,0.591,0.826)	(0.071,0.159,0.299)	0.17633
$B7$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.261,0.394,0.635)	(0.043,0.106,0.227)	0.12534
$B11$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.174,0.303,0.577)	(0.028,0.082,0.181)	0.09710
$B12$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.102,0.202,0.443)	(0.017,0.054,0.158)	0.07633
$B13$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.068,0.155,0.402)	(0.011,0.042,0.144)	0.06567
$B14$	(0.5,0.7,0.9)	(1.5,1.7,1.9)	(0.035,0.092,0.268)	(0.005,0.024,0.095)	0.04134
$B10$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.020,0.061,0.206)	(0.003,0.016,0.073)	0.03067
$B18$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.011,0.040,0.158)	(0.001,0.010,0.056)	0.02234
$B2$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.007,0.030,0.143)	(0.001,0.008,0.051)	0.0200
$B1$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.004,0.023,0.130)	(0.000,0.006,0.047)	0.01767
$B3$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.002,0.015,0.100)	(0.000,0.004,0.035)	0.0130
$B24$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.001,0.010,0.076)	(0.000,0.002,0.027)	0.0096
$B16$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.000,0.007,0.069)	(0.000,0.001,0.024)	0.0084
$B27$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.000,0.004,0.053)	(0.000,0.000,0.018)	0.0060
$B8$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.000,0.003,0.048)	(0.000,0.000,0.017)	0.0056
$B26$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.000,0.002,0.036)	(0.000,0.000,0.013)	0.0043
$B9$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.000,0.001,0.027)	(0.000,0.000,0.009)	0.0030
$B4$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.000,0.000,0.024)	(0.000,0.000,0.008)	0.0026
$B23$	(0.5,0.7,0.9)	(1.5,1.7,1.9)	(0.000,0.000,0.016)	(0.000,0.000,0.005)	0.0016
$B20$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.000,0.000,0.012)	(0.000,0.000,0.004)	0.0013
$B25$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.000,0.000,0.009)	(0.000,0.000,0.003)	0.0010
$B22$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.000,0.000,0.007)	(0.000,0.000,0.02)	0.0006
$B17$	(0.3,0.5,0.7)	(1.3,1.5,1.7)	(0.000,0.000,0.005)	(0.000,0.000,0.001)	0.0003
$B21$	(0.1,0.3,0.5)	(1.1,1.3,1.5)	(0.000,0.000,0.005)	(0.000,0.000,0.001)	0.0003
$B19$	(0.5,0.7,0.9)	(1.5,1.7,1.9)	(0.000,0.000,0.003)	(0.000,0.000,0.001)	0.0003

Results of FWASPAS

In this part, after deriving the MTSCB weights, the fuzzy WSPAS is used to rank the overcoming strategies that pass the MTSCB. In total, seven approaches to overcome MTSCB are created. They are noted as $S1, S2, \dots, S7$, and will be appraised using fuzzy WSPAS. The expert panel rated each solution using the fuzzy rating scale presented in Table 3 and created a WASPAS fuzzy decision-making matrix shown in Table 5. Next, Eqs. (6) and (7) are used to calculate the fuzzy normalized values of the WASPAS decision matrix (Masoomi et al., 2023, 2025).

WASPAS fuzzy normalized decision matrix of weight for the summation, calculated using Eq. (8). WASPASXij, multi fuzzy kernel weighted decision matrix, calculated utilizing Eq. (10. The dimming efficiency measurement was defuzzified using the centre procedure using Eq. (12) and Eq. (13). Finally, Eq. (14) is used to calculate Qi, the weighted set of sums and multipliers.

Strategies for overcoming MTSCB are given ranks based on their Qi value. Table 6 presents the fuzzy WSPAS results. In addition, the relative fuzzy weight,$\hat{w}j$, of the MTSCBs is obtained from Eq. (3).

Table 5. Decision matrix

MTSCBs	$S1$	$S2$	$S3$	$S4$	$S5$	$S6$	$S7$
$B1$	(0.30,0.50,0.67)	(0.50,0.70,0.87)	(0.23,0.43,0.63)	(0.43,0.63,0.83)	(0.57,0.77,0.90)	(0.57,0.77,0.90)	(0.50,0.70,0.83)
$B2$	(0.63,0.83,0.97)	(0.57,0.77,0.93)	(0.70,0.90,1.00)	(0.43,0.63,0.80)	(0.57,0.77,0.93)	(0.50,0.70,0.90)	(0.50,0.70,0.87)
$B3$	(0.43,0.63,0.80)	(0.43,0.63,0.83)	(0.57,0.77,0.90)	(0.63,0.83,0.97)	(0.37,0.57,0.73)	(0.57,0.77,0.90)	(0.37,0.57,0.73)
$B4$	(0.50,0.70,0.90)	(0.50,0.67,0.80)	(0.63,0.83,0.97)	(0.57,0.77,0.93)	(0.43,0.63,0.80)	(0.63,0.80,0.93)	(0.37,0.57,0.77)
$B5$	(0.57,0.73,0.87)	(0.57,0.77,0.90)	(0.37,0.57,0.77)	(0.30,0.50,0.70)	(0.57,0.77,0.90)	(0.50,0.70,0.87)	(0.63,0.80,0.90)
$B6$	(0.70,0.90,1.00)	(0.57,0.77,0.93)	(0.70,0.90,1.00)	(0.37,0.57,0.73)	(0.50,0.70,0.87)	(0.50,0.70,0.87)	(0.57,0.77,0.93)
$B7$	(0.57,0.77,0.93)	(0.37,0.57,0.77)	(0.50,0.70,0.90)	(0.63,0.83,0.97)	(0.50,0.70,0.87)	(0.43,0.63,0.83)	(0.37,0.57,0.77)
$B8$	(0.30,0.50,0.70)	(0.50,0.70,0.87)	(0.30,0.50,0.70)	(0.43,0.63,0.83)	(0.43,0.63,0.80)	(0.43,0.63,0.80)	(0.57,0.77,0.90)
$B9$	(0.43,0.63,0.80)	(0.37,0.57,0.77)	(0.50,0.70,0.90)	(0.37,0.57,0.77)	(0.63,0.83,0.97)	(0.37,0.57,0.77)	(0.57,0.77,0.93)
$B10$	(0.57,0.77,0.93)	(0.57,0.77,0.90)	(0.63,0.83,0.97)	(0.37,0.57,0.77)	(0.50,0.70,0.87)	(0.43,0.63,0.80)	(0.57,0.77,0.90)
$B11$	(0.37,0.57,0.77)	(0.57,0.77,0.93)	(0.43,0.63,0.83)	(0.50,0.70,0.87)	(0.63,0.83,0.97)	(0.37,0.57,0.77)	(0.63,0.83,0.97)

$B12$	(0.57,0.77,0.90)	(0.43,0.63,0.80)	(0.43,0.63,0.80)	(0.43,0.63,0.80)	(0.50,0.70,0.87)	(0.37,0.57,0.73)	(0.50,0.70,0.87)
$B13$	(0.37,0.57,0.77)	(0.57,0.77,0.93)	(0.50,0.70,0.90)	(0.50,0.70,0.87)	(0.50,0.67,0.80)	(0.63,0.83,0.97)	(0.50,0.70,0.87)
$B14$	(0.37,0.57,0.73)	(0.43,0.63,0.80)	(0.30,0.50,0.70)	(0.63,0.83,0.97)	(0.63,0.83,0.97)	(0.43,0.63,0.80)	(0.30,0.50,0.70)
$B15$	(0.23,0.43,0.63)	(0.50,0.70,0.87)	(0.37,0.57,0.77)	(0.50,0.70,0.87)	(0.57,0.77,0.93)	(0.50,0.70,0.87)	(0.57,0.77,0.90)
$B16$	(0.57,0.77,0.90)	(0.57,0.77,0.93)	(0.57,0.77,0.90)	(0.37,0.57,0.73)	(0.37,0.57,0.77)	(0.50,0.70,0.83)	(0.50,0.70,0.90)
$B17$	(0.57,0.77,0.93)	(0.37,0.57,0.73)	(0.63,0.83,0.97)	(0.57,0.77,0.93)	(0.43,0.63,0.83)	(0.43,0.63,0.83)	(0.30,0.50,0.70)
$B18$	(0.43,0.63,0.80)	(0.57,0.77,0.93)	(0.57,0.77,0.90)	(0.37,0.57,0.77)	(0.43,0.63,0.83)	(0.43,0.63,0.80)	(0.30,0.50,0.70)
$B19$	(0.30,0.50,0.70)	(0.43,0.63,0.83)	(0.23,0.43,0.63)	(0.57,0.77,0.90)	(0.63,0.83,0.97)	(0.50,0.70,0.87)	(0.43,0.63,0.80)
$B20$	(0.70,0.90,1.00)	(0.57,0.77,0.93)	(0.70,0.90,1.00)	(0.37,0.57,0.77)	(0.43,0.63,0.83)	(0.50,0.70,0.83)	(0.57,0.77,0.90)
$B21$	(0.37,0.57,0.77)	(0.37,0.57,0.77)	(0.43,0.63,0.83)	(0.70,.090,1.00)	(0.77,.093,1.00)	(0.43,0.63,0.83)	(0.63,0.80,0.90)
$B22$	(0.43,0.63,0.83)	(0.50,0.67,0.80)	(0.37,0.57,0.77)	(0.37,0.57,0.77)	(0.57,0.77,0.93)	(0.43,0.63,0.80)	(0.57,0.77,0.93)
$B23$	(0.63,0.80,0.93)	(0.57,0.77,0.93)	(0.50,0.70,0.90)	(0.37,0.57,0.77)	(0.37,0.57,0.77)	(0.50,0.70,0.90)	(0.43,0.63,0.83)
$B24$	(0.57,0.77,0.90)	(0.50,0.70,0.90)	(0.57,0.77,0.93)	(0.50,0.70,0.87)	(0.57,0.77,0.90)	(0.70,.090,1.00)	(0.23,0.43,0.63)
$B25$	(0.57,0.77,0.93)	(0.37,0.57,0.77)	(0.63,0.83,0.97)	(0.43,0.63,0.80)	(0.50,0.70,0.90)	(0.50,0.70,0.90)	(0.57,0.77,0.93)
$B26$	(0.43,0.63,0.83)	(0.57,0.77,0.93)	(0.63,0.83,0.97)	(0.43,0.63,0.83)	(0.10,0.30,0.50)	(0.43,0.63,0.80)	(0.30,0.50,0.70)
$B27$	(0.50,0.70,0.87)	(0.37,0.57,0.77)	(0.57,0.77,0.90)	(0.30,0.50,0.70)	(0.23,0.43,0.63)	(0.43,0.63,0.83)	(0.57,0.77,0.93)

Table 6. Fuzzy WASPAS results and ranking of the strategies to overcome MTSCBs

strategies	Aggregate Fuzzy summation value	0.5 $Q_{i,sum}$	Aggregate Fuzzy multiplication value	0.5 $Q_{i,mult}$	Qi	Ranking
$S1$	(2.87,1.86,1.44)	(2.03)	(2.64,1.64,1.22)	(1.82)	(1.92)	1
$S2$	(2.58,0.67,1.41)	(1.54)	(2.46,1.59,1.20)	(1.73)	(1.64)	5
$S3$	(2.80,1.85,1.43)	(2.00)	(2.61,1.63,1.21)	(1.80)	(1.90)	2
$S4$	(2.30,1.63,1.32)	(1.73)	(2.12,1.42,1.11)	(1.54)	(1.63)	6
$S5$	(2.31,1.63,1.31)	(1.74)	(2.12,1.42,1.10)	(1.54)	(1.63)	7
$S6$	(2.64,1.81,1.42)	(1.93)	(2.53,1.62,1.21)	(1.77)	(1.85)	3
$S7$	(2.58,1.75,1.38)	(1.88)	(2.40,1.54,1.17)	(1.68)	(1.78)	4

It is challenging to determine which method for defeating MTSCB is most urgent for the effective and efficient implementation of MTSC. Still, the results of the suggested fuzzy SWARA-WASPAS hybrid framework have made it comprehensive and systematic. The fuzzy SWARA results indicate that "a deficiency of technology to facilitate business optimization (B5)" has the highest weight (0.2630) and is the main MTSCB hindering the successful implementation of MTSCM.

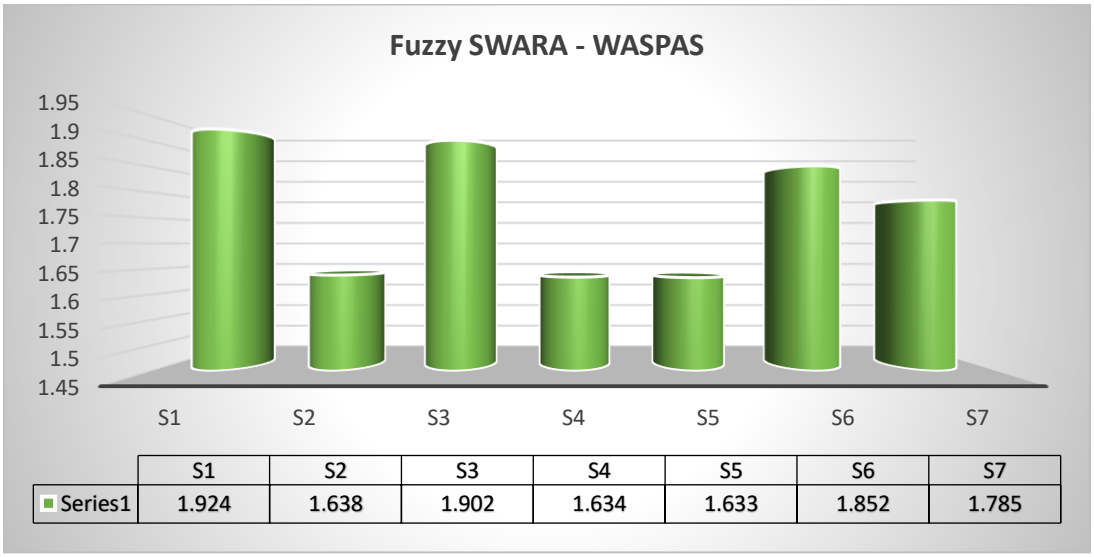

Fig. 2. Final ranking obtained by integrated fuzzy methods

Discussion

Discussion on the ranking of the barriers

The barriers to technology adoption to promote activities (B5) were the most pressing problem facing Iran's medical tourism industry, hindering the implementation of exceptional innovations to sustain the supply chain. Technical support is among the main factors in the medical tourism supply chain. These results highlight that M.T. organizations and medical centres lack technical knowledge, particularly in emerging and developing countries, such as Iran. These organizations face a significant challenge in learning and developing technical skills, such as advanced equipment, waste management, and recycling (Labanauskaitė et al., 2020). However, these institutions are partly due to a deficiency of development and research facilities, which hinders the development of their technological capacities (Gupta & Barua, 2018). The incompatibility of developing nations' cultures with nations of origin (B12), "weighted (0.2136), is the 2nd MTSCB that hinders the successful implementation of the MTSCM. Developing countries, particularly

Iran, have an Islamic culture and intransigent cultural policies, which have hampered the successful implementation of the MTSC. These nations can earn substantial income by overcoming cultural barriers (Kim & Lee, 2019). The third significant barrier to MTSC is the "deficiency of training and technical expertise" (B6). The medical tourism industry is a difficult field and requires strong technical skills. M.T. organizations and medical centres often lack the technical knowledge and expertise to perform activities related to education sustainability in the supply chain. Usually, there is no single individual suited to a particular task, or the person lacks sufficient experience and skills (Fraiz et al., 2020). Results take us back to the thought that there should be financial accessibility to employ new staff and doctors with the necessary skills, or to train existing staff to develop the skills required. The "lack of R&D capacity" (B7) also presents a significant obstacle that needs special attention. In connection with the last challenge of the deficiency of organizations, skilled workforce, and lack of development and research capacities necessary to implement innovation, expand new technologies or ideas, and thus promote sustainable development in the MTSC (Labanauskaitė et al., 2020). Based on Table 3, ratings have been assigned to all serious barriers and other MTSCBs that affect the regular operation of the MTSCM.

Discussion on the strategies

Examination of approaches to overcome barriers to MTSC (second stage of analysis) shows that no single method is sufficient to overcome these obstacles, as demonstrated by the gap in the total score weights of strategies with barriers (Table 7).

Based on previous studies, investigating the obstacles and approaches to overcome the challenges for the MTSC is one of the methods to advance the sustainable development agenda of emerging economies in developed, developing nations (Kusi-Sarpong et al., 2019). Consequently, this analysis identified and appraised a comprehensive framework of obstacles and remedial strategies for MTSC, supported by a multi-criteria decision-making approach.

Table 7. Strategies for overcoming barriers in the medical tourism supply chain.

Strategies	Description
Economic and incentives-based strategy (ST1)	Present an inaccurate image of Iran to global audiences (negative publicity and economic and political sanctions) and remove obstacles to foreign investment in Iran. Support the national private sector to develop the national medical tourism infrastructure.
Sustainable proficiencies and skill development strategy (ST2)	This approach creates an environment where laborers and doctors can develop environmentally sustainable capabilities, such as technologies and know-how that support sustainable innovation ideas to minimize environmental destruction.
Long-term strategic planning (ST3)	Strategic planning responds to long-term assessments that inform the overall strategic direction of supply chain management. Strategic planning involves significant decision-making.

Research and Development strategy (ST4)	This approach aims to support the development of analytical facilities within T.M. institutions to improve services.
Networking strategy (ST5)	This strategy aims to build collective capacities and competencies within the nation and foreign institutions and organizations. Collaboration may involve exchanging equipment and technologies, and joint training of laborers and physicians.
Collaboration, cooperation, and coordination among MTSC actors. (ST6)	Teamwork, collaboration, and coordination among different parties are essential to meet the needs of medical tourism.
Marketing and promotion strategy (ST7)	Prioritizing tourism attractions, alongside other policies, to appeal to foreign markets, recognize barriers, address problems and violations that deter tourism, create conditions for visitors to enter, and encourage tourists to enter the country. Encourage tourist attractions, identify national capacity in the health sector, build confidence in the quality of national service, and direct requirements to national sources.

To remove the barriers, the "Economic and Incentive approach" (ST1) is considered the ideal strategy. The lack of technology to boost operations and the optimization barrier are significant obstacles, and the "economic and incentive approach" (ST1) may be the most effective way to overcome them. Allocation of segregated funds for the acquisition of new technologies and research facilities will improve the capacity of T.M. institutions to develop and absorb the technology.

The fuzzy results from WASPAS show the ranking of approaches to overcome MTSCB in the following order: S1 > S3 > S6 > S7 > S2 > S4 > S5. The findings are shown in Figure 3. The results from WSPAS show that "Long Term Strategic Planning (ST3)" is ranked second in overcoming MTSCB. "Cooperation, cooperation, and parts coordination of the supply chain (ST6)" is the third-highest approach to surpass the MTSCB. It helps integrate local and regional agencies, providers, agents, and medical centres, thereby increasing MTSC's overall effectiveness. "Promotion and Marketing Strategy (ST7)" is the fourth-highest-rated approach for surpassing the MTSCB.

The "Economic and Incentive approach" (ST1) helps overcome many obstacles, such as B1, B3, B5, B6, B8, B11, B17, B19, and B21. "Long-term strategic planning (ST3)" is impressive in overcoming various obstacles, including B4, B8, B12, B14, B18, B20, and B22.

"Cooperation, collaboration, and coordination among parts of the supply chain (ST6)" effectively overcome various obstacles, including B2, B9, B15, B16, B26, and B27. The "Marketing and Promotion Approach (ST7)" can remove barriers B7, B18, B22, B23, and B24. Decision-makers must focus on strategies in order of their priorities to eliminate or reduce the impacts of MTSCB.

Managerial implications

The suggested framework is essential for researchers, academics, and policymakers to streamline MTSC and humanize all stakeholders in tourism organizations. Scoring Solutions to overcome MTSCB help M.T. stakeholders and related customers, and reduce revenue, to provide a preferable planning approach to strengthen MTSC. Consequently, this analysis can inform organizations (including government organizations, transport systems, global agencies, patients, medical centres, etc.) and help them conduct MTSC more efficiently. Consequently, these actors can see which approaches to defeat MTSCB require the most attention when designing and implementing impressive action plans.

This analysis identifies "lack of technology to facilitate operations optimization," cultural incompatibility between developing nations and their nations of origin, and "lack of technical expertise and training." Creation and "lack of R&D capacity are significant obstacles to sustainable innovations in the supply chain of medical tourism. Organizations and managers can design seminars and special training programs to enhance their staff and physicians' technical skills and competencies. Policymakers and regulators in developing nations can examine the current frameworks across various organizations to better understand current obstacles. Additionally, Policymakers can focus on building the capacity of the medical tourism segment through supporting technology acquisition and upskilling.

According to this study's findings, policymakers can fund research and build technological capabilities, as they are more creative in sustainable development. Governments must also plan and fulfil preferable tax structures and incentives for institutions working for sustainable development.

Conclusion

This MTSC's operations are conducted in a highly turbulent environment characterized by numerous uncertainties and challenges, including volatile and changing demand, weak infrastructure, and an unskilled workforce. Skills, incomplete information, and insufficient funding. Medical tourism organizations must navigate these obstacles, challenges, and uncertainties to carry out their activities. Several barriers exist that can impede the impressive management of the T.M. and pose challenges in the MTSC. This analysis identifies 27 MTSCBs and 7 strategies for overcoming them, based on a literature review and expert opinion. Hybrid Fuzzy SWARA Framework - Proposed fuzzy WASPAS ranks MTSCB remediation solutions for impressive and efficient MTSC.

The offering of this analysis has two parts. Initially, the calculation of the weights for the MTSCB using SWARA was fuzzy because the MTSCB hindered the success of medical tourism proceedings, and the results suggest that the lack of technology to facilitate the optimization of the proceedings was the main factor. Of the MTSCB. Second, ranking MTSCB bypass strategies using fuzzy WASPAS is useful, as they help decision-makers efficiently implement MTSC. In particular, the results show that "economic and incentive strategies" and "long-term strategic planning are the main approaches to defeating the MTSCB, thus facilitating the economic development of the country. No studies have been performed to explore and classify MTSCB and MTSC. This article examines the use of a hybrid framework for rating approaches to overcome MTSCB, which may be seen as essential cooperation to MTSC.

Author Contributions

For research articles with multiple authors, a short paragraph outlining their individual contributions must be included. The following statements should be used: “Conceptualization, X.X. and Y.Y.; methodology, X.X.; software, X.X.; validation, X.X., Y.Y. and Z.Z.; formal analysis, X.X.; investigation, X.X.; resources, X.X.; data curation, X.X.; writing—original draft preparation, X.X.; writing—review and editing, X.X.; visualization, X.X.; supervision, X.X.; project administration, X.X.; funding acquisition, Y.Y. All authors have read and agreed to the published version of the manuscript.”

All authors contributed equally to the conceptualization of the article and writing of the original and subsequent drafts.

Data Availability Statement

Data available on request from the authors.

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Ethical considerations

The authors avoided data fabrication, falsification, and plagiarism, as well as any form of misconduct.

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Conflict of interest

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