

Factors affecting the development of medical tourism in fertility: an artificial neural network approach in Iran

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pISSN: 0853-1773 • eISSN: 2252-8083
<https://doi.org/10.13181/mji.oa.268172>
Med J Indones. 2026;35:178–85

Received: April 20, 2025

Accepted: June 09, 2026

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ABSTRACT

BACKGROUND Medical tourism for infertility care is expanding, but the relative contribution of health system and service factors to destination desirability remains uncertain. This study aimed to identify and rank the determinants of medical tourism for infertility care and predict “desirability” destination using an artificial neural network (ANN).

METHODS A cross-sectional study at the Research Institute for Reproductive Sciences, Yazd, Iran (study period 2021–2023). Consecutive consenting medical tourists completed the validated medical tourists attracting factors (MTAF-46) questionnaire consisting of 10 domains. The primary outcome was destination desirability. An ANN (feed-forward, supervised learning) was trained on a random split of the dataset and evaluated on held-out data. Performance was summarized by area under the receiver operating characteristic curve (AUC), accuracy, sensitivity, and specificity. Variable importance was used to characterize the type, direction, and relative strength of associations.

RESULTS A total of 430 respondents were analyzed. The evaluation set showed a strong discrimination (AUC: 95.2%) with overall accuracy 91.3%, sensitivity 57.1%, and specificity 98.1%. Higher scores across several domains were positively associated with desirability; the top contributors were: medical services, economic factors, advertising and marketing, administrative and financial services, and support services. Class proportions indicated that “desirable” cases were less frequent (11.0% in the evaluation set), and model performance favored specificity, consistent with conservative positive classification.

CONCLUSIONS The development of infertility medical tourism in Yazd is mainly driven by the quality of core clinical services and economic factors. Effective marketing, transparency in administrative and financial processes, and efficient support services also enhance the destination’s attractiveness.

KEYWORDS advertising, Iran, marketing, medical services, medical tourism, medical tourists

The tourism industry is proliferating worldwide,¹ and medical tourism is one of its major branches, which has expanded since the late 1990s.^{2,3} Medical tourism occurs when people travel to other cities or countries to access non-emergency medical services that are unavailable, delayed, unspecialized, or very expensive in their city of residence.⁴ Medical

tourism plays a significant role in supporting national economic growth. Investment in this sector can boost gross domestic product, enhance foreign exchange generation and service quality, establish a positive trade balance, and support the travel and tourism sector.⁵ According to a report by Woodman,⁶ medical tourism represents a global industry valued

at approximately USD 100 billion, with an estimated annual growth rate of around 20–25%. As a result, health managers have consistently highlighted the growth of medical tourism.⁷

Identifying the factors that influence the growth of the medical tourism sector can help enhance the quality of services, build on the industry's advantages, and eliminate current drawbacks or restrictions. Various studies have identified factors that influence the attraction of medical tourists and the further development of this industry. In a qualitative study conducted by Malhotra and Dave,⁸ aimed at identifying key factors driving the development of India's medical tourism industry, the five main factors that influence the development of medical tourism in India were identified as economic factors, medical expertise, service quality, a strong private sector, and cultural compatibility. To identify obstacles to the growth of medical tourism in Iran, Hadian et al⁹ conducted a methodological investigation. The findings indicated that the absence of technological infrastructure, participation of different groups in the tourism industry, and cultural and political considerations were the main obstacles. Additionally, Çavmak and Çavmak¹⁰ examined the barriers to medical tourism growth and ranked the important elements that contributed to its development in Turkey. This study indicated that despite Turkey's considerable potential for healthcare services and its attractive travel destinations, substantial marketing efforts are necessary to attract medical tourists.

Iran is recognized as a major regional player in the Middle East medical tourism sector, supported by its competitive pricing and high-quality clinical services. According to annual reports from the Iranian Ministry of Health, the country attracts more than one million medical tourists per year, many of whom seek specialized infertility treatments. Within this context, Yazd has become a prominent destination for reproductive medicine, drawing a substantial number of cross-border patients owing to its advanced clinical outcomes and specialized centers. As one of Iran's major medical tourism hubs, Yazd has achieved notable strides in several areas, including dentistry, cardiology, cosmetics, and, most notably, infertility treatment. Yazd is home to international-standard treatment facilities, and many visitors travel to the city annually to receive care.^{11,12} There are specific characteristics of medical tourism in the field of fertility

that justify the need for independent studies. First, the needs of patients in this field differ because of specific emotional and psychological challenges, which require services to be specifically designed to support patients. Second, medical specialties and advanced techniques such as *in vitro* fertilization are very important in this field, and there are significant differences in the quality and credibility of these services between countries. Additionally, the medical tourism market in this field has specific dynamics, including target demographics and intense competition among countries to attract patients.

Despite the growing body of literature on medical tourism, most previous studies have primarily focused on identifying influential factors using conventional statistical techniques or qualitative approaches. However, the development of medical tourism is a multidimensional phenomenon shaped by complex and potentially nonlinear interactions among economic, clinical, social, cultural, and infrastructural variables. These complexities are particularly pronounced in fertility medical tourism, where patients' decisions are influenced simultaneously by treatment quality, emotional considerations, accessibility, costs, and institutional reputation. Recent advances in data-driven analytical methods have highlighted the potential of artificial neural networks (ANNs) to model complex relationships and uncover patterns that may not be detected through traditional analytical approaches. Nevertheless, evidence regarding the application of ANN techniques to fertility medical tourism remains limited, especially in developing countries and regional medical tourism hubs. To address this gap, the present study employed an ANN-based approach to identify and rank the key factors influencing the development of fertility medical tourism in Yazd, Iran.

METHODS

This cross-sectional study was conducted at the Research Institute of Reproductive Sciences in Yazd from August 23, 2021 to April 15, 2023 to examine the factors influencing the growth of medical tourism using an ANN approach.

Data were gathered using a researcher-developed questionnaire (medical tourists attracting factors [MTAF]-46) to determine the factors influencing the appeal to medical tourists. The intraclass correlation

coefficient of this questionnaire was 0.779 and the Cronbach's alpha coefficient was 0.817. The reliability of the questionnaire was acceptable ($p < 0.001$, $r = 0.840$), with a comparative fit index of 0.918. The final version of the questionnaire consisted of 46 questions across 10 domains (medical services, human resources, support services, administrative and financial services, advertising and marketing, cultural and political factors, information, economic factors, geographical and environmental factors, and tourism industry infrastructure).¹³

The study population included medical tourists to the Research Institute of Reproductive Sciences in Yazd who were selected by convenience sampling and provided informed consent. The inclusion criteria were the provision of informed consent to participate in the study and the ability to answer the questions. Individuals who did not provide consent or were unwilling to participate were excluded from the study and analysis. An initial sample size of 384 people was obtained by considering the ratio of reproductive science tourists to the total number of medical tourists in Yazd at a maximum of 50%, a significance level of 5%, and an error rate of 5% using Cochran's formula. The final sample size was calculated to be 430, allowing for a 10% probability of non-cooperation. Data were collected face-to-face, using questionnaires.

An ANN was employed to analyze the data. By analyzing experimental data, ANNs transfer the knowledge or laws concealed within the data to the network structure. ANNs are a subset of artificial intelligence approaches used to solve a wide range of issues, including control, diagnosis, optimization, and prediction. These networks mimic some of the activities of the human brain and are modeled based on its structure. An ANN is composed of processing units called neurons, which are responsible for processing information and transforming input layers into output layers, similar to a biological neural network.^{14–16} Every neuron has a unique weight and is directly related to other neurons. By examining the previously recorded data, these neurons, which are composed of three input layers, a hidden layer, and an output layer, learn the link between the input and output variables. The input layer data are randomly split into three categories: 70% of the data is used for training, 15% is used for validation, and the remaining 15% is used for testing.¹⁷ Figure 1 shows an ANN.

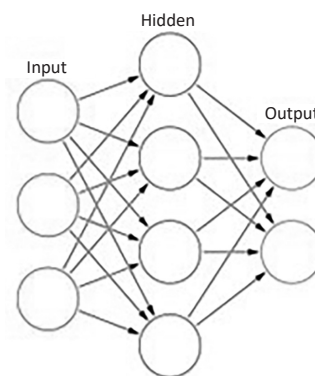


Figure 1. A view of the artificial neural network (ANN)

Data were analyzed using SPSS software version 24 (IBM Corp., USA) with a significance level of 5%, and distribution tables of frequency, percentage, and abundance were used to describe the data. Hyperbolic tangent and softmax activation functions and a cross-entropy error function were used in the ANN structure. The characteristic curve of the receiver operating characteristic (ROC) performance and indicators of sensitivity, specificity, and accuracy were used to check the detection power of the ANN.

This study used human subjects and was approved by the Institutional Research Ethics Committee, School of Public Health - Shahid Sadoughi University of Medical Sciences (No: IR.SSU.SPH.REC.1399.170). Before beginning the study, participants provided informed consent.

RESULTS

Most participants were aged 30–40 years (52.6%). A total of 267 medical tourists were women (62.1%) and the highest proportion of participants were homemaker (48.6%). Furthermore, 52.3% of medical tourists held diploma or sub-diploma qualifications, and 40.7% were referred to this medical center by a physician. Most patients referred to this treatment center had no previous children (73.0%) (Table 1).

Table 2 presents the overall structure of the ANN, illustrating how diverse demographic inputs and factors related to the development of medical tourism are fed into the input layer, processed in the hidden layer, and finally generated by two output units. The use of hyperbolic tangent and softmax activation functions in the hidden and output layers, respectively, ensures optimal model performance. In addition, the standardization of quantitative

Table 1. Frequency and percentage of demographic characteristics of medical tourists

Characteristics	n (%) (N = 430)
Age (years)	
<30	144 (33.5)
30–40	226 (52.6)
>40	60 (14.0)
Male sex	163 (37.9)
Occupation	
Homemaker	209 (48.6)
Self-employed	90 (20.9)
Employee	83 (19.3)
Farmer	37 (8.6)
Nurse or physician	11 (2.6)
Education level	
High school	108 (25.1)
Diploma	117 (27.2)
Associate degree	71 (16.5)
Bachelor	112 (26.0)
Master's degree	17 (4.0)
Doctorate degree	5 (1.2)
How to get acquainted with this treatment center	
Broadcasting (radio and television)	43 (10.0)
Cyberspace	51 (11.9)
Website	22 (5.1)
Relatives	97 (22.6)
Friends	42 (9.8)
Physician	175 (40.7)
Number of previous children	314 (73.0)

variables contributed to improving the network algorithm. A total of 430 data points were evaluated, and the ANN structure consisted of 68 units (Table 2).

During the training phase, which lasted approximately 14 hundredths of a second, 5.3% of the predictions were incorrect. Approximately 8.7% of predictions from the evaluation data were incorrect. The cross-entropy errors for the training and evaluation datasets were 45.449 and 30.718, respectively. For the training dataset, the sensitivity, specificity, and overall accuracy of the ANN model were 83.33%, 96.55%, and 94.71%, respectively, while for the evaluation dataset, the corresponding values were 85.71%, 92.03%, and 91.33% (Table 3).

The area under the ROC curve of the ANN was 95.2% (Figure 2). Medical services, economic factors,

Table 2. Structure of ANN according to demographic variables and development factors of medical tourism

Layers	Structure of ANN	
Input layer	Qualitative variables	1 Occupation
		2 Gender
		3 City of residence
		4 Education
		5 Ability to pay medical expenses
		6 Accommodation in Yazd city
		7 How to get acquainted with this treatment center
	Quantitative variables	1 Medical services
		2 Administrative and financial services
		3 Advertising and marketing
		4 Manpower
		5 Support services
		6 Information
Hidden layer		7 Economic factors
		8 Cultural and political factors
		9 Geographical and environmental factors
		10 Tourism industry infrastructure
		11 Age
		12 Number of previous children
		13 Average monthly household income
Number of units		68
Method of standardization of quantitative variables		Standardized
Hidden layer	Number of hidden layers	1
	The number of units in the hidden layer*	3
	Activation function	Hyperbolic tangent
Output layer	The dependent variables	1
	Number of units	2
	Activation function	Softmax
	Error function	Cross-entropy

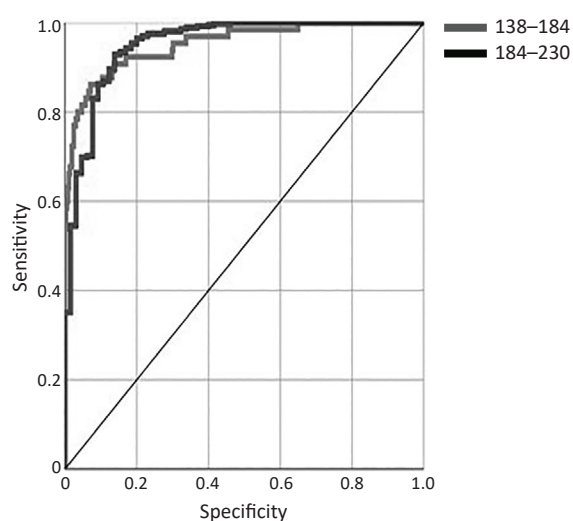
ANN=artificial neural network

*Excluding the bias unit

advertising and marketing, administrative and financial services, and support services were the dominant factors in attracting medical tourists and developing the medical tourism industry (Figure 3).

Table 3. Observed and predicted values according to demographic variables and development factors of medical tourism

Observed values		Predicted values			Sensitivity (%)	Specificity (%)	Accuracy (%)
		Desirability	Lack of desirability	Correct values (%)			
Training data	Desirability	35	9	79.5	83.33	96.55	94.71
	Lack of desirability	7	252	97.3			
	Total percentage	13.9%	86.1%	94.7			
Evaluation data	Desirability	12	9	57.1	85.71	92.03	91.33
	Lack of desirability	2	104	98.1			
	Total percentage	11.0%	89.0%	91.3			

**Figure 2.** The performance characteristic curve of the artificial neural network (ANN)

DISCUSSION

The primary objective of this study was to identify and evaluate the key factors influencing the development of infertility medical tourism at the Yazd Research Institute of Reproductive Sciences. To achieve this, an ANN approach was employed, which, as a powerful data mining technique, is capable of capturing complex nonlinear relationships among variables and ranking factors based on their predictive importance.¹⁷ The ANN results indicated that the development of infertility medical tourism was predominantly influenced by medical services, economic factors, marketing and advertising, administrative and financial services, and support services, with medical services and economic considerations emerging as the most dominant predictors.

One key element in the growth of the medical tourism sector is the scope of medical services. Xu et al¹⁸ examined sustainable entrepreneurship and international educational management in medical

tourism. According to that study, the development of medical tourism was significantly influenced by several elements, both directly and indirectly, including the cost, quality of medical services, infrastructure, and information and communication technologies. These results are consistent with those of the present study. Ushakov et al¹⁹ also emphasized the importance of enhancing advanced medical services in Thailand and their vital contribution to the expansion of medical tourism, which is consistent with the findings of the present study. In 2020, Mosadeghrad and Sadeghi²⁰ conducted a qualitative study in Tehran and employed thematic analysis to examine the data. Twenty-two justifications for selecting Iran as a destination for medical care were identified, falling into seven categories: type of services (disease type and severity, availability, and comprehensiveness of services), quality of services (disease expertise and dedication of physicians and staff, state-of-the-art equipment, amenities, rapid and easy service delivery process, and effective results), cost of services (medical service tariff and health insurance coverage), prior experience of the patient, advertisements (hospital and tourism company advertisements, word-of-mouth, and Internet), contextual factors (cultural affinity, tourist attractions, and political atmosphere), and social and economic factors of the patient. Finally, medical tourists identified quality and inexpensive medical services as the three main reasons for choosing Iran,²⁰ which is consistent with the findings of our study. Other studies have pointed to the provision of quality medical services as a critical factor in the development of medical tourism and greater loyalty of tourists to medical centers.²¹⁻²³ These results are consistent with those of the present study.

Another significant factor that attracts medical tourists for infertility treatment is the economy. Suess et al⁷ suggested that medical tourism should be developed

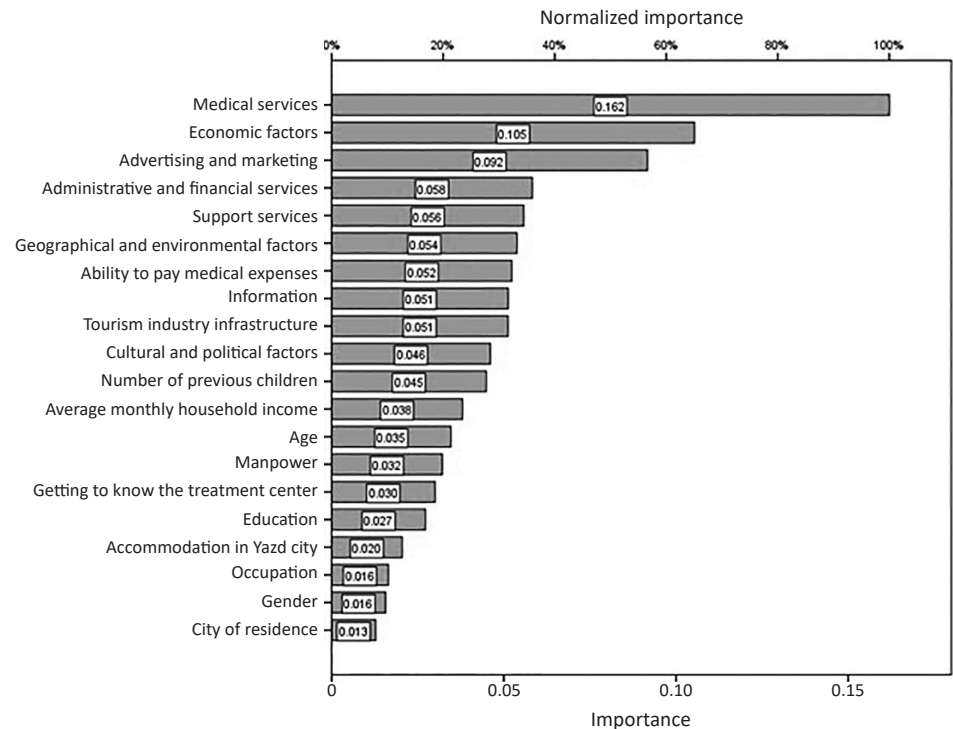


Figure 3. Relative importance of medical tourism development factors and demographic variables

to enhance the economics and quality of life of urban residents. The findings suggest that the economic benefits of medical tourism contribute substantially to social welfare, highlighting the importance of this sector as a driver of employment, income generation, and local economic growth.⁷ This agrees with the present study's results regarding the importance of economic factors in the development of medical tourism. More specific models should be presented for Asian medical marketing, especially in specialized markets in this industry. Zarei and Maleki²⁴ concluded that perceived service quality and satisfaction are the most important factors in attracting medical tourists. They also found that the main obstacles to medical tourism were the lack of economic factors, coordination between medical market stakeholders, quality of medical services, insurance coverage, and effective laws.²⁴ This study also showed the need to pay attention to economic factors, which is consistent with the results of the present study. Hadian et al⁹ and Dang et al²⁵ also mentioned the importance of economic factors in the development of medical tourism, which is consistent with the results of the present study.

Advertising and marketing were identified as factors influencing the development of the medical tourism industry. Cham et al²⁶ investigated the factors affecting the growth of Malaysian medical tourism and found that marketing and advertising factors such as

social media are influential in this area. Katsoni et al²⁷ pointed out the need for a good website as a successful strategy for marketing medical tourism in Greece. Several studies have highlighted the importance of advertising and marketing strategies in enhancing the visibility of medical tourism destinations and attracting international patients.^{28,29} The results of the present study are consistent with this evidence, underscoring the role of marketing activities in the development of fertility medical tourism.

Administrative and financial services are influential variables in attracting medical tourists. Kim et al³⁰ examined the development of medical tourism in South Korea to achieve competitive advantage. They concluded that insufficient promotion, lack of centralized administrative and support systems, lack of appropriate strategies for competing countries, and an inadequate number of medical professionals have led to a lack of development in the medical tourism industry.³⁰ The results of that study confirm the need to pay special attention to administrative services and are consistent with the present study's results. Ghosh and Mandal³¹ stressed the importance of focusing on the quality of medical care, administrative and financial services, medical tourism infrastructure, destination city appeal and culture, and service accessibility, which is consistent with our study. Lee et al³² and Lovelock et al³³ also note the significance of financial services

in luring medical tourists. As medical service costs increase, travelers are exposed to more financial risks, which ultimately results in a decline in the number of visitors returning to a particular medical facility.^{32,33} The results of these studies also confirm those of the present study.

Another significant element in the growth of the medical tourism sector is the support service dimension. The index of support services (the treatment center's reception from the bare minimum of amenities needed) was proposed as a crucial metric for the field's stakeholders.³ The results of this study are consistent with the findings of the support service dimension emphasizing the need to pay attention to this vital dimension. Seo and Park³⁴ assessed medical tourism promotion policies in South Korea and found that detailed support services for medical tourists could lead to competitiveness in the medical tourism industry and, ultimately, its development, which is consistent with the findings of the present study. In the development of the medical tourism business, Nilashi et al³⁵ and Chhabra et al³⁶ stressed the significance of support services, including the use of limited physical space and facilities for teaching and advising patients after providing treatments. These results are consistent with the findings of this study.

This study has several limitations that should be considered when interpreting the findings. First, data were collected using a convenience sampling approach, which may limit the representativeness of the study population and introduce selection bias. Participants who agreed to participate may have differed from those who did not, potentially affecting the observed relationships among the study variables. Second, the study was conducted at a single specialized fertility treatment center in Yazd, Iran. Although this center attracts a large number of domestic and international patients and is recognized as a major reproductive medicine institution in the region, the findings may not be fully generalizable to other medical tourism destinations, healthcare settings, or medical specialties. Finally, the coronavirus disease 2019 pandemic affected the study implementation process and prolonged data collection, which may have influenced participant recruitment and travel patterns during the study period. Future studies involving multiple centers and more diverse patient populations are recommended to improve the generalizability of the findings.

Regarding the generalizability of the data collected from the Yazd Reproductive Sciences Institute, several factors support the applicability of the findings to other settings. Infertility treatment methods are standardized worldwide; therefore, the effective strategies identified may also apply to other centers. Additionally, the diverse patient population at this center, including international patients, reflects the patterns observed in similar contexts. Furthermore, factors such as service quality represent challenges and opportunities reported in many infertility medical tourism destinations. Nevertheless, this study acknowledges the contextual limitations and emphasizes the need for further research.

In line with the aim of this study to identify the factors affecting the development of fertility medical tourism, the findings indicate that medical services, economic factors, advertising and marketing, administrative and financial services, and support services are the main determinants of attracting medical tourists. Among these factors, the quality and scope of medical services play the most influential role. The application of an ANN approach represents an important methodological contribution of this study, enabling the identification and ranking of complex factors affecting fertility medical tourism development. From a practical perspective, improving service efficiency through reducing waiting times, upgrading medical facilities and equipment, adopting advanced treatment techniques, enhancing transparency in administrative and financial processes, strengthening multilingual and targeted marketing strategies, and maintaining competitive and standardized costs can substantially increase the attractiveness and competitiveness of fertility medical tourism destinations. At the policy level, healthcare policymakers, tourism authorities, and healthcare managers should prioritize investments in specialized fertility services, international accreditation, digital marketing infrastructure, patient support systems, and intersectoral collaboration between the health and tourism sectors. Such measures can facilitate the sustainable development of fertility medical tourism, enhance patient satisfaction, strengthen international competitiveness, and contribute to both public health and economic growth.

Conflict of Interest

The authors affirm no conflict of interest in this study.

Acknowledgment

The authors would like to thank and appreciate all the people who participated in this study.

Funding Sources

None.

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