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# Assessment and Optimization of a Spatial Model of Access to Family Physician Centers in Shiraz Using Geographic Information System

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## Abstract

**INTRODUCTION:** The present study aimed to assess and optimize the spatial model of access to family physician centers in Shiraz using the Geographic Information System (GIS Software).

**METHODS:** This descriptive-analytical cross-sectional study was performed in four stages in all family physician centers and clinics in Shiraz. In the first stage, a review study was performed to determine site selection criteria, and in the second stage, the criteria were prioritized and weighted using the method of Analytical Hierarchy Process (AHP). In the third stage, the data were recorded in GIS Software, and finally, in the last stage, the spatial data were assigned to databases.

**FINDINGS:** Based on the results, the field of geography with a weight of 0.549 was the most important area, and the criterion of population age structure with a weight of 0.451 assumed the most critical importance in the selection of appropriate sites for the establishment of family physician centers. According to Moran's index (MI=0.055), family physicians are randomly distributed in Shiraz, and about 20% of the population do not have standard access to family physician centers.

**CONCLUSION:** As evidenced by the results of the current study, people living in the suburbs of Shiraz had far less access to family physician centers, as compared to those residing in central parts. Moreover, the spatial distribution of family physicians in Shiraz does not follow a specific pattern. It is necessary to plan and take effective measures to establish new centers or redistribute existing centers in accordance with the priorities obtained from the results of this study in an attempt to increase healthcare access in suburban areas using GIS and other related techniques.

**Keywords:** Family physician; GIS; Shiraz.

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## Introduction

The family physician program is one of the most advanced projects implemented in developed countries in which special attention is devoted to general public health. This program has been tried and proven to be effective in 60 countries worldwide (1-3). The family physician is a complete health care system, serving as a key on the path from the lowest levels of service to the highest ones. In this program, the general practitioner and his/her team are responsible for the health of individuals and families under their coverage. They need to even follow them up even after their referral to specialists.

The referral from a family physician to a specialist, if performed properly, reduces expensive and unnecessary referrals to specialists, clears up people's confusion, and

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increases their satisfaction with health services (2). Therefore, to meet the health needs of people, the government has no other choice but to implement the family physician program (4-6) which aims to reduce service response time, avoid wastage of financial resources of the country, increase accountability, and enhance people's access to health services (7). Access to health services has a major role to play in the promotion of health, tranquility, and security in society; moreover, it is an important indicator for the achievement of social justice (8).

Furthermore, assiduous attention has been recently devoted to fast, timely, and inexpensive access to health centers in any community, especially urban communities, due to such issues as traffic in large cities, population size, and transportation (9, 10). Optimal access to health refers to the provision of the right services at the right time in the right place. Access can be studied from economic, social, cultural, and spatial dimensions 655(11). Spatial and geographical accessibility is one of the most important aspects of demand for services (12).

Potential spatial access to health services is measured by two criteria of regional availability and accessibility (13). The establishment of new service centers imposes a huge financial burden on the healthcare system. Therefore, it is of utmost importance to determine the optimal location for these centers for the benefit of all citizens. To establish these centers, several environmental factors must be adapted, including population, distance from health services, economic constraints, transient conditions, and social inadequacies. Therefore, optimal site selection without considering the impact and interaction of users will only add to the existing problems.

In this regard, healthcare policymakers are looking for policies that can also minimize geographical inequalities in the field of health. In this regard, evidence-based methods and various techniques can be useful (14). Geographic information system (GIS) as one of these techniques is of great help in defining service delivery areas (15). It is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. This system is able to combine and analyze information from different sources and display them visually in the form of maps. In so doing, it is useful in identifying and examining many location-related problems in epidemiological research and health policy (16).

This system is a quantitative technique in decision-making and has the potential to determine patterns of access to health services to identify underserved areas in terms of access to health services (17). Various studies have been conducted at home and abroad on the use of GIS in the health care system (19, 20). The majority of domestic studies have focused on such fields as the distribution of various diseases, including cancers, malnutrition, and some infectious diseases (21). In order to execute development programs and increase people's access to health services, the Ministry of Health has implemented the family physician plan in urban areas of Fars province.

Based on the literature review, no research has been performed on site selection for family physician centers in Shiraz. Considering that the selection of family physician centers was more based on family physicians' willingness to participate in this program, the present study aimed to evaluate and optimize the spatial pattern of access to family physician centers in Shiraz using GIS. Decision-makers and health officials can decide on an appropriate location for the establishment of family physician centers and optimize access to health services, increasing access and reducing inequality.

## Methods

This descriptive-analytical cross-sectional study was performed in four stages in all family physician centers and clinics in Shiraz. In the first stage, the criteria considered for site selection of family physician centers were identified using a comprehensive review of previous studies. To this end, original articles (except for qualitative and review studies) were searched using the following keywords: primary health care, general practitioner, family physician, location, spatial access, and Geographic Information System.

The search strategy was performed using the aforementioned keywords and the availability of abstract and full texts of articles from 2000-2017. The query was conducted on Pub Med, Science Direct, ProQuest, ISI, Wiley, Embase, and Magiran databases. In the second stage, the obtained criteria were used to prepare the survey form which consisted of two main parts. The first part was an appendix letter containing the title and aims of the research, how to access the survey form questions,

how to complete the form, highlighting the need for accuracy and precision in answering, emphasizing the confidentiality of collected data, introducing the researcher, respecting organization, and finally, appreciating the respondents.

The second part included the research questions. In this section, the experts were asked to rate the importance of each criterion on a scale ranging from 1-10 and add their own suggestions. A total of 15 experts (including university professors, employees in the field of family physicians, and family physicians) were selected as a sample to complete the survey form. In this stage, to collect information, the Delphi technique was performed in one-step since the percentage agreement was above 75% and the criteria were approved. Moreover, purposive sampling was used. The survey forms were provided to the experts to obtain their opinions.

After the collection of survey forms, the obtained data were entered into SPSS software (version 18) and analyzed. The result of the analysis helped determine the criteria for an optimal site selection for family physician centers. In order to determine the importance of the obtained criteria, the Analytic Hierarchy Process (AHP) was used and the criteria were compared in pairs. To this end, the experts compared each pair of criteria to determine the relative importance of each criterion when compared to the other one, attributing values varying from 1-9.

Following that, the completed questionnaires were collected and the results were entered into Expert choice software (version 11) to identify the relative importance of the criteria and sub-criteria against each other and calculate the inconsistency rate. In order to calculate the inconsistency rate, the weight vector was calculated by multiplying the pairwise comparison matrix by the vector of relative weights. Thereafter, the compatibility vector was obtained by dividing the elements of the weighted sum vector by the relative priority vector. In the next step, the largest eigenvalue of a pairwise comparison matrix was calculated through the Lmax, and finally, the incompatibility index was extracted from the table. The inconsistency rate of less than or equal to 0.1 is indicative of consistency in pairwise comparisons.

In the third stage, the availability of data and information regarding variables and criteria were checked, finalized, and entered into GIS software. To do this, the relevant centers were referred to receive information on each of the obtained criteria. After assessing the existence of the criteria, the information regarding geographical distance from the next physician center, the availability of a pharmacy and laboratory, as well as population density, were entered into GIS software. Thereafter, based on the obtained data, the distribution of these centers in Shiraz was examined, and finally, the areas in need of family physician centers were determined.

In order to create a database in the GIS, the location of all family physician centers in Shiraz was initially implemented in Google Earth and then turned into a spatial layer using GIS software. This layer was then placed on the population layer of 2018 based on 2011census blocks. In the last stage, according to the existing criteria and information obtained from the relevant centers, the spatial database was designed to display the current and desired situation in the GIS environment using Arc-GIS9.3 software. For this purpose, by creating a Georeference database in the GIS, spatial and descriptive information was collected in the form of digital maps and tables, respectively.

Subsequently, with the score of the extracted criteria, the potential of centers for the establishment was determined by spatial analysis tools, and the existing centers were overlapped with it. Following that, after the removal of the centers located in a suitable place, other remaining areas of the city were assessed to select a new place for the establishment of family physician centers using the identified criteria and the selected places were introduced. In order to determine the distribution uniformity of family physician centers in Shiraz, Moran's index which is a spatial autocorrelation coefficient was used (22).

The spatial autocorrelation is a valuable tool that demonstrates spatial changes over time (23). Depending on the order of geographical units in the studied area, the cluster pattern, random distribution, or dispersion of units are formed. In an attempt to measure the similarity/ dissimilarity of each pair of adjacent units, spatial autocorrelation is formed when these similarities/dissimilarities are determined for spatial patterns. The existence of spatial autocorrelation among the studied phenomena signifies that the values of geographical phenomena are strongly correlated with each other (positive or negative). The spatial autocorrelation coefficient of adjacent geographical phenomena will have a weak or

strong spatial relationship or a random pattern depending on communication methods and different apparent order. The value obtained for the Moran index can be +1, 0, -1. A value of -1, 0, and +1 points to scattered, random, and clustered distribution of data (24).

## Findings

The initial search for previous studies to determine the criteria for locating family physician centers yielded a total of 669 articles. Since some of these articles were not free or were duplicates, they were removed, leaving out 332 articles. The revision of titles left us with only 122 articles. After reviewing the abstract, 15 articles were completely related, two of which were duplicates. Finally, 13 thoroughly relevant articles remained. The assessment of these articles provided three criteria of geographical distance, population density, and population age structures which were placed in two main categories of population and geography. The Delphi form was prepared using these criteria.

The first round of Delphi resulted in the addition of some new criteria, including the availability of other services in the vicinity of family physician centers, the economic composition of the care, as well as the socio-economic level of the population. Moreover, the criteria obtained in the second round of Delphi were as follows: the presence of other services in the vicinity of family physicians, the economic composition of the care, the socio-economic level of population, traffic volume, geographical distance, as well as the density and age structure of the population. These criteria were divided into three components according to Table 1.

The results of the AHP technique regarding the importance of criteria demonstrated that geography with a weight of 0.549 was the most important area, and the criterion of age structure with a weight of 0.451 assumed the most critical importance in determining the location of family physician centers. The results of the AHP technique are displayed in Table 2.

Figure 1 depicts the distribution of family physician centers and population based on census blocks in Shiraz.

The examination of the access status of the population (including different sub-criteria, such as distance, type of passages, and traffic node) to family physician centers indicated that people do not have access to these centers in the suburbs. In fact, the areas marked as yellow in Figure 2 illustrate population blocks without access to family physician centers (more than 120,000 people).

**Table 1.** Classification of criteria for site selection of family physician centers

| Component | Criterion |
|---|---|
| Demographic | Population age structure |
| Economic | Economic composition of the provided care<br>Socio-economic level of population |
| Geographical | Traffic volume<br>Geographical distance from the next center<br>Availability of other services in the vicinity of family physicians |

**Table 2.** Results of AHP technique in determining the weight and importance of criteria

| Domain | Weight of domain | | Criterion | Weight of criterion | Priority |
|---|---|---|---|---|---|
| Geography | 0.549 | 1 | Geographical distance from the next center | 0.305 | 1 |
| | | | Traffic volume | 0.160 | 2 |
| | | | Availability of other services in the vicinity of family physicians | 0.084 | 3 |
| Population | 0.451 | 2 | Population age structure | 0.451 | 1 |

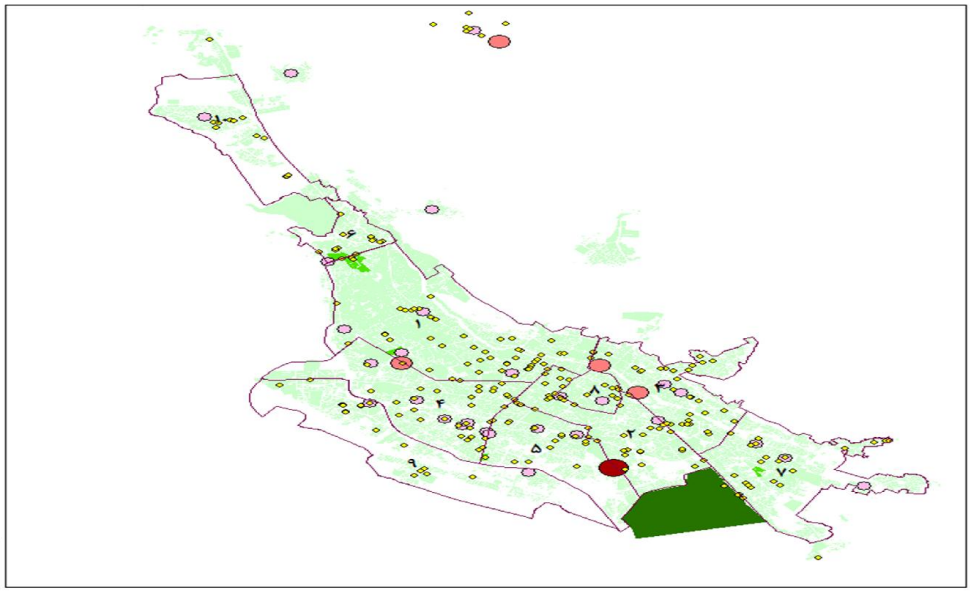

**Figure 1.** Distribution of family physician centers in Shiraz

In order to evaluate citizens' access to the services of family physician centers in different areas of Shiraz, a standard service radius (1500 meters) was obtained for all centers using the method of spatial analysis and creating an operating radius on the point layer of family physician centers. Moreover, the red circles in Figure 3 illustrate the scope of family physician center services. According to this map, to determine the areas without a family physician center, the population layer at the level of census blocks was integrated with the layers of information related to service radius. In so doing, the population within the service radius of each center and the area of the city covered by each family physician center were determined. The model obtained from this map indicates that the central parts of Shiraz have higher access to the services of family physician centers, as compared to suburbs.

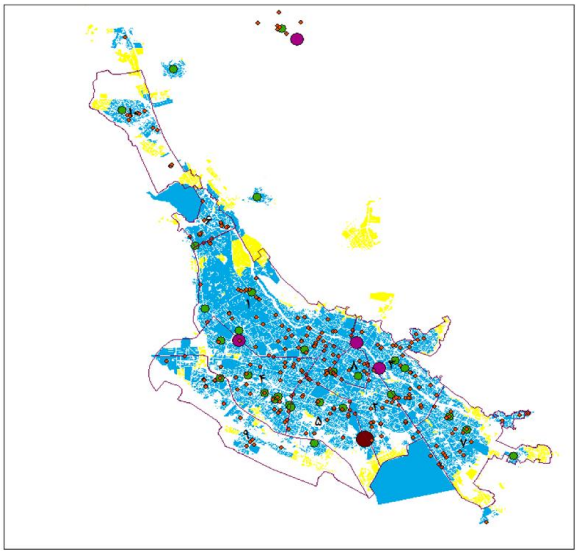

**Figure 2.** Access status of the population to family physician centers

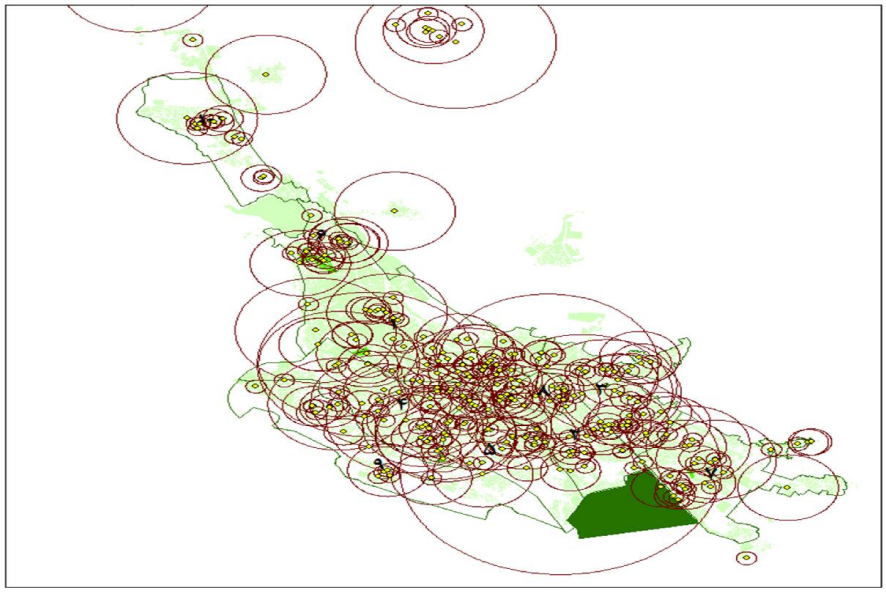

**Figure 3.** Pattern of access to family physician centers in Shiraz based on the service radius of 1500 meters

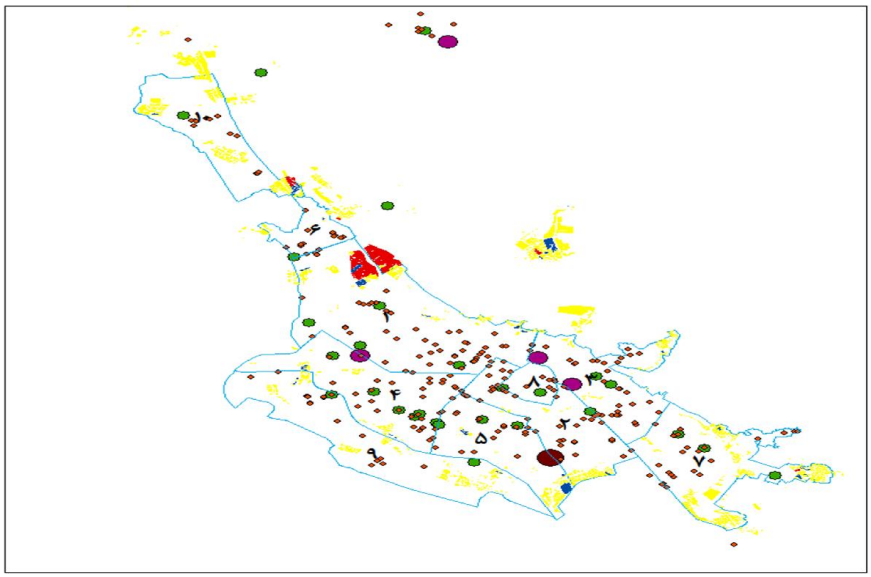

**Figure 4.** Determining the favorable areas for the establishment of family physician centers in Shiraz

In order to determine and prioritize areas access to family physician centers and determine suitable areas for the establishment of new centers, the high-access areas were eliminated from the information layer of the whole city and deprived areas were identified. Thereafter, the new layer was divided into three groups based on population, and the priority of centers was determined in accordance with the population of each area (Figure 4). Accordingly, as illustrated in Figure 4, the areas marked as red, blue, and yellow are given priority for the establishment of new centers, respectively.

In order to determine the distribution uniformity of family physician centers in Shiraz, the Moran index was used. In fact, to investigate the distribution of family physician centers in the city, the existing centers in Shiraz were initially positioned in the GIS environment. Following that, the distribution of these centers was obtained using

the Moran index which was reported as 0.0105. Since Moran's index of 0 signifies the random distribution of the expressed pattern, family physician centers were randomly distributed in Shiraz.

## Discussion and Conclusion

As evidenced by the results of the present study, people living in the suburbs have far less access to family physician centers, as compared to those residing in central parts of the city. In fact, the central parts of Shiraz have higher access to family physician services than the suburbs. Moreover, it was revealed that family physician centers were randomly distributed in Shiraz. In this regard, it is necessary to establish new centers based on specific criteria and standards; moreover, special attention should be devoted to suburbs. In their study, Alavi et al. pointed out that the northeastern, central, and southeastern parts in district 7 of Tehran Municipality had more priority and privilege for the construction of hospitals (25).

The results of the referred study were consistent with those obtained in the present research which reported that family physicians and hospitals were mostly located in the central parts of the city. In the same context, Albi in Nigeria conducted a study to assess the spatial distribution of health centers using GIS and showed that the spatial distribution of health centers did not follow any specific pattern or criteria (27). In India, Venkatramanan et al. used GIS to study the availability of primary care facilities in the Nagapattinam area. The results of the stated study showed that the area was weak in terms of transportation issues and most people had to travel a long distance to receive care. It was the major barrier to accessing primary care centers in that area (26).

In a similar vein, Ranga and Panda in their study in the northern and rural areas of India concluded that some areas have the highest level of access to inpatient health care and some others suffer from the shortage of facilities. Furthermore, the most important factor affecting spatial access was the distance to the nearest large and dense urban area (28). In Iran, various studies have assessed site selection for family physician centers, hospitals, and health centers using geographic information system by Soltani and Zargari Marandi in Shiraz (29), Mikaniki et al. in Birjand (30), Ziari et al. in Semnan, Kaffash Charandabi et al. in Tehran (31), and Atashgahi and Yazdani in Nasrabad, Isfahan (32).

The results of the stated studies indicated the inappropriate distribution of health centers and the need to establish new centers for equitable access to health centers (33&34). The results of these studies are in agreement with the findings of the present research. In fact, it seems that the site selection and establishment of family physician centers and other centers are not based on standard principles and criteria in other cities of Fars province and Iran, as well as other countries.

Due to numerous challenges posed to geographic access to family physician centers, the use of GIS can be a useful and inexpensive tool to decentralize health data analysis in areas with insufficient financial resources (35), leading to improved access and justice (36). It is worthy to note that in addition to intra-sectoral coordination within the health system, there is a need for inter-sectoral coordination with other sections of society to promote access and justice.

Some criteria affecting site selection for family physician centers, such as traffic volume or population density, are related to other sections of society, and in various studies, the same criteria have played a major role in the lack of access to health centers (26). Therefore, intra-sectoral and inter-sectoral coordination, as well as the use of such tools and techniques as GIS is essential in decision-making for the establishment of new centers and reorganization of existing centers. The results of this study pointed out that people have far less access to family physician centers in the suburbs, as compared to those residing in the central parts of the city.

In addition, the spatial distribution of family physician centers does not follow a specific pattern. It is necessary to plan and take measures to establish new centers or redistribute existing centers in order to increase access in the suburbs using GIS and other related techniques. The results of the current study can be of great help to healthcare decision-makers to consider high-priority areas in the establishment of new centers, thereby providing access and justice, which is one of the important goals of the health system.

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## Conflict of Interests

Authors declared no conflict of interests regarding the publication of the present study.

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