JCHR

Journal of Community Health Research 2020; 9(4): 241-255.

Investigating the Level of Access to Hospital Medical Facilities Using the Geographical Information System (GIS) in Yazd, Iran, in 2019

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ARTICLE INFO

Original Article

Received: 12 September 2020
Accepted: 30 November 2020

OPEN ACCESS

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ABSTRACT

Introduction: proper geographical access to hospital medical facilities will increase people's visits to receive non-emergency services and no delay in providing emergency services. This research aimed to determine the level of access to hospital medical facilities with Geographical Information System in Yazd in 2019.

Methods: This research is descriptive and applied. The required data for analyzing access included the information related to all existing hospitals, demographic data, and the layer of Yazd's population blocks. Data analysis was carried out with GIS10.3 software.

Results: Yazd city has 11 hospitals and 1915 active beds. The number of hospitals was proportional to the total population, but there was a shortage of 147 active beds. The per capita hospital space was 0.40 square meters, which is more than the standard (0.37 m^2). The distribution of hospitals and beds in different regions of Yazd was inequitable. The population with high or desirable access (the population within a 1500-meter radius of the hospitals) to the hospitals with emergency, internal and surgery, pediatric, and gynecology units made up 54.12, 41.92, 44.44, and 48.34 percent of the Yazd's population, respectively. Also, the population with limited access (the population out of a 3000-meter radius of hospitals) to the hospitals with emergency, internal and surgery, pediatric, and gynecology units made up 15.40, 31.72, 21.78, and 18.89 percent of the Yazd's population, respectively.

Conclusion: Regarding the obtained results, it is concluded that there is no shortage of hospitals and hospital space in Yazd, and the number of beds is not way below the international standard. However, locating the hospitals is not so that a large proportion of the population is placed within the radius of high or desirable access to hospitals.

Keywords: Health Services Accessibility, Hospital, Spatial distribution, Locating, geographical information system, Yazd

How to cite this paper:
Askari R, Shafiee M, Charrahi Z, Almodarresi SA, Afrazandeh SM. Investigating the Level of Access to Hospital Medical Facilities Using the Geographical Information System (GIS) in Yazd, Iran, in 2019. J Community Health Research 2020; 9(4): 241-255.

[DOI: 10.18502/jchr.v9i4.4977]

Introduction

Enjoying a healthy, productive, and high-quality life along with acceptable longevity and without any diseases or disabilities is a public right that is the pre-requisite to meeting sustainable development. To reach this goal, providing appropriate equipment and facilities such as delivering health services and having access to these services is necessary for providing people's physical, mental, social, and spiritual health in all stages of life (1). Desirable access to healthcare services for all regions and areas means providing the right services in the right place at the right time. As the center of gravity to provide healthcare services, hospitals are considered among the determining factors in achieving equitable distribution of care in all network levels (2). Location is perceived as an important factor in the success or failure of a hospital. A hospital has to be constructed in a place where is easily accessible for all people under its coverage (3). An inappropriate location leads to waste of time and energy, increases transportation costs, reduces access, and increases using cars (4). The presence of inequity and lack of spatial balance in bio-standards among a city's residents is not a new phenomenon worldwide. However, in less developed countries like Iran, cities' spatial differences have worsened due to enormous social-economic differences and inequity and imbalance in urban services (5).

Iran's urban population has greatly increased during the past two decades because of two factors, migration and increasing population growth (6). Rapid urbanization and lack of proper planning have caused problems including 1) imbalanced distribution of facilities and services, 2) inconsistent physical development and growth of cities, 3) causing trouble in maintaining security and shortage of housing and growth of slum housing, 4) causing trouble in delivering services and urban per capitals' falling short of standards (7). The main duty of urban planners is to determine the centers so that all urban residents can easily access them. Besides, it can be said that the planners try to optimize the distribution of service centers in urban areas, and this distribution is proportional to population distribution or the level of demand in different areas. As urban areas become more complicated, the planning task becomes more difficult (8). One of the basic solutions to this problem is using spatial analysis, a type of approach in geographical studies based on which the local-spatial variety of phenomena is investigated, and effective factors or controllers of distribution patterns are studied (9). It is a well-known fact that basic healthcare services cannot reach the majority of the population because of poor geographic access unless quantitative location-allocation and GIS models are used (10).

In research done on investigating the inequity in the accessibility of hospital medical facilities using Geographical Information System in Kermanshah metropolis, Reshadat et al. (2015) demonstrated that the existing hospitals covered only 51.48% of the city residents, and locating the hospitals had not been done based on the density of population and families and had been done without sufficient planning (2). Similarly, Jamali et al. (2011) examined hospitals' locations in Tabriz city using the previous methodology. They found out that the hospitals suffered from the inconsistent distribution so that some areas of the city were not within the radius of access to any hospitals, and there were considerable overlaps between access radii in some other areas (11). Moreover, Sa'ad Ebrahim's (2013) results in investigating people's access to hospitals in the Kebbi state in Nigeria indicated people's lack of consistent access to those medical centers(12).

Yazd city is located in the center of Iran. Based on the 2016 census of population and housing, Yazd's city has been reported to have a 529,672 population. This city contains five regions with over 10,729 hectares, and there are 11 general and specialized hospitals in this city (3). Given the lack of research on the level of residents' access to medical centers, comparison of medical facilities against the existing standards, and the per capita medical services usage, investigating this issue is

[DOI: 10.18502/jchr.v9i4.4977]

required. Hence, the present research aimed to investigate the distribution and level of access to medical centers in Yazd Province in 2019.

Research Method

This research is descriptive and is considered applied research in terms of the purposes. The required data for analyzing access included the information related to all existing hospitals, demographic data, the regions' area, and the layer of population blocks of Yazd's city. The information related to Yazd's hospitals was collected by visiting the Vice-Chancellor's Office in Treatment Affairs in Yazd University of Medical Sciences, demographic data, and the regions' area through visiting Yazd municipality, and the layer of population blocks through the Statistic Center of Iran. This research was conducted on 11 public and private hospitals (Shahid Sadoughi Yazd, Shahid Rahnamoun, Afshar, Mojibian, Mehrab Burn Center, Madar, Mortaz, Goudarz, Shohadaye Kargar, Shah Vali, Seyed Al-Shohada Yazd) in Yazd.

Considering the obtained information, access analysis was done based on the following criteria:

Access analysis in the proportion of the number of required hospitals to population

There must be one hospital for each 45000 to 50000 people (11).

Access analysis in the proportion of the number of active beds to 1000 people

According to the standard, four beds must be considered for every 1000 people (2).

Access analysis based on hospitals per capita

The standard hospital per capita is 0.37 square meters (13).

Access analysis based on access radius

In most of the world's countries, the hospitals functional radius has been considered 1000-1500 meters (14). Two access radius has been considered in the present study, namely high access covers the part of the population placed within the 1500-meter radius of hospitals; medium access covers the part of the population located between 1500-meter and 3000-meter radius of hospitals; and low access covers the part of the population placed outside the 3000-meter radius of hospitals.

Access analysis is meaningful when the function of the units under study are the same. For example, two health homes or two healthcare centers have the same function, but their functions are different. Therefore, in the current study, access analysis was carried out according to access radius based on the similarity of existing units in Yazd's hospitals.

Concerning the spatial nature of this research, GIS software was employed to analyze according to access radius. In this software, as the local properties integrate with data and tables, a better understanding of the real world is achieved. GIS is a powerful software application for storing, collecting, editing, analyzing, showing information, selecting the layers, and displaying them. These layers are connected to data and can show local information (15). Using the buffer tool in the toolbox of Analysis Tools in this application, the access radii of hospitals and populations of each area with high, medium, and low access were specified. In the next step, the overlapping areas of the hospitals' access radii and the population with high or desirable access to two or three hospitals were determined using the Intersect tool.

Results

Access analysis in the proportion of the number of required hospitals to population

Considering one hospital for each 50000 people, ten hospitals are required and considering one hospital for each 45000 people, 11 hospitals are required in Yazd city. Given the current conditions in which there are 11 hospitals in Yazd, the number of hospitals is proportional to the whole population. There is one hospital for every 46860 people in Yazd. Regarding the fact that there are three hospitals in region one, four hospitals in region two, two hospitals in region three, and two hospitals in the historical region, and there are no hospitals in region four, three hospitals need to be constructed in region four. In contrast, there is one

[DOI: 10.18502/jchr.v9i4.4977]

extra hospital in region two. Therefore, the distribution of hospitals in regions of the town of Yazd is inequitable.

Access analysis in the proportion of the number of active beds to 1000 people

According to the standard of four active beds for every 1000 people (one bed for every 250 people), 2062 beds are required in Yazd. Concerning Yazd's current conditions in which there are 1915 active beds, there is a shortage of 147 active beds. The number of active beds in proportion to the population of 1000 is 3.72 in Yazd city. The number of active beds is 3.11, 5.43, 4, 0, and 3.99 in regions one, two, three, and four, respectively. The highest number belongs to region two (5.43 beds), and the lowest one belongs to area four (no beds). The distribution of active beds in proportion to the population is inequitable in Yazd.

Access analysis based on hospitals per capita

According to the standard of 370 square meters of hospital space for every 1000 people (the standard hospital per capita is 0.37 square meters), 190,721 square meters of hospital space are required in Yazd city. Given the current conditions in which there are 206,117 square meters of hospital space in Yazd, the existing hospital space is more than the required space. The per capita hospital space in the town of Yazd is 0.40 square meters. This space per capita is 0.45, 0.39, 0.57, 0, and 0.87 in regions one, two, three, four, and the historical region, respectively. The highest rate belongs to region five (0.87), and the lowest one belongs to region four (zero). Therefore, the hospital per capita is inequitable in the different areas of the city of Yazd.

Table 1. Features of hospitals in Yazd city

NO.	Hospital	Fixed bed	Active bed	Type of activity	Field of activity	Under coverage	Type of ownership	Region	Existing space	Land area
1	Shahid Sadoughi Yazd	582	474	Training-medical	general	University	Owned	3	45000	50000
2	Shahid Rahnamoun	381	222	Training-medical	General	University	Owned	Historical	39000	49000
3	Afshar	220	145	Training-medical	Specialized	University	Owned	1	33000	40000
4	Mehrab Burn Center	56	44	Training-medical	Specialized	University	Owned	1	10000	12000
5	Mojibian	150	125	Medical	General	Private	Owned	2	6500	4550
6	Madar	52	47	Medical	Specialized	Private	Owned	2	2620	2000
7	Mortaz	150	147	Medical	General	Private	Owned	2	16000	16500
8	Goudarz	220	209	Medical	General	Charity	Endowed	Historical	21023	44000
9	Shohadaye Kargar	256	293	Medical	General	Social Security	Owned	2	18955	162878
10	Shah Vali	76	43	Training-medical	General	(Azad) University	Owned	3	5267	8215
11	Seyyed Al-Shohada	165	166	Medical	General	Charity	Charity	1	8752	10828

[DOI: 10.18502/jchr.v9i4.4977]

Table 2. Population, hospitals, beds, and hospital per capita in different regions of Yazd

Region	Area in hectare	Population	Population density	Number of existing hospitals	Number of required hospitals (for every 50000 people)	Number of required hospitals (for every 45000 people)	Proportion of population to hospital	Number of existing active beds	Number of required active beds	Number of active beds for each 1000 people	Existing hospital space	Required hospital space	Shortage of hospital space	Per capita hospital
One	2450.84	114134	46.40	3	2	3	38044	355	457	3.11	51752	42230	-9522	0.45
Two	2088.17	112800	54	4	2	3	28200	612	451	5.43	44075	41736	-2339	0.39
Three	2677.62	87964	32.90	2	2	2	43982	517	352	5.8	50267	32547	-17720	0.57
Four	222807	131725	59.10	0	3	3	-	0	527	-	0	48738	47738	0
Historical	1285.10	68840	53.60	2	1	2	34420	431	275	4	60023	25471	-34552	0.87
Town of Yazd	10729.81	515463	48.04	11	10	11	46860	1915	2062	3.72	206117	190721	-15936	0.40

Access analysis based on access radius

Considering the obtained information, based on the similarity of the existing units in Yazd's hospitals, access analysis was conducted on the basis of the hospitals with emergency units, hospitals with internal and surgery units, hospitals with pediatric units, and hospitals with gynecology units.

Table 3. Features of existing units in Yazd's hospitals

Hospital's name	With the following units				
	Emergency	Internal	Surgery	Pediatric	Gynecology
Shahid Sadoughi Yazd	*	*	*	*	*
Shahid Rahnamoun	*	*	*		
Afshar	*			*	*
Mehrab Burn Center	*				
Mojibian	*	*	*	*	*
Madar	*				*
Mortaz	*	*	*	*	*
Goudarz	*	*	*	*	*
Shohadaye Kargar	*	*	*	*	*
Shah Vali	*	*	*	*	*
Seyed Al-Shohada Yazd	*	*	*	*	*

Access analysis based on access to hospital emergency

54.12% of the total population of Yazd city has high or desirable access (38.29% high access to one center, 13.52% high access to two centers, and 2.30% high access to three centers), 30.5% has medium access, and 15.40 has low or undesirable access to the hospitals with emergency units. In contrast, 45.88% of the population does not have high access to the hospitals with emergency units, and 13.52 and 2.30% of the population has access to two and three hospitals with emergency units, respectively, which shows the imbalance in locating the hospitals.

[DOI: 10.18502/jchr.v9i4.4977]

Table 4. Access analysis based on access to hospital emergency

Description	Population (person)	Population (%)
All around the town of Yazd	529,672	100
High access to the hospitals with emergency units	286637	54.12
Medium access to the hospitals with emergency units	161541	30.50
Low access to the hospitals with emergency units	81494	15.40
High access to three hospitals with emergency units	12173	2.30
High access to two hospitals with emergency units	71630	13.52
High access to one hospitals with emergency units	202834	38.29
No access to the hospitals with emergency units	243035	45.88

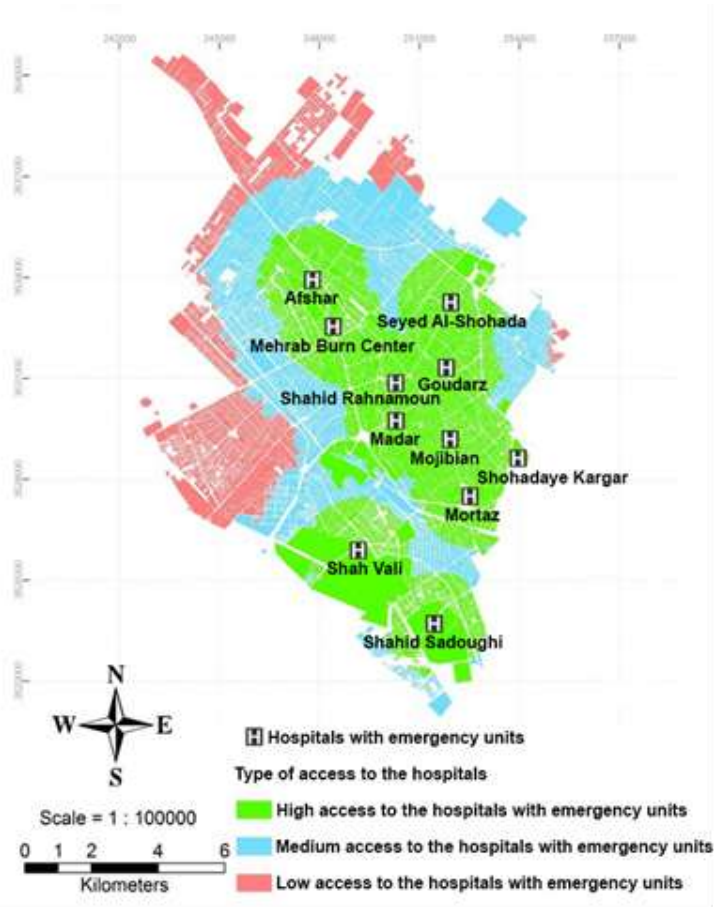

Figure 1. Level of access to hospitals with emergency units

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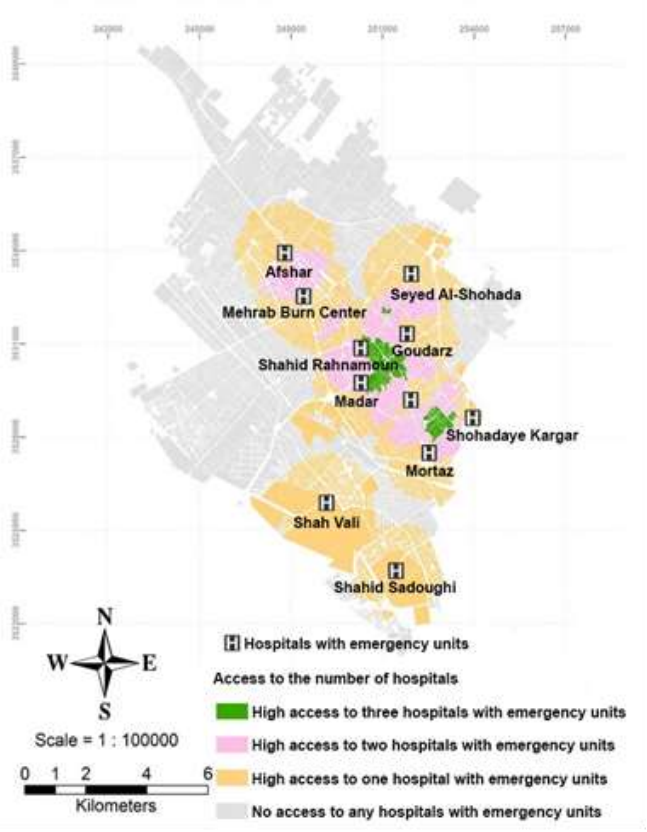

Figure 2. High level of access to hospitals with emergency units

Access analysis based on access to internal and surgery units

41.92% of the total population of Yazd has high or desirable access (28.88% high access to one hospital, 8.80% high access to two hospitals, and 0.93% high access to three hospitals with internal and surgery units), 26.36% has medium access, and 31.72% has low or undesirable access to the hospitals with internal and surgery units. In contrast, 61.40% of the population does not have high or desirable access to the hospitals with internal and surgery units, and 8.80 and 0.93% of the population do not have access to two and three hospitals with internal and surgery units, respectively. Therefore, compared with access analysis based on access to hospital emergency, a larger area of the population does not have desirable access to the hospitals with internal and surgery units.

Table 5. Access analysis based on access to internal and surgery units

Description	Population (person)	Population (%)
All around the town of Yazd	529,672	100
High access to the hospitals with internal and surgery units	222031	41.92
Medium access to the hospitals with internal and surgery units	139612	26.36
Low access to the hospitals with internal and surgery units	168029	31.72
High access to three hospitals with internal and surgery units	4935	0.93
High access to two hospitals with internal and surgery units	46617	8.80
High access to one hospitals with internal and surgery units	152522	28.88
No access to the hospitals with internal and surgery units	325198	61.40

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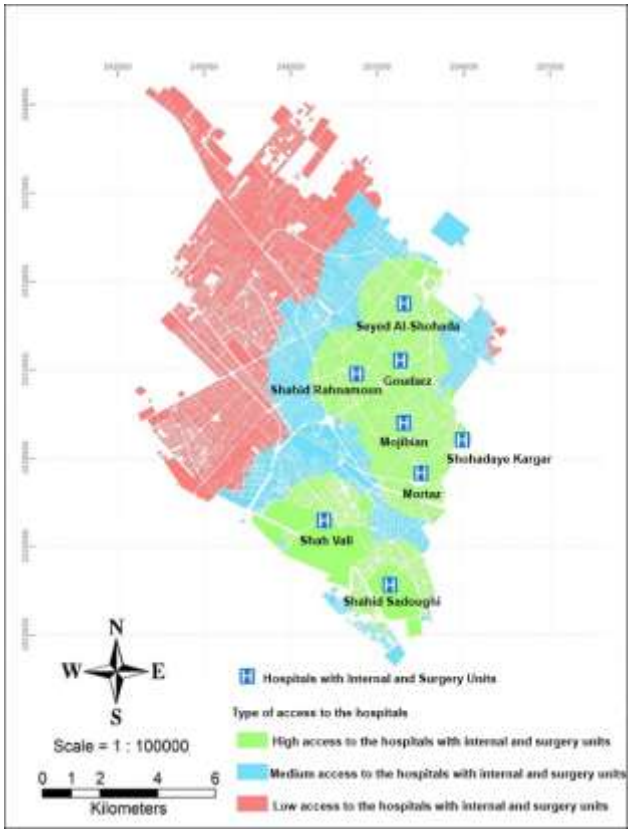

Figure 3. Level of access to the hospitals with internal and surgery units

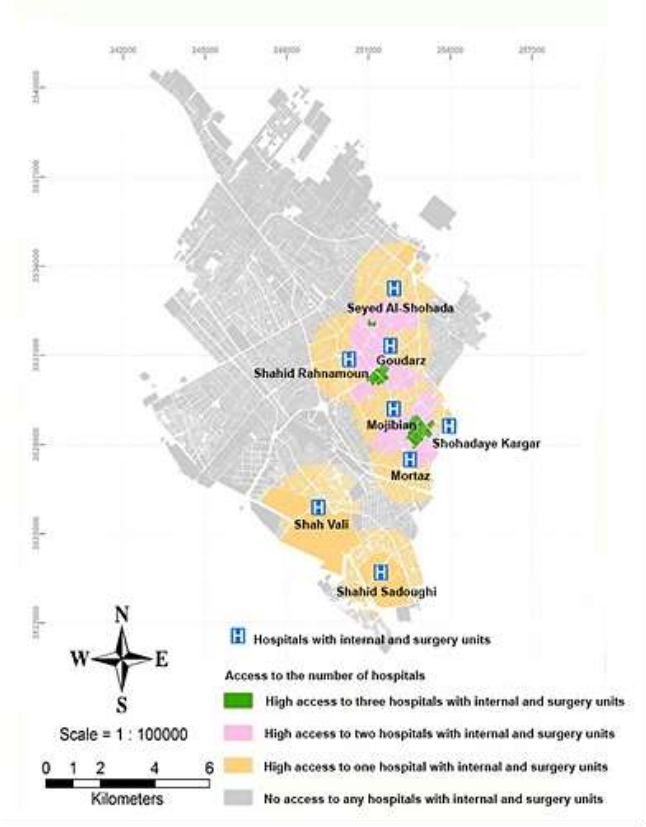

Figure 4. High access level to hospitals with internal and surgery units

[DOI: 10.18502/jchr.v9i4.4977]

Access analysis based on access to pediatric units

44.44% of the total population of the city of Yazd has high or desirable access (33.24% high access to one hospital, 6.82% high access to two hospitals, and 0.69% high access to three hospitals with pediatric units), 33.78% has medium access, and 21.78% has low or undesirable access to the hospitals with pediatric units. In contrast, 61.40% of the population does not have high or desirable access to the hospitals with pediatric units, and 8.80 and 0.93% of the population do not have access to two and three hospitals with pediatric units. Therefore, compared with access analysis based on access to hospital emergency, a larger area of the population does not have desirable access to the hospitals with pediatric units.

Table 6. Access analysis based on access to pediatric units

Description	Population (person)	Population (%)
All around the town of Yazd	529,672	100
High access to the hospitals with pediatric units	235406	44.44
Medium access to the hospitals with pediatric units	178906	33.78
Low access to the hospitals with pediatric units	115360	21.78
High access to three hospitals with pediatric units	3643	0.69
High access to two hospitals with pediatric units	36109	6.82
High access to one hospitals with pediatric units	176078	33.24
No access to the hospitals with pediatric units	313842	59.25

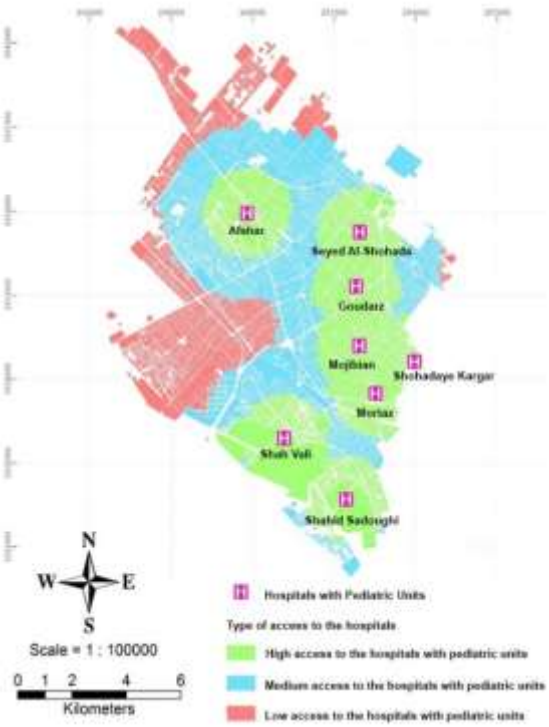

Figure 5. Level of access to hospitals with pediatric units

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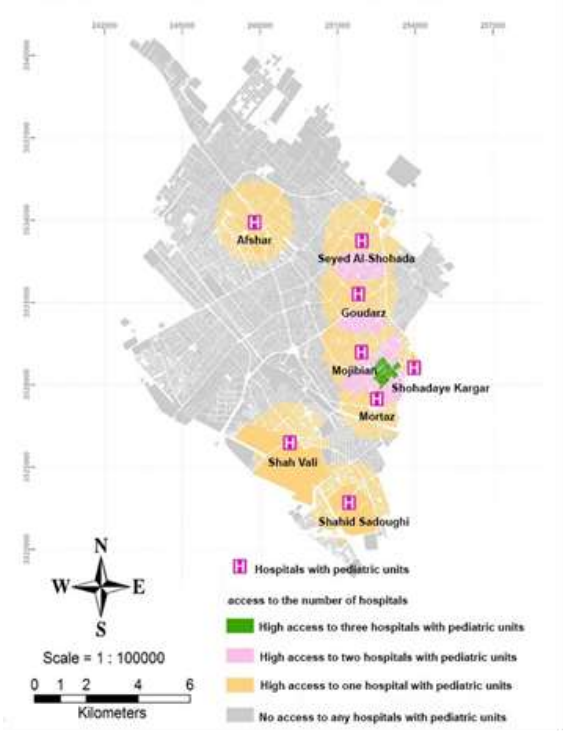

Figure 6. High access level to hospitals with pediatric units

Access analysis based on access to gynecology units

48.34% of the total population of Yazd city has high or desirable access (34.39% high access to one hospital, 9.01% high access to two hospitals, and 0.95% high access to three hospitals with gynecology units), 32.77% has medium access, and 18.89% has low or undesirable access to the hospitals with gynecology units. In contrast, 55.64% of the population does not have high or desirable access to the hospitals with gynecology units, and 9.01, and 0.95% of the population do not have access to two and three hospitals with gynecology units, respectively. Therefore, compared with access analysis based on access to hospital emergency, a larger area of the population does not have desirable access to the hospitals with gynecology units.

Table 7. Access analysis based on access to gynecology units

Description	Population (person)	Population (%)
All around the town of Yazd	529,672	100
High access to the hospitals with gynecology units	256066	48.34
Medium access to the hospitals with gynecology units	173558	32.77
Low access to the hospitals with gynecology units	100048	18.89
High access to three hospitals with gynecology units	5035	18.89
High access to two hospitals with gynecology units	47737	9.01
High access to one hospitals with gynecology units	182174	34.39
No access to the hospitals with gynecology units	294726	55.64

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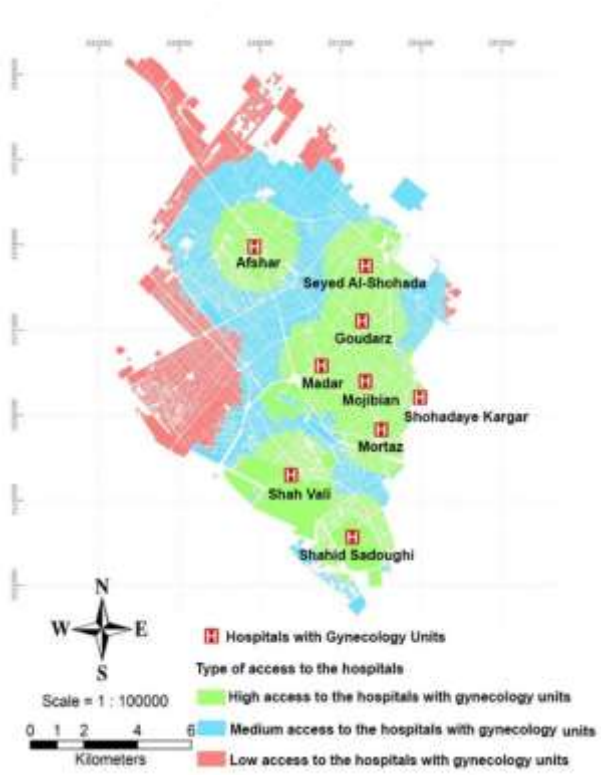

Figure 7. Level of access to hospitals with gynecology units

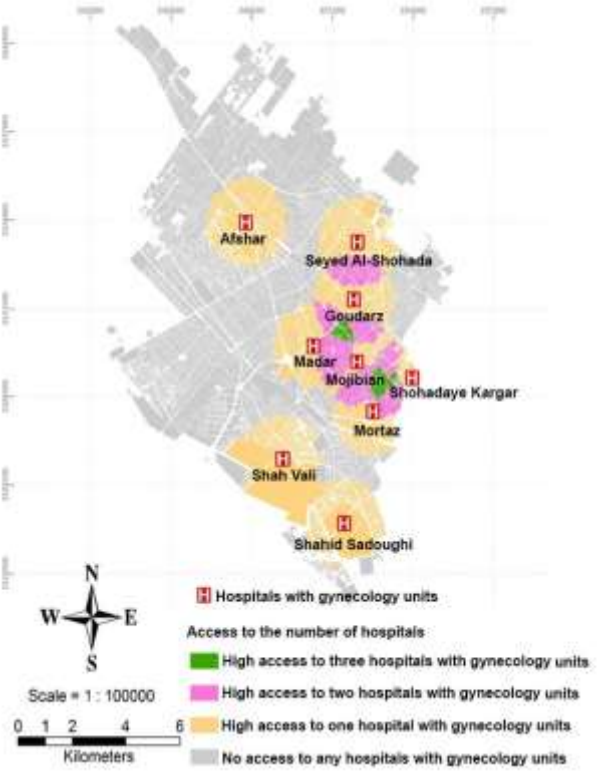

Figure 8. High access level to hospitals with gynecology units

[DOI: 10.18502/jchr.v9i4.4977]

Discussion

By selecting suitable places to construct service provider centers all around the city, easy and quick access to such centers will become possible (16). This fact is very important and crucial for hospitals that directly play a role in individuals' and society's health (2). The present study was carried out with the aim of determining the level of access to hospital medical facilities in the town of Yazd using the geographical information system (GIS).

The present study results show that the number of existing hospitals (11 hospitals) and the per capita hospital space (0.4) meets the standard. The distribution of hospitals, however, is not inequitable in different regions of the town of Yazd. Similarly, the results of Bazargan's research (2018) have shown that the hospitals are mainly centralized in region 8 of the town of Mashhad, while there are no hospitals in regions 5 and 11. They also reveals that the highest access to hospitals exists in regions 8 and 13 (17). The results of the study conducted by Taghvaei et al. (2011) in Isfahan demonstrated that the half-west of Isfahan is without any hospitals, and its half-east is suffering from a shortage of hospitals. In contrast, hospitals' high centralization in the central and northern parts of Isfahan has caused functional radius overlaps. Therefore, spatial equity in access to services has not been observed (18).

Regarding the proportionality of the existing hospitals to population, the results of other studies (2, 4, 6, 11, 19-21) are not in line with those of this study in a way that the number of existing hospitals in region 11 in Tehran (10 hospitals) is much more than the number of required hospitals (6 hospitals). There is a shortage of hospitals in other cities under study (i.e., Kermanshah, Hamedan, Zanjan, Noor Abad, Tabriz, and Dezful). Thus, considering the carried out studies, it seems that there is a lack of hospitals in most of the cities in Iran. Furthermore, the hospitals' location-selection is inequitable in Yazd city even though there is no hospital lack.

The current study results showed 3.61 active beds for every 1000 people in the Yazd, which is not way below the international standards(2). The distribution of beds, however, is not equitable in different regions of Yazd. According to similar studies, there are 2.35, 3.63, 4.95, 2.63, 2.73, and 0.81 active beds for every 1000 people in towns of Kermanshah, Hamden, Tehran (region 11), Zanjan, Tabriz, and Dezful, respectively (2, 4, 6, 11, 19, 20). among which only the result of the study on Hamedan is in line with the present study, and the results of other studies are not in line with those of this study in a way that the number of beds in region 11 in Tehran is above international standards and even most of the advanced countries, and the number of beds in towns of Kermanshah, Zanjan, Tabriz, and Dezful are way below the international standards. The difference in results might be because those studies were conducted within 3 to 8 years before the present study, and the number of hospitals and active beds may have increased by now. In a study by Jay Pan et al. (2016) in China, the average number of hospital beds for every 1000 people was 2.849, which varies between 0.362 and 26.605 in different areas. This 70-time difference in bed density reflects the enormous inequity of health resources in China(22).

The present study results indicated that 45.88% of the population does not have high or desirable hospital emergency access, while 15.82% of the population has high access to two or three hospitals with emergency units. Inappropriate spatial planning and not considering spatial equity in locating hospitals has led to the hospitals' high access radius overlaps, while some other parts of the city have been placed outside the hospitals' access radius. Reshadat et al. (2015) also showed that 51.49 % of the population of Kermanshah town lacked access to hospitals, while 18.79 % of its population had access to two or three hospitals, which indicates that locating hospitals has been done without considering the whole population's access (2). Since in this study, like the study on Kermanshah city, all hospitals have been considered to investigate the level of access to the hospitals with emergency units and the results of both studies are similar within the 1500-meter radius, the results of the study on Kermanshah are

[DOI: 10.18502/jchr.v9i4.4977]

in line with those of the present study. The distinction between the present study and the one done on Kermanshah town is that the hospitals' functional difference has not been considered in the latter (specialized hospitals, in particular, have totally different functions with general ones). By contrast, access to hospital medical facilities have been investigated considering the differences in inpatient wards (emergency, internal, surgery, pediatric, and gynecology) in the current study. In addition, in the study on Kermanshah, one 1500-meter access radius has been considered and access level has been examined in two levels of "with access" and "without access." However, in the present study, two access radii, i.e. a 1500-meter radius and a 3000-meter access have been considered and access level has been investigated in three levels including high, medium, and low access. Masoodi et al. (2015) also showed that 44% of the population of Bandar Abbas city had full access (less than 1000 meters), 18% had good access (1000-2000 meters), 12% had relatively good access (2000-3000 meters), and 25% had low access to the hospitals. Therefore, the study results on Bandar Abbas were in line with those of this study (23). According to the results obtained from other studies, locating hospitals in most of the cities in Iran has been done without considering the access level. As a result, a large proportion of the population is not placed within the access radius of any hospitals, while a considerable proportion of the population has access to two or three hospitals due to the hospitals' functional radius overlaps. Most of the studies carried out outside Iran have also revealed that spatial equity has not been taken into account in locating medical centers. According to a study conducted by Shawky Mansour et al. (2015) in Riyadh Governorate, Saudi Arabia, 45.4% of the population of Riyadh residents resided at a distance of 1 kilometer, 29.6% resided at a distance of 1 to 2 kilometers, 18.95% lived at a distance of 2 to 5 kilometers, 5.3% resided at a distance of 5 to 10 kilometers, and 0.67% resided at a distance of over 10 kilometers from the nearest hospitals, which indicated the imbalance in distribution of healthcare and medical facilities (24). Based on the study done by Pengyan Zhang et al. (2015) in Lankao county in Henan Province in China, the residents of over 60 villages, making up one third of the population of that town, lived at a distance of 10 kilometers from the nearest hospital, which was indicative of low access of a large proportion of the population to hospitals (25). Although based on calculations done in the study of Cristina Merciu et al. in Bucharest, Romania, different levels of access to hospitals have been shown, the access level has been proved good as a result of the transportation network's density (26). According to a study carried out by Nai Yang et al. (2016) in Wuhan, China, the average travel time to the nearest hospital was 0.644 hour.

Moreover, the residents of the central regions of the city enjoyed more medical resources, high quality medical resources, and shorter travel time than the residents of suburbs (27). The study of Lars Brabyn et al. (2002) in New Zealand showed that the average travel time to the nearest general hospital was 17.9 minutes, while this period for was more than 1 hour (golden time) from 167295 people residing in southern and northern areas of that country. Therefore, new hospitals were required to be built (28). Based on the results obtained from the study by Luis Rosero-Bixby (2004) in Costa Rica, access to hospitals care was inequitable(29). According to the study by Szymon Wisniewski, in lodz voivodeship, Poland (2016), the center and west of the city had high access to hospitals while access level in southern and eastern parts was very low(30).

One of the most difficult steps in this research was to collect the required data (maps) that organizations and agencies did not have the necessary co-operation to deliver the maps. Finally, after months of effort, the necessary data was provided

Conclusion

Considering the obtained results, it is concluded that there is no shortage of hospitals and hospital space in Yazd city, and the number of beds is not way below the international standard. However,

[DOI: 10.18502/jchr.v9i4.4977]

locating hospitals is not in a way that a large part of the population enjoys high or desirable access to hospitals. Therefore, it is recommended that new hospitals be built by considering the same access to the population. Furthermore, the studies on the level of access were designed and carried out by considering the hospitals' functional differences, and given the hospitals' functional differences, it is required that decisions on existing inpatient units in each hospital and other services be made in harmony with state and private sectors and by considering the same access level of the population.

Acknowledgment

This article is the result of the research project No. with the code of ethics IR.SSU.SPH.REC.1396.66 approved by Yazd University of Medical Sciences. The researchers would like to thank all Yazd hospitals and Vice-Chancellor's Office in Treatment Affairs at Yazd University of Medical Sciences.

Conflict of Interest

The author does not declare any conflict of interest.

Author contribution

M.A. and R.A. designed the study. R.A. and M.SH, performed the analysis. Z.CH and A.A contributed to the interpretation of the results. MA. wrote the manuscript. All authors discussed the results and commented on the manuscript.

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[DOI: 10.18502/jchr.v9i4.4977]