JCHR

Journal of Community Health Research 2022; 11(1): 36-44.

Spatial analysis of the COVID-19 prevalence pattern in Yazd province, Central part of Iran (February 2020 to January 2021)

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ARTICLE INFO

Original Article

Received: 10 January 2022
Accepted: 23 February 2022

OPEN ACCESS

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ABSTRACT

Introduction: Yazd province is the center of Iran and the highway for travelers to other cities. This province is susceptible to disease transmission in Iran. This study aimed to spatial analysis of corona virus prevalence, predicting the spread and determination of hot spot areas in Yazd province, central part of Iran.

Methods: This analytical Cross-sectional study was conducted in Yazd province from February 2020 to January 2021. Patients with COVID-19 admitted to hospitals in Yazd province were selected by census. Required information includes the number of patients as well as their place of residence were collected through the hospital information system (HIS) of Shahid Sadoughi Hospital in Yazd, Iran. The inclusion criteria were positive polymerase chain reaction (PCR) test for COVID-19 and registration of patient information in the hospital emergency department. After collecting the data, it was entered into the ArcGIS software is 9.3.1. software. Moran's I measure and chi square test were used to data analysis. Significant level were considered 5 %.

Results: Overall disease prevalence in Yazd province was equal to 0.0053. The prevalence of disease was higher in men women (55.7%, 3412 cases). The highest prevalence of the disease occurred in Yazd city (0.0096) and the highest death occurred in Meybod city (20.8%). Bahabad city also had the highest number of transfer (2.7%). Areas one (15.2% and 932 patients) and two (15.9% and 975 patients) of Yazd city were the most infected areas. There was no significant spatial pattern between the prevalence of the disease in the cities (Moran's Index: 0.18, P-value = 0.58).

Conclusion: There was no spatial pattern in the prevalence of the disease and only in the city of Yazd, regions one and two need the special attention of policymakers.

Keywords: Covid-19 disease, geographical distribution, Yazd, Iran.

How to cite this paper:
Madadizadeh F, Ghelmani SY, Fallah Tafti T. Spatial analysis of the COVID-19 prevalence pattern in Yazd province, Central part of Iran (February 2020 to January 2021). J Community Health Research 2022; 11(1): 36-44.

[Downloaded from jhr.ssu.ac.ir on 2026-11-18]

[DOI: 10.18502/jchr.v11i1.9094]

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Introduction

On December 29 in 2019, hospital physicians in Wuhan, China, noticed unusual cases of patients with pneumonia. The first case of the disease was observed on December 12. An unusual outbreak of pneumonia followed on December 12 and was reported to the World Health Organization on December 31 (1). Following the global spread of the virus, the World Health Organization (WHO) issued a statement on January 30 in 2020, declaring the new Covid-19 virus to be the sixth leading cause of public health emergency worldwide, posing a threat to all countries. On February 11, 2020, the World Health Organization officially chose a new name for the new coronavirus, COVID-19 (2).

Examination of the infection situation in the provinces of Iran shows that Qom province was the first province to be infected with corona on February 19 with 2 cases, followed by the neighboring provinces of Tehran, Markazi and Isfahan. Based on daily frequency and cumulative frequency, Tehran, Isfahan and Alborz provinces do not have favorable conditions, but the correction of cumulative frequency of patients according to the population of each province gives a more realistic description of the disease situation in each province. Therefore, contrary to the perception of simple results, the results of this modified index showed that the provinces of Semnan, Qom, Yazd, Markazi and Qazvin have critical conditions and need special attention.

The report of the Epidemiology Committee of Yazd province shows that the situation in the three cities of Ardakan, Meybod and Yazd Emergency and other cities of the province are also becoming the situation of these three cities. Therefore, identifying the pattern of disease spread in the province, determining the hot spots of the disease and also discovering the spatial correlation in the incidence of the disease and predicting disease-prone areas is of particular importance. One of the tools that has helped specialists in detecting disease patterns and geographical spread is the GIS system (3-5).

The use of GIS has reduced interventions and the optimal use of time and cost has been provided. In different geographical areas, part of the software services of this system is valuable (6). The use of this technology in identifying areas with disease transmission potential is one of the vital issues of Yazd province health system and doing this will help managers in health policy to determine the location of interventions in the cities of the province. Risk plans are a good guide for health managers. In short, the GIS provides researchers with the reality of what is happening in the environment in the form of statistical models and readable maps. This system is for the study of spatial epidemiology and the distribution of factors that are influenced by environmental factors and by providing the possibility of integrating data from different sources, the possibility of extracting information and discovering connections between different phenomena (7).

Previous studies have analyzed the spatial epidemiology of data on the number of cases of coronavirus and predict the prevalence of the disease (8-10). Park (2020) examined the early transmission of COVID-19 virus in South Korea in a study using spatial visualization. In this study, the distribution pattern of this virus was classified into two clusters. All analyzes and visualizations were performed using ggplot2 software in R as well as Cytoscape.7.8 and information including the number of infected people, the number of recoveries and the number of deaths as well as the cause of the virus in both clusters were examined separately. Has been (11). Andersen et al. (2021) in a study using spatial analysis examined the determinants of local transmission of Covid-19 in the United States. In this study, socio-economic variables were compared with infected and death data from January 22 to June 30, 2020. Cluster analysis was performed to examine high-risk areas, then with a three-stage regression of underlying factors associated with high risk patterns for morbidity and mortality. Factors related to vulnerability at the community level included age,

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[DOI: 10.18502/jchr.v11i1.9094]

disability, language, race, occupation and urban status (12).

According to the above, the main purpose of this study was to spatial analysis of corona virus prevalence,g predicting the spread and determination of disease-prone areas in Yazd province, central part of Iran.

Materials and Methods

This analytical Cross-sectional study was conducted in Yazd province from February 2020 to January 2021 (for one year). Patients with COVID-19 admitted to hospitals in Yazd province were selected by census. Required information includes the number of patients as well as their place of residence were collected through the hospital information system (HIS) of Shahid Sadoughi Hospital in Yazd, Iran. The inclusion criteria were positive polymerase chain reaction (PCR) test for COVID-19 and registration of patient information in the hospital emergency department.

Study area

Yazd province is geographically located in the center of Iran with geographical coordinates of 31.53 ° N and 54.22 ° E. and according to the 2016 census has a population of One million one hundred and thirty eight thousand five hundred and thirty three people.

Due to its location in the center of Iran, this province is the main highway for travelers to reach other provinces, so it plays a key role in the distribution of Covid disease. Cities of Yazd province include Ardakan, Abarkoh, Bafgh, Bahabad, Taft, Khatam, Ashkezar, Mehriz, and Meybod

The geographical map of the cities of Yazd province is presented in Figure 1.

In this study, in order to further investigate the prevalence of the disease, ten urban areas of Yazd city were studied in depth.

Ten Urban Areas of Yazd City

Area 1 includes the area: Azadshahr - Khezrabad - Carton Sazi - Shahneh (distance: Azadegan Boulevard and Meraj Street) Khairabad - Eishabad - Shahid Nasiri Sports Stadium (distance: Meraj St., Azadegan Boulevard to Abolfazl Square, Janbaz Boulevard, Taft Road)

Area 2 includes the area: Razmandegan town - Qasem Abad - Shafiee sand and railway (distance: Taft road, Kowsar boulevard, Daneshjoo boulevard, Prof. Hesabi boulevard) 15 Khordad - Silo alley - Faizieh alley - Asatid alley - Safaieh, Bonyad alley, Dakhmeh lands (between Prof. Hesabi Boulevard, Daneshjoo Boulevard, Timsar Fallahi, Ashraf Boulevard, Javadalameh, Golestan, Mehravaran Toobi, Jihad Boulevard, Pasdaran Boulevard, Hamidia Municipality, Apartments behind the Radio and Television, Toobi Lands.

Area 3 includes: Najafabad and Rahmatabad, blood transfusion and all lands around Shahid Dashti Boulevard and Tareh Bar Old Square, Mehr Gol Narges Apartments, Social Security, Modares Boulevard between Shohada Mihrab and Bozorg Shahr Park, Akramabad - Akramieh, Hossein Abad Rismani.

Area 4 includes: Mehdi Abad - Imam Ali Town - Imam Hossein Town - Housing and Urban Development - Abazar Alley, Imam School (distance: Modares Boulevard, Kashani, Martyrs of the Altar, Chamran Street) Naeem Abad and Akbarabad (distance : Daneshjoo Blvd., Shahid Beheshti, Montazer Ghaem, Basij Blvd., Shahid Asizadeh Blvd., Musa Ibn Jafar Blvd., Kashani)

Area 5 includes: Khajeh Khezr, Gazargah, Yaghoubi, Malmir, Abshour, Park Shahr, 10th of Forudin, Imam Khomeini, Deh Fajr Boulevard, between Saheb Al-Zaman Square and Daneshjoo Park, Maryam Abad, Hassan Abad Moshir, Imam Khomeini St. from the Green Space intersection Towards Khaldabrin

Area 6 includes: Chahar Manar, Dolatabad, Mosalla St., Lab Khandagh, Kushkeno, Fahadan, Green Space, Wheat Garden, Sheikhdad, former slaughterhouse, Seyed Al-Shohada Includes area: Seyed Sahra - Nasrabad - Kasnavieh - Mahmoudabad - areas around Toos Boulevard (distance: Nawab Safavi Boulevard, Dolatabad Boulevard, Motahari Street, Jomhory Boulevard, Toos Boulevard to the north)

Area 7 includes Ahrestan, Jahanfar, Chah Qiblah (distance: Kosar Boulevard, Janbaz

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Boulevard, Azadegan Boulevard, 17 Shahrivar Boulevard, Pakenjad Boulevard, Bahonar Boulevard) Includes the area: Khorramshad - Sardurah - Buick Alley - Behind the Garden, Hana Alley (Distance: Montazer Ghaem Boulevard - Beheshti Boulevard - Bahonar Boulevard - Pakenjad Boulevard - 22 Bahman Boulevard - Shahid Rajaei Street - 10th of Farvardin Street)

Area 8 includes: Areas: Imamshahr, Burns, Ghadir Park, Afshar Hospital (between 22 Bahman Boulevard, 17 Shahrivar Boulevard, Azadegan Boulevard, Imam Hossein Boulevard, Vakil Street, Jomhuri Eslami Boulevard, Shahid Motahari Street) Areas around Jomhory Boulevard To the Quran Gate (between Imam Hussein Boulevard, Vakil Street, Tus Boulevard to the north)

Area 9 includes: Shahedieh area (Aberandabad, Nasrabad, Gardfaramarz) Zarch city

Area 10 includes: Qasem Naghi - Dehno - Seyed Mirza - Mohammadabad - Fahraj



Figure 1. The geographical map of the cities of Yazd province in Iran

Statistical analysis

After collecting the data, it was entered into the ArcGIS software is 9.3.1. software. Then, maps of disease progression in the province, zoning map of the probability of the disease in the cities of the province, comparison of the probability of the disease in different cities, determination of centers with more spread (hot spots) and Geographical distribution of the disease in Yazd province were prepared. Moran's I measure was used to determine overall spatial autocorrelation in the study data. Chi-square test was used to compare the prevalence in different urban areas of Yazd city. Significance level was considered 5% in all tests.

Results

A total of 6,131 patients were studied during the study period, of which 55.7% 3412 cases)were male and the rest were female. The mean (standard deviation) of age was 54.86 (19.029), 82.8% (5092 cases) of patients recovered and only 11.4% (689 cases) died (Table 1). According to the population of Yazd province, the prevalence of the disease in this province was estimated at 0.0053.

According to table 2, Most of the confirmed cases were located in Yazd (88.4%) and the lowest number of patients lived in Bahabad city(0.6%).

According to the results presented in Table 3, in the whole period, the highest prevalence of the disease was in Yazd city with 0.0096 (0.96 %) and the lowest prevalence was in Bafgh city with 0.0014 (0.14%) (Table 3).

As it can be seen in Table 4, the most recovered patients was in Taft city with 88.3% and the lowest was in Bafgh city with 72.1%. The highest number of patients moved to another province was from

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Bahabad city with 2.7%. The highest patient discharge was in Ashkzar city with 11.5% ,and The lowest was in Abarkoh city with 2%. The highest death rate was related to Meybod city with 20.8%. and the lowest rate was related to Mehriz with 7.5% (Table 4).

Table 1. Description of the final status of patients

Final status of patients	Number	Percent
Recovered	5092	82.8
Moved to another province	47	0.8
Discharged	303	5.0
Dead	689	11.4
Total	6131	100.0

Table 2. Description of the current residence of patients

Name of city	Number	Percent
Yazd	5422	88.4
Ardakan	75	1.2
Abarkoh	149	2.4
Bafgh	43	0.7
Bahabad	37	0.6
Taft	60	1.0
Khatam	84	1.4
Ashkezar	104	1.7
Mehriz	80	1.3
Meybod	77	1.3
Total	6131	100.0

Table 3. Estimation of the prevalence of COVID-19 diseases in Yazd province

Name of city	Number of cases	Population(2016 Cencus)	Prevalence
Yazd	5088	529673	0.00960
Ardakan	118	75271	0.00156
Abarkoh	199	51552	0.00141
Bafgh	72	50845	0.00141
Bahabad	54	17221	0.00313
Taft	79	18464	0.00162
Khatam	121	36562	0.03304
Ashkezar	167	32566	0.00538
Mehriz	112	51733	0.00216
Meybod	121	99727	0.00162

Table 4. Estimation of the frequency distribution of patients in different cities based on the disease status

Name of city	Patient status	Number	Percent
Yazd	Recovered	4519	82.0
	Moved to another province	41	0.8
	Discharged	261	4.8
	Dead	601	11.1
	Total	5422	98.7
Ardakan	Recovered	58	73.3
	Discharged	5	6.7
	Dead	12	16.0
	Total	75	96.0
Abarkoh	Recovered	129	84.6
	Moved to another province	2	1.3
	Discharged	3	2.0
	Dead	15	10.1
	Total	149	98.0

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Name of city	Patient status	Number	Percent
Bafgh	Recovered	32	72.1
	Discharged	3	7.0
	Dead	8	18.6
	Total	43	97.7
Bahabad	Recovered	30	81.8
	Moved to another province	1	2.7
	Discharged	2	5.4
	Dead	4	10.8
	Total	37	100.0
Taft	Recovered	53	88.3
	Discharged	2	3.3
	Dead	5	8.3
	Total	60	100.0
Khatam	Recovered	69	81.0
	Moved to another province	1	1.2
	Discharged	5	6.0
	Dead	9	10.7
	Total	84	98.8
Ashkezar	Recovered	78	74.0
	Moved to another province	1	1.0
	Discharged	12	11.5
	Dead	13	12.5
	Total	104	99.0
Mehriz	Recovered	67	83.8
	Discharged	7	8.8
	Dead	6	7.5
	Total	80	100.0
Meybod	Recovered	57	72.7
	Moved to another province	1	1.3
	Discharged	3	3.9
	Dead	16	20.8
	Total	77	100.0

Results of Analysis of urban areas of Yazd city were presented in table 5, results showed that areas number one and two had the highest prevalence of the disease in the study period (15.2 % and 15.9 %, respectively), so they can be mentioned as hot spot area of the disease, although results of chi square test showed in terms of disease prevalence there was a statistically significant difference between ten urban areas ($P < 0.05$).

The colors of the areas are shown in Table 5 from the hot spot areas in red to the areas with low prevalence in white, respectively.

Table 5. Description of the disease prevalence in urban areas of Yazd city (February 2020-January 2021)

Urban areas of Yazd city	Number of patients	Prevalence
Area 1	932	15.2
Area 2	975	15.9
Area 3	472	7.7
Area 4	615	10.0
Area 5	509	8.3
Area 6	652	10.6
Area 7	406	6.6
Area 8	550	9.0
Area 9	183	3.0
Area 10	128	2.1

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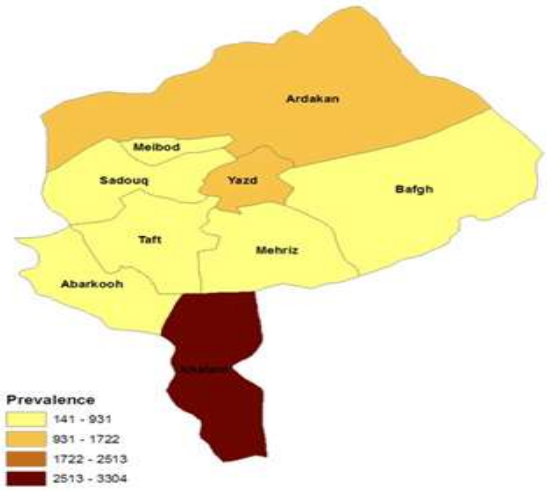


Figure 2. Spatial distribution of the disease prevalence in Yazd province

In calculating the spatial correlation of the cities of Yazd province using Moran's I measure, the P-value was equal to 0.58. Thus, the null hypothesis that there is no spatial correlation between natural hazards in the cities of Yazd province is accepted (Moran's Index: 0.18, P-value = 0.58).

Therefore, with a 95% confidence interval, the spatial pattern obtained during the study for COVID 19 disease in the province was not clustered and had no spatial correlation.

Discussion

Spatial epidemiological analysis of data on the number of cases of coronavirus and prediction of the spread pattern of the disease can be of great help in controlling the disease. The study of spatial analysis of disease data has played an effective role in disease control, so that since 1993, the World Health Organization has been preparing maps of the geographical distribution of the disease and spatial analysis of the data. Epidemics have been controlled. The aim of this study was to spatially analyze the incidence of coronavirus, to predict how to spread and determine disease-prone areas in Yazd province from February 2020 to January 2021.

A total of 6,131 patients were studied during the study period, in which the percentage of men was higher than women. Similar studies have shown that men were more likely to be hospitalized than women (13, 14). The mean age of hospitalized people was 54.86 years. This indicates that older people are at greater risk. Previous studies have shown that mortality from COVID-19 complications is higher in this age group and age increases the risk of symptomatic disease and disease severity (15, 16). Therefore, serious measures should be taken to educate and raise awareness of men and the elderly about COVID-19.

The prevalence of the disease based on population reform showed that Yazd city had the highest prevalence and Bafgh city had the lowest prevalence. Yazd is an industrial destination for many workers and occupations. Also, due to the geographical location of the map center of Iran, it is located on the main highways of the country and many travelers pass through the city of Yazd in order to reach their destination. The presence of non-native migrants due to relocation of their current place of residence and their own city can be the cause of many transmissions of this dangerous disease alone and lead to the increasing prevalence of this disease.

Mir Jalili et al. Estimated the prevalence of Covid-19 disease at 14.91 and reported the highest rate in Ardakan city and the lowest rate in Taft, Mehriz and Khatam cities. While in the present study, the highest prevalence was reported in Yazd and the lowest in Bafgh (17). The observed differences can be due to the time of the study and

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the target population or method of data collection. Also, in addition to the patients, the present study compared the rate of recovery, discharge and death in different cities in one step ahead. Based on the findings of this study, the most improvement occurred in Taft city and the least in Bafgh city. The lowest occurred in Ardakan city. In comparison with the death toll, Meybod city had the highest death toll and Bahabad city had the lowest death toll.

In this study, different areas of Yazd were examined for the prevalence of the disease. Areas one and two were the main foci of Covid-19 disease with a large difference. Eishabad, Shahid Nasiri Sports Stadium and Region 2 include Razmandegan Town, Qasem Abad, Sand Town, Railway. These two areas, since area one is at the entrance of the city and area two includes railways, so the passage of passengers can be one of the causes of contamination of these areas.

Findings of our study showed that Bahabad city had the highest number of patients sent to the provincial capital. The reason for this can be the history of the city's declining city, which has become a city since 2009 and the necessary facilities in this city are still lacking, and it is necessary to equip the respected officials of this city with more advanced facilities.

The results of the present study in calculating the spatial correlation of cities in Yazd province using Moran analysis showed that there was no significant spatial pattern ($p = 0.58$). In the study of Saffary et al. (2020), which was conducted to analyze the spatial dependence of COVID-19 cases in the United States, a significant but very weak spatial correlation was reported (18). It is suggested that due to the extent and dynamics of the transmission of this disease, more studies should be done at longer intervals.

One of the strengths of this study is the collection and analysis of information by regions and also by city, which provided a very accurate picture of the situation in the province. One of the limitations of this study is the lack of environmental data, which could not be used due to high missing. Another limitation of this study was the impossibility of calculating the probability of disease in each region.

Conclusion:

Men are more exposed to this disease due to social activities. The highest outbreak of the disease occurred in Yazd and the highest death occurred in Meybod, which requires special attention to these two cities. Also, Bahabad city had the highest number of dispatches, and it is necessary to send the necessary equipment to this city to prevent the accumulation of all patients in the center of the province. Zones one and two, which were the entrance of Yazd city and the railway area, were the most polluted areas, so it is necessary for the policymakers of the province to take more action to observe more health issues in the terminal and railway. There was no significant spatial pattern between the prevalence of the disease in the cities, so it is recommended to follow the health instructions continuously until the disease is eradicated.

Conflicts of interest

The authors state that they had no conflicts of interest in this study.

Author's contribution

All authors contributed to this project and article equally. All authors read and approved the final manuscript.

Ethical approval

This article was the result of a research from Shahid Sadoughi University of Medical Sciences in Yazd with the code of ethics committee approved and the IR.SSU.REC.1399.033 registration code.

Financial support and sponsorship

The researchers themselves funded this study.

Acknowledgement

This study was the result of a research grant No. 7763 given by Shahid Sadoughi University of Medical Sciences in Yazd on the prevalence of Covid 19.

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[DOI: 10.18502/jchr.v11i1.9094]

We would like to thank all the officials of Shahid Sadoughi Hospital in Yazd who cooperated in collecting data.

Authors' contributions

F.M. and T.F. conceived of the presented idea **FM** wrote the manuscript with support from F.M and Y.G. All authors read the manuscript and verified it.

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[DOI: 10.18502/jchr.v11i1.9094]