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Geographical Distribution and Underlying Diseases of Patients with COVID-19 Referred to Afzalipour Hospital in Kerman city

Mohammad Mehdi Ghaemi [1], Hamid Reza Samzadeh [2], Sadrieh Hajesmaeel-Gohari [1], Elaheh Shafiei [2], Roghayeh Ershad Sarabi [1*]

1. Medical Informatics Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
2. Department of Health Information Sciences, Faculty of Management and Medical Information Sciences, Kerman University of Medical Sciences, Kerman, Iran

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ABSTRACT

Background: COVID-19 is a novel disease that infected many people around the world. It is essential to find the potential high-risk locations and provide suitable healthcare interventions to control COVID-19 distribution. Using a geographic information system, this study aimed to investigate the distribution trends of patients with COVID-19 in Kerman, Iran.

Methods: The information of registered patients of Afzalipour hospital in Kerman city who were admitted before July 22, 2020, was collected and used in this paper. The patients' addresses were converted into geocodes. The trend of disease prevalence in connection with population density in different parts of Kerman was investigated. After that, the average nearest neighbor analysis was performed to check the random distribution of disease cases. Data were checked for randomness by High/Low clustering analysis.

Results: : The spread of the COVID-19 disease started in Kerman city's north, south, and west and then distributed to the center. The southern and western regions were in high-high clusters, and the central and northern regions were in low-low clusters in terms of COVID-19 outbreak risk. Regression showed a significant correlation between underlying diseases and patients' age with the incidence of Covid-19 disease.

Conclusion: The prevalence of COVID-19 had been higher in densely populated areas and also in areas with poorer economic conditions. Therefore, paying attention to these areas as well as applying strict rules can help control the spread of COVID-19. The result of this study could be useful for public health experts and healthcare managers to manage better this pandemic.

Keywords: Geographic Information System, COVID-19, Coronavirus, Spatial Analysis

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***Correspondence:** Roghayeh Ershad Sarabi; Email: a.ershadsarabi@gmail.com

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Introduction

COVID-19 is a novel disease that originated in Wuhan, China, in late 2019; a respiratory infectious disease that is caused by a virus from a large family of coronaviruses called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). COVID-19 was introduced as a pandemic by the WHO as it was affecting many countries worldwide (1). Almost nine months after the onset of COVID-19, it has infected 39,847,965 people and caused 1,112,594 deaths across the world (2). This is a highly spread disease transmitted through direct contact with infected people and exposure to their respiratory droplets released through conversations, coughs, and sneezes. Therefore, observing social distancing and wearing a face mask can help prevent the spread of COVID-19 (3).

In order to identify the potential high-risk locations and provide suitable healthcare interventions and adequate resources to control disease distribution, it is essential to pay attention to the place of living and working of an infected patient (4, 5). One of the tools for determining and displaying the disease cases' locations and exposure sites, disease clusters, and spatial patterns is the geographic information system (GIS) which is a computer-based system for gathering and analyzing geographic data (6). This system can help public health professionals and policymakers monitor health challenges and respond to them by visualizing and mapping health data (7). The GIS has been used in different infectious diseases such as Zika virus disease (8), Legionnaires' disease (9), and brucellosis (10). It is also used in the COVID-19 pandemic to screen disease distribution and assist in establishing preventive and control strategies (11, 12). A study was conducted on the data of COVID-19 patients for seven weeks in Sergipe, Brazil in which GIS found six active clusters of COVID-19 in terms of transmission (11). In another study, the data of 485 suspected and confirmed COVID-19 patients were extracted from Sina Weibo (a Chinese social media). The GIS was used in this research to calculate the distance between patients' homes and the closest determined hospitals. Results showed that about one-third of the cases lived more than three kilometers far from the closest hospital (12). Certainly, the epidemiological study of this pandemic with GIS can be useful to detect potential factors related to geographic distribution and facilitate rapid actions to control the situation and even prevent further outbreaks.

Iran ranked 13th in terms of COVID-19 prevalence (2). Kerman, the largest province of Iran, was one of the provinces with a red status in COVID-19 (13). The city of Kerman is the capital of this province (14). Providing epidemiological information in the form of detailed maps to show high-risk places can give travelers and public health experts a clear view to manage this pandemic. There was no epidemiological study showing the spatial trend of COVID-19 distribution in Kerman city. Therefore, this study aimed to explore and show the distribution trends of patients with COVID-19 to control and manage this highly prevalent disease.

Material and Methods

This cross-sectional study was conducted during the COVID-19 outbreak in 2020 in Kerman, Iran. Five regions (which included 310 sub-regions) of Kerman city is selected as the study area with longitude 56.95447-57.17383 and latitude 30.22924-30.34891. The smallest administrative unit of data is an alley. Patients' information and the geographic data of Kerman city are involved in our method. The information of registered patients of Afzalipour hospital in Kerman city who were admitted before July 22, 2020, was collected and used in this paper. The geographic data included a 1:100,000 scale map of Kerman designed in 2015 as the mother map, and the population reference was the last national census. With the 2020 official reference data of the population (Statistical Center of Iran), the population of Kerman city was estimated at 776,052 people (15). Then the addresses were converted into geocodes. Data quality was evaluated and the data were prepared.

First, the data were extracted from the hospital database from 13/2/2020 to 21/8/2020. Then, the spatial data of the patients were obtained based on the addresses recorded in their files. At this stage, inaccurate addresses (36 cases) and addresses outside the neighborhoods of Kerman city (988 cases) were excluded from the study. Next, the ratio of abundance of cases to population density in each neighborhood was obtained and analyzed. In the descriptive part of the study, the trend of disease prevalence concerning population density in different parts of the city was investigated. After that, to check the random distribution of disease cases, an average nearest neighbor analysis was performed. Data were checked for randomness by High/Low clustering analysis. We used other analyzes such as multi-distance spatial cluster analysis (Ripley's K-function), hotspot analysis (Getis-Ord Gi*), geographically weighted regression, and ordinary least squares (OLS) to understand general patterns and trends of spatial data.

Results

The number of patients admitted to the Afzalipour hospital during 190 days with an initial COVID-19 diagnosis was 2642 of whom 1510 were male and 1132 female. The patients who were located in the neighborhoods of Kerman were 1378, and 1323 patients had been referred from outside of Kerman. The number of infected men was more than women (Table 1). Most of the patients were aged between 20 to 80 years (Table 2).

Table 1. The number of COVID-19 patients based on sex and residence information

	Men	Women	Totals
Number of patients outside Kerman city	716	548	1264
Number of patients in Kerman city	794	584	1378
Total patients	1510	1132	2642

Table 2. The number of COVID-19 patients based on age information

Age	Frequency	Percentage Frequency	Cumulative frequency
0-20	101	7.33	101
21-40	300	21.77	401
41-60	398	28.88	799
61-80	466	33.82	1265
81>	113	8.2	1378

The most common symptom among the patients was respiratory distress (898 cases) followed by fever (744 cases). Although there were patients who did not have respiratory distress, their PO2 was less than 93 (29 cases). Most patients (908 patients) presented only one symptom. However, some patients had different gastrointestinal, pulmonary, and other symptoms simultaneously. Eight hundred sixty-nine patients had obvious changes in favor of COVID-19 on their CT scan results (Figure 1).

One thousand, two hundred, forty-two patients claimed that they had not been in contact with another patient and only 136 patients had precisely reported contact with COVID-19 patients.

Nine hundred forty patients had underlying problems; the most common of which were hypertension (273 cases), addiction (263 cases), and diabetes (257 cases) (Figure 2).

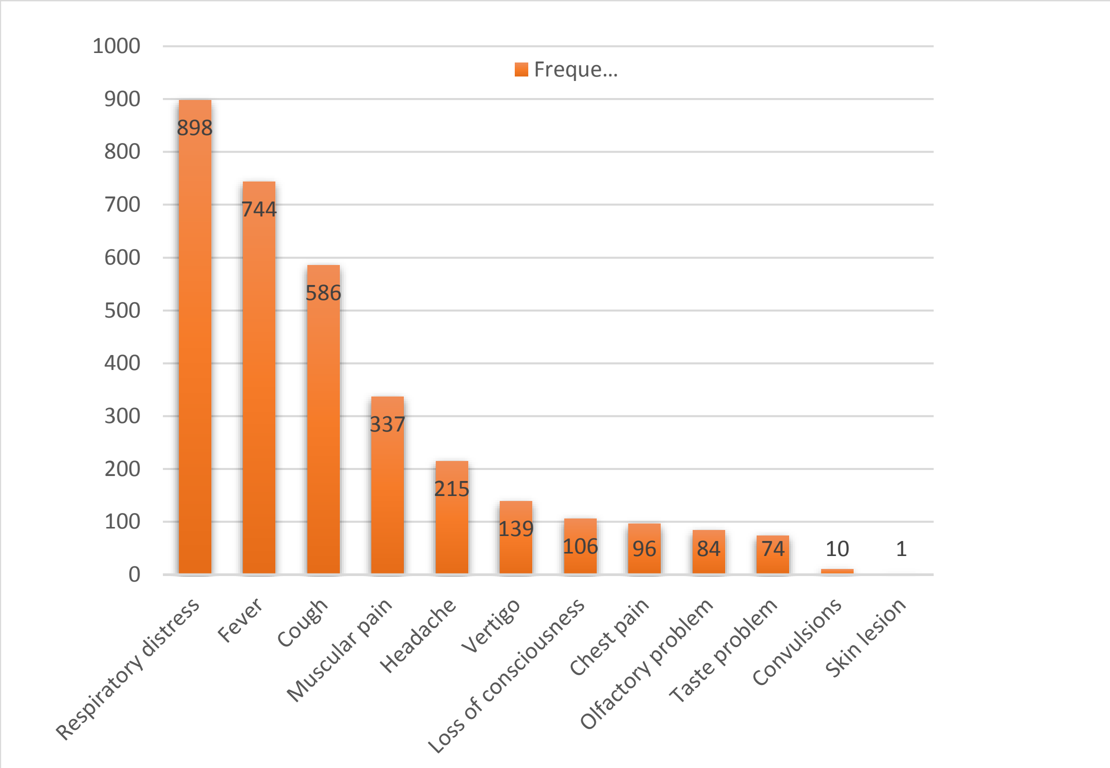

Figure 1. Frequency of symptoms in COVID-19 patients.

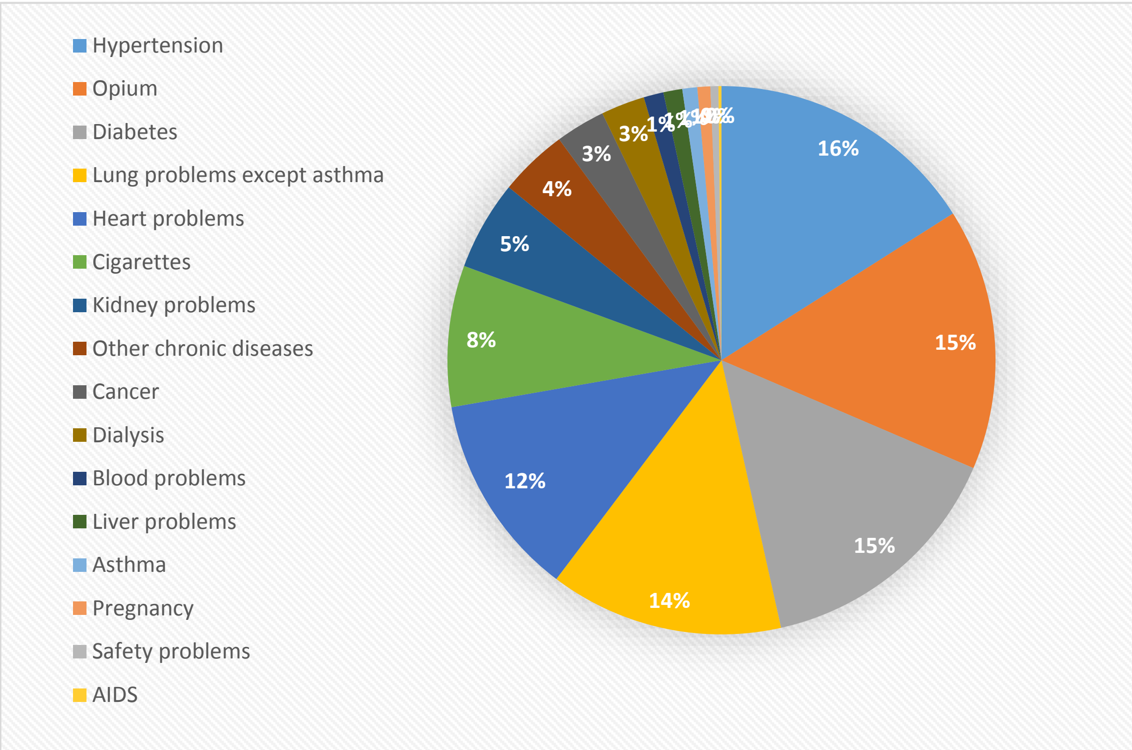

Figure 2. Frequency of underlying problems in COVID-19 patients.

The spatial distribution maps of patients in Kerman city during the 190 days of the study showed that the spread of the disease started in the north, south, and west of the city and gradually developed to the center (Figure 3). In northern Kerman, the spread of expansion is limited to the ring road. The areas closer to the city center are less involved. In the south, the most alarming areas are Azad University, Bahonar University, and the penitentiary. In the west, it started from the border between Keshavarz Blvd. and Red Crescent St. and has spread around especially to the west of this area (east of Elia town).

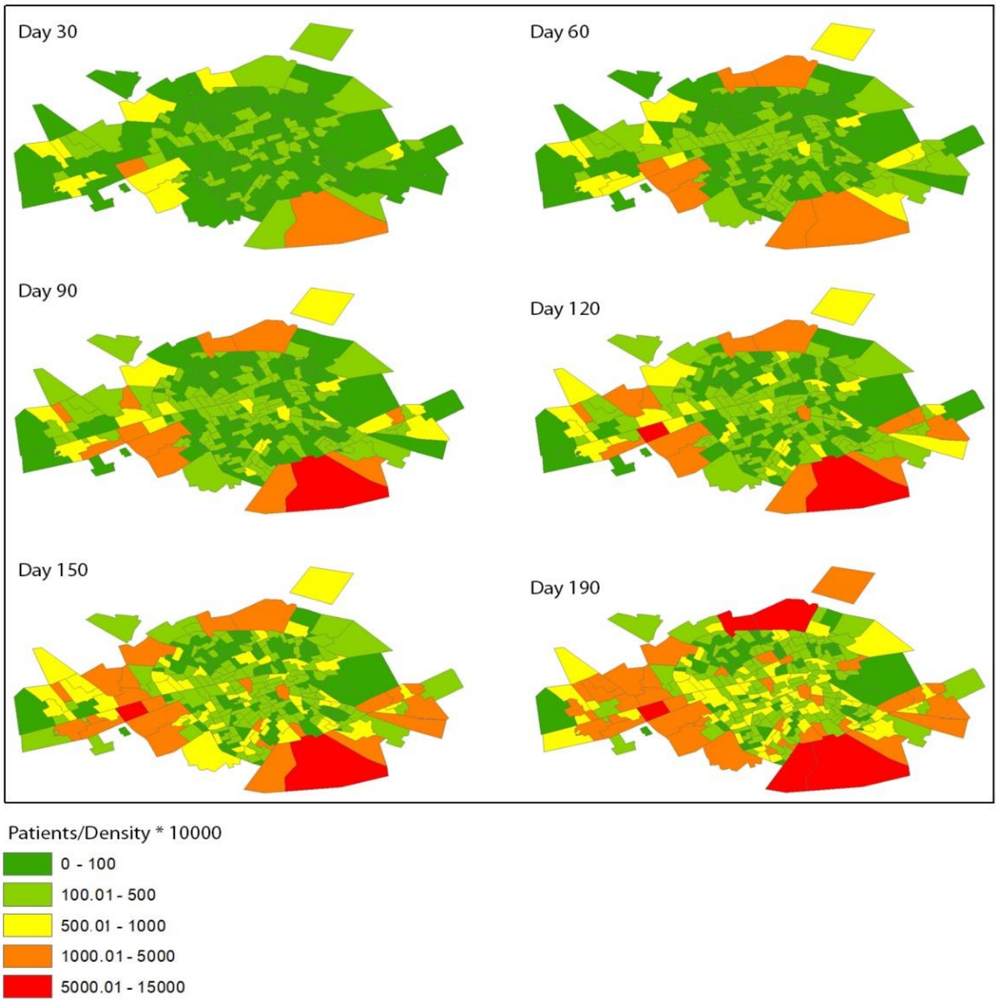

Figure 3. Distribution trend of COVID-19 in Kerman city.

Average nearest neighbor analysis showed that the distribution of disease cases was not random (P=0.000181) and High/Low clustering analysis also showed that spatial clustering for data was possible (P=0.000041) which is shown in Figure 4. Based on the clustering, the high-risk southern and western areas were located in High/High clusters, and the low-risk central and northern areas of Kerman were located in Low/Low clusters.

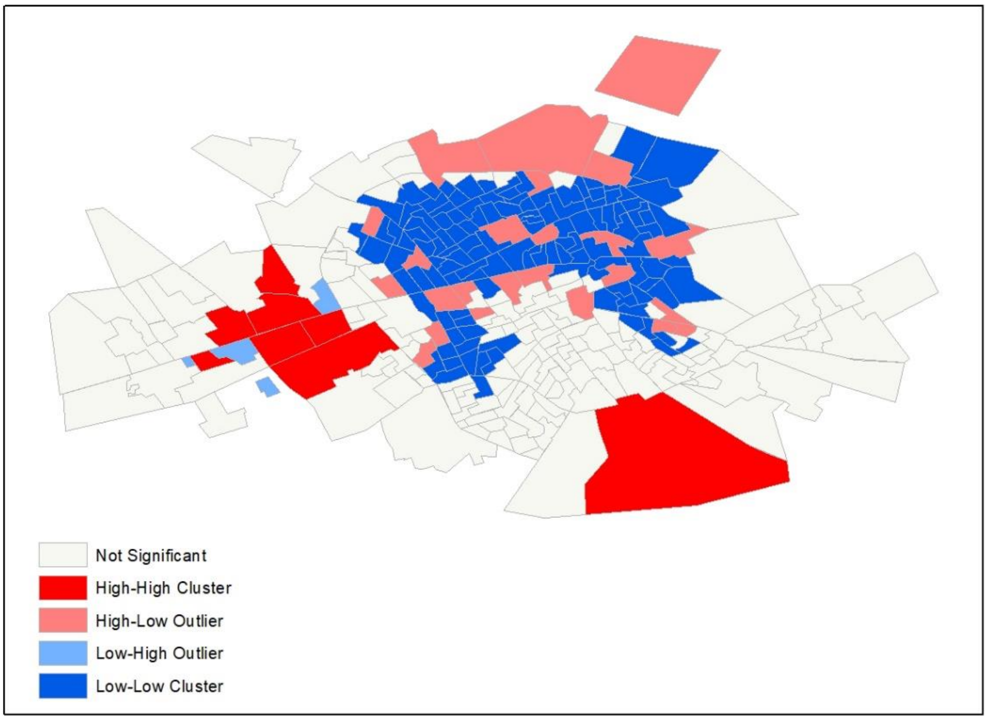

Figure 4. COVID- 19 disease clustering on the 190th day of the study.

The K-Ripley function also showed that the spatial clustering or scattering of the features' centrality changes with the change in the size of the neighborhood unit; thus, it confirms the clustering (Figure 5).

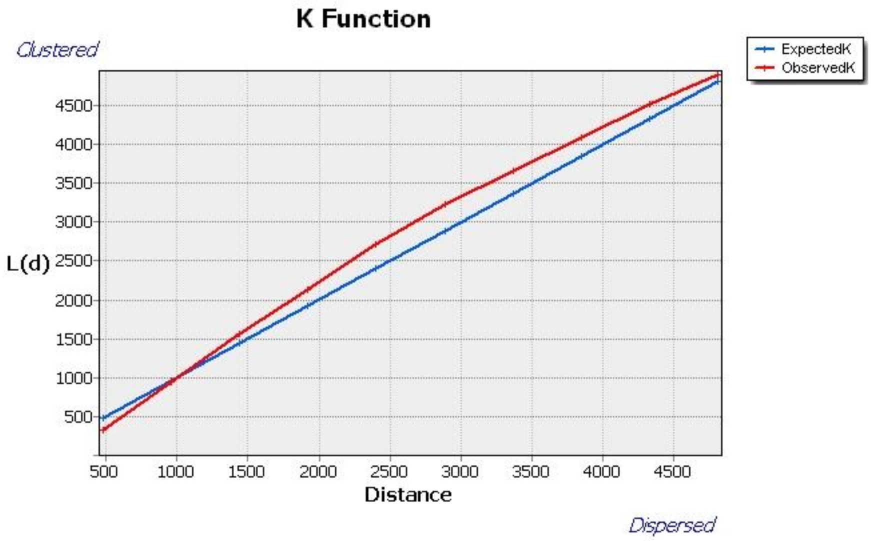

Figure 5. Results of Ripley's K function analysis for clustering of the centrality of the features.

The study of high-risk and low-risk points analysis in the map obtained by hotspot analysis (Getis-Ord Gi *) had a similar result. By clustering high-risk and low-risk areas based on age, underlying problems, and symptomatic CT scans it was shown that patients with underlying problems and patients with abnormal CT scans followed a pattern similar to that of patients' hotspots, but the patients' age pattern was based on points. The distribution of hotspots of the disease was less consistent (Figure 6).

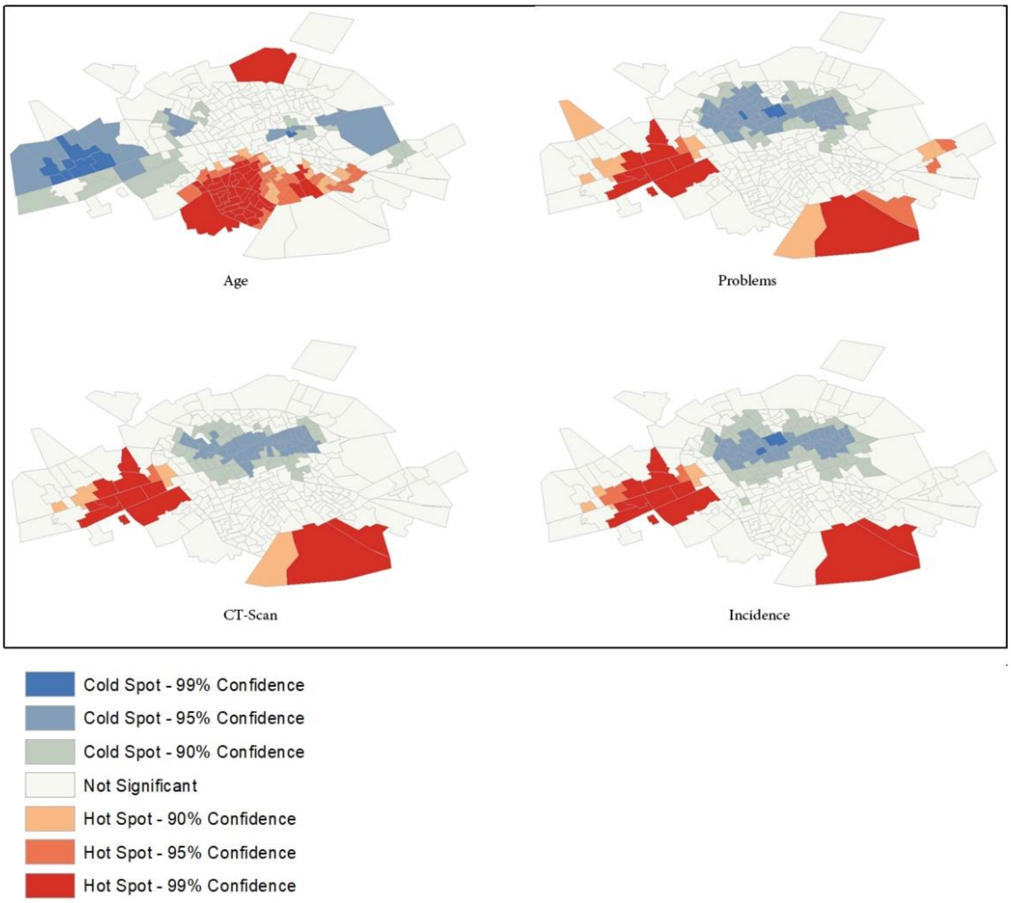

Figure 6. High-risk and low-risk areas of COVID-19 disease on the 190th day of the study.

Examination of geographical rhythmic regression and least squares regression showed that, at a 95% confidence level, there is a significant correlation between patients' underlying problems and age with COVID-19 disease (Figure 7).

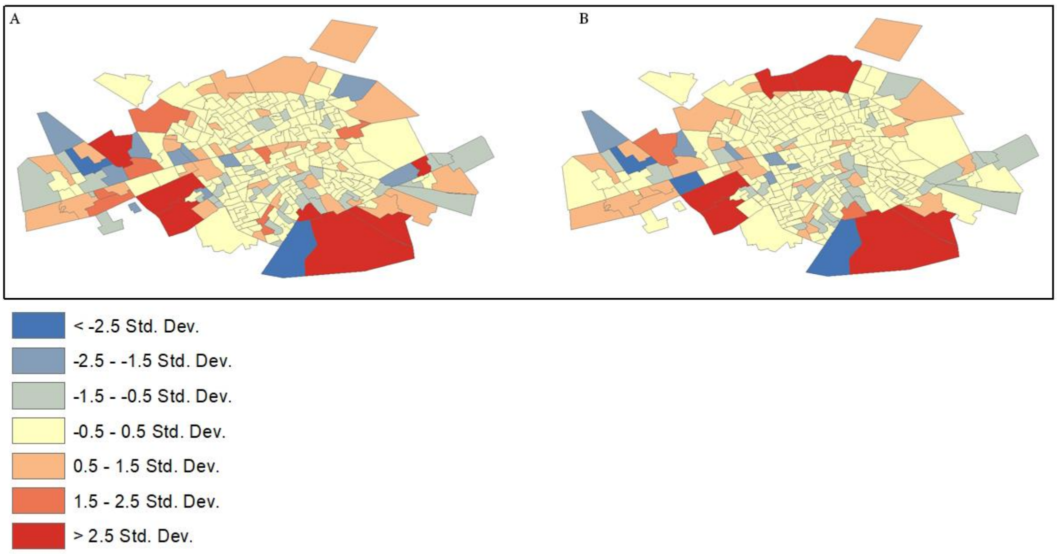

Figure 7. Geographical rhythmic regression (A) and least squares regression (B).

Discussion

This study attempted to investigate and discover the trend of prevalence and distribution of COVID-19 disease in Kerman city regarding geographical areas in a 190-day period (from January to June 2020). The results of this study showed that the spread of the disease started from the north, south, and west of Kerman and gradually distributed to the center. The southern and western regions are in high-high clusters, and the central and northern regions are in low-low clusters. The prevalence of COVID-19 is related to different economic, social, and environmental factors (16). The highest prevalence in the northern part of the city is related to the northern ring road neighborhoods. On the one hand, it is a high-traffic area and on the other hand, its residents are of low economic status; therefore, health protocols such as wearing masks and disinfecting hands are less respected. The existence of a prison in the southern part of the city can be an affecting factor in increasing the prevalence of COVID-19 in this area. The high prevalent areas in the west of the city are the residential settlements that have large populations; therefore, the physical distance is less observed in these areas. The results of a study by Lorenz in 2021 showed that population density has been a barrier to preventing and managing COVID-19 outbreaks (17).

Regression showed a significant correlation between underlying diseases and patients' age with the incidence of COVID-19 disease. Approximately half of the patients were in the age group of 20 to 60 years. Moreover, the number of male patients was more than females. These results are consistent with the other epidemiologic study on the COVID-19 patients hospitalized in Baqiyatallah hospital in Tehran. In this study, most of the patients were in the age group of 50-60 years and were male (18). The results of other studies also confirm the finding which shows that male patients and the elderly (older than 50 years) are at higher risk of COVID-19 disease. These results indicate that the active population of the community is more exposed to the coronavirus, which can lead to economic problems. Therefore, to avoid an economic crisis in the future, policymakers should impose stricter protocols to prevent the spread of this disease; also, people should pay more attention to these protocols. These findings will be useful for helping in crises involving economic elements (19).

About 68% of patients had an underlying disease, such as blood pressure, diabetes, cardiovascular diseases, or pulmonary problems. This result indicates that COVID-19 disease is more common in people with underlying diseases and such patients can face more dangerous complications. Although a similar study showed that only 10.8% of the patients had disease comorbidity, its results revealed that underlying diseases could significantly increase the COVID-19 mortality rate by 53% (18). A systematic review study also showed that comorbidities such as diabetes, hypertension, cardiac diseases, and obesity were prevalent in patients with the middle east respiratory syndrome (MERS) (20).

About 90% of patients claimed that they had no previous contact with COVID-19 patients. It indicates that a person can be a carrier of the disease while he/she does not have specific disease symptoms, and so he/she can infect many people. One study showed that an asymptomatic carrier as much as a symptomatic patient could spread the coronavirus and infect others. Due to the risk of an asymptomatic carrier in the spread of the disease, all society members must pay serious attention to observance of physical distancing and using masks; also, based on the results of this study and similar studies, more research should be done on the risk of asymptomatic spread of the disease. (21).

This is the first study that revealed the spatiotemporal distribution of COVID-19 patients in Kerman city. However, there are some limitations. We used only the COVID-19 patients' data admitted to Afzalipour hospital, while several health centers in Kerman city test suspected patients for COVID-19. Gathering the patients' information from these centers may change the results. COVID-19 patients are admitted to Payambar Azam hospital as well; perhaps, patients with high socioeconomic status were admitted to this hospital or were taken care of at home. Therefore, further study is needed to achieve more accurate results based on information from all COVID-19 referral centers in Kerman city. The other limitation is that we did not have access to the patients' socioeconomic information; therefore, we could not review the effect of these factors on COVID-19 prevalence deeply.

Conclusion

According to the results of logistic regression analysis, the prevalence of COVID-19 had been higher in densely populated areas and areas with poorer economic conditions. Therefore, paying attention to these areas as well as applying strict rules can help control the spread of COVID-19. This study's results could be used by policymakers in the field of healthcare and municipal services to make appropriate decisions for controlling and managing the COVID-19 disease.

Ethical approval

This study was approved by the ethical committee of Kerman University of Medical Sciences (code: IR.KMU.REC.1399.493).

Authors' contributions

Ghaemi and Ershad Sarabi designed the present study. Data gathering and analysis were done by Samzadeh and Ghaemi, respectively. Ershad Sarabi, Ghaemi, Hajesmaeel Gohari, and Shafiei participated in drafting the manuscript. All authors approved the final version of the manuscript.

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