Short Report: Measures to Control Covid-19 Epidemic in Public and Reduce the Patient Load in Hospitals: A Report From Iran

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ABSTRACT

After presenting the novel coronavirus (SARS-CoV-2) in china, it has spread rapidly in the community and now has declared as a pandemic causing coronavirus disease 2019 (COVID-19). At the date of writing this report, the COVID-19 has affected 192 countries and one international conveyance (the Diamond Princess cruise ship harbored in Yokohama, Japan) around the world with the total cases of 341,529. In Iran, the emergence of the disease was reported with two cases of COVID-19 deaths in Qom city on February 19, 2020, that caused great concern for the health system and the general public. It was rapidly spread around the country and reach to 21,638 definite cases by March 22, 2020. The special nature of the disease in rapid transmission among individuals in society requires urgent measures and serious actions to control it as quickly as possible. In this report, we describe the current status of the COVID-19 response strategy for reducing transmission in public and patient load in hospitals in Iran. Although Iran has tried to use the successful experience of other countries, such as China, for various reasons, such as non-quarantine of Qom province, as the primary site of disease propagation, lack of public quarantine, lack of seriousness by some citizens and officials, the lack of facilities and personal protective equipment needed for staff use, and restrictions regarding purchasing equipment from other countries due to international sanctions, have served as obstacles to achieve good results.

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1. Introduction

On December 31, 2019, China reported cases of pneumonia to the World Health Organization (WHO) caused by a novel coronavirus, subsequently named SARS-CoV-2 [1]. The disease has spread rapidly worldwide until it was topped by the WHO Secretary-General as a global concern and named as coronavirus disease 2019 (COVID-19) [2]. It was reported as a pandemic as the novel coronavirus has continued to rapidly spread worldwide [3]. At the date of writing this report, the COVID-19 has affected 192 countries and territories around the world and one international conveyance (the Diamond Princess cruise ship harbored in Yokohama, Japan) with the total affected cases of 341,529. In Iran, despite ongoing trade and travel between China and Iran, there was no reported case until two cases of COVID-19 deaths were reported in Qom city on February 19, 2020 [4]. The news of the emergence of the disease with two deaths caused great concern for the health system and the general public. In this report, we describe the current status of the COVID-19 response strategy for reducing transmission in public and patient load in hospitals in Iran and defects, as well.

2. Current Status Report

Since the primary report, Iran has reported increasing numbers of cases and deaths caused by COVID-19. Health officials have identified evidence of transmission by Chinese cases who infected others in Qom. All patients had a history of traveling to China or were in contact with someone who had a history of traveling to China. At present (Mar 22, 2020), all 31 provinces of Iran are affected by COVID-19. The total number of 21,638 infected cases, 1,685 deaths, and 7,913 recovered cases have been reported (Figure 1).

3. Control Measures in Iran

The Iranian New Year is the largest annual mass travel event in the country coming soon at the end of March, in which there is a higher risk of spreading COVID-19. In response, provincial governments severely restricted traveling across Iran. Most authorities have closed public transit and restricted outbound transportation (airplanes, trains, private vehicles, and buses). Many provinces, such as Mazandaran province implemented fever check posts at the borders of the province with the cooperation of police and Iranian Red Crescent volunteers. After a preliminary examination, febrile persons are referred to the quarantine center if needed. Schools and universities were closed and all concerts and events with mass gatherings were canceled. All people were encouraged to stay at home except for buying the necessary supplies. The Ministry of Health and Medical Education (MOHME) sent regular and informative text messages to the public. Businesses that did not provide essential services have been closed and other offices' working hours decreased by taking preventive measures and personal protective considerations.

Due to the existence of primary health services in the health network system as well as the establishment of a family physician system in some provinces, the first line of screening and identification of suspected cases was established. This strategy reduced the number of patients admitted to the second and third lines of the health system.

An online self-screening system was implemented by the MOHME at https://Salamat.gov.ir for decreasing unnecessary visits to medical services. On the other hand, the implementation of this system provides a relative estimate of suspected cases using the online syndromic surveillance system. Similar systems in each province were also set up by universities, such as the Mazandaran University of Medical Science to make it available to the general public for proper guidance and primary treatment measures (http://corona.mazums.ac.ir). In addition, the central hotline was provided in the MOHME as well as in provincial universities to answer public questions about COVID-19.

The Iranian government announced 16600 billion Rials (US $395 million) to fund the response capacity and empower the health system. Rapid construction of one 1000 beds hospital in Qom as the primary focus was on the agenda. A specialized fever clinic (Corona Clinic) was deployed in cities to examine referrals from a first health level (Health centers or family physicians) as well as people who needed visiting a specialist in the initial screening by the web-based system.

Assigning dedicated pre-hospital emergency ambulance codes with proper personal and protective equipment to transfer suspected COVID-19 patients to the selected hospitals for hospitalization. For this purpose, triage guidelines developed by the Emergency Medical Organization were used.

At early days of pandemic, Pasteur Institute was the only laboratory with needed facilities to evaluate samples of suspected patients. Subsequently, by sending necessary facilities to academic centers throughout Iran, it was possible to perform necessary COVID-19 lab exams elsewhere in Iran.
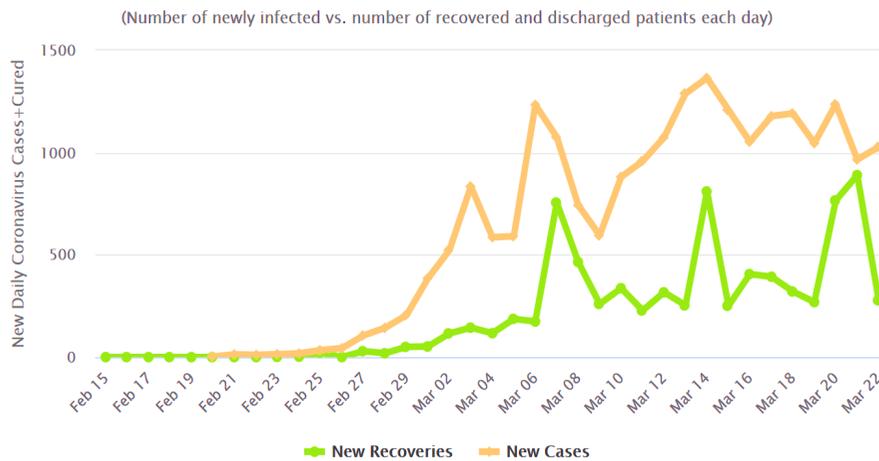
(Number of newly infected vs. number of recovered and discharged patients each day)

Figure 1. Newly infected cases vs newly recovered cases in Iran

In each province, one or more hospitals were allocated in the early days for hospitalization and treatment of CO-VID-19 patients using special triage and treatment protocol (Figure 2). With the increase in the number of patients, other hospitals have also increased their capacity to accommodate patients with COVID-19 by discharging patients and canceling elective clinical practices. Private hospitals, charities, and military hospitals were also used.

Numerous operational guides were provided to all occupational groups and the general public on decontamination and personal protection. Clinical and specialized guidelines for different levels of health care delivery were also developed using the experiences of China and the documentation provided by the WHO.

The potential capability of social media was used to prevent the spread of rumors and false news while informing the public at the right time. This strategy is very applicable to a penetration rate of over 90% of mobile Internet coverage in Iran. In addition, the appropriate informative and training programs were broadcast on all television and radio networks.

Despite informing the general population on the risk of COVID-19, unfortunately, due to the lack of proper collaboration of all affected areas, control measures were not successful. These included no closure of religious centers with public gatherings, such as Imam Reza's shrine in Mashhad and Hazrat Masoumeh's shrine in Qom. In addition, some religious leaders also put their audience and followers at risk for COVID-19 disease by expressing illogical and unscientific instructions in their speeches. However, subsequently, with the emergence of more cases of the disease and the deteriorating dimensions of its deterioration, the most prominent religious

authorities in Iran emphasized the application of the principles of epidemic control.

Role of the WHO: The director-general of the WHO declared a public health emergency of international concern (PHEIC) for COVID-19 that poses a public health risk to other states through the international spread and requires a coordinated international response [5]. After the emerging and rapid progression of COVID-19 in Iran, and due to international sanctions imposed on Iran, it is not possible to purchase the resources and equipment from other countries. In this particular situation, WHO supported scientifically and Shipped personal protective equipment and laboratory kits to Iran that has been a very valuable act.

4. Discussion

The most effective treatment for communicable diseases, especially those with high epidemic potential, is prevention [6]. Therefore, the priority of prevention over treatment needs to be removed from the slogan more than ever. A practical example may be found in China. The Chinese precautionary measures have included case finding everywhere, quarantining contaminated areas, and restricting traffic for millions of residents. Quarantining the Hubei province, as the center of the virus outbreak, establishing a curfew in the cities under quarantine, establishing central monitoring teams and sending them from the central government to the provincial capitals involved in the epidemic, mobilizing all facilities of government agencies and hospitals, increasing the length of Chinese New Year holidays, traffic control, cancellation of all communities, and strengthening public health education were the most important measures taken by the Chinese government to effectively deal with
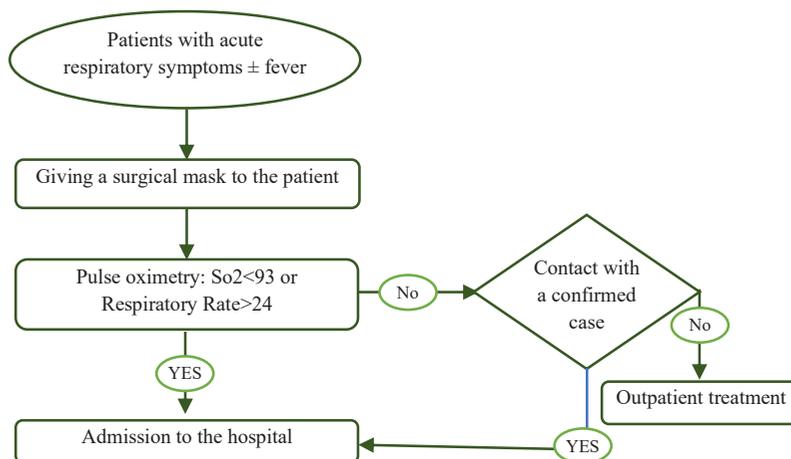
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Figure 2. Process of triage and treatment of suspected cases at coronavirus disease 2019 (COVID-19) referral hospitals

the virus. Therefore, they were able to gradually reduce the incidence of the new virus and its resulting mortality until they closed the newly established Wuhan Hospital.

South Korea was another country that experienced a significant spread of the disease in its early stages. Within a short period of mid-February, it implemented the most stringent quarantine measures for some cities and the northern Gyeongsang province. The closure of higher education centers and schools for a long period, the prohibition of mass gatherings, quarantining the places where the virus was rapidly spreading, the use of electronic maps to identify patients and their movements, the strict quarantine of patients, allocation of extra funds to combat coronavirus epidemic, raising national alert levels, and conducting public lab testing to identify even asymptomatic patients and carriers were among the most effective measures taken by Koreans.

Iran has also sought to capitalize on the successful experience of these countries and implement necessary measures to control the epidemic. However, some obstacles and problems, such as non-quarantine of Qom province, as the primary site of disease propagation, lack of public quarantine, lack of seriousness by some citizens and officials, lack of facilities and personal protective equipment needed for staff use, and restrictions on equipment purchases from other countries due to international sanctions, have served as obstacles to achieve good results.

5. Conclusion

The outbreak is currently not under control in Iran and worldwide. Managing outbreaks internationally requires the cooperation of all countries and the use of basic public health strategies. In Iran, with current actions, we hope to reach a stable condition in the emergence of new cases up to mid-April [7]. To achieve this end, we need to impose further restrictions on public contacts and unnecessary communications. Due to continued international sanctions, the WHO and many other international non-governmental organizations are expected to continue their supports for Iran in order to succeed in controlling the COVID-19 epidemic.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article.

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Authors' contributions

All authors contributed in preparing this article

Conflict of interest

The authors declared no conflict of interest.

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Case Report: Spatial Analysis of COVID-19 and Exploration of Its Environmental and Socio-Demographic Risk Factors Using Spatial Statistical Methods: A Case Study of Iran

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ABSTRACT

Background: Iran detected its first COVID-19 case in February 2020 in Qom province, which rapidly spread to other cities in the country. Iran, as one of those countries with the highest number of infected people, has officially reported 1812 deaths from a total number of 23049 confirmed infected cases that we used in the analysis.

Materials and Methods: Geographic distribution by the map of calculated incidence rates for COVID-19 in Iran within the period was prepared by GIS 10.6 Spatial autocorrelation (Global Moran's I) and hot spot analysis were used to assess COVID-19 spatial patterns. The ordinary least square method was used to estimate the relationship between COVID-19 and the risk factors. The next step was to explore Geographically Weighted Regression (GWR) models that might better explain the variation in COVID-19 cases based on the environmental and socio-demographic factors.

Results: The spatial autocorrelation (Global Moran's I) result showed that COVID-19 cases in the studied area were in clustered patterns. For statistically significant positive z-scores, the larger the z-score is, the more intense the clustering of high values (hot spot), such as Semnan, Qom, Isfahan, Mazandaran, Alborz, and Tehran. Hot spot analysis detected clustering of a hot spot with confidence level 99% for Semnan, Qom, Isfahan, Mazandaran, Alborz, and Tehran, as well. The risk factors were removed from the model step by step. Finally, just the distance from the epicenter was adopted in the model. GWR efforts increased the explanatory value of risk factor with better special precision (adjusted R-squared=0.44)

Conclusion: The highest CIR was concentrated around Qom. Also, the greater the distance from the center of prevalence (Qom), the fewer the patients. Hot spot analysis also implies that the neighboring provinces of prevalence centers exhibited hot spots with a 99% confidence level. Furthermore, the results of OLS analysis showed the significant correlation of CIR is with the distance from epicenter (Qom). The GWR can result in the spatial granularity providing an opportunity to well understand the relationship between environmental spatial heterogeneity and COVID-19 risk as entailed by the infection of CIR with COVID-19, which would make it possible to better plan managerial policies for public health.

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1. Introduction

Coronaviruses belong to the Coronaviridae family. They are a large group of viruses with positive-sense, single-stranded enveloped RNA found in animals and humans [1]. Two major coronavirus outbreaks in many countries, the Middle East respiratory syndrome coronavirus (MERS-COV) [2] and the severe acute respiratory syndrome coronavirus (SARS-COV) have been recorded [3]. The new Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) [4]. The disease was first identified in 2019 in Wuhan, the capital of Hubei in China, and has spread globally, resulting in a coronavirus pandemic [5]. According to the World Health Organization, the number of confirmed cases is 375,498 and the number of deaths is 16,362 across 196 countries on 23 March 2020 [6]. The mortality rate is 3.4 %; however, it ranges from 0.2% to 15%, according to age group and other health problems [7].

Since the epidemic of SARS and MERS, many studies have analyzed the viral transmission of the diseases using different techniques, like the SI model and spatial statistics to assess the spatial clustering of the coronaviruses [8, 9]. Understanding the viral transmission of COVID-19 is critical using a spatially explicit model. Iran detected its first COVID-19 case in February 2020 in Qom province, which rapidly spread to other cities in the country. Iran, as one of those countries with the highest number of infected people, has officially reported 1812 deaths among a total number of 23049 confirmed infected cases till now. Factors, ranging from the level of humidity, temperature, distance from the epicenter, to those, such as population density, socio-demographic characteristics, and level of urbanization may probably be the contributing factors, which change the pattern of prevalence of the novel infection in different areas. In the current study, statistical and spatial analysis were applied to determine spatial distribution and prevalence of COVID-19 infection associated with environmental and socio-demographic factors in the various provinces of Iran. This information is beneficial in identifying the regions with high risk for the disease and provide stakeholders with prioritizing public health interventions. The aim of this study was to exhibit the geographical and spatial distribution of the COVID-19 epidemic in all the provinces in Iran.

2. Materials and Methods

Study area

The Islamic Republic of Iran is located in Western Asia with a vast area of 1,648,195 km2. Iran is the second-largest and most populous country in the Middle East. The country has about 85 million people with the significant youth population actively involved in the production and other socio-economic activities. It shares borders Armenia, Azerbaijan, and Turkmenistan in the North, Turkey in the Northwest, Iraq in the West, Persian and Oman Gulf in the South and Afghanistan and Pakistan in the East and Southeast, respectively. With a diverse climate, Iran is an arid, semiarid subtropical area with annual precipitation of 680 mm (26.8 in) in the eastern parts and more than 1,700 mm (66.9 in) in the northern and western parts, respectively. The temperature, on the other hand, ranges from 5°C to 10°C and 20°C to 30°C or more in winters and summers, respectively. The country has thirty-one provinces administered from the capital Tehran [10].

COVID-19 cases data

Data on COVID -19 cases from 23 February to 22 March 2020 were collected from the Ministry of Health and Medical Education of Iran. Cases were detected using the diagnostic tool kits, which were confirmed in the hospital. A total number of 23049 cases from Iran provinces were used in the analysis. The number of recovered cases and deaths from COVID-19 was also considered. Figure 1 exhibits all data collected since the time of this study.

Environmental and socio-demographic factors

The environmental factors considered in this analysis were humidity, temperature, precipitation, elevation, number of travels to provinces, and the distance from the epicenter. Other important socio-demographic factors were population, age, educational status, and vitamin D intake per province. The details of the mentioned parameters are shown in Table 1.

The COVID -19 incidence rate (cases per 100,000 population) was the measure used for the severity of disease in this analysis, which was assessed by Equation 1. The cumulative incidence rate is the proportion of the population at risk within a given period of time [11].

Eq. (1). Cumulative incidence rate=

$$\frac{\textit{Total number of new cases}}{\textit{Number of population atrisk}}$$

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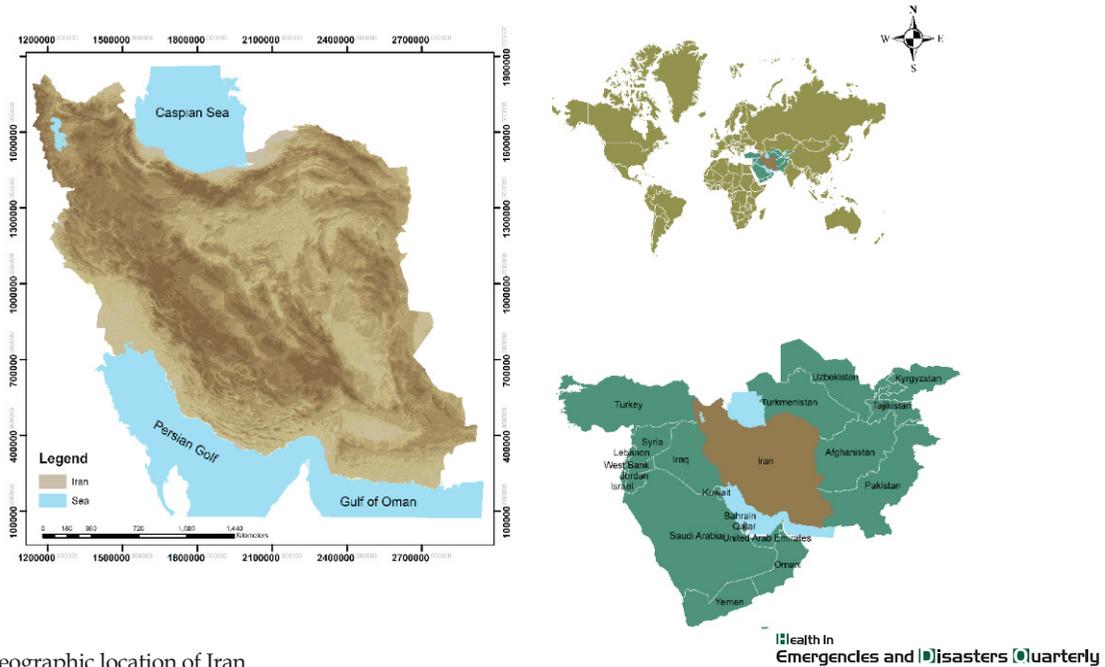
Figure 1. Geographic location of Iran

The cumulative incidence rate map in adjacent provinces to Qom (as the major infected city in Iran) is shown in Figure 2. As depicted, provinces, such as Bushehr, Chaharmahal and Bakhtiari, Kerman, Kermanshah, Khuzestan, Kohgiluyeh and Boyer-Ahmad, North Khorasan, Sistan and Baluchestan, and West Azerbaijan had the lowest cumulative incidence rate (CIR<10) from February 23 to March 22, 2020.

Spatial pattern analysis

Spatial autocorrelation (Global Moran's I) [12], and hot spot analysis [13] were used to assess COVID-19 spatial patterns, such as spatial distribution characteristics, spatial clustering, and spatial hot spots in the Iran provinces. The spatial analysis methods were applied for the disease analysis. 'Spatial autocorrelation' (global Moran's I) measures spatial autocorrelation based on both feature locations and feature values simultaneously. The global Moran's I index values fall between _1.0 and +1.0. This index evaluates whether the pattern expressed is clustered (>0), dispersed (=0), or random (<0). The 'hot spot analysis' (Getis-Ord Gi*) calculates each feature in the dataset is a z-score. For statistically significant positive z-scores, the larger the z-score is, the more intense the clustering of high values (hot spot). For statistically
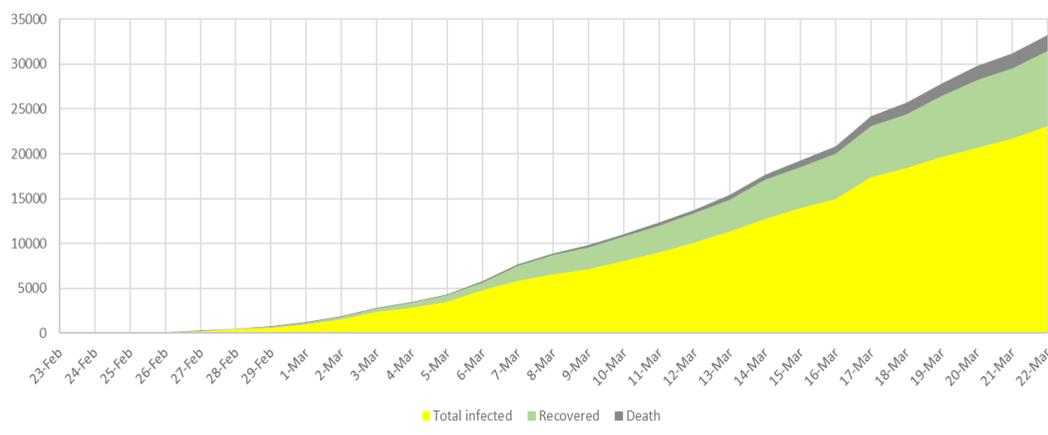
Figure 2. An increasing trend in the total infected and recovered cases and deaths, from February 23 to March 22, 2020

36.3% of the total infected cases were recovered and 7.8% of the total infected cases died at the time of this study in Iran.

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Table 1. Data sources

Data	Spatial Resolution	Source
Population	Province scale	Statistical Centre of Iran
Age	Province scale	Statistical Centre of Iran
Illiteracy rate	Province scale	Statistical Centre of Iran
Number of travels to provinces	Province scale	Statistical Centre of Iran
Humidity	Province scale	Iran metrological organization
Precipitation	Province scale	Iran metrological organization
Temperature	Province scale	Iran metrological organization
Vitamin D intake per province	Province scale	Ecological descriptive study of vitamin D status in Iran
Distance from epicenter	30m	Euclidean distance tool and zonal statistical tool in ArcMap 10.6
Elevation	30m	Extracted by Digital Elevation Model (DEM) and zonal Statistics tool in ArcMap10.6)

significant negative z-scores, the smaller the z-score is, the more intense the clustering of low values (cold spot).

Spatial statistical models

The ordinary Least Square (OLS) method was used to estimate the relationship between COVID - 19 and the risk factors. This method minimized the sum of squared differences between the observed response and the ones predicted from the explanatory method. OLS regression is a powerful technique for modeling continuous data, particularly when it is used in conjunction with dummy variable coding and data transformation [14]. The COVID-19 was the dependent variable used in the model. Trust in the model can be assessed according to six rules: 1. the coefficients have the expected signs; 2. there is no redundancy among explanatory variables; 3. the coefficients are statistically significant; 4. the residuals are normally distributed; 5. there is a strong adjusted R-square value; 6. the residuals are not spatially autocorrelated [15]. Collinearity was accounted for the variables utilized according to the six rules of the OLS model.

The least-square regression model interpretation was based on multi-collinearity, robust probability, adjusted R, and Akaike Information Criteria (AIC). The statistically significant variables were indicated by the robust probability, which shows their significance in the model. To examine the VIF values and robust probability, the OLS model was run several times until all the redundant variables were removed from the model. This procedure continued until narrowing down to non-redundant and

significant variables. The AIC was then used to determine the best OLS model.

The next step was to explore Geographically Weighted Regression (GWR) models that might better explain the variation in COVID -19 cases based on the environmental and socio-demographic factors. Spatial autocorrelation (Global Moran's I) was utilized to assess whether the environmental and socio-demographic factors exhibited a random spatial pattern [16], and where adequate models have a random distribution of the residuals [17].

Geographically weighted regression

Under the assumption that the strength and direction of the relationship between the dependent variable and its predictors may be modified by contextual factors, the GWR model was applied. The results were analyzed using the spatial relationship tools within the spatial statistics toolbox in the ArcGIS Arc toolbox. The explanatory variables used in OLS were used in the GWR modeling in other to access the difference in model improvement, which can be due to modeling approach or environmental and socio-demographic factors. The GWR model was applied to analyze the relationship between COVID-19 cases and environmental and socio-demographic factors changes from one province to another. The GWR detects spatial variation and shows how the relationship varies in space and produces information useful for interpreting spatial non-stationarity [18].

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