Geospatial Analysis of COVID-19 Spread in Cairo Governorate Using Geographic Information System

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ABSTRACT

COVID-19 has caused a global public health crisis affecting most countries including Egypt. Due to the widespread pandemic, the spread of COVID-19 has drawn increasing global attention. This study aims to analyze the reported COVID-19 cases by spatial statistical methods, exploring the geographical distribution patterns of the COVID-19 pandemic in Cairo from 14 February 2020 to 18 May 2021. In order to better understand of the spread of this new virus, the spatial patterns of COVID-19 cumulative cases have been characterized by using ArcGIS ver. 10.3.1 based on spatial autocorrelation and cluster analysis using Global Moran’s I (Moran, 1950), Local Moran’s I and Getis-Ord Gi to explore the spatial gathering hotspots and cold spots of the COVID-19 pandemic. Up to 18 May 2021, Cairo Province had reported 79,130 COVID-19 cases. The top five districts with respect to incidence were Al Mouski (0.097/100000), Badr (0.088/100000), Qasr Al nieil (0.088/100000), Al Gammalia (0.066/100000) and Al Zamalek (0.064/100000). Global Moran’s I analysis results showed that the Morbidity rate, recovery and fatality of COVID19 was in the clustering pattern, and there was less than 1% likelihood that this clustering pattern could be the result of random chance. While local spatial correlation analysis showed that the value of 71 sheikhs belonging to the HH aggregation class. The Getis-Ord Gi statistic was applied and the results showed that the clustering of high values (hot spots) for Morbidity with a confidence level of 99% distributed in eastern, southern and the northeast of Cairo.

Key Words: COVID-19, GIS, Spatial autocorrelation, Hot/cold spots, Cairo.

1. Introduction

COVID-19 has become one of the most serious global public health crises in modern times. The disease was declared a pandemic on 11 March 2020 and has currently affected more than 216 countries and territories (Cucinotta, 2020). As of 3 August 2020, there were more than 17.6 million confirmed COVID-19 cases and over 680,000 associated deaths around the globe (WHO, 2020). A key element of epidemiologic research, the geographical distribution of the disease, is demonstrated by the importance...
given to the “person, place and time” descriptor of health events in the classical epidemiology textbooks (Werneck, 2008). This thematic aspect of COVID-19 requires analysis that adopts an interdisciplinary approach, and geography is one of the few disciplines that purports to offer a synthetic approach to the interplay between the biophysical and human variables (Turner, 2002), by approaching the environment from a holistic perspective with a focus on the forms and processes that concur in a geographical space (Sauer, 1925). Other disciplines define the physical, historical and social characteristics and processes, but geography situates these in a spatial, territorial, locational and landscape perspective (Pattison, 1964). The complex reality of the environment-society dialectic must be understood in the context of the integrative approach of geography. Geographical information systems (GIS) have today revolutionized these spaces—which, in simple terms, give the ability to view spatial or geographic information in a meaningful way, be it interactive maps or other infographics. There are numerous uncertainties in the Covid pandemic, many of them have a spatial component that contributes to the pandemic being interpreted as geographical and technically mappable (Subramanian et al., 2020).

In the battle against Covid in Cairo, there have been limited Covid risk maps and application of Covid spatial epidemiology. For these purposes, with the emergence of Covid as a global pandemic, the use of geospatial and statistical methods has become extremely important. Statistical modeling and spatial epidemiology in small areas have been developed to solve problems where disease clusters and hotspots are located (Franch-Pardo et al., 2020). Some of the principal spatial techniques explored by Robertson (Robertson et al., 2014) are spatial autocorrelation, spatial time interactions, hotspots, and clusters, used throughout emerging infectious disease research. Advances in geostatistical methods have provided for substantially improved efficiency in the processing and analysis of complex geo-referenced data with multiple variables on different geographical scales, providing epidemiologists with new instruments to incorporate space and place in their study. Based on the numbers available, we demonstrate in this paper spatial cluster patterns of Covid-19 inside Cairo, information that should prove useful for improved, future control of the pandemic.

2. Materials and Methods

2.1 Study Area

Cairo is the largest city in Egypt and the country's capital. It is located on the Eastern bank of the Nile, Cairo is a governorate and a city. Cairo bordered from the north by Qalyobia governorate and from the eastern and southern sides by the desert hinterland, and from the western side by the River Nile and Giza Governorate. Cairo, the largest city in Africa, is located on the Nile River, 160 kilometers (100 miles) inland from the Mediterranean
Sea and 135 kilometers (80 miles) west of the Red Sea as showed in figure (1). The total area of Cairo reaches \((3085.10) \text{ km}^2\). The inhabited area reaches about \((190.42) \text{ km}^2\). Cairo is the largest governorate all over the Republic in terms of population. The total population is estimated to 9,539,673 up to 2017 according to the Central Agency for Public Mobilization and Statistics, Egypt, representing approximately 10.6% of Egypt's total population. The arithmetic density of population reaches \((46.86 \text{ inhabitants / km}^2)\). Cairo consists of four regions comprising (46) districts divided into 325 sheikhs "according to the latest amendment of the administrative boundaries of Cairo governorate in 2021". The main four regions of Cairo divided as follows: The northern region comprises (8) districts, the eastern region includes (14) districts the western region includes (12) districts and the southern region includes (12) districts.

**Figure 1.** Map of the study area (location and administration).
2.2 Data Collection

Data of COVID-19 cases during study period, From 14 February 2020 to 18 May 2021, was collected from the Egyptian Ministry of Health and Population (MOHP). To estimate the Morbidity of COVID-19 for each Shiakha, the population data estimated Morbidity rates "cases/100000 population" of Cairo were obtained by the Central Agency for Public Mobilization and Statistics, Egypt. The total number of confirmed cases, recovered and deaths from COVID-19 provided by (MOHP) which were further used for spatial analysis. Cumulative Morbidity rate reveals the percentage of a population who gets sick in a specific duration of time. The spatial patterns of these cases were analyzed by a Geographical Information Systems (GIS) approach applying ArcGIS software, version 10.3.1 to create a spatial database and to analyze the spatial distribution of officially reported COVID-19 cases.

2.3 Statistical Analysis of COVID-19

Measuring spatial autocorrelation is an important method for quantitative analyses in geography. This method can be treated as a cornerstone of spatial statistics. Spatial analysis is essential to understand the spatial spread of infection and its association with the community and environment, especially in the early stages of an outbreak. Spatial autocorrelation was studied by Global Moran’s I (Moran, 1950), Local Moran’s I according to Anselin (1995), and Getis-Ord General G.

2.3.1 Spatial Clustering Analysis

Spatial autocorrelation was applied to assess the spatial correlation between variables through matching location similarity and attribute similarity (Huo et al., 2012). Global Moran’s I, an index of spatial autocorrelation based on cross products is mathematically expressed as follows:

\[ I = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n} (x_i - \bar{x})} \]

Where n is the number of regions; xi the attribute value at area I; \( \bar{x} \) the mean value of the attribute in the study region; and wij element of a spatial lag operator W (spatial weights of matrix W). The significance of the index is usually tested in a situation of normal distribution (Mazzulla et al., 2012). Global Moran’s I varies between -1 and 1 with a positive value meaning that a point in question is prone to be clustered by adjacent points, while a
negative value means the opposite. Values close to 0 indicate that the data is randomly distributed. **Local Moran’s I analysis** (Anselin, 1995) was applied to identify statistically significant hotspots, cold spot and outliers. Local Moran’s I is expressed by the following formula:

\[ I_i = x_i \sum_j w_{ij} x_j \]

The variables and calculation of the Local Moran’s I are thus similar to those of Global Moran’s I. It is possible to acquire the mean and the variance of \( I_i \) based on randomization, and inference can be carried out by normalized statistic with Z-score and \( p \)-value indicating statistical significance. The different classes of \( z \)-values are represented as High-High (HH) or Low-Low (LL). High, positive \( z \)-values indicate that an area is surrounded by areas have similar values. Conversely, a low negative \( z \)-score indicates a statistically significant spatial anomaly, *i.e.* a high-value area surrounded by low-value areas (HL) with a LH area representing the inverse (Huo et al., 2011; Samphutthanon et al., 2013).

### 2.3.2 Getis-Ord General G

Local spatial autocorrelation explores within the global pattern to recognize clusters (hot spots) that either drives the overall clustering, or that shows heterogeneities that depart from global pattern (Ord and Getis, 2001). Local hot spot analysis tool (Getis-Ord Gi*) used to explore the spatial gathering hotspots and cold spots of the COVID-19 pandemic in Cairo. The Getis-Ord Gi* Index is defined as:

\[
Gi^* = \frac{\sum_{j=1}^{n} w_{ij} x_j - \bar{x} \sum_{j=1}^{n} w_{ij}}{\sqrt{n \sum_{j=1}^{n} w_{ij}^2 - \left( \sum_{j=1}^{n} w_{ij} \right)^2}} \frac{1}{S \sqrt{n-1}}
\]

Where \( n \) is the number of spatial units that need to be analyzed, \( x_i \) and \( x_j \) are the attribute values of the COVID-19 confirmed case in locations \( i \) and \( j \), respectively, \( W_{ij} \) is the spatial weight between elements \( i \) and \( j \), and \( x \) is the average value of the attributes and \( S \) is the standard deviation.
3. Results

3.1 Analysis of COVID-19 pandemic in Cairo

3.1.1 Mapping the distribution of COVID-19

The Morbidity and fatality rates of Covid-19 in the (46) districts provinces in Cairo as can be seen from Table (1) and Figure (2), depicting the situation during the study period, (From 14 February 2020 to 18 of May 2021), the top five districts with respect to cases number of Covid19 were the following provinces: Nasr city (5466), Helwan (3882), Bolaq (3093), Al Sayeda Zainab (3015) and Al Khalifa (2975). Moreover, the districts with the highest Morbidity rate were Al- Mouski (0.097/100000), Badr (0.088/100000), Qasr Al-Niel (0.088/100000), Al Gammalia (0.066/100000) and Al Zamalek (0.064/100000), Figure (3).

Table 1. Morbidity and fatality rate of Covid-19 in Cairo regions.

| Region          | district       | total population | Confirmed cases | Covid-19 Morbidity (per 100000) | Fatality cases | Percentage of fatality |
|-----------------|----------------|------------------|-----------------|---------------------------------|----------------|------------------------|
| Northern Region | Rod El farag   | 148353           | 1414            | 0.010                           | 164            | 0.12                   |
|                 | Monshat naser  | 263187           | 1357            | 0.005                           | 267            | 0.20                   |
|                 | Bab Elsharya   | 47541            | 1253            | 0.026                           | 184            | 0.15                   |
|                 | Al thaher      | 73212            | 1207            | 0.016                           | 131            | 0.11                   |
|                 | Al azbbakya    | 20132            | 1196            | 0.059                           | 136            | 0.11                   |
|                 | Al shrok       | 88909            | 1194            | 0.013                           | 114            | 0.10                   |
|                 | 15 Mayo        | 95313            | 1163            | 0.012                           | 96             | 0.08                   |
|                 | New Cairo 2    | 92360            | 1085            | 0.012                           | 114            | 0.11                   |
|                 | Total          | 829007           | 9869            | 0.012                           | 0.012          | 0.11                   |
| Southern Region | Nasr city 1    | 646634           | 5466            | 0.008                           | 505            | 0.09                   |
|                 | Helwan         | 530967           | 3882            | 0.007                           | 362            | 0.09                   |
|                 | Bolaq          | 49046            | 3093            | 0.063                           | 294            | 0.10                   |
|                 | Al Sayeda Zainab| 138826         | 3015            | 0.022                           | 307            | 0.10                   |
|                 | Al khalifa     | 107197           | 2975            | 0.028                           | 283            | 1.75                   |
|                 | Masr El qadima | 254980           | 2867            | 0.011                           | 246            | 0.09                   |
|                 | Badr           | 31877            | 2818            | 0.088                           | 276            | 0.10                   |
|                 | Al wayli       | 80774            | 2516            | 0.031                           | 248            | 0.10                   |
|                 | Al gammalia    | 37045            | 2453            | 0.066                           | 342            | 0.14                   |
|                 | Al marg        | 813529           | 2236            | 0.003                           | 185            | 0.08                   |
|                 | Al basatine    | 504659           | 2231            | 0.004                           | 218            | 0.10                   |
|                 | Nasr city 2    | 73523            | 2106            | 0.029                           | 210            | 0.10                   |
|                 | Total          | 3269057          | 35658           | 0.011                           | 0.011          | 0.10                   |
Table 1. (Continued) Morbidity and fatality rate of Covid-19 in Cairo regions.

| Region          | district               | total population | Confirmed cases | Covid-19 Morbidity (per 100000) | Fatality cases | Percentage of fatality |
|-----------------|------------------------|------------------|-----------------|----------------------------------|----------------|------------------------|
| **Eastern Region** |                        |                  |                 |                                  |                |                        |
| Al darb El Ahmar| 59578                  | 2033             | 0.034           | 249                              | 0.12           |
| Ain shams       | 625848                 | 1890             | 0.003           | 171                              | 0.09           |
| New Cairo 3     | 72203                  | 1825             | 0.025           | 165                              | 0.09           |
| Tora            | 234559                 | 1813             | 0.008           | 152                              | 0.08           |
| Al mouski       | 16973                  | 1649             | 0.097           | 206                              | 0.12           |
| Abdin           | 41076                  | 1629             | 0.040           | 192                              | 0.12           |
| Al Teben        | 73385                  | 1623             | 0.022           | 121                              | 0.07           |
| Al Matarya      | 613709                 | 1597             | 0.003           | 178                              | 0.11           |
| Al Sahel        | 322323                 | 1551             | 0.005           | 169                              | 0.11           |
| Hadaek Al- Qopa | 321968                 | 1550             | 0.005           | 156                              | 0.10           |
| New Cairo 1     | 138363                 | 1525             | 0.011           | 148                              | 0.10           |
| Al Nnozha       | 235557                 | 1499             | 0.006           | 124                              | 0.08           |
| Masr Al Gadida  | 136619                 | 1468             | 0.011           | 122                              | 0.08           |
| Al Salam 1      | 489674                 | 1432             | 0.003           | 102                              | 0.29           |
| **Total**       | **3381835**            | **23084**        | **0.007**       | **0.007**                        | **0.11**       |
| **Western Region** |                        |                  |                 |                                  |                |                        |
| Al Zaton        | 177431                 | 1066             | 0.006           | 109                              | 0.10           |
| Al -moqatam     | 228316                 | 1058             | 0.005           | 111                              | 0.68           |
| Al Masara       | 275071                 | 1023             | 0.004           | 94                               | 0.28           |
| Al -Sharabya    | 190695                 | 1000             | 0.005           | 78                               | 0.08           |
| Al Maady        | 90231                  | 996              | 0.011           | 91                               | 0.09           |
| Al Zamalek      | 15225                  | 977              | 0.064           | 129                              | 0.13           |
| Qasr Al niel    | 10760                  | 949              | 0.088           | 75                               | 0.08           |
| Dar El– Salam   | 525638                 | 924              | 0.002           | 79                               | 0.26           |
| Shobra          | 78128                  | 864              | 0.011           | 98                               | 0.11           |
| Al zawya El- hamra | 324107              | 734              | 0.002           | 34                               | 0.05           |
| Al Amerya       | 155402                 | 367              | 0.002           | 17                               | 0.05           |
| Al-Salam 2      | 156633                 | 331              | 0.002           | 37                               | 0.11           |
| **Total**       | **2227637**            | **10289**        | **0.005**       | **0.005**                        | **0.17**       |
| Desert Hinterland | 310087                | 230              | 0.001           | 0.001                            | 0.17           |
| **Total Cairo** | **10017623**           | **79130**        | **0.008**       | **0.008**                        | **0.16**       |
Figure 2. Geographical distribution of cumulative confirmed COVID-19 cases in Cairo from 14 February 2020 to 18 of May 2021.

Figure 3. Morbidity rate of COVID-19.
3.2 Mapping Population Density

Population density has been used as a surrogate measure of social distancing capacity and study has shown that COVID-19 transmission is potentially more likely to occur among districts with higher population densities as can be seen from the map of population density in Cairo, figure (4).

![Population density map of Cairo](image)

**Figure 4.** Population density.

3.3 Analyses of Spatial Patterns

3.3.1 Global Spatial Cluster Analysis

Here, a spatial autocorrelation statistical model is used to conduct a global autocorrelation test of the significance of the Moran's I index on the COVID-19 outbreak data of Cairo From 14 February 2020 to 18 of May 2021. Cairo 46 administrative regions were greater than zero (positive) for Covid-19 according to Global Moran’s I calculations (Figure 5-A). Moran’s I and the z-score were 0.525915 (p=0< 0.01), 15.856186, respectively, indicating that the morbidity of Covid-19 was significant positive spatial autocorrelation and spatially clustered between regions in Cairo COVID-19 pandemic. It can be found that the Moran's I index for recovery cases of Covid-19 Moran's I = (0.499273) is greater than zero. The z-score is 15.05645 and p < 0.01 (Figure 5-B), indicating that there is a significant
positive spatial autocorrelation, and Moran's I index for Covid-19 fatality cases (Moran's I = 0.370994) is greater than zero. The z-score is 11.22548 and p < 0.01 (Figure 5-C), indicating that there is a significant positive spatial autocorrelation also.

Figure 5. Global spatial autocorrelation analysis of Covid-19 (global Moran's I index).
3.3.2 Local Spatial Cluster Analysis

Local spatial cluster analysis used to reveal the correlation between the spatial geographical unit and its adjacent spatial unit attribute feature values, and to identify ‘hot spots’ and heterogeneity test of their data. The results of Local Moran’s I analysis for the morbidity cases reveals that the value of 71 sheikhs belonging to the HH aggregation class. Eastern, Northern and southern Cairo were found to be the major High morbidity cluster of COVID-19, while western Cairo was identified as Low morbidity clusters. The Covid-19 morbidity in Cairo shows that the current COVID-19 pandemic has developed hotspots (HH) and cold spots may develop (LL). The results are shown in Figure (6). A Similar clusters pattern was observed for the recovery cases as displayed in Figure (7) indicating that Cairo has a highly recovery rate of COVID-19. Cluster analysis of fatality cases, showed Eastern and Southern Cairo as high fatality cluster of COVID-19 while Northern and western Cairo were identified as Low fatality clusters as displayed in Figure (8).

![Local spatial autocorrelation analysis of COVID-19 morbidity cases.](image)

**Figure 6.** Local spatial autocorrelation analysis of COVID-19 morbidity cases.
Figure 7. Local spatial autocorrelation analysis of COVID-19 recovery cases.

Figure 8. Local spatial autocorrelation analysis of COVID-19 fatality cases.
3.3.3 Hot Spot Analysis

To identify COVID-19 hot-spots, the Getis-OrdGi statistic was applied and the results are depicted in Figure 7. The clustering of high values (hot spots) for morbidity were distributed with a confidence level of 99% in eastern, southern and northern east of Cairo while the indicator detected clustering of low values (cold spots) in the central part of the western region of Cairo with a confidence level of 99% as demonstrated in Figure (9). The clustering of the cold spot with a confidence level of 95% and 90% was distributed around the central part of the western region, similar clustering distribution of the hot spot and cold spot were observed for the recovery and fatality cases as displayed in Figures (10) & (11). The spread of the COVID-19 virus is affected by some factors (Lin et al., 2020) such as higher population density and population movement which may lead to higher COVID-19 infections (Ahmadi et al., 2020).

Figure 9. Hot-spot map of COVID-19 morbidity cases in Cairo.
Figure 10. Hot-spot map of COVID-19 recovery cases in Cairo.

Figure 11. Hot-spot map of COVID-19 fatality cases in Cairo.
4. Discussion

The COVID-19 pandemic in Cairo is a part of the worldwide pandemic of coronavirus disease (COVID-19). Egypt's health ministry announced the first case in the country at Cairo International Airport on 14 February 2020. This study is the first study that maps vulnerability to COVID-19 morbidity, recovery cases and associated fatality in Cairo at a high resolution. This study aims to analyze the reported Covid-19 incidence by spatial statistical methods, exploring the geographical distribution of the disease. The spatial autocorrelation (global Moran’s I) during the study period showed that the Morbidity rate, recovery and fatality of COVID-19 in the study area was in the clustering pattern, and there was less than 1% likelihood that this clustering pattern could be the result of random chance. While local spatial correlation analysis showed that the value of 71 locations belonging to the HH aggregation class because these areas have high population density. Eastern and southern Cairo was found to be the major High morbidity cluster of COVID-19, while western Cairo was identified as Low morbidity clusters. Answers to the questions whether the disease will stay in the same geographic location or spread to nearby areas, and whether the measures applied to contain further spread are effective, require HL cluster analysis extended over a longer time. Hot spot analysis (Getis-Ord GI) is considered as a helpful tool to recognize spatial clusters of both high and low values, and has previously been applied to model several disease outbreaks (Martin et al., 2011; Firestone et al., 2012). Following identifying the districts in the hot spots’ area, preventive measures should be taken to halt the further spreading of the virus in neighboring districts and governorates, especially those located in cold spots. There is also a need to evaluate the influencing factors such as environmental, climatic, etc. components that have caused the formation of hot spot clusters in these districts. Our study also showed that the risk for severe cases of COVID-19 infection is high in the most parts of Cairo. This may be due to the high prevalence of population density in the capital. Population mobility could be regarded as a factor that led to the spread of the disease. The high infection rate in Cairo at this initial stage is expected, given that Cairo is a major travel hub and Bole International Airport, located in the governorate, is one of the largest international airports in Africa. This exposes Cairo to a higher risk of imported cases and, subsequently, to an early surge of infections, leaving the areas outside the governorate at a higher risk of later infection. Besides, epidemiological and virological data suggests that COVID-19 is primarily transmitted to contacts through respiratory droplets, virus-contaminated objects and surfaces. In the absence of effective human intervention, environmental factors and climate (such as humidity and wind direction) may spur the spread of the pandemic (Lin et al., 2020; Ward et al.,
2020). Some recent studies also indicate that temperature, humidity and wind speed may affect the morbidity rate of COVID-19 (Ahmadi et al., 2020; Ma et al., 2020). Therefore, climate factors related to the spread of the virus should be considered for some controlled measures. There are differences in climatic conditions in different regions and areas with high humidity are at greater risk of virus transmission. Control measures should be strengthened. The possibility of airborne transmission of the virus also needs to be considered in COVID-19 prevention and control. During an pandemic, population density in public places (supermarkets, shopping malls) and public transport (subway, bus) should be controlled, and the risk of spread of the disease should be reduced by frequent disinfection and wearing masks. In order to contain the spread of the virus, Egypt suspended schools and universities for one month and encouraged electronic distance learning. Also, Egypt imposed a curfew from 7 pm until 6 am, during which all shops and markets are closed from 5 pm to 6 pm and are subjected to a complete shutdown on Fridays and Saturdays. Besides, all means of public and private transportation are suspended during curfew hours. Flight into or out of Egypt were also suspended in an attempt to reduce the risk of importing infection. All sports and many social activities were also banned to prevent the spread of COVID-19. (Medhat, M. A., et al., 2020) Egypt abandoned individual hospitals in every governorate to be assigned as quarantine hospitals for COVID-19 patients. Egyptian Ministry of Health and Population (MOHP) decided to relay on a medical team composed of different specialties to take care of the inpatients in these quarantine hospitals (Medhat, M. A., et al., 2020). Depending on Egypt's situation on the WHO official website https://covid19.who.int/region/emro/country/eg, there have been 325,508 confirmed cases of COVID-19 and 18,333 coronavirus-related deaths reported in the country since the pandemic began until 23 October 2021. Egypt has administered at least 9,391,465 doses of COVID vaccines so far. Assuming every person needs 2 doses, that’s enough to have vaccinated about 4.7% of the country’s population. As of 23 October 2021, a total of 25,083,832 vaccine doses have been administered.

5. Conclusions

- COVID-19 is characterized by a long incubation period, strong infectivity and difficulty of detection, which has led to the sudden outbreak and the rapid spread of an pandemic. This situation requires GIS and big data technology to allow rapid responses and analyses, a quick supply of information about the pandemic dynamics and an understanding of the pandemic spread rules to provide timely support for the prevention and control decisions and actions.
This study depended on the preparation of new geodatabase for the COVID-19 pandemic based on the COVID-19 pandemic available data and using ArcGIS spatial statistics methods to analyze spatial patterns of the COVID-19 pandemic and explored the correlation analysis from 14 February 2020 to 18 of May 2021.

- Hotspot analysis coupled with Anselin local Moran’sI provides a scrupulous and objective approach to determine the locations of statistically significant clusters of COVID-19 cases shedding light on the high-risk districts. The study offers maps that can guide the targeted interventions necessary to contain the spread of COVID-19 in Cairo.

6. Recommendations

This study identified the provinces with high and low Covid19 clusters in Cairo. Spatial correlations between districts may provide instructive information for the control of Covid-19 pandemic in Cairo. Follow-up HL cluster analysis with a longer time perspective is advised.

7. Author contribution

The authors confirm contribution to the paper as follows: study conception and design: Second. Author; data collection and methodology: First. Author; Geodatabase Preparation: All. Authors; analysis and interpretation of results: Second. Author; draft manuscript preparation: First. Author. All authors reviewed the results and approved the final version of the manuscript.

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9. Declarations

Authors declare that no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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التحليل الجغرافي لإنتشار فيروس كوفيد-19 بمحافظة القاهرة باستخدام نظم المعلومات الجغرافية

الملخص

تسبب فيروس كورونا المستجد (كوفيدي-19) في أزمة صحية عامة عالمية أثرت على معظم البلدان بما في ذلك مصر. ونظراً لتفشي الجائحة، جذب تطور كوفيدي-19 اهتماماً عالمياً متزايداً.

وتهدف هذه الدراسة إلى تحديد ورصد الانتشار المكاني للجائحة اعتماداً على استخدام اساليب التحليل الإحصائي لحالات الإصابة المُبمغة بكوفيدي-19. فضلا عن استكشاف أنماط التوزيع الجغرافي للجائحة كوفيدي-19 بالقاهرة في الفترة من 91 فبراير 0202 إلى 91 مايو 0209.

وعلى أساس الهدف، تم تطبيق برنامج ArcGIS v.10.3.1 لتطبيق تحميل الارتباط المكاني المكاني وتحديد نمط التوزيع الجغرافي من خلال تطبيق مؤشر موران العالمى Global Moran's I، وتطبيق مؤشر موران المحلي Local Moran's I، وتطبيق مؤشر Getis-Ord Gi لاستكشاف البقع الساخنة والباردة للجائحة كوفيدي-19. أُبَيَّنَت مباشرة القاهرة عن 9492 حالة اصابة بكوفيدي-19 وذلك حتى 91 مايو 0211 واحتلت الأقسام الآتية المراكز الخمس الأولى من حيث ارتفاع معدل الإصابة والذي بلغ نحو (97/000/0000) بالموسي و(88/000/0000) بصر النيل و(66/000/0000) بالجمالية و(44/000/0000) بالزمالة. وأظهرت النتائج تحليل موران العالمي أن معدل الإصابة والتعافي والوفاة في كوفيدي-19 كان في نمط التجميع High clustered في المناطق للكثافة السكانية المرتفعة. بينما أظهر تحليل الارتباط المكاني المحلي أن قيم 91 شياخة تنتمي إلى فئة تجميع High High cluster، وأن تجمع القيم العالية التي تمثل البقع الساخنة توزعت في شرق وجنوب شرق القاهرة بمستوى ثقة 99%.

الكلمات المفتاحية: كوفيدي 19، نظم المعلومات الجغرافية، الارتباط المكاني الثقافي، البقع الساخنة/الباردة، القاهرة.