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(REVIEW ARTICLE)

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A systematic literature review of [illegible] geographic information system in COVID-19 studies

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Abstract

Geographic information science (GIS) has established itself as a distinct domain and incredibly useful whenever the research is related to geography, space, and other spatio-temporal dimensions. However, the applications of GIS in the study of COVID-19 remained limited. In this systematic literature review, the current applications of GIS in COVID-19 studies were assesed. A total of 50 research articles related to applications of GIS were systematically retrieved and reviewed. There thematic groups were grouped, namely

- The use of GIS for mapping COVID-19,
- How to assess the impacts of the COVID-19 pandemic on socio-economies and environment, and
- The assessment of the community vulnerability and risks during the pandemic.

It was found that GIS shows great importance in the study of COVID-19. The wide range of applications offered by GIS could significantly improve how we fight the COVID pandemic.

Keywords: Geographic Information System; Spatial analysis; Spatial statistics; Web mapping; Applications; COVID-19; Literature review

1. Introduction

Since early 2020, the COVID-19 pandemic has been a substantial threat to public health worldwide. COVID-19 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (1). The virus quickly spread to other countries in eastern Asia, Europe, and the remainder of the world (2). As of 05 July 2023, a total of 768,983,095 confirmed cases of COVID-19 including 6,953,743 deaths were reported to World Health Organization (3). It is therefore, applications offered by GIS play important roles for understanding the COVID-19 pandemic.

Geographic Information Systems (GIS) is a suite of software tools for mapping and analyzing data which is georeferenced (assigned a specific location on the surface of the Earth, otherwise known as geospatial data). GIS can be used to detect geographic patterns in other data, such as disease clusters resulting from toxins, sub-optimal water access, etc. GIS has been commonly used for monitoring and management of natural resouces (4–7), environment (8–10) and climate change (11,12). The applications of GIS have been widely applied in health sciences such as effective and fast decision making (13,14), prediction and analysis of diseases (15,16), management of health programs (17,18), diseases (19,20) and environmental health (21,22), accessing mental health services (23,24), disease mapping (25,26), and investigating epidemics (27,28). For instance, there have been attempts to investigate the use of GIS in disease

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studies such as the analysis the geography of disease (29) and in the study of the global distribution of infectious diseases (30).

The objective of this study is to conduct a systematic literature review of applications offered by GIS to help address different issues related to the study of the COVID-19 pandemic. The content is presented under three sub-sections; namely the use of GIS for mapping COVID-19, investigating of the impacts of the COVID-19 pandemic on socio-economies and environment, and the assessment of the community vulnerability and risks during the pandemic.

2. Methodology

2.1. Materials

In this study, a total of 50 scientific papers colected from Web of Science, SCOPUS, and Google scholar databases was used. These were mostly high impact and were mainly published in recent years after the COVID-19 outbreak.

2.2. Methods

We firstly queried Web of Science, Google Scholar, and SCOPUS databases with different combinations of keywords including 'GIS' or 'Geographic Information System', 'spatial analysis', 'mapping' or 'WebGIS', 'COVID-19' or 'SARS-CoV-2', 'the COVID-19 pandemic', 'applications' or 'the use', and 'review' or 'overview'. Four different sub-topics was then identified based on applications of geospatial techniques including GIS, remote sensing, GPS and Internet mapping technologies in the study of the COVID-19 pandemic. Finally, different types of applications of geospatial techniques in the study of COVID-19 were summarised and discussed.

3. Results and discussion

3.1. Mapping the spatial distribution of the COVID-19 pandemic

GIS tools can map and visualize the relationship between location coordinates and COVID-19 pandemic (31). One of the first example of WebGIS application during this pandemic is the web-based near-real-time COVID dashboard created by the Johns Hopkins University (32,33) . Later the WHO and different local and regional governing bodies also followed the same direction (3).

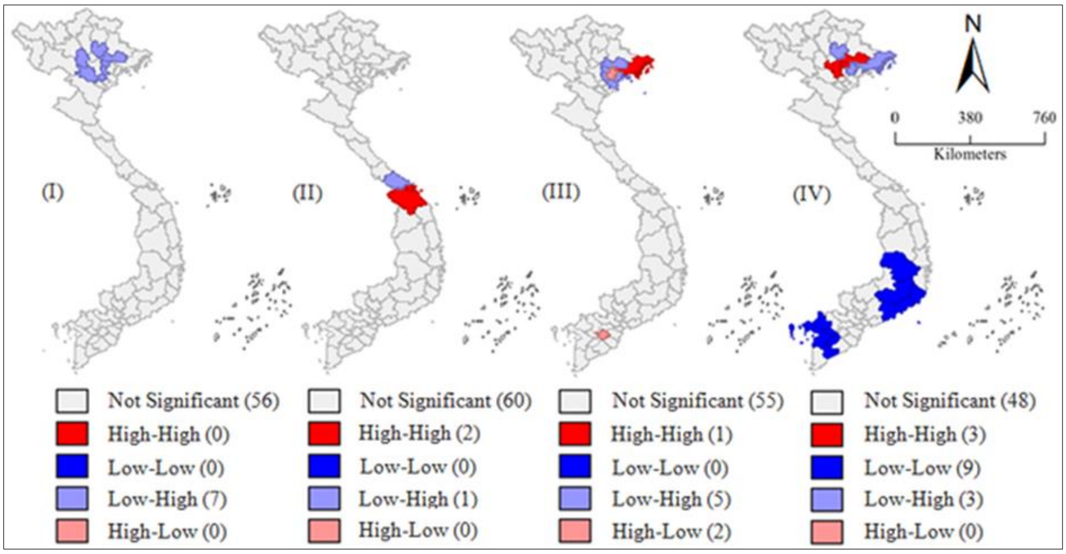

Figure 1 An example of using spatial statisitcs to identify spatial clustering of transmitted cases in four COVID-19 waves in Vietnam (34)

A part from using WebGIS, spatial statistics have been also used for detecting COVID-19 spatial clustering and hot spots. For instance, to identify the spatio-temporal clustering of COVID-19 hot spots and cold spots in Vietnam using spatial statistics. The local Getis-Ord's G_i^* statistic was successfully applied to detect hotspots and coldspots of COVID-19 cases in four waves in Vietnam. The results showed that seven hotspots of COVID-19 cases in provinces were detected in areas of high population density in the north-eastern region of Vietnam (Figure 1). Also in Vietnam, the local Moran's I spatial statistic and Moran scatterplot were successfully employed to identify high-high and low-low clusters and low-high and high-low outliers of COVID-19 cases from a dataset of 10,742 locally transmitted cases in four COVID-19 waves in 63 prefecture-level cities/provinces in Vietnam (Figure 1) (34). A Moran's I autocorrelation and spatial cluster analysis for identifying Coronavirus disease COVID-19 using GIS approach was also successfully carried out in Iraq (35).

3.2. Investigating impacts of the COVID-19 pandemic on socio-economies and environment

Since the COVID-19 pandemic spread globally, the social-economies and environment of almost all countries were badly affected (36). Accordingly, attempts have been made on the use of GIS in the study of impacts of the COVID-19 pandemic on social and economic activities and environment. For instance, a GIS-based spatiotemporal modelling of urban traffic accidents during the COVID-19 pandemic was successfully caried out in Tabriz City, the capital of East Azerbaijan province, north-west Iran (37).

As for environment change, the effects of lockdown on environmental degradation during the pandemic in Kabul city, the capital of Afghanistan, were also monitored using geospatial data and a statistical model of the Analytical Hierarchy Process (38). A recent study of (39) has investigated long-term effects of COVID-19, and its impact on business, employees, and CO_2 emissions, using Arc-GIS Survey 123 and Arc-GIS mapping. Similar findings were also reported by that, there were many positive environmental impacts during the COVID-19 lockdown, such as the reduction in air pollutant emissions ($PM_{2.5}$, PM_{10}, PM, NO_2, O_3, CO, and SO_2) globally (40).

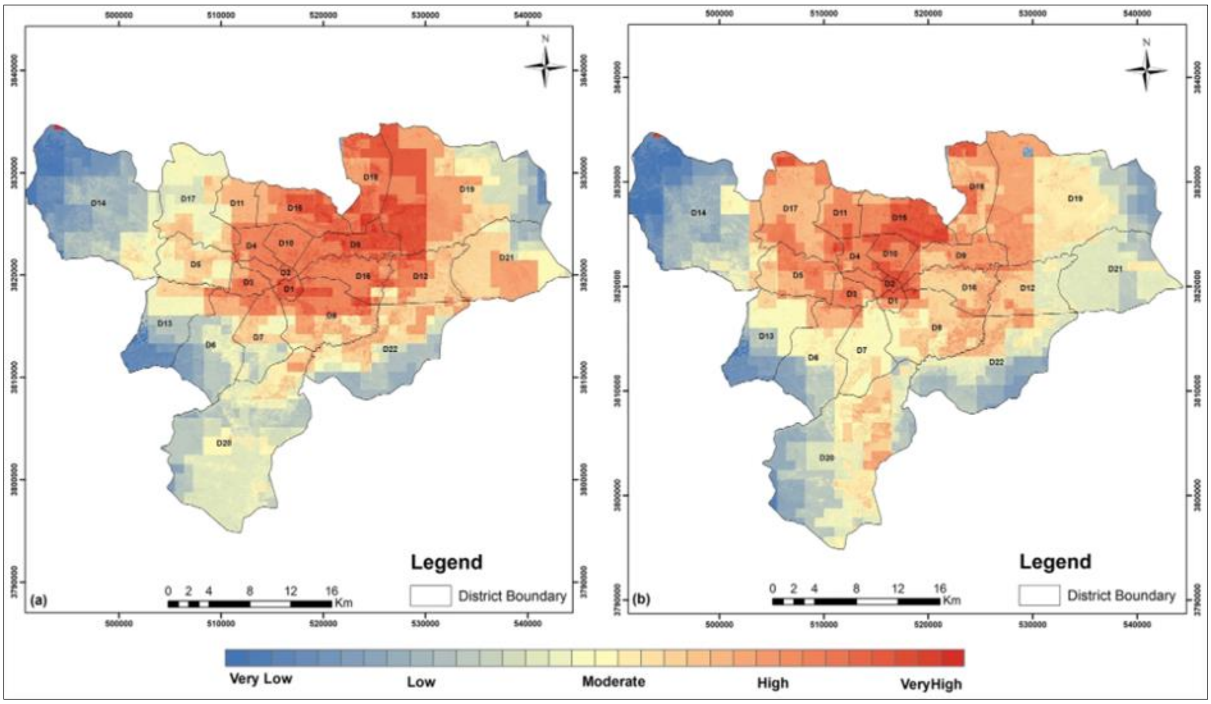

Figure 2 An example of using GIS to identify the intensity of environmental quality degradation over the Kabul city: a before COVID19 (left) and during the lockdown (right)

3.3. Assessing the community vulnerability and risks during the COVID-19 pandemic

With the main advantage of spatial analysis, GIS has been widely employed to assess the COVID-19 vulnerability in many contries over the world. For instance, in Palestine, the COVID-19 vulnerability map for the West Bank was successfully developed using the combination of Analytic Hierarchy Process, GIS, multi-criteria decision analysis and some selected potential criteria including population, population density, elderly population, accommodation and food service activities, school students, chronic diseases, hospital beds, health insurance, and pharmacy (41) (Figure 3).

Through geographic information system, attempts were also made to model the COVID-19 vulnerability using an integrated fuzzy multi-criteria decision-making approach, namely fuzzy-analytical hierarchy process and fuzzy-technique for order preference by similarity to ideal solution for West Bengal in India, (42). Also with the help of GIS, the analysis of vulnerability to COVID-19 occurrence was also successfully carried out other contries such as in the

United States (43), Ethiopia (44), Algeria (45), and México (46). A part from vulnerability assessment, a GIS-based spatial modeling approach was adopted to identify of risk factors contributing to COVID-19 incidence rates in Bangladesh (47), India (48) and other severely COVID-19 affected countries (48–50).

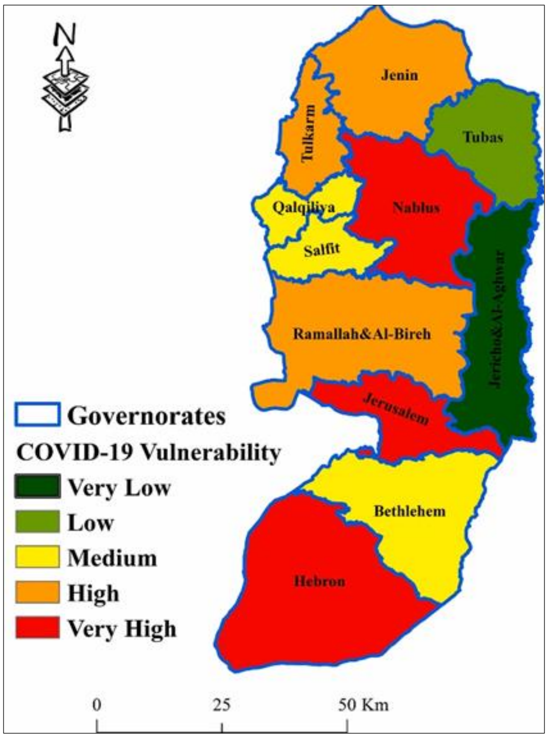

Figure 3 An example of using GIS for COVID-19 vulnerability map for the West Bank in Palestine (41)

4. Conclusion

To overcome limitation of recent studies in reviewing the applications of GIS in the study of COVID-19 pandemic, this work is a synthesis on the wide range of applications offered by GIS in COVID-19 studies. A total of 50 research articles related to applications of GIS were systematically retrieved and reviewed. The content was presented under three sub-sections; namely

- The use of GIS for mapping COVID-19,
- How to assess the impacts of the COVID-19 pandemic on socio-economies and environment, and
- The assessment of the community vulnerability and risks during the pandemic.

It was found that GIS shows great importance in the study of COVID-19 The wide range of applications offered by GIS could significantly improve how we fight the COVID pandemic. This study confirms the effectiveness of GIS in the study of the COVID-19 pandemic. This review provides new reflections and facilitates the development and improvement of GIS to study COVID-19.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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