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Environmental influencing factors of COVID-19 based on geographic information system techniques: A literature review

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Abstract. The global outbreak of COVID-19 has witnessed a significant and widespread impact since its emergence in 2019. It caused serious negative effects on both population health and economy widely. Numerous researches have been done on the COVID-19 pandemic. There were many articles focused on respective environmental influencing factors of COVID-19. In this research, we reviewed the research examining the environmental factors influencing COVID-19 based on geographic information system technology. We found that five influencing aspects, namely the natural environment, air pollution, society, economy, and government management had significant impact on the transmission of coronavirus. These influencing factors affected the COVID-19 by affecting the virus, the infection opportunity, and the susceptible populations. As these researches indicated the connection between COVID-19 and environmental influencing factors, scientific communities and government should abstract the essences to make valuable decisions in the future.

Keywords: COVID-19, environmental influencing factors, GIS.

1. Introduction

From December 2019 onwards, COVID-19 rapidly spread across the globe. According to the World Health Organization (WHO), as of 29th March 2023, there have been a staggering 761,402,282 confirmed cases of COVID-19, with a tragic loss of 6,887,000 lives. They included 99,238,143 confirmed cases of COVID-19 with 120,894 deaths in China [WHO]. Lately, United States, China, India, France, Germany, and Brazil had top confirmed numbers of cases [WHO]. The COVID-19 epidemic has brought a heavy threat to human life security and socio-economic burden. It is critical to effectively prevent and control the COVID-19 epidemic. The development of GIS technology provides effective technical means for epidemic prevention and control, and plays a critical role in the prevention and control of COVID-19.

A Geographic Information System (GIS) is a computer-based tool used to acquire, store, retrieve, process, analyze, and visualize geospatial data [1]. GIS can be applied across various fields including urban planning, environmental conservation, healthcare and marketing. Especially, it has been used for public health and disease control effectively.

Numerous notable efforts have been made in response to COVID-19, focusing on information dissemination and global case tracking. Esri, for instance, has played a crucial role by creating tools that incorporate mathematical models employed by epidemiologists, including the COVID-19 Hospital

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Impact Model for Epidemics (CHIME). In the early stages of the pandemic, Esri successfully implemented CHIME within ArcGIS Pro, utilizing Susceptible, Infected, Recovered (SIR) modeling. This integration enables the projection of hospital-related impacts and facilitates spatial visualization of these effects [2].

In Indonesia, the Emergency Spatial Support Center (ESSC), an initiative of Esri Indonesia, has developed the COVID-19 Geoportal. This platform utilizes data and information from multiple sources, following the principles of big data management. Esri has provided robust spatial portal developer software to support the functionality of the Geoportal. It is worth noting that there is currently a lack of a comprehensive system in Indonesia to facilitate spatial-based decision-making at the local level. Thus, the development of a GIS dashboard is highly recommended to assist provincial and district governments in making informed decisions [3].

The COVID-19 dashboard was launched by the CSSE team at Johns Hopkins University (JHU) in January 2020. It is followed by WHO for the WHO COVID-19 dashboard at the same month. They used Esri technology to create the dashboard and it immediately widespread to became the global reference for COVID-19 [3].

It has been extensively researched and managed by government agencies and international researchers, leading to many remarkable results. Although there are many research outcomes in terms of disease control and economy effects, systematic summaries about epidemic influencing factors are lacking. Therefore, this article will provide an overview of the research on the environmental influencing factors of the new COVID19 epidemic based on geographic information technology.

2. Method

Researches for this review were retrieved from Scopus, Google scholar, and CNKI. All of the websites are prestigious and comprehensive platform for academic articles. At first, we focused on several query to search articles: (“Coronavirus” OR “COVID-19” OR “SARS-CoV-2”) to confirm Covid-19 related researches. Moreover, we used another query to get articles about factors for virus transmission in the environment (“Environmental factors” OR “Influencing factors”). At last, using the operator “AND” to combined all the keywords to retrieved the articles related to our review topic. In order to limit the research technique in Geographic Information System (GIS), we filter out irrelevant articles according to their research approaches.

3. Discussion

People can effectively aid the disease control actions by studying the influencing factors of the spreading of COVID-19. The numerous environmental influencing factors can be divided as: the natural environment, air pollution, society, economy, and government management.

For natural environmental factors, people have controversial statements about effects of the UV radiation in sunlight on transmission of COVID-19. Some researchers claims that UV radiation in sunlight had positive relationship with the spreading of COVID-19. Based on data from the Seoul Metropolitan Area and the Daegu and North Gyeongsang Province, there was a positive relationship between daylight hours and the number of COVID-19 cases. One plausible hypothesis suggested a potential link between two factors that is increased viral transmission could occur before the virus is inactivated by sunlight [4]. On the contrast, some researches argued that UV radiation in sunlight could inactivate coronavirus. For instance, researchers used OMI satellite data to develop the SARS CoV D90 = 40 J/m2 model, and it suggested that outdoor horizontal surfaces, left unoccupied for a minimum of 90 minutes and exposed to UVB sunlight levels typically observed during midday under clear-sky conditions, are expected to experience approximately 90% inactivation of coronavirus. This phenomenon is more prominent during the Spring through Autumn months for mid- and low-latitude regions, while equatorial sites exhibit this effect consistently throughout the year [5].

Several natural factors were proved to have negative correlation with the spreading of COVID-19, which are atmospheric pressure, humidity, and temperature [6]. Atmospheric pressure plays a critical role in governing the dynamics of air movement, as well as influencing precipitation patterns and

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humidity levels. There was negative correlation between atmospheric pressure and coronavirus transmission which is because high pressure limits the suspension time of virus particles in the environment. Indirectly, atmospheric pressure can have an impact on reducing the spread of the virus by potentially constraining people's mobility [7].

Humidity has negative correlation with the COVID-19 transmission. Elevated relative humidity levels contribute to the inactivation of viral lipid membranes, leading to reduced stability and transmission of COVID-19 [7].

Several studies have identified a negative correlation between infection rates and temperature [7]. Yu Wu claims that an observed association indicates that each 1 °C rise in temperature corresponds to a 3.08% decrease in daily new cases [8]. Similarly, the statistics from Liu J presents that an observed relationship suggests that for every 1 °C increase in Diurnal Temperature Range (DTR), there was a decrease in the number of patients with a lag of 03, and the combined Relative Risk (RR) was calculated as 0.90. [9]. Also, Lin demonstrated that during the epidemic, days characterized by lower air temperatures were associated with an 18.18-fold higher risk (95% CI: 5.6, 58.8) of increased daily incidence of SARS compared to days with higher temperatures [10]. All these data indicate that the lower temperature, the higher number of COVID-19 cases. However, the other researches showed that temperature and UV radiation have no association with the spreading of COVID-19 [11].

In term of air quality, COVID-19 can be promoted by air pollution and exposure of chemicals. Those threatening substances led to impairment of human immune system, which can further cause COVID-19 infection and severity. To provide specific insights, research conducted by Lim indicated that a yearly increase of 1 metric ton in PM2.5 (log) would result in a 1.25-fold increase in the death rate [4]. Similarly, Wu, Nethery et al. found that even a slight increase of 1 μg/m3 in PM2.5 is associated with an 8% rise in the COVID-19 death rate, with a 95% confidence interval ranging from 2% to 15% [12].

Moreover, researchers assumed that ozone levels will breach the respiratory epithelial barrier, making the public more susceptible to infection [4]. According to discoveries from Sentinel-5P satellite, atmospheric inversion allows NO2 to accumulate at the surface, preveting air pollution from spreading. This has led to a high incidence of respiratory diseases and inflammation among local people [13]. Furthermore, the presence of oxidants in air pollution has the potential to cause DNA damage in the virus, leading to genomic alterations that may increase its infectivity or amplify its pathogenicity [14].

Chemical exposure also contributes to the spread of COVID-19, as long-term exposure to chemicals can damage the respiratory system and reduce immunity. Instances of such substances include metals like arsenic, cadmium, and lead, as well as endocrine-disrupting chemicals (EDCs) such as bisphenol A, phthalates, and perfluorinated chemicals [14].

Within society, many of these factors rely on population dynamics, making the spread of COVID-19 closely intertwined with population migration, which can potentially facilitate the transmission of COVID-19. Studies have shown a positive correlation between the migration index and confirmed cases of COVID-19. This indicates that during the initial phase of the epidemic, as migration rates increase, the likelihood of disease transmission also rises [15].

For the cold chain, the household refrigerators have formed closed loops of cold chain logistics that can reach many families in the world. It is likely to provide the perfect living space and global mobile environment for COVID-19, making the spreading of pandemic difficult to control [1].

In economic perspective: GDP, median household income, and income inequality have positive association with the COVID-19 transmission. At a national level, there is a positive correlation between gross domestic product (GDP) and various COVID-19 metrics such as the amount of cases, deaths, and infection growth rates. Using GBRTs analysis, an efficient machine learning algorithms [16], it was discovered that the number of cases exhibited a positive correlation with GDP, albeit in a nonlinear fashion. More specifically, there is a notable increase in the number of COVID-19 cases once a country's GDP surpasses the threshold of 60 billion US dollars. Furthermore, if the number of tourists visiting a country exceeds 20 million, the rate of increase in COVID-19 cases tends to rise rapidly.

Results of GWR and MGWR suggested that the considerable variation in disease incidence observed in the United States can be attributed to factors such as median household income and income inequality

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[17]. As the disease continued to spread, the economy rapidly declined, and unemployment rose. In the United States, for example, unemployed individuals face the risk of losing their health insurance coverage, thereby exacerbating the existing health disparities within the country [18].

For government management, the response of Chinese government can reduce the spread of coronavirus, and it has been demonstrated by several researches.

Non-pharmaceutical interventions (NPIs) encompass a range of measures, such as intercity travel restrictions, early case detection, early isolation, as well as the implementation of contact restrictions and social distancing. Without non-pharmacologic interventions (NPI), the model predicted a rapid increase in COVID-19 cases in China, projecting a 67-fold increase in the number of cases by February 29, 2020 [19]. Following the implementation of the travel ban from Wuhan on January 23, 2020, the overall progression of the epidemic in mainland China was only delayed by a modest 3 to 5 days. Furthermore, this measure resulted in a substantial reduction of international case importations, reaching nearly 80% by mid-February [20]. Overall, control measures have been effective in reducing the spread and severity of the epidemic.

4. Conclusion

This review integrated current articles about environmental factors of COVID-19 in terms of Geographic Information System. We categorized numerous environmental factors into the following divisions: Nature, air pollution, society, economy, and government management. Several factors have negative relationship with the transmission of coronavirus: UV radiation of sunlight, humidity, temperature, and Non-pharmaceutical interventions. On the contrary, air pollution, human mobility, human ages, GDP, inequality of income, and cold-chain logistics are positively related to the spreading of COVID-19. Among these, sunlight have controversial opinions from different researchers.

Our results point out that environmental factors have vital associations on the COVID-19 and many factors have controversial opinions. Some other researches discussed the pandemic with singular or binary factors, however, they lack of the comprehensive integration. In the future, it is necessary to explore the relationship between complex influencing factors of the pandemic. Meanwhile, various national control approaches could have different effects on the COVID-19 transmission which still required further study. As the growing need of interdisciplinary collaboration, utilizing scientific techniques to understand and resolve global issues are in demand. At last, we aims to study and create more available research to facility the communities to work in the COVID-19 pandemic.

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