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Commentary

Leveraging GIS and spatial analysis for informed decision-making in COVID-19 pandemic

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With more than 65 million confirmed cases and over 1.5 million case-fatalities around the world, the coronavirus disease (COVID-19) pandemic had changed the dynamics of human lives globally [1]. Different Geographic Information System (GIS) techniques are widely used across scientific disciplines, including public health, since the mid-1960s. In a study in 2014, it was found that one-fourth of the studies out of the reviewed 829 articles used GIS in some way, especially for infectious disease mapping [2]. Recently, GIS has played a critical role in understanding the spatial clustering and transmission trend of the ongoing COVID-19 [3]. However, it can be argued that the applications of GIS technologies could have provided more insights for research and practice in the context of COVID-19.

One of the most reliable documentation and near-real-time GIS-based tracking of COVID-19 cases was created and maintained by the Johns Hopkins University. The online dashboard and near-live tracking of cases and COVID-19 related fatalities were the first of its kind and aided the scientific community and practitioners in comprehending the magnitude of the pandemic during the early days [3]. Following these initiatives, the World Health Organization (WHO) has created its own online dashboard that reports country-level confirmed cases, daily deaths, and trends in an interactive manner [1]. More local level examples have provided substantial information to the public regarding what is happening in their communities [4]. One other early application of GIS in COVID-19 related studies was determining whether meteorological factors have any association with the virus transmission. Studies used different statistical and spatial analytical techniques to examine the relation between COVID-19 cases and temperature, wind speed, solar radiation, daylight hours, and humidity [5]. These techniques include different regression analysis types (Paez, Lopez et al. 2020 used seemingly unrelated regressions to identify the correlation between incidence rate, temperature, and humidity. Their study reported lower incidence rates at a higher temperature and higher humidity level. Similarly, other studies also reported a non-linear relationship between COVID-19 infection rate and temperature, humidity, and air quality improvement [6,7]). Further applications of GIS in COVID-19 related studies were focused on either visualizing the case counts on maps or displaying it based on different administrative boundaries. However, a few studies used GIS for hotspot analysis to identify the concentration of confirmed cases or deaths or vulnerable locations. These hotspot analyses helped to identify the spatial clustering of the incidences and aided in identifying the clusters of vulnerable groups, regions needed immediate action, and clusters of cases among fast responders and hospital workers [5].

Among other spatial analysis techniques, proximity analysis was used by a few studies to identify the distances to the nearest health care facilities. These studies used network analysis to calculate the accessibility to health care facilities and resources to determine the resiliency level of any cities [8]. Global and Local Moran's Index, Spatial Autocorrelation Indices, Local Indicators of Spatial Association (LISA) model were similarly used to determine the clusters of confirmed cases or how different communities are affected by pandemic and whether there was any relation between race and COVID-19 mortality rate. The study in the Chicago

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area was found that the COVID-19 related mortality rate was much higher among the African American communities, and it has a relation with minority status and language [9].

Few studies also used satellite images, particulate matter concentration (NO_2, CO, SO_2, CO_2), and Air Quality Index (AQI) to compare how air quality had changed during this pandemic. One of the studies in China found that the usual trend of NO_2 and SO_2 concentrations decrease before the festival and increase afterward was not noticed in 2020 [10]. Similar studies on human mobility and transportation activities found a reduction in vessel activity in the lockdown period in the European Union maritime regions. Although social distancing and spatial transmission is the most crucial aspect of this pandemic, GIS was not used extensively. At the same time, as we are moving to a world after COVID-19, GIS and other spatial analysis techniques could be of incredible help for the policymakers to adopt different spatially explicit policies during this pandemic as well as in the post-pandemic world.

So far, very few studies had used geospatial analysis to identify Spatio-temporal clusters and prediction modeling for COVID-19 transmission. These studies utilized the Poisson probability distribution model, Kernel density analysis, and space-time scanning analysis to identify high-risk Spatio-temporal clusters for transmission of COVID-19 [11,12]. Future epidemiological studies focusing on spatial and temporal variations of COVID-19 may inform clusters of high-risk individuals necessitating targeted interventions and other public health measures. It is well accepted by now that travel restrictions helped to slow down the COVID-19 spread to some extent. However, only two studies so far studied how travel restrictions may have limited the epidemic trajectory. One of them developed a global model based on internationally reported cases and mobility data to project the impact of travel limitations on the national and international spread of the epidemic and revealed that the Wuhan travel ban only hindered the overall epidemic trajectory by 3 to 5 days in other cities of China but had a significant influence on the international scale dispersion [13]. As the world is going back to its previous day to day activities and countries are opening its border to international travels, it would be good to use spatial-modeling to predict the best and worst-case scenarios and prepare accordingly.

As different countries are experiencing advanced waves of COVID-19, countries must prepare themselves with better surveillance and contract-tracing techniques. The integration of GIS-based surveillance methods will provide greater flexibility and efficiency to prevent any outbreak and track the cases in a near-real-time manner. China already employed a social-media based contract tracing app in March. The integration of GIS in such applications will help identify the cases or clusters and trace other people in contact with the patients and keep them in quarantine. Google community mobility reports provide data on how communities are moving around during this pandemic, and spatial analysis of those could help understand the outbreak trends [19]. ArcGIS and other open-source GIS software provide web-based application development options, which could be of great advantage for more accurate and geocoded surveillance and contact tracing. However, as ArcGIS is not open-source and costs a significant amount of money, it would be beneficial to use platforms to allow reproductivity. For example, RStudio and ecosystem is a powerful platform to perform both statistical and spatial analysis [14–17]. The use of open-source spatial analysis software and the data from open-source repositories (i.e., google community mobility reports) will help underprivileged communities use the techniques to reproduce the studies and extract the intended benefit of that scientific work. Paez, Lopez et al. 2020 is an excellent example of reproducible studies. It used open-source data and software platforms and made the code available to the public.

One of the best uses of GIS is to predict spatially explicit growth, which is still missing in COVID-19 related studies. GIS has not been used widely to track the transmission pattern and predict transmission at the initial stages. It is essential to leverage GIS to predict the confirmed case numbers and specific locations where the outbreak would happen with higher statistical precision. Although both suitability analysis and hotspot analysis were used to some extent, those could be further used to identify health care facilities, as well as quarantine sites, informing local and regional resource mapping and subsequent planning. However, alongside the distance to the health care facilities, GIS could be employed to identify the areas underserved by the existing infrastructures. Therefore, this analysis could be of immense benefit to the practitioners in identifying areas that would need immediate action and eliminate service disparities [18]. Similarly, satellite images and processed rasters could be used in GIS to identify the changes in Green House Gas (GHG) compositions, Urban Heat Island (UHI) effects and energy consumption patterns, and epidemiological clusters. Such GIS-based modeling of the spatially-explicit numbers and growth direction may enable the policymakers to adapt context and location-specific policy measure to prevent outbreaks, isolate infections, minimize community transmission, enforce public health guidelines, whenever necessary.

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None declared.

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