# APPLICATION OF SPATIAL ANALYSIS IN THE DETECTION OF POPULATION AT RISK FROM COVID-19 IN SERBIA

Suzana LOVIĆ OBRADOVIĆ, *Geographical institute „Jovan Cvijić" of the Serbian academy of sciences and arts;* s.lovic@gi.sanu.ac.rs

Stefana MATOVIĆ, *Geographical institute „Jovan Cvijić" of the Serbian academy of sciences and arts;* s.babovic@gi.sanu.ac.rs

## Introduction

The first case of Coronavirus Disease 2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was recorded in late 2019 in Wuhan, China (WHO 2020), after which it gradually spread to all other inhabited continents. After the first reported case outside the borders of China, in Thailand on January 13, Ministry of Health, Labor and Welfare reported imported case of laboratory-confirmed 2019-novel coronavirus in Japan on 15 January, and five days later National IHR Focal Point (NFP) in the Republic of Korea (WHO, 2020).

The first identified case in Serbia was recorded on March 6, 2020. Until the end date of the study (21 November), 110,351 confirmed cases were recorded at the state level, while the data at the municipality level were available for a limited period. The number of recorded cases varied not only over time, but also varied with space. The virus, in addition to the medical one, thus acquired a geographical dimension, and spatial analyzes gained credibility for active participation in the research of its spread.

## Background and objective

Spatial analyzes have a tradition in the research of infectious diseases since the middle of the 19th century (John Snow's map of cholera outbreaks in 1854), but their wider application is in line with the development of geographic information systems. The integration of place in demographic research has become a necessity (Lović Obradović & Vojković, 2020), and the necessity of implementing geographic information in the identification of vulnerable groups to COVID-19 stems from the fact that each space is determined by a set of characteristic features. In this regard, an individual approach is necessary for defining place-specific measures to protect the population and prevent the spread of viruses. Therefore, spatial contexts of demographic and health data is becoming increasingly important (Kumar, 2007). The incorporation of the spatial information in the study enables the identification of potential risk areas.

Researches, published in the world's most eminent scientific journals, indicate that there are different degrees of resistance of certain categories of the population to COVID-19 (Beam Dowd et al. 2020; Lee et al. 2020; Koff Williams 2020; Sidaway, 2020; Huang et al. 2020). Thus, among the most vulnerable are: the population aged 65 and over, as well as people of any age with certain underlying medical conditions (cardiovascular and respiratory disease, cancer, diabetes, etc.). The importance of identifying the population at risk comes to the fore if the number of suspected cases exceeds the available testing capacity in a country or an area, or places were elderly people and among others, those with underlying chronic medical conditions such as lung disease, cancer, heart failure, hypertension, diabetes, who show signs of acute respiratory illness, etc., may need respiratory support sooner than people who are not in a risk group" (European Centre for Disease Control and Prevention 2020). Finally, the objective of the manuscript is identifying potential risk areas of COVID-19 based on the spatial grouping of population demographic characteristics (population aged 65 and over) and the share of the infected by COVID-19 in the total population of the municipality in the period from March 6, to April 14, 2020.

## Methodology

*Study area:* The research covers the territory of the Republic of Serbia. The analysis included 168 municipalities, as the lowest territorial level for which the data on infected by COVID-19 are available.

*Data:* Data on the population aged 65 and over in total population, were taken from the publication of the Municipality and Regions in the Republic of Serbia and refer to 2018, as the year with the last official data on the studied parameters. As a determinant of the age structure of the population, the share of people older than 65 was chosen because the strictest prohibition measures from the beginning of the declaration of the state of emergency on March 15, 2020 referred to this group of the population. As a secondary source, for the purposes of geocoding (obtaining longitude and latitude coordinates), the Google Earth application was used, for the determination of the locations of municipal centers.

*Analytical strategy:* We used optimized hotspot analysis, to determine statistically significant hotspots and coldspots of vulnerable group, based on the local spatial dependence indicator $Gi^*$. The results of the analysis indicate the formation of statistically significant hotspots (shades of red), when the value of the neighborhood (a group features around the feature, including feature itself) is statistically significantly higher than the study area. In this case are very high values of *p*-value and very low values of *z*-score the feature is marked as a coldspot (shades of blue) when the value of the neighborhood is statistically significantly lower than the study area (very low values of *p*-value and very high values of *z*-score). Confidence level can be 90%, 95% and 99% and is conditioned by the values of *z*-score (standard deviation), and *p*-value (probabilities). Non-significant features are marked with gray color, and they do not belong to cold- or hotspot, which means that the features are not spatially clustered. The analysis was conducted in ArcGIS Pro (Version 2.5).


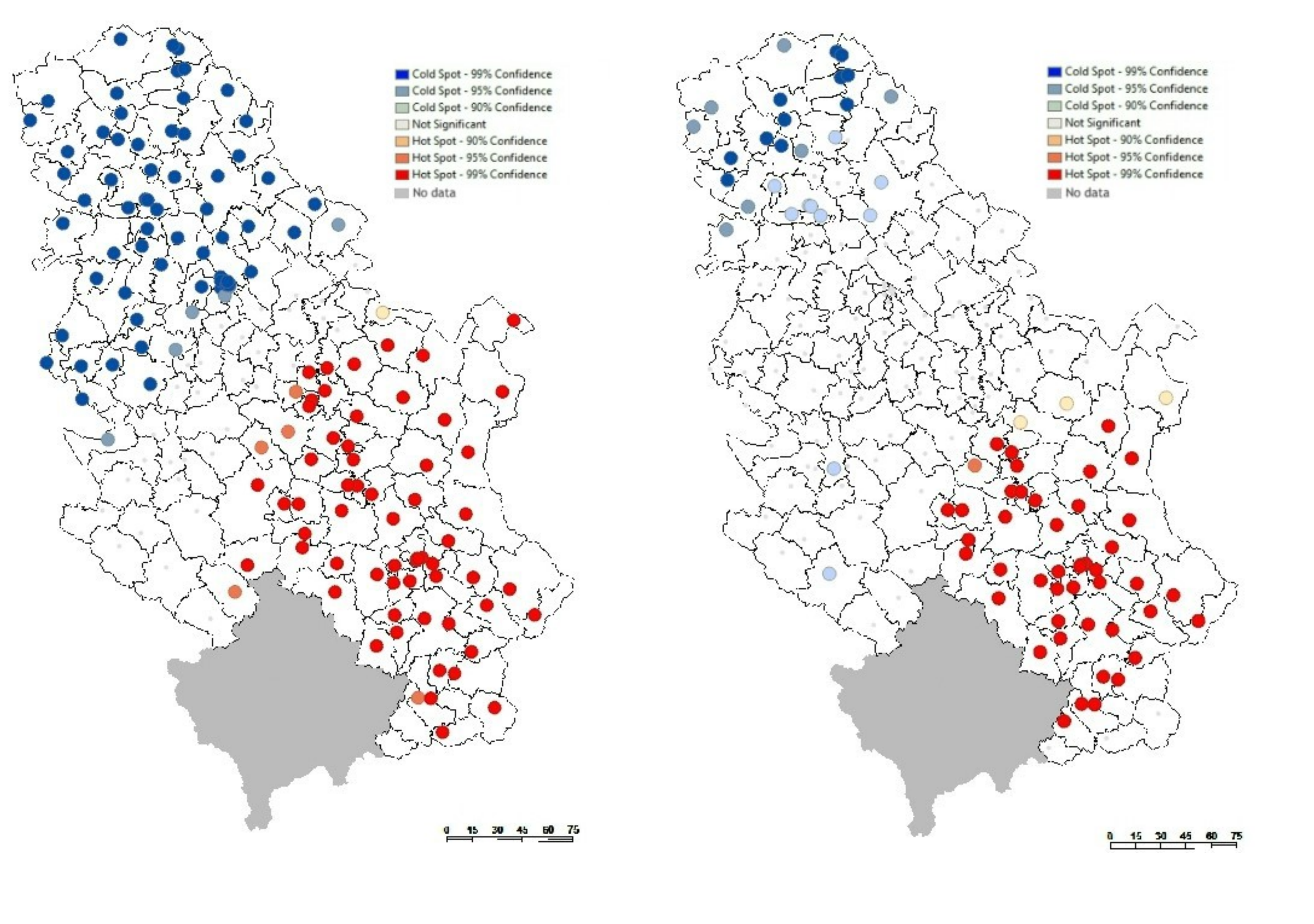


*Figure 1.* Optimized hot spot analysis results: (A) The share of the population aged 65 and over and (B) the share of the infected by COVID-19

## Results

Results are cartographically presented. Figure 1A shows the results of the optimized hot spot analysis of the share of the population aged 65 and over in the total population of the municipality. Two strong clusters are formed. The cluster of 64 statistically significant hotspots is concentrated in the central, eastern, southern, and southeastern parts of Serbia. In these municipalities, the share of people aged over 65 is higher than the national average and they are also surrounded by the municipalities with higher values. The cluster of 67 statistically significant coldspots is concentrated in the northern and western parts of Serbia, including the Belgrade region. Other municipalities are marked as non-significant, which means that the values of the share of people older than 65 in the total population do not tend to be spatially clustered, but are randomly distributed in space.

Cartographically presented results of the optimized hot spot analysis indicated notably grouping of statistically significant coldspots and hotspots of infected by COVID-19 in the period from March 6 to April 14, 2020, pointing to two different Serbia (Figure 2B). A strong cluster of 47 statistically significant hotspots is located in the southern, eastern, and southeastern parts of Serbia. The cluster of 25 statistically significant coldspots is located in the northern part of Serbia. Two cold spots in the western and southwestern parts of Serbia were also identified and they can be marked as a "pocket".

Based on a match between the spatial grouping of the population aged 65 and over, as the population at risk, and the high number of cases, areas with increased risk were detected in southern and southeastern Serbia. Forty-six municipalities are marked as potentially risked areas. Also, there is a match of the spatial grouping of the less vulnerable population with a low number of cases (25 municipalities). These areas are defined as a less endangered and are concentrated in the northern part of Serbia.

## Conclusion and discussion

Determining potentially endangered municipalities that make up a spatial cluster with a high share of a vulnerable population to COVID-19 accounts for the effect of space. This is especially important for monitoring, evaluation, and proposal of new population policies at the local level (de Castro, 2007). The increased share of the population at risk also means increased pressure on the health system, so it is necessary to provide health equipment and the optimal number of health workers. Based on the obtained results, it is possible to define place-specific measures for each municipality. The method used in the paper can be applied at all administrative-territorial levels for which data are available. Future research will focus on the including of as many parameters as possible that may indicate population at risk. The use of spatial analysis, in this case, optimized hot spot analysis, has shown that geospatial information can help to fight COVID-19 and reduce the number of infected and dead. The particular importance of this paper is a contribution to the crisis headquarters and decision-makers to increase preparedness in more risky areas. Namely, the Government of the Republic of Serbia, on the recommendations of the crisis headquarters had defined specific measures but only after a sharp increase in the number of infected. Determining the spatial clusters of the risky areas makes it possible to define measures in advance and thus protect the population that is more likely to become ill or die from COVID-19.

## Literature

Amramab, O., Amiria, S., Lutz, R. B., Rajan, B., & Monsivais, P. (2020). Development of a vulnerability index for diagnosis with the novel coronavirus, COVID-19, in Washington State, USA. *Health & Place, (64),* 102377 https://doi.org/10.1016/j.healthplace.2020.102377

Chen, T.,Wu, D., Chen, H., Yan, W., Yang, D., Chen, G., Ma, K., Xu, D., Yu, H., Wang, H., Wang, T., Guo, W., Chen, J., Ding, C., Zhang, X., Huang, J., Han, M., Li, S., Luo, X., Zhao, J., & Ning, Q (2020). Clinical characteristics of 113 deceased patients with coronavirus disease 2019: retrospective study. *BMJ 2020,* 368. https://doi.org/10.1136/bmj.m1091

de Castro, M. C. (2007). Spatial Demography: An Opportunity to Improve Policy Making at Diverse Decision Levels. *Popul Res Policy Rev, 26,* 477–509. https://doi.org/10.1007/s11113-007-9041-x

European Centre for Disease Prevention and Control (2020). Rapid risk assessment: Coronavirus disease 2019 (COVID-19) pandemic: increased transmission in the EU/EEA and the UK – seventh update. https://www.ecdc.europa.eu/en/publications-data/rapid-risk-assessment-coronavirus-disease-2019-covid-19-pandemic

Kamel Boulos, M. N., & Geraghty, E. M. (2020). Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: how 21st century GIS technologies are supporting the global fight against outbreaks and epidemics. *Int J Health Geogr, 19,* 8. 10.1186/s12942-020-00202-8

Kumar, N. (2007). Spatial Sampling Design for a Demographic and Health Survey. *Popul Res Policy Rev, 26,* 581–599. https://doi.org/10.1007/s11113-007-9044-7

Lović Obradović, S. (2019). *Models of spatial manifestation of demographic processes in Serbia.* (Unpublished doctoral dissertation). Geographical Faculty, Belgrade.

Lović Obradović, S., & Vojković G. (2020). The Impact of Spatial-Demographic Disparities on Fertility Variations in Serbian Municipalities – An Example of Hidden Content Research. In M. Krevs (Eds.), *Hidden geographies,* Springer, Cham (accepted for printing).

Mahsin, M. D., Deardon, R., & Brown, P. (2020). Geographically dependent individual-level models for infectious diseases transmission, *Biostatistics,* kxaa009, https://doi.org/10.1093/biostatistics/kxaa009

WHO (2020) Novel Coronavirus (2019-nCoV) SITUATION REPORT - 1 21 JANUARY 2020. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200121-sitrep-1-2019-ncov.pdf

https://data.humdata.org/dataset/coronavirus-covid-19-cases-and-deaths/resource/2ac6c3c0-76fa-4486-9ad0-9aa9e253b78d

https://covid19.rs