Geo-Spatial analysis of SARS-CoV-2 infection in uMgungundlovu – Kwa-Zulu Natal, South Africa

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WCE WORLD CONGRESS OF EPIDEMIOLOGY 2024

Outline of the Presentation

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Introduction

- In 2019 a novel coronavirus disease was identified, epidemiologically linked to a wet market in Wuhan, China; virus :SARS-CoV-2; disease :COVID-19 [1,2].
- 1st September 2024, the World Health Organization recorded 776,137,815 cases and 7,061,330 deaths[3].
- January 2022, South Africa experienced four recognizable COVID-19 pandemic waves with 3-month periods of low transmission between each wave [5].
- Wave 1: ancestral strain with an Asp614Gly mutation, Wave 2: beta variant (B.1.351), Wave 3: delta variant (B.1.617.2), Wave 4: omicron variant (B.1.1.529) [5].
- Research needs include crossing different variables to interpret transmission including spatial analysis and spatiotemporal dimensions; geographical impact on public health measures; and predictive modelling of the evolution of the disease. Thus, using geospatial and statistical tools has become particularly relevant [6].

Aim and Objectives

Aim

The aim of this research project is to utilize geospatial analysis in understanding the distribution patterns of SARS-CoV-2 and its relationship with certain co-existing factors.

Specific objectives

1. Descriptive analysis of SARS-CoV-2 cases within uMgungundlovu District.
2. Investigate the spatial patterns of SARS-CoV-2 within uMgungundlovu District.

Study setting

Fig 1. KwaZulu-Natal District distribution

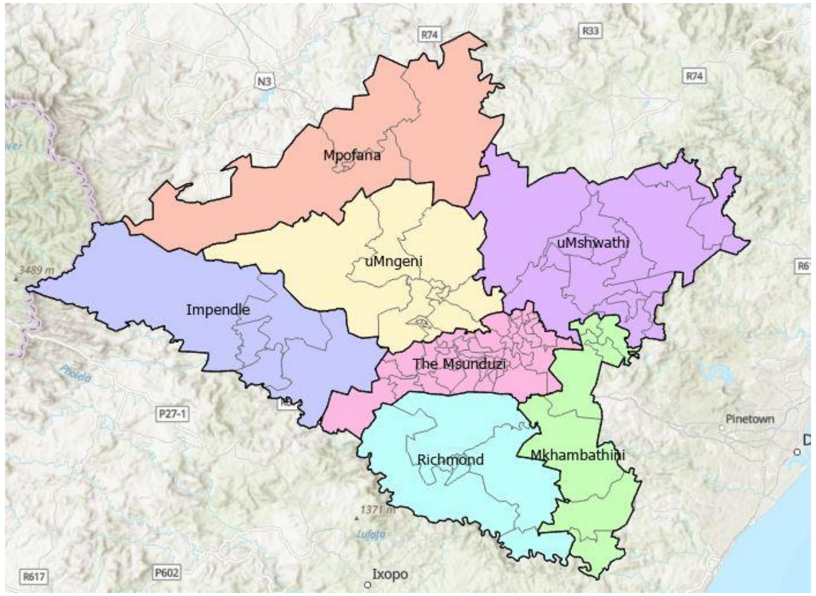


Fig 2. uMgungundlovu local municipality distribution

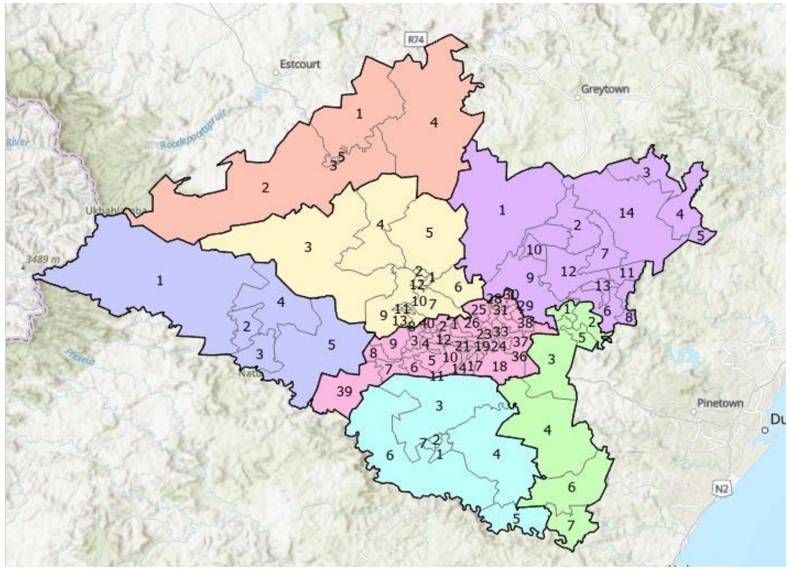


Fig 3. uMgungundlovu ward distribution

Methods

- All laboratory confirmed positive cases during the surge periods formed part of the study sample.
- Laboratory confirmed SARS-CoV-2 positive cases, including individual level data such as age, gender, ward number obtained from The National Institute for Communicable Diseases daily line lists.
- Statistical analyses were conducted using the R statistical software for data analysis and programming.
- Spatial characteristics of SARS-CoV-2 were investigated over the first four waves of transmission using ESRI ArcGIS Pro v2.0.
- Including Local Indicators of Spatial Association (LISA) with Moran’s “I” as the measure of spatial autocorrelation; and Kernel Density Estimation (KDE).
- Base layers used to complete spatial analysis - municipal demarcation board (open data source)

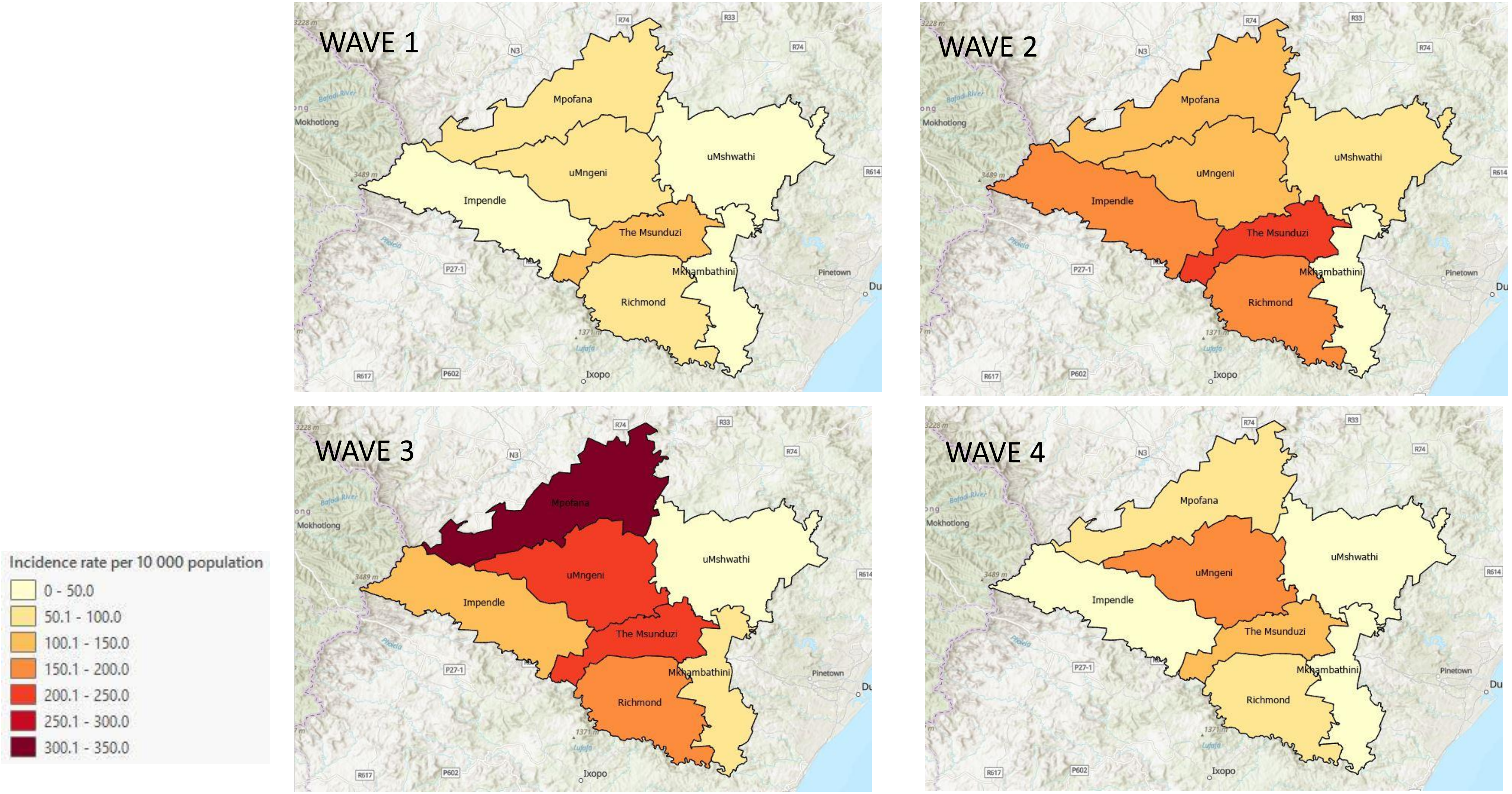
Results

Table 1: Descriptive analysis of SARS-CoV-2 cases

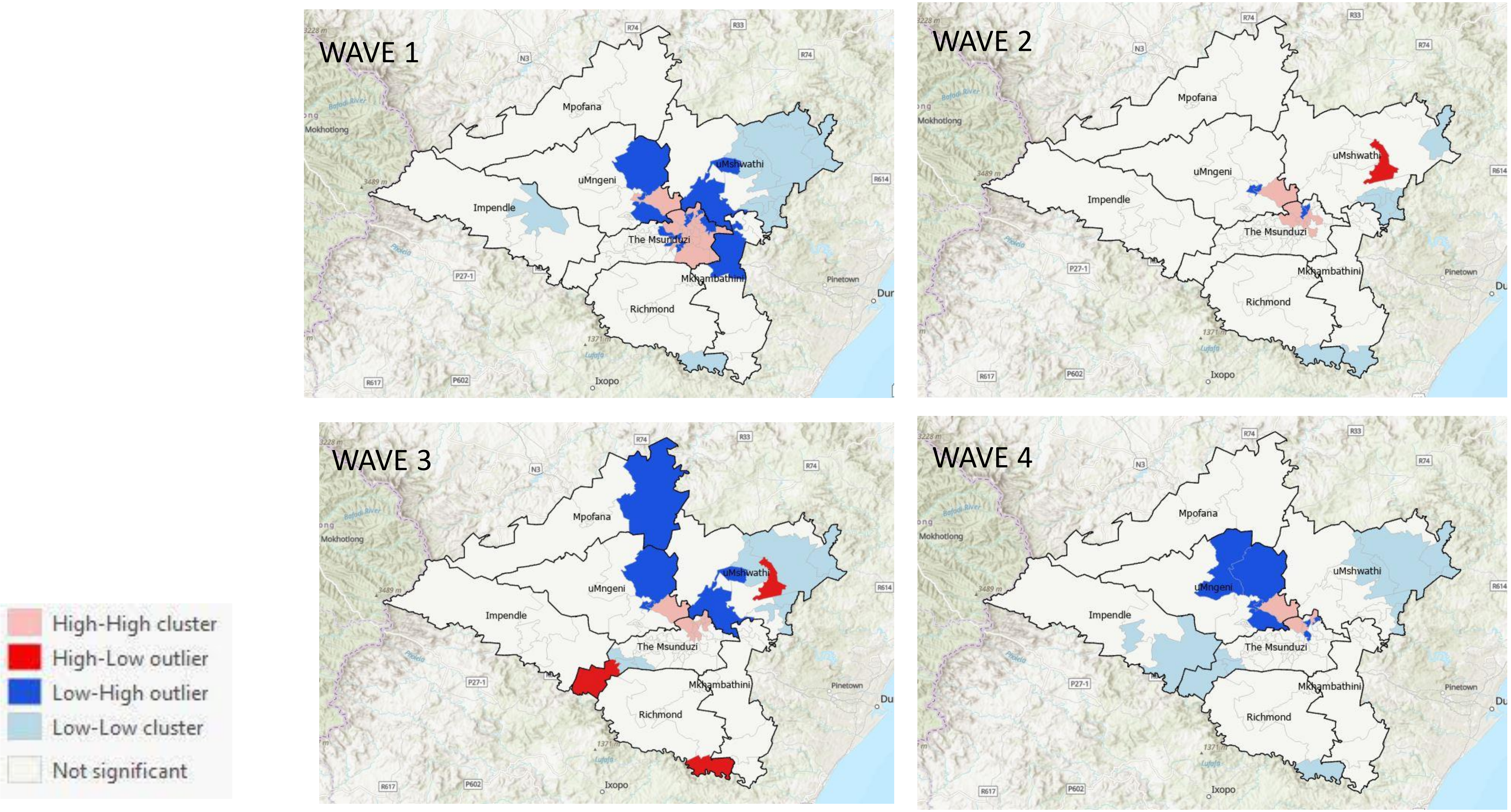
	Wave 1 – 10 304 cases	Wave 2 – 17 159 cases	Wave 3 – 20 765 cases	Wave 4 – 10 569 cases
Gender (incidence rate per 10 000)	Female: 112.1 (86.2 to 138.0)[1] Male: 74.6 (47.7 to 101.5)[1]	Female: 180.8 (155.0 to 206.6)[1] Male: 122.4 (95.6 to 149.1)[1]	Female: 207.0 (181.2 to 232.7)[1] Male: 168.3 (141.5 to 195.0)[1]	Female: 107.8 (77.8 to 115.1)[1] Male: 79.7 (52.9 to 106.6)[1]
Age	Mean age: Male: 40.1 years Female: 40.5 years ($p = 0.58$)[2]	Mean age: Male: 41.55 years Female: 40.89 years ($p = 0.28$)[2]	Mean age: Male: 33.66 years Female: 35.53 years ($p<0.001$)[2]	Mean age: Male: 39.48 years Female: 38.82 years ($p = 0.058$)[2]
Age group (incidence rate per 10 000)	Highest- 80 years&older: 262.4 (29.5 to 495.3)[1] Lowest- 0-9 years: 14.2 (-25.1 to 53.5)[1]	Highest- 70-79 years: 350.4 (211.4 to 489.5)[1] Lowest- 10-19 years: 64.9 (22.8 to 107.1)[1]	Highest- 40-49 years: 315.9 (257.1 to 374.6)[1] Lowest- 0-9 years: 118.5 (79.4 to 157.5)[1]	Highest- 70-79 years: 214.9 (74.8 to 354.9)[1] Lowest- 10-19 years: 44.1 (1.9 to 86.3)[1]
Municipality(incidence rate per 10 000)	Highest- Msunduzi: 137.4 (112.7 to 162.2)[1] Lowest- uMshwathi: 24.7 (-35.3 to 84.7)[1]	Highest- Msunduzi – 206.4 (181.7 to 231.0)[1] Lowest- Mkhambathini: 61.7 (-21.7 to 145.1)[1]	Highest- Mpofana – 304.8 (201.5 to 408.0)[1] Lowest- uMshwathi – 55.8 (-4.1 to 115.8)[1]	Highest- uMngeni: 175.8 (112.0 to 239.6)[1] Lowest- uMshwathi: 28.7 (-31.3 to 88.7)[1]

[1] 95% CI; [2] Fishers Exact Test

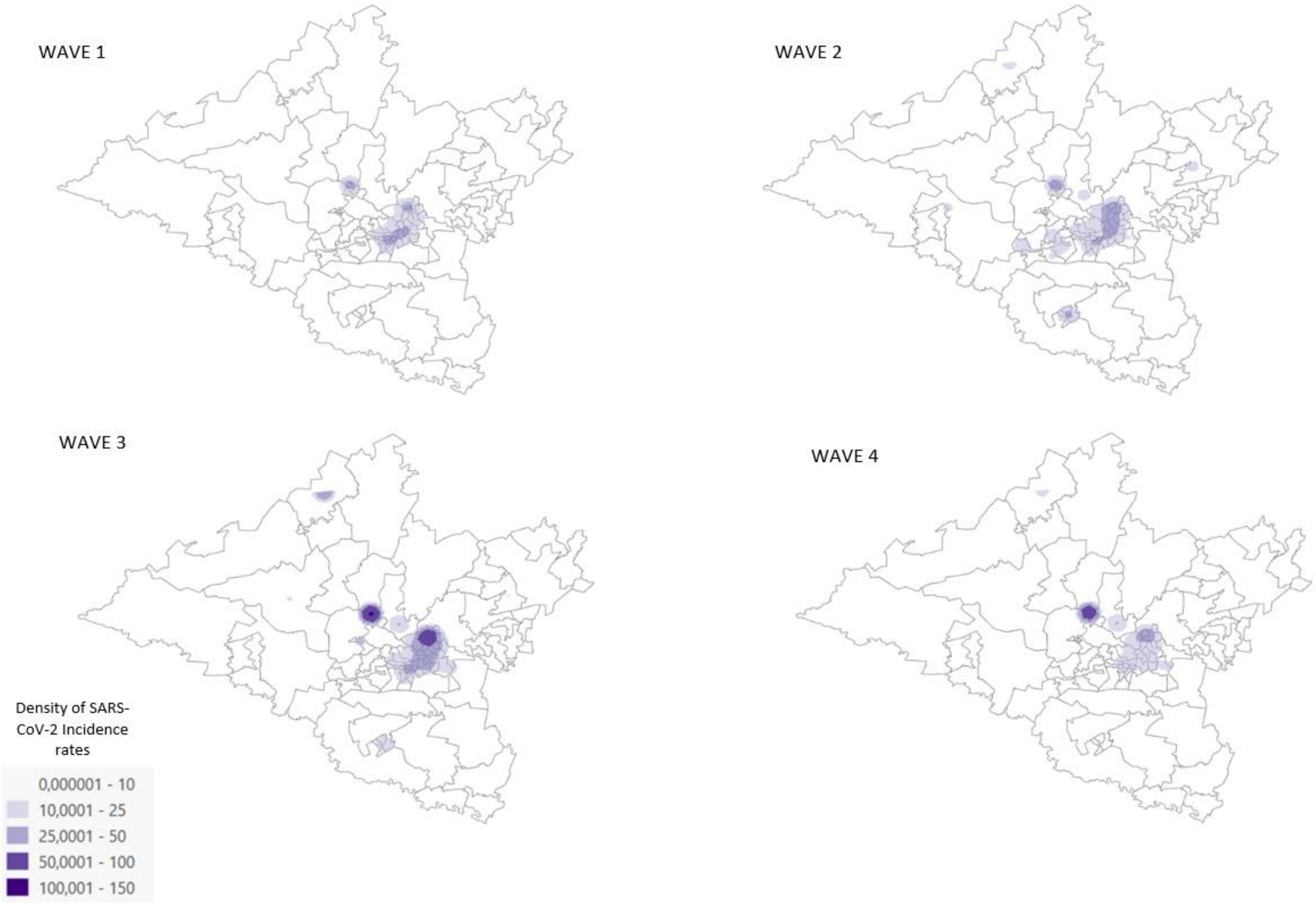
Choropleth map of SARS-CoV-2 incidence rate per LM, per wave



LISA analysis of SARS-CoV-2 incidence rate per wave



SARS-CoV-2 incident case density maps per wave



Discussion

- Higher incidence rates in females, urban areas, and older age groups. However, change in incidence rates over time.
- Under-reporting (stigma, fear of hospitalization, hard to reach areas)
- Predominant circulating variant per wave
- Vaccination coverage
- Health seeking behavior
- Immune related response
- Wave 1- Lockdown, fear of the unknown; Wave 2 – super-spreader events; Wave 3 – social unrest, congregate setting; Wave 4 – quick, omicron

Conclusion

- Relationship between infection and increased economic activity, population density and urban development, driven by increased contact.
- Differences in infection across waves highlight important characteristics of the predominant circulating variant, providing useful information on the evolution of the virus.
- The nature configuration of the social and built environment may be associated with increased infection.
- A Geospatial approach of analyzing infectious disease transmission is proposed to guide control efforts (e.g., testing/tracing and vaccine rollout) .
- However, locally specific empirical research is required to assess other relevant factors associated with increased infection.

Acknowledgements

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Thank You!