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Local-Scale Spatial Variability in SARS-CoV-2 Seroprevalence in an Indian Megacity

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BACKGROUND

- While the diversity in SARS-CoV-2 transmission across geographies and risk groups is well recognized, there has been limited investigation into spatial heterogeneity at a local scale, that is variability across a single city.
- Identifying patterns and factors associated with spatial variability requires population representative samples which are challenging to obtain but critical for mitigation strategies including vaccine distribution.
- The objective of this study was to assess the spatial variability in anti-Spike SARS-CoV-2 seroprevalence in the general household population in Chennai, India just prior to and during the Delta wave.

METHODS

- From Jan to May 2021, we sampled 4,828 participants from 2,723 unique households across 100 spatial locations in Chennai, India using a probability proportional to population density sampling approach.
- All participants provided a blood sample and underwent a household and individual survey.
- 4,712 samples were tested for antibodies to the Spike protein (anti-S IgG) of SARS-CoV-2 by the Abbott ARCHITECT AdviseDx SARS-CoV-2 IgG II assay (manufacturer's cutoff: ≥50 AU/mL).
- Covariance of seroprevalence estimated by location was quantified using a spatial semivariogram.
- SARS-CoV-2 seroprevalence by spatial location was plotted using splines estimated by generalized additive models.
- Associations between seroprevalence and spatial attributes (zone, population density), study characteristics (time), and household and individual-level covariates were estimated using mixed effects logistic regression accounting for clustering within households and locations.
- This study was approved by the institutional review boards at the Johns Hopkins University School of Medicine and YR Gaitonde Center for AIDS Research and Education.

RESULTS

- The median age was 38, 49% self-identified as female and 11% reported a history of COVID-19 vaccination.
- Population density ranged from 124 to 286 people per square 100 meters.
- Overall, anti-S IgG prevalence was 61.9% (95% confidence interval [CI]: 60.5-63.3%) but ranged from 41.5% to 73.1% across the 12 zones and from 25.5% to 100% across the 100 locations (Figure 1B).
- Intraclass correlation coefficients indicated that 10% and 5% of the variance was attributable to household and location level variation, respectively.
- Generalized additive models indicated that anti-S IgG prevalence varied significantly across the city (Figure 2A). A spatial semivariogram indicates that observations of seroprevalence closer to each other had less variance than observations further apart, with a steady increase in variance from 0 to 4 km.
- In univariate models incorporating spatial characteristics of places, population density per 100 square meters at the location of a person's home (OR, 4.5 [95% CI 1.2, 16.4]) and the zone of residence (multiple significant OR) were associated with seroprevalence.

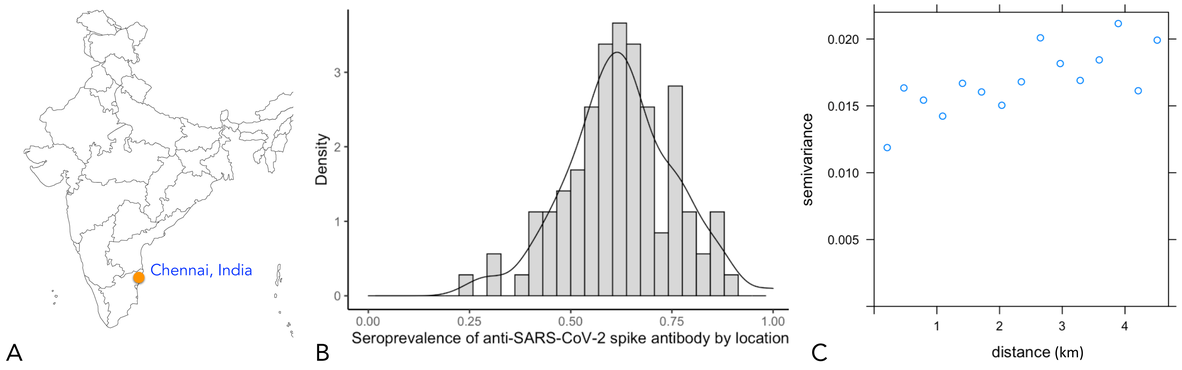


Figure 1: Map of study location (A), distribution of anti-S IgG prevalence by location (B), and spatial semivariogram describing the variance of seroprevalence of points within specific distance bands (C).

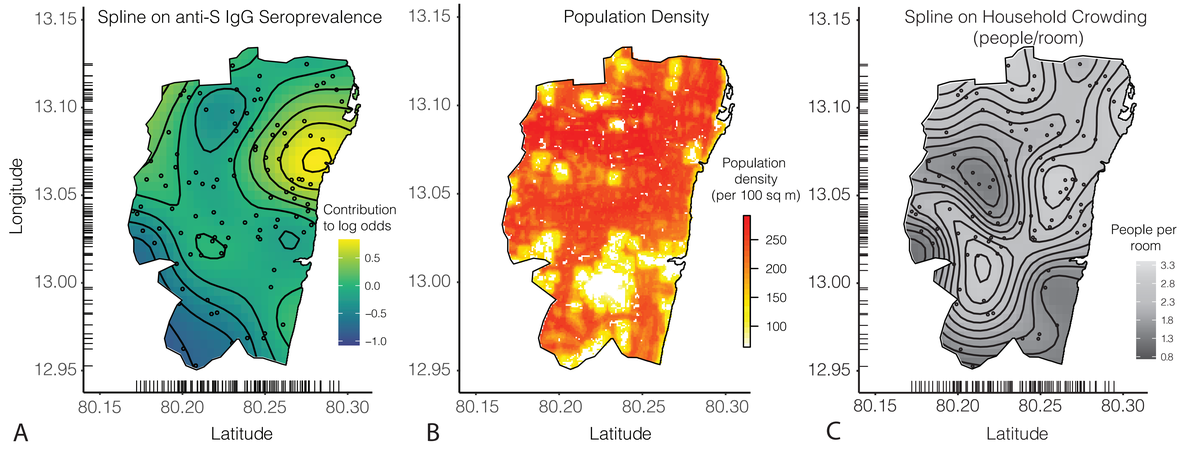


Figure 2: Spatial splines on anti-S IgG seroprevalence (A) and household crowding (C) as well as population density (B).

Table. Adjusted odds ratios (OR) of SARS-CoV-2 seroprevalence.

	Anti-S IgG (≥50 AU/mL)
Variable	Adjusted OR (95% CI)
Log_{10}(Population density per 100 m^2)	3.15 (0.90, 10.90)
Age (in years)	
5-17	1.02 (0.69, 1.40)
18-29	REF
30-39	1.05 (0.87, 1.26)
40-49	1.12 (0.91, 1.36)
≥50	1.01 (0.83, 1.22)
Time of sampling	
9 Jan – 14 Feb	1.15 (0.86, 1.53)
15 Feb – 9 Mar	REF
10 Mar – 24 Mar	1.01 (0.74, 1.38)
25 Mar – 19 Apr	0.64 (0.46, 0.88)
20 Apr – 13 May	0.82 (0.59, 1.13)
Gender	
Female	REF
Male	0.72 (0.63, 0.82)
Transgender	0.55 (0.16, 1.89)
Household ventilation system	
Neither coolers nor air conditioning	REF
Coolers only	1.01 (0.75, 1.36)
Air conditioning only	0.89 (0.73, 1.09)
Air conditioning & cooling systems	0.52 (0.36, 0.75)
Household crowding (person/rooms)	0.95 (0.74, 1.21)
No. of regular visitors to home	1.08 (1.02, 1.14)
Received COVID-19 vaccine	2.50 (1.95, 3.21)

CONCLUSIONS

- We observed substantial spatial heterogeneity of SARS-CoV-2 burden in this high prevalence setting that was not fully explained by individual, household or population factors.
- In this highly dense megacity, we observed a positive association between local population density and seroprevalence even after adjusting for individual- and household-level factors including household crowding.
- Such local variability in seroprevalence has implications not only for transmission but for scale-up of vaccines, which remain in limited supply in many low- and middle-income countries.

ACKNOWLEDGEMENTS

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