

# Population-Based Serosurvey for Severe Acute Respiratory Syndrome Coronavirus 2 Transmission, Chennai, India

Sriram Selvaraju, Muthusamy Santhosh Kumar, Jeromie Wesley Vivian Thangaraj, Tarun Bhatnagar, Velusamy Saravanakumar, Chethrapilly Purushothaman Girish Kumar, Krithikaa Sekar, Ezhilarasan Ilayaperumal, Ramasamy Sabarinathan, Murugesan Jagadeesan, Masanam Sriramulu Hemalatha, Manoj Vasant Murhekar, and the Chennai COVID Sero-Surveillance Team

We conducted a cross-sectional survey to estimate the seroprevalence of IgG against severe acute respiratory syndrome coronavirus 2 in Chennai, India. Among 12,405 serum samples tested, weighted seroprevalence was 18.4% (95% CI 14.8%–22.6%). These findings indicate most of the population of Chennai is still susceptible to this virus.

On August 15, 2020, India had the third highest number of coronavirus disease (COVID-19) cases globally (1). The Indian state of Tamil Nadu reported 332,105 cases and 5,641 deaths on August 15, and ≈35% cases were from the state capital, Chennai (2). Administratively, Greater Chennai Corporation (GCC) is divided into 15 zones that are further divided into 200 wards with populations ranging from 4,400–104,558 (3). The total population of GCC is 7.1 million and 31% of the population resides in slums.

As a part of nationwide containment strategy, Chennai was under lockdown beginning March 25, 2020; beginning May 4, the lockdown was relaxed in a phased manner. Wearing facemasks in public has been mandatory since April 13. However, the number of COVID-19 cases has been increasing in Chennai since May.

Serologic surveys can provide a comprehensive picture of community spread of severe acute

respiratory syndrome coronavirus 2 (SARS-CoV-2), the causative agent of COVID-19 (4). During the first week of May, the unweighted seroprevalence in Chennai was 2% (5). We conducted a community-based serosurvey in July 2020, to estimate the seroprevalence of SARS-CoV-2 in GCC.

## The Study

We conducted a household-based cross-sectional survey among usual residents ≥10 years of age in GCC. To estimate a seroprevalence of 2%, with 20% relative precision, design effect of 2.5, and 95% CI, we needed a sample size of 11,710 persons, which we rounded to 12,000. We used a multistage cluster sampling method to select the survey participants. In the first stage, we selected 51 wards by using probability proportion to population size method. In the second stage, we randomly selected 6 streets from each ward from which to recruit participants. The survey team selected a random starting point in each street and visited contiguous households to enroll ≥40 consenting persons ≥10 years of age. When no one was home or household members were unavailable, the team proceeded to the next house and completed the survey until ≥40 persons were enrolled from each street. We included all eligible persons in the household who consented.

After obtaining written consent from persons ≥18 years of age, and assent and parental or guardian approval from persons <18 years of age, we interviewed participants to collect information. We used the Open Data Kit application (<https://opendatakit.org>) to collect sociodemographic details, and information on exposure to laboratory-confirmed COVID-19 case, history of COVID-19 symptoms in the past 3 months, and COVID-19 testing status.

Author affiliations: Indian Council of Medical Research–National Institute for Research in Tuberculosis, Chennai, India (S. Selvaraju, K. Sekar, E. Ilayaperumal); ICMR–National Institute of Epidemiology, Chennai (M. Santhosh Kumar, J.W. Vivian Thangaraj, T. Bhatnagar, V. Saravanakumar, C.P. Girish Kumar, R. Sabarinathan, M.V. Murhekar); Greater Chennai Corporation, Chennai (M. Jagadeesan, M.S. Hemalatha)

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After the interview, we collected 3–5 mL of venous blood from each participant into BD Vacutainer Blood Collection Tubes (Becton Dickinson, <https://www.bd.com>). We later tested serum samples for IgG against SARS-CoV-2 by using SARS-CoV-2 IgG immunoassay (Abbott, <https://www.corelaboratory.abbott>) (Appendix, <https://wwwnc.cdc.gov/EID/article/27/2/20-3938-App1.pdf>) (6). The study protocol was approved by the Institutional Ethics Committee of ICMR-National Institute of Epidemiology.

We analyzed the data to estimate weighted seroprevalence of SARS-CoV-2 and 95% CI by using appropriate sampling weights. We further adjusted the seroprevalence for assay characteristics (6). We estimated the total number of SARS-CoV-2 infections among persons  $\geq 10$  years of age and infection-to-case ratio (ICR) (Appendix).

The survey teams visited 7,234 households from 321 streets across 15 zones. Of the 18,040 residents  $\geq 10$  years of age in the visited households, 14,839 (82.3%) were available at the time of survey, among whom 12,405 (83.6%) consented to participate (Appendix Table 1). The mean age of survey participants was 41.1 years (SD 17.3 years); 52.7% were female and 47.3% were male. Among 496 (4%) persons who reported prior reverse transcription-PCR (RT-PCR) testing for COVID-19, 119 (24%) reported testing positive (Table 1).

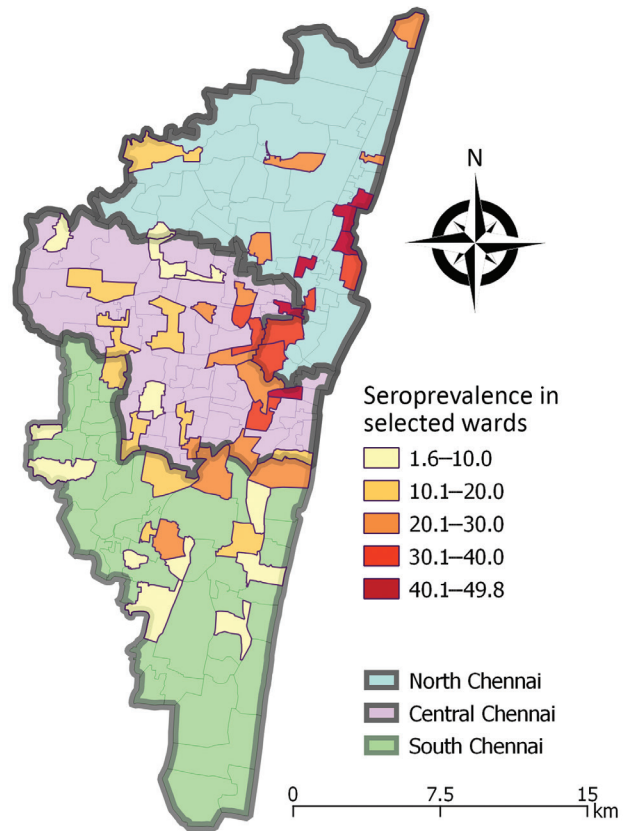
Among 12,405 serum samples tested, 2,673 were positive for IgG, a weighted prevalence of 18.7% (95% CI 15.1%–22.9%). After adjusting for the test sensitivity and specificity, seroprevalence was 18.4% (95% CI 14.8%–22.6%) (Table 2). The weighted seroprevalence was higher among female participants (20.6%, 95% CI 16.7%–25.3%) than male participants (16.6%, 95% CI 13.2%–20.6%) ( $p < 0.001$ ). Weighted seroprevalence was lowest among persons  $\geq 60$  years of age (13.4%, 95% CI 10.3%–17.4%) than younger persons ( $p = 0.001$ ) (Table 2). We retested 100 seronegative and 40 seropositive samples and results were concordant.

From our data, we estimated a total of 1,509,701 (95% CI 1,212,711–1,856,190) SARS-CoV-2 infections in Chennai. ICR per laboratory-confirmed case was 21.4 (95% CI 17.2–26.3) until July 7 and 19.2 (95% CI 15.4–23.6) until July 14, 2020.

## Conclusions

Our community-based survey indicated that  $\approx 1/5$  persons in Chennai was exposed to SARS-CoV-2 by July 2020. We noted a wide variation in the extent of infection across wards and seroprevalence ranged from 2%–50% (Appendix Table 3).

Seroprevalence was higher in northern Chennai and adjoining wards of central Chennai than in



**Figure.** Seroprevalence of SARS-CoV-2 among residents of Chennai, India, July 2020. Values represent percent seroprevalence. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

southern Chennai (Figure). Chennai witnessed a surge in COVID-19 cases in last week of April 2020 and  $>65\%$  of cases were in northern Chennai (7). The number of cases showed a declining trend after the first week of July. Northern Chennai has a higher population density (55,000/km<sup>2</sup>) than Chennai (27,000/km<sup>2</sup>) and has several slum areas (7). High population density and persons living in close proximity might have contributed to the higher seroprevalence observed in northern Chennai.

Seroprevalence was lower among male participants. Laboratory surveillance data in India showed a higher proportion of laboratory-confirmed COVID-19 among male than female patients (8). Comparable seroprevalence between children and adults suggests exposure within and outside of the household settings. Lower prevalence among persons  $\geq 60$  years of age could be due to lower exposure to infected persons or stricter adherence to nonpharmaceutical interventions. Serosurveys conducted in Santa Clara County, California, USA reported lower seropositivity among persons  $\geq 60$  years of age (E. Bendavid,

**Table 1.** Characteristics of 12,405 participants in a SARS-CoV-2 serosurvey, Chennai, India, July 2020\*

Characteristics	No. (%)
Age, y, n = 12,319	
10–19	1,473 (12.0)
20–29	2,105 (17.1)
30–39	2,353 (19.1)
40–49	2,353 (19.1)
50–59	1,927 (15.6)
≥60	2,108 (17.1)
Sex, n = 12,319	
M	5,785 (47.0)
F	6,493 (52.7)
Transgender	41 (0.3)
History of respiratory symptoms, n = 12,248	175 (1.4)
Symptomatic persons seeking medical care, n = 175	121 (69.1)
Hospitalization among persons seeking medical care, n = 121	71 (58.7)
Reported contact with COVID-19 case, n = 12,248	173 (1.4)

\*Among 12,405 persons enrolled in the survey, age and sex data were not available for 86 participants. COVID-19, coronavirus disease; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

et al. unpub. data, <https://doi.org/10.1101/2020.04.14.20062463>); however, in Spain, seropositivity was similar across all age groups (9) and in Greece, seroprevalence was higher among persons ≥60 years of age (10).

Most seropositive participants in our survey did not report any symptoms nor had any known contact with COVID-19 patient. IgG developed among most (107/119; 90%) recovered COVID-19 patients in our

survey. Among 105 participants for whom ≥15 days had passed between RT-PCR confirmation of COVID-19 and blood sample collection for our serosurvey, 99 (94.2%) had seroconverted. Even after accounting for a 2-week delay for development of antibodies (11), ≈6% of COVID-19 patients were seronegative. Discordance between RT-PCR test results and presence of IgG might be due to poor B cell response or antibodies waning over time (12).

The ICR ranged from 19–21 and was lower than the ICR of 82–130 reported during the nationwide seroprevalence survey in India conducted in May 2020 (5). Lower ICR reflects a high level of case detection, resulting from extensive COVID-19 testing in the city. By July 15, 2020, Chennai had conducted 14,270 tests/million population.

Our study had 2 limitations. First, ≈1/3 persons from the visited households did not participate in the survey. Among them, 17.7% were not available at the time of visit and 13.5% refused to participate. Due to time constraints, we did not revisit households where persons were not available. The proportion of female participants and children 10–19 years of age was higher among persons who did not participate in the survey (Appendix Table 2), which might have influenced the seroprevalence estimates in either direction. Second, we might have underestimated the seroprevalence because antibodies to

**Table 2.** Characteristics of persons with IgG against SARS-CoV-2, Chennai, India, July 2020\*

Characteristics	No. tested	No. positive	Unadjusted seroprevalence, % (95% CI)	Weighted seroprevalence, % (95% CI)	p value	Test performance-adjusted seroprevalence, % (95% CI)
Overall	12,405	2,673	21.5 (20.8–22.3)	18.7 (15.1–22.9)	NA	18.4 (14.8–22.6)
Sex						
M	5,785	1,115	19.3 (18.3–20.3)	16.6 (13.2–20.6)	<0.001	16.3 (12.9–20.3)
F	6,493	1,538	23.7 (22.7–24.7)	20.6 (16.7–25.3)	Referent	20.3 (16.4–25.0)
Transgender	41	5	12.2 (4.1–26.2)	2.8 (0.2–27.6)	0.093	2.4 (0.0–27.3)
Age, y						
10–19	1,473	351	23.8 (21.7–26.1)	18.9 (14.7–24.0)	Referent	18.6 (14.4–23.7)
20–29	2,105	478	22.7 (20.9–24.6)	21.1 (16.8–26.2)	0.211	20.8 (16.5–25.9)
30–39	2,353	535	22.7 (21.1–24.5)	18.5 (14.6–23.1)	0.802	18.2 (14.3–22.8)
40–49	2,353	551	23.4 (21.7–25.2)	19.6 (15.5–24.5)	0.671	19.3 (15.2–24.2)
50–59	1,927	408	21.2 (19.4–23.1)	20.4 (16.1–25.5)	0.419	20.1 (15.8–25.2)
≥60	2,108	335	15.9 (14.4–17.5)	13.4 (10.3–17.4)	0.001	13.1 (9.9–17.1)
History of respiratory symptoms						
Yes	175	114	65.1 (57.6–72.7)	59.8 (47.5–71.0)	<0.001	59.6 (47.3–70.9)
No	12,073	2,529	20.9 (20.2–21.7)	18.3 (14.7–22.5)	Referent	18.0 (14.4–22.2)
Contact with COVID-19 case						
Yes	173	94	54.3 (46.6–61.9)	45.3 (34.6–56.6)	<0.001	45.1 (34.3–56.4)
No	11,938	2,498	20.9 (20.2–21.7)	18.3 (14.8–22.5)	Referent	18.0 (14.5–22.2)
Don't know	137	51	37.2 (29.1–45.9)	22.1 (14.0–33.1)	0.363	21.8 (13.7–32.8)
Ever tested for COVID-19						
Yes	496	198	39.9 (35.6–44.3)	34.2 (26.9–42.5)	<0.001	33.9 (26.6–42.3)
No	11,752	2,445	20.8 (20.0–21.6)	18.0 (14.6–22.1)	Referent	17.7 (14.3–21.8)
COVID-19 test result, n = 496						
Positive	119	107	89.9 (83.0–94.7)	NA	NA	NA
Negative	342	83	24.3 (19.8–29.2)	NA	NA	NA
Don't Know	35	8	22.9 (10.4–40.1)	NA	NA	NA

\*COVID-19, coronavirus disease; NA, not applicable; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.



nucleocapsid protein have been shown to decline after infection (13).

In conclusion,  $\approx 80\%$  of the population in Chennai is still susceptible to SARS-CoV-2 infection. Transmission is expected to continue in wards with lower seroprevalence. Maintaining high testing rates and monitoring adherence to nonpharmacological interventions in GCC should be continued. In addition, periodic serosurveys would help monitor the trend of infection and assess the effects of varying containment measures in the city.

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Chennai COVID Sero-surveillance team (in alphabetical order): Shravan Kumar Adavat, Akshitha, Vasudevan Arumugam, Ashwini, M. Balusamy, Chandrabalu, Sauvik Dasgupta, Tamil Mani Devi, Gomathi, R Gopinath, D. Gunasekaran, R. Hari Krishnan, Satham Hussain, A. Jayakumar, Chitra Jayaprakash, Jayasree, Annamma Jose, I. Kalaimani, Kalayarasi, Anbarasan Kaliyappan, Bharath Kathavarayan, Krishna Yadav Kattagoni, T. Karunakaran, Maheshwari Krishnan, Ramesh Kumar Kumaraswamy, P. Ashok Kumar, K. Satish Kumar, Maheshkumar Madasamy, T. Magesh, Karthikesan Masilamani, A. Mohan, Rajesh Mondal, Murugesan, Nandhakumar, Kumaravel Padmanaban, R. Vijaya Prabha, C. Prabhakaran, Josephine Pradhan, E.B.Arun Prasath, G. Preethi, Michael Raj, Ranjithkumar, Rajmohan, K. Ramu, D. Sudha Rani, Catherine Remy, N. Santhanakumar, S.Sarath Kumar, Anbalagan Selvaraj, Selvendiran, Sentrayan, Shalini, R. Sivakumar, Harshal Bhimrao Sonekar, A. Suresh, Suresh, Udhayakumar, V. Vettrichelvan, Hari Vignesh, and John Arokyadoss Yesuraj.

### About the Author

Dr. Selvaraju is a scientist at ICMR-National Institute for Research in Tuberculosis, Chennai, India. His research interests include estimation of burden of tuberculosis and building laboratory, surveillance, and workforce capacity to detect, respond and prevent drug resistant tuberculosis in India.

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Address for correspondence: Manoj V. Murhekar, ICMR – National Institute of Epidemiology, Second Main Road, Tamil Nadu Housing Board, Ayapakkam, Near Ambattur, Chennai 600077, Tamil Nadu, India; email: mmurhekar@nieicmr.org.in