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)

DOI: https://doi.org/10.3201/eid2702.203938

After the interview, we collected 3–5 mL of venous blood from each participant into BD Vacutainer Blood Collection Tubes (Becton Dickenson, 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 ≥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 ≥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 ≥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 ≈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 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^2) than Chennai (27,000/km^2) 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.

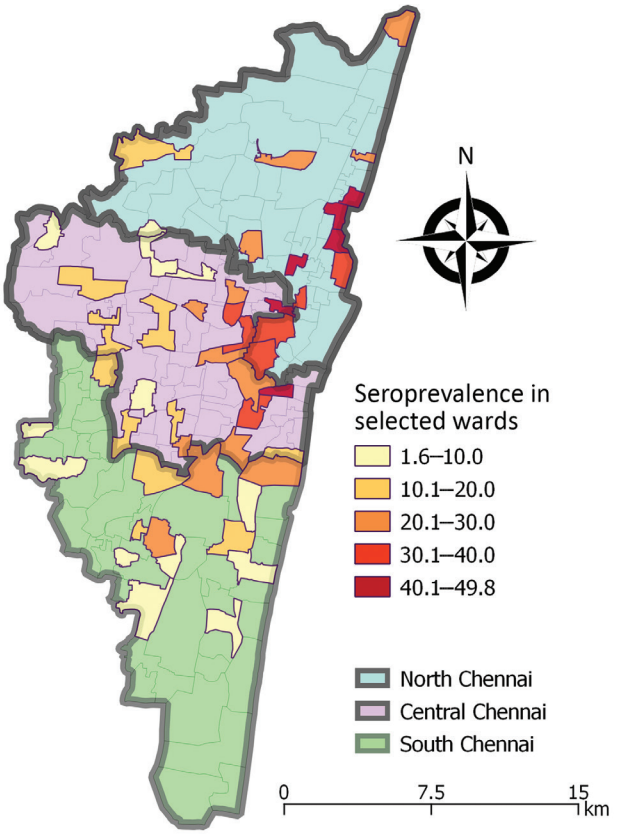

Figure. Seroprevalence of SARS-CoV-2 among residents of Chennai, India, July 2020. Values represent percent seroprevalence. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

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 ≥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 ≥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	2529	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, ≈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.

This study was funded by Greater Chennai Corporation public health department (PHDC no. 2797/20 dated July 9, 2020).

Acknowledgments

We thank the Greater Chennai Corporation health officials for support in field operations. M.J. and M.S.H. are employees of Greater Chennai Corporation.

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. Harikrishnan, 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 Rexy, 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.

References

1. World Health Organization. Coronavirus disease (COVID-19) situation report – 207 [cited 2020 Aug 15]. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200814-covid-19-sitrep-207.pdf
2. State Control Room, Directorate of Public Health and Preventive Medicine Health and Family Welfare Department, Government of Tamil Nadu. Media bulletin 15.18.2020: daily report on public health measures taken for COVID-19 [cited 2020 Aug 15]. https://stopcorona.tn.gov.in/wp-content/uploads/2020/03/Media-Bulletin-15-08-20-COVID-19-6-PM.pdf.
3. Greater Chennai Corporation. About Greater Chennai Corporation. [cited 2020 Sept 7]. https://www.chennaicorporation.gov.in/about-chennai-corporation/aboutCOC.htm
4. Koopmans M, Haagmans B. Assessing the extent of SARS-CoV-2 circulation through serological studies. Nat Med. 2020;26:1171–2. https://doi.org/10.1038/s41591-020-1018-x
5. Murhekar MV, Bhatnagar T, Selvaraju S, Rade K, Saravanakumar V, Vivian Thangaraj JW, et al. Prevalence of SARS-CoV-2 infection in India: findings from the national serosurvey, May–June 2020. Indian J Med Res. 2020;152:48–60. https://doi.org/10.4103/ijmr.IJMR_3290_20
6. SARS-CoV-2 IgG immunoassay. Instructions for use. Abbott. May 2020 [cited 2020 Sep 07]. https://www.corelaboratory.abbott/us/en/offerings/segments/infectious-disease/sars-cov-2
7. Special correspondent. Coronavirus: with over 65% of cases, all eyes on north Chennai. The Hindu. 2020 Apr 29 [citied 2020 Oct 26]. https://www.thehindu.com/news/cities/chennai/coronavirus-with-over-65-of-cases-all-eyes-on-north-chennai/article31467330.ece
8. ICMR COVID Study Group; In alphabetical order: Abraham P, Aggarwal N, Babu GR, Barani S, Bhargava B, et al. Laboratory surveillance for SARS-CoV-2 in India: performance of testing & descriptive epidemiology of detected COVID-19, January 22–April 30, 2020. Indian J Med Res. 2020;151:424–437. https://doi.org/10.4103/ijmr.IJMR_1896_20
9. Pollán M, Pérez-Gómez B, Pastor-Barriuso R, Oteo J, Hernán MA, Pérez-Olmeda M, et al. Prevalence of SARS-CoV-2 in Spain (ENE-COVID): a nationwide, population-based seroepidemiological study. Lancet. 2020396;535–44. https://doi.org/10.1016/S0140-6736(20)31483-5
10. Bogogiannidou Z, Vontas A, Dadouli K, Kyritsi MA, Soteriades S, Nikoulis DJ, et al. Repeated leftover serosurvey of SARS-CoV-2 IgG antibodies, Greece, March and April 2020. Euro Surveill. 2020;25:2001369. https://doi.org/10.2807/1560-7917.ES.2020.25.31.2001369
11. Long QX, Liu BZ, Deng HJ, Wu GC, Deng K, Chen YK, et al. Antibody responses to SARS-CoV-2 in patients with COVID-19. Nat Med. 2020;26:845–8. https://doi.org/10.1038/s41591-020-0897-1
12. Sekine T, Perez-Potti A, Rivera-Ballesteros O, Strålin K, Gorin JB, Olsson A, et al.; Karolinska COVID-19 Study Group. Robust T cell immunity in convalescent individuals with asymptomatic or mild COVID-19. Cell. 2020;183:158–168.e14. https://doi.org/10.1016/j.cell.2020.08.017
13. Ripperger TJ, Uhrlaub JL, Watanabe M, Wong R, Castaneda Y, Pizzato HA, et al. Orthogonal SARS-CoV-2 serological assays enable surveillance of low-prevalence communities and reveal durable humoral immunity. Immunity. 2020;53:925–933.e4. https://doi.org/10.1016/j.immuni.2020.10.004

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

Article DOI: https://doi.org/10.3201/eid2702.203938

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

Appendix

Laboratory Procedures

We tested 12,405 serum samples for the presence of IgG against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) on the ARCHITECT i2000SR automated analyzer (Abbott, https://www.corelaboratory.abbott) by using the Abbott SARS-CoV-2 IgG immunoassay (*1*). The assay is a chemiluminescent microparticle immunoassay used for the qualitative detection of IgG to the nucleocapsid protein of SARS-CoV-2 in human serum and plasma. The sensitivity of the assay is 100% and specificity is 99.6% (*2*). The IgG in the sample binds to SARS-CoV-2 antigen-coated microparticles and undergoes a chemiluminescent reaction, producing a direct relationship between the amount of IgG and relative light units (RLU). The presence or absence of antibody in the sample is determined by comparing the RLU in the sample to the calibrator RLUs. The presence of antibody level above the cutoff index value $\geq$1.4 was interpreted as positive. Assay calibration was performed with positive and negative quality controls before analyses of samples. As a part of quality control, we retested 1% of the negative serum samples by using the same assay.

Statistical Analysis

The cross-sectional study considered 3 stages of sampling design. In the first stage, 51 wards were selected from among 200 wards in Chennai by using a probability proportional to size method. In the second stage, 6 streets were selected in each ward by using simple random sampling. The final stage was selecting the number of eligible persons in the household who agreed to participate in the survey.

We used a sampling fraction to compute the probability of selection at each stage of sampling. We computed design weights by the inverse of product of probabilities at all stages. The design weights were normalized and attached to the master dataset.

We used a random effects logistic regression model to address the clustering effect of estimates at all levels of hierarchical structure identified in the design. The hierarchical structure used in the analysis was ward, street, and household levels.

We modeled overall seroprevalence by using random intercept model for inclusion of each of the levels with design weights. We used the Akaike Information Criterion to select the final model. We also used this model to estimate seroprevalence for other factors, such as age and sex.

Seroprevalence estimates were obtained by exponentiating the log odds values obtained from the model and converting into probability to calculate corresponding 95% Wald confidence interval. We used the lme4 package from R software (R Foundation for Statistical Computing, https://www.r-project.org) to perform analysis.

We compared the weighted seroprevalence by selected demographic characteristics, history of respiratory symptoms, contact with laboratory-confirmed case of coronavirus disease, and coronavirus disease testing. We considered $p<0.05$ statistically significant.

We adjusted the weighted seroprevalence for test characteristics by using the following formula (*3*):

$$\text{Adjusted prevalence} = \frac{Weighted\ prevalence + specificity - 1}{Sensitivity + specificity - 1}$$

References

1. SARS-CoV-2 IgG immunoassay. Instructions for use. Abbott. May 2020 [cited 2020 Sep 07]. https://www.corelaboratory.abbott/us/en/offerings/segments/infectious-disease/sars-cov-2

2. Bryan A, Pepper G, Wener MH, Fink SL, Morishima C, Chaudhary A, Jerome KR, Mathias PC, Greninger AL. Performance characteristics of the Abbott Architect SARS-CoV-2 IgG assay and seroprevalence in Boise, Idaho. J Clin Microbiol. 2020;58:e00941–20. PubMed https://doi.org/10.1128/JCM.00941-20

3. Sempos CT, Tian L. Adjusting coronavirus prevalence estimates for laboratory test kit error. Am J of Epidemiol. 2020 Aug 17 [Epub ahead of print]. PubMed https://doi.org/10.1093/aje/kwaa174

Appendix Table 1. Selection of wards, streets, and households and number of persons in a serosurvey for SARS-CoV-2, Greater Chennai Corporation, India, July 2020*

		No. Wards		No. streets		No. households		No. persons		
Code	Zone	Total	Selected	Total	Selected	Surveyed	Responded (%)	Eligible	Available (%)†	Enrolled (%)‡
1	Thiruvottriyur	14	3	1,290	22	438	416 (95.0)	907	756 (83.4)	654 (86.5)
2	Manali	7	1	1,446	6	164	162 (98.8)	421	271 (64.4)	245 (90.4)
3	Madhavaram	13	2	1,831	12	295	271 (91.9)	737	597 (81.0)	368 (61.6)
4	Tondiarpet	14	4	3,071	29	682	650 (95.3)	1,605	1,181 (73.6)	866 (73.3)
5	Royapuram	15	4	1,596	24	598	493 (82.4)	1,315	1,130 (85.9)	945 (83.6)
6	Thiru-Vi-Ka Nagar	14	5	2,712	31	849	709 (83.5)	1,816	1,477 (81.3)	1,085 (73.5)
7	Ambattur	15	4	3,541	24	536	462 (86.2)	1,361	1,157 (85.0)	984 (85.0)
8	Anna Nagar	16	4	2,645	24	719	538 (74.8)	1,496	1,244 (83.2)	974 (78.3)
9	Teynampet	18	5	1,973	35	747	731 (97.9)	1,605	1,332 (83.0)	1,236 (92.8)
10	Kodambakkam	15	4	2,575	24	572	539 (94.2)	1,270	1,122 (88.3)	990 (88.2)
11	Valasarvakkam	13	2	6,675	12	353	344 (97.5)	724	578 (79.8)	522 (90.3)
12	Alandur	12	2	2,047	12	306	281 (91.8)	747	649 (86.9)	510 (78.6)
13	Adyar	13	7	5,701	42	1,058	1,026 (97.0)	2,537	2,056 (81.0)	1,855 (90.2)
14	Perunkudi	11	3	3,115	18	460	454 (98.7)	1,051	957 (91.1)	890 (93.0)
15	Sozhinganallur	10	1	2,392	6	158	158 (100.0)	448	332 (74.1)	281 (84.6)
Total		200	51	42,610	321	7,935	7,234 (91.2)	18,040	14,839 (82.3)	12,405 (83.6)

*SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.
†Percentage calculated out of eligible participants.
‡Percentage calculated out of available participants.

Appendix Table 2. Seroprevalence of IgG antibodies against SARS-CoV-2 by selected wards, Greater Chennai Corporation, India, July 2020*

	No. persons		Unweighted seroprevalence,	Test performance adjusted
Ward Name	Tested	Positive	% (95% CI)	seroprevalence, % (95% CI)
Ward 47–Korukkupet	245	123	50.0 (43.7–56.3)	49.8 (43.5–56.1)
Ward 39–New Washermen Pet	230	113	49.0 (42.5–55.5)	48.8 (42.3–55.3)
Ward 14–Kaladipet	200	94	47.0 (40.1–53.9)	46.8 (39.8–53.7)
Ward 43–Royapuram	243	115	47.0 (40.7–53.3)	46.8 (40.5–53.1)
Ward 115–Royapettah	240	106	44.0 (37.7–50.3)	43.8 (37.5–50.1)
Ward 77–Pulianthope	157	68	43.0 (35.3–50.7)	42.8 (35.0–50.5)
Ward 104–Egmore	242	97	40.0 (33.8–46.2)	39.8 (33.6–46.0)
Ward 61–Egmore	227	83	37.0 (30.7–43.3)	36.7 (30.4–43.1)
Ward 54–Kondithoppu	219	76	35.0 (28.7–41.3)	34.7 (28.4–41.1)
Ward 50–Royapuram	252	84	33.0 (26.2–39.8)	32.7 (25.9–39.5)
Ward 58–Choolai	247	82	33.0 (27.1–38.9)	32.7 (26.8–38.6)
Ward 74–Nammalwarpet	186	61	33.0 (27.1–38.9)	32.7 (26.8–38.6)
Ward 118–Teynampet	247	81	33.0 (27.2–38.8)	32.7 (26.9–38.6)
Ward 111–Royapettah	246	68	28.0 (22.4–33.6)	27.7 (22.1–33.3)
Ward 8–Tiruvottriyur	249	66	27.0 (21.4–32.6)	26.7 (21.1–32.3)
Ward 71–Otteri	241	64	27.0 (21.5–32.5)	26.7 (21.1–32.3)
Ward 171–Saidapet	246	66	27.0 (21.5–32.5)	26.7 (21.2–32.2)
Ward 122–Raja Annamalai Puram	249	64	26.0 (20.6–31.4)	25.7 (20.2–31.2)
Ward 173–Raja Annamalai Puram	259	64	25.0 (19.7–30.3)	24.7 (19.4–30.0)
Ward 21–Manali	245	59	24.0 (18.7–29.3)	23.7 (18.3–29.1)
Ward 1–Kathivakkam	205	47	23.0 (17.2–28.8)	22.7 (16.9–28.5)
Ward 97–Ayanavaram	241	56	23.0 (17.7–28.3)	22.7 (17.4–28.0)
Ward 140–Saidapet	261	60	23.0 (17.9–28.1)	22.7 (17.6–27.8)
Ward 177–Velachery West	274	62	23.0 (18.0–28.0)	22.7 (17.7–27.7)
Ward 36–Vyasarpadi	148	32	22.0 (15.3–28.7)	21.7 (15.0–28.4)
Ward 107–Chetpet	251	56	22.0 (16.9–27.1)	21.7 (16.5–26.8)
Ward 163–Adambakkam	240	49	20.0 (14.9–25.1)	19.7 (14.6–24.8)
Ward 93–Mugappair East	247	42	17.0 (12.3–21.7)	16.7 (12.0–21.4)
Ward 126–Raja Annamalai Puram	254	44	17.0 (12.4–21.6)	16.7 (12.0–21.3)
Ward 145–Nerkundram	269	47	17.0 (12.5–21.5)	16.7 (12.1–21.2)
Ward 170–Ekkattuthangal	266	45	17.0 (12.5–21.5)	16.7 (12.2–21.2)
Ward 84–Korattur	237	38	16.0 (11.3–20.7)	15.7 (11.0–20.3)
Ward 180–Thiruvanmiyur	273	44	16.0 (11.7–20.3)	15.7 (11.3–20.0)
Ward 100–Anna Nagar	240	36	15.0 (10.5–19.5)	14.7 (10.1–19.2)
Ward 133–West Mambalam	244	37	15.0 (10.5–19.5)	14.7 (10.2–19.2)
Ward 89–A.N.W. Extension	254	36	14.0 (9.7–18.3)	13.7 (9.4–17.9)
Ward 22–Kavankarai	203	22	11.0 (6.7–15.3)	10.6 (6.3–15.0)
Ward 137–Nesapakkam	236	26	11.0 (7.0–15.0)	10.6 (6.6–14.7)
Ward 67–Peravallur	246	24	10.0 (6.3–13.7)	9.6 (5.9–13.4)
Ward 129–Saligramam	249	25	10.0 (6.3–13.7)	9.6 (5.9–13.4)
Ward 150–Karambakkam	253	26	10.0 (6.3–13.7)	9.6 (5.9–13.4)
Ward 193–Thoraipakkam	281	29	10.0 (6.5–13.5)	9.6 (6.1–13.2)
Ward 65–Kolathur	255	23	9.0 (5.5–12.5)	8.6 (5.1–12.2)
Ward 178–Velachery East	260	24	9.0 (5.5–12.5)	8.6 (5.1–12.1)

Ward Name	No. persons		Unweighted seroprevalence, % (95% CI)	Test performance adjusted seroprevalence, % (95% CI)
	Tested	Positive		
Ward 183–Kottivakkam	261	23	9.0 (5.5–12.5)	8.6 (5.1–12.1)
Ward 80–Pudur	246	17	7.0 (3.8–10.2)	6.6 (3.4–9.8)
Ward 188–Madipakkam	350	24	7.0 (4.3–9.7)	6.6 (3.9–9.3)
Ward 168–Ullagaram	279	18	6.0 (3.2–8.8)	5.6 (2.8–8.4)
Ward 175–Thiruvanmiyur	277	15	5.0 (2.4–7.6)	4.6 (2.0–7.2)
Ward 156–Mugalivakkam	270	8	3.0 (1.0–5.0)	2.6 (0.6–4.7)
Ward 32–Lakshmipuram–Madhavaram	165	4	2.0 (0.0–4.1)	1.6 (0.0–3.8)

*SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

Appendix Table 3. Characteristics of persons surveyed for enrollment in severe acute respiratory syndrome coronavirus 2 serosurvey, Greater Chennai Corporation, India, July 2020

Characteristics	Participated in the survey, no. (% of total)	Refused to participate in serosurvey, no. (% of total)
Total	12,319	2,434
Age, y*		
10–19	1,473 (12.0)	522 (21.4)
20–29	2,105 (17.1)	468 (19.2)
30–39	2,353 (19.1)	406 (16.7)
40–49	2,353 (19.1)	364 (15.0)
50–59	1,927 (15.6)	302 (12.4)
≥60	2,108 (17.1)	372 (15.3)
Sex**		
M	5,785 (47.0)	1,015 (41.7)
F	6,493 (52.7)	1,412 (58.0)
Other	41 (0.3)	7 (0.3)

*χ^2 test comparing those participated and those who refused, 184.12 ($p<0.001$).
**χ^2 test comparing those participated and those who refused, 22.9 ($p<0.001$).