Population-based repeat cross-sectional seroprevalence survey of SARS-CoV-2 IgG antibodies in Pimpri Chinchwad Municipal Corporation Area, Maharashtra, India

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ABSTRACT

Context: Population-based seroepidemiological studies are recommended to measure the extent of spread of coronavirus disease of 2019 (COVID-19) infection in an area. The present seroprevalence survey was planned with the aim to estimate the cumulative burden of the COVID-19 disease in the Pimpri Chinchwad corporation area.

Aims: To estimate the cumulative burden of the COVID-19 disease in the Pimpri Chinchwad corporation area.

Settings and Design: The study was carried out in Pimpri Chinchwad Municipal Corporation (PCMC) city area. It was a descriptive cross-sectional survey.

Materials and Methods: A population-based seroprevalence study for immunoglobulin G (IgG) antibodies for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was carried out among 10082 residents in the age group of 6 years and above selected by cluster random sampling. Thirty-five clusters were in slums, 45 clusters in tenements and 120 clusters from housing societies. The fieldwork for the collection of samples was carried out from 16 June to 17 June 2021. For antibody testing, a kit from Abbott (SARS-CoV-2 IgG) was used which employs chemiluminescent microparticle immunoassay (CMIA) technology.

Statistical Analysis Used: Frequency analysis was done for sociodemographic variables, the cumulative incidence of COVID-19, age-stratified infection rate, risk factors and COVID symptomatic versus asymptomatic cases. Chi-square test of association was applied to test the association between seropositivity and sociodemographic and clinical profile of participants.

Results: The overall seropositivity for IgG antibodies was 81.34%. Those living in the Gaothan area (tenements) had a positivity rate of 84.5%. The age group between 45 and 60 years had a seropositivity of 91%.

Conclusions: The study indicates that a considerable proportion of the population had encountered the novel coronavirus approaching herd immunity.

Keywords: IgG, India, Pimpri Chinchwad, SARS-CoV-2, seroprevalence

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Introduction

In India, the first case of coronavirus disease of 2019 (COVID-19) was reported on 30 January 2020.[1] As of 18 June 2021, this is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

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29,762,793 laboratory-confirmed cases and 3,83,490 deaths were reported from India. There is a wide variation in the reporting of cases across the States/Union Territories and the districts within each State. Population-based seroepidemiological studies are recommended to measure the extent of the spread of infection in an area and recommend containment measures accordingly.

The World Health Organization (WHO) has recommended three types of seroepidemiological studies: (i) cross-sectional surveys, most appropriate after the peak transmission is established; (ii) repeated cross-sectional investigation in the same geographic area to establish trends in an evolving pandemic; and (iii) longitudinal cohort study with a serial sampling of the same individuals.

The serological test for COVID is based on the detection of immunoglobulin G (IgG) antibodies. Apart from screening, we can estimate herd immunity by determining the immune status.

Pimpri Chinchwad Municipal Corporation (PCMC) has more than 2,53,747 cases in its region with more than 4246 deaths. Although contact tracing and testing have been done on most of the subjects, the subclinical profile of the disease poses a lot of challenges in formulating interventions. A seroprevalence survey can give policymakers a detailed analysis of the extent of infection in the community. This will help policymakers design policies in an efficient manner. Also, primary healthcare physicians will be benefitted from the improvement of diagnostic accuracy of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by such seroprevalence surveys. The present seroprevalence survey was planned with the aim to estimate the cumulative burden of the COVID-19 disease in the Pimpri Chinchwad corporation area.

Subjects and Methods

The study was a population-based cross-sectional study. The study participants were from the general population aged 6 years and above of PCMC area. It was carried out between 16 June 2021 and 26 June 2021. As per the previous serosurvey carried out in PCMC in October 2020, the seroprevalence rate of SARS-CoV-2 IgG antibodies was 34.04%; with 0.1% precision, 99% confidence interval and design effect of 2.5%; the sample size calculated was 9687 which was rounded to 10000. All individuals identified for recruitment into the investigation and those aged above 6 years were included in the study. Also, those who refused to participate and had contraindication for venepuncture were excluded from the study. Further, the participants eligible after exclusion were selected using stratified cluster random sampling.

The PCMC area was divided into 106 administrative wards. The area was stratified into slum and non-slum areas. PCMC also caters to approximately seven lakh population who live in close houses with no or minimal space between them. Although they differ marginally in their housing structures, they were broadly referred to as ‘Chawl-like settlements’ or Gaotan during the study. Hence, non-slum areas were further stratified into Gaotan and elite areas.

Probability proportionate to size sampling was done to calculate sample size for each of these strata as per the 2011 census. Clusters were selected from the cumulative sample from each stratum. The household was considered as a sampling unit and the sample was taken from all the individuals in a house. Two hundred clusters with 50 samples from each cluster of three strata based on the housing structure of slum, tenements (Gaotan) and housing societies (elite) with 35, 45 and 120 clusters each, respectively, were selected.

The stratum was further divided into four quadrants based on the number of clusters, north-east, north-west, south-east and south-west. The first house of the cluster was then randomly selected from the quadrant. In a cluster, every fourth house was selected from the first house. If the house was closed or nonresponsive, the next house was taken until the required number of households was met. For elite areas with apartments, one house was selected randomly from every fourth apartment.

The survey form questionnaire included sociodemographic data of the subject, the COVID-19 exposure history, symptoms in case of confirmed/suspected COVID-19, details of COVID-19 tests done and COVID-19 vaccination status. The questionnaire was administered by the trained medical officers/auxiliary nurse midwives (ANMs). Blood samples were collected by trained laboratory technicians. 3–5 ml blood samples were collected from each subject. The serum was separated from these blood samples by centrifugation. The testing of samples was done using Abbott CMIA with 92.7% sensitivity and 99.9% specificity. The serum samples were stored in a −200°C deep freezer for a period of 6 months.

Ethical approval was taken from the institutional ethics committee, PCMC’s PGI and YCMH, Pimpri. Informed consent was obtained from all the individuals willing to participate in the investigation. For children under the legal age, consent was obtained from a parent or legal guardian. The obtained data was entered in Microsoft (MS)-Excel worksheet. Frequency analysis was done for sociodemographic variables, the cumulative incidence of COVID-19, age-stratified infection rate, risk factors and COVID symptomatic versus asymptomatic cases. Chi-square test for association was applied to test the association between seropositivity and sociodemographic and clinical profile of participants.

Results

Out of the total 10082 population surveyed, 6299 (62.5%) were living in the elite area followed by the tenements area (23%) and slum (14.5%). Gender-wise, females were 5236 (52%) and males were 4846 (48%). Age-wise, 8452 (84%) surveyed were above 18 years of age; also, we had surveyed 1630 (16%) population
from 6 to 18 years age. Religion-wise, 89% population surveyed was Hindu followed by Buddhist (3.5%). 93% population surveyed was literate, only 7% were illiterate. When we assessed the socioeconomic status (SES) by the modified Kuppuswamy scale, 3675 (37%) subjects belonged to upper lower SES, followed by upper-middle-class (19%), although 25% of participants did not give adequate information to decide their SES.

The overall seroprevalence of SARS Cov-2 IgG antibodies was 81% in the PCMC area [Table 1]. Seropositivity for SARS-Cov-2 IgG antibodies was found to be higher in tenement areas (84.48%) of Pimpri Chinchwad city as compared to slum area (82.5%) and elite area (80.0%) which was statistically significant ($P = 0.001$) [Table 2]. There was no difference in seropositivity among participants as per religion, gender and SES. The age group above 45 years had 91% (2932) of seropositivity, those between 18 and 44 years had 78.9% (4125), while the age group between 6 and 18 years age had 70% (1150) seropositivity; this difference was found to be statistically significant ($P = 0.001$) [Table 2]. Those participants who had confirmed COVID-19 in the past one year had 96% (1250) of seropositivity [Figure 1]. One thousand two hundred and forty-nine participants having a history of symptoms suggestive of COVID-19 infection had significantly ($P = 0.001$) higher seropositivity (95%) than asymptomatic participants (79%) [Table 2].

With reference to 81% seroprevalence found in the present study, 20,31,129 were the estimated COVID-19 infections that occurred in Pimpri Chinchwad city till the end of June 2021. Among these estimated COVID-19 infections, symptomatic to asymptomatic patient ratio was 308935:1721991 (1:5.5) cases. As of 7 July 2021, there were 4301 COVID-19 reported deaths in Pimpri Chinchwad city. So, with estimated 20 lakh infections, it gives an infection fatality rate (IFR) of 0.21% which is very less as compared to the reported case fatality rate of 1.67% [Table 3].

To summarize the results, overall seropositivity is 81%. The highest seropositivity is observed in tenements (Gaothan) followed by slums and elite. Across all age groups, seropositivity is above 70% (It is above 90% among 45 years and above). Significant association ($P = 0.001$) of COVID-19 IgG antibody seropositivity was observed with the area of residence, age group, confirmed cases of COVID-19 and history of COVID-19 symptoms. In Pimpri Chinchwad city, observed IFR was 0.21% of estimated infections as compared to reported case fatality rate of 1.67% among reported cases; also, there are approximately six estimated asymptomatic infections per one symptomatic infection.

**Discussion**

The seroprevalence survey was planned with the aim to estimate the cumulative burden of the COVID-19 disease in the Pimpri
Chinchwad corporation area and to examine the associated risk factors.

The study found 81% seropositivity in Pimpri Chinchwad city. The seropositivity found in the twin city is very high compared to the previous serosurvey which was performed in October 2020. This indicates that the novel coronavirus has almost infected two-thirds population of the city which may be attributed to the drastic second wave of the virus along with universal immunization against the coronavirus. In the study, we have estimated seropositivity based on IgG antibodies against the coronavirus. It has been postulated that IgG prevalence studies may underestimate the true population-level immunity to COVID-19. [10] Herd immunity may be higher than antibodies level due to immunity conferred by T cells as inferred by the researchers at the Karolinska Institute. [19]

There was variation in seroprevalence as per the type of residence; those who lived in tenement areas had higher seropositivity as compared to elite and slum areas of Pimpri Chinchwad. This trend is similar to the previous survey. [9] The reason behind the higher seroprevalence might be the close proximity of the houses in the tenement areas with overcrowding conditions and poor ventilation which is favourable to airborne spread of coronavirus. A similar trend of higher seropositivity in slum areas was found in the Malegaon serosurvey [11] and the national serosurvey by ICMR. [12] The age-stratified seroprevalence was above 70% across all age groups. The seroprevalence above 60 years was 90% and below 18 years was 70%. The high seroprevalence among the geriatric population may be due to higher exposure as well as due to vaccination against coronavirus. The study done by Ghose et al. [11] found a uniformed seroprevalence of 51% among those below 60 years age group participants but found low seroprevalence above 66 years age participants. The high seroprevalence in children in this study suggests high household transmission of SARS-CoV-2 in spite of measures like strict lockdown.

Tokyo study by Takita et al. [8] reflects results suggesting that a community-based investigation of prevalence, rather than state- or prefecture-level, would be beneficial in exploring the cause of epidemic contagion. The primary care physicians per unit population have a critical role in identifying and notifying the key epidemiological factors related to COVID-19, affecting the seroprevalence.

Religion- and gender-wise there was no significant difference in seroprevalence, conversely, seroprevalence studies done in Malegaon [11] and Pune [13] found higher seroprevalence among Muslim participants while national seroprevalence study found higher seroprevalence in males. [10] Based on 81% seroprevalence of SARS-CoV-2 antibodies in Pimpri Chinchwad found in our study, there were approximately 20 lakh cases of SARS-CoV-2 which is 10 times of actual detected cases. Further, we have found symptomatic and asymptomatic COVID case ratio of 1:6 in Pimpri Chinchwad.

The IFR in this study was 0.21% which is similar to the seroprevalence study in Pune city. [15] This is also consistent with a global median IFR of 0.27%, estimated from a meta-analysis of multiple studies. [14] The IFR is slightly higher than that of 0.11% found in the national serosurvey. [12] The difference may be due to the selective reference of severe cases to big cities like Pimpri Chinchwad because of better healthcare facilities for severely ill COVID cases.

To conclude, the study found a two-thirds population of Pimpri Chinchwad had IgG antibodies against SARS-CoV-2, and for every symptomatic case of COVID, there were six asymptomatic cases which mean widespread transmission of COVID in the city. The study may partly explain the declining trend of SARS-CoV-2 cases in Pimpri Chinchwad city in spite of easing of lockdown restrictions.

The limitation of the study is that it does not test cellular immunity against the virus which provides protective and long-lasting immunity against the virus. It has been postulated that IgG prevalence studies may underestimate the true population-level immunity to COVID-19. [10] Herd immunity may be higher than antibodies level due to immunity conferred by T cells as inferred by the researchers at the Karolinska Institute. [19] A study from Singapore also suggests the role of T cells in the immunity against COVID-19. [15]

**Table 3: Summary statistics**

| Statistical variable                      | Numbers & percentage |
|------------------------------------------|----------------------|
| Total population of PCMC                 | 2497085              |
| Detected COVID-19 cases (PCMC) as on 7 July 2021 | 258796               |
| Estimated COVID-19 cases (81.34% seropositivity) | 2031129             |
| Estimated asymptomatic seropositive (84.78%) | 1721991              |
| Estimated symptomatic seropositive (15.22%) | 308935               |
| Asymptomatic to symptomatic seropositive ratio | 5.57                |
| Deaths (PCMC) as on 7 July 2021          | 4301                 |
| Seropositivity in PCMC                   | 81.34%               |
| IFR                                      | 0.21%                |
| Case fatality rate                       | 1.67%                |

**Key message**

The study may partly explain the declining trend of SARS-CoV-2 cases in Pimpri Chinchwad city in spite of easing of lockdown restrictions.

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Conflicts of interest
There are no conflicts of interest.

References
1. Andrews MA, Areekal B, Rajesh KR, Krishnan J, Suryakala R, Krishnan B, et al. First confirmed case of COVID-19 infection in India: A case report. Indian J Med Res 2020;151:490-2.
2. Government of India. COVID-19 Dashboard. Available from: https://www.mygov.in/covid-19. [Last accessed on 2021 Jun 18].
3. World Health Organization. A Coordinated Global Research Roadmap: 2019 Novel Coronavirus; March 2020. Geneva: WHO; 2020.
4. Clapham H, Hay J, Routledge I, Takahashi S, Choisy M, Cummings D, et al. Seroepidemiologic study designs for determining SARS-COV-2 transmission and immunity. Emerg Infect Dis 2020;26:1978-86.
5. World Health Organization. Population-based age stratified seroepidemiological investigation protocol for COVID-19 virus infection. Available from: https://www.who.int/publications-detail/population-based-age-stratified-seroepidemiological-investigation-protocol-for-covid-19-virus-infection. [Last accessed on 2020 Apr 24].
6. Kontou PI, Braliou GG, Dimou NL, Nikolopoulos G, Bagos PG. Antibody tests in detecting SARS-CoV-2 infection: A meta-analysis. Diagnostics (Basel) 2020;10:319.
7. PCMC. COVID-19 Dashboard. Available from: http://103.224.247.133:8080/Covid19PCMC/. [Last accessed on 2021 Jun 18].
8. Takita M, Matsumura T, Yamamoto K, Yamashita E, Hosoda K, Hamaki T, et al. Geographical profiles of COVID-19 outbreak in Tokyo: An analysis of the primary care clinic-based point-of-care antibody testing. J Prim Care Community Health 2020;11:2150132720942695.
9. Banerjee A, Gaikwad B, Desale A, Jadhav SL, Rathod H, Srivastava K. Severe acute respiratory syndrome-coronavirus-2 seroepidemiology study in Pimpri-Chinchwad, Maharashtra, India coinciding with falling trend-Do the results suggest imminent herd immunity? Indian J Public Health 2021;65:256-60.
10. Sekine T, Perez-Potti A, Rivera-Ballesteros O, Ljunggren H, Aleman S, Buggert M, et al. Robust T cell immunity in convalescent individuals with asymptomatic or mild Covid-19. Cell 2020;183:158-68.
11. Saple P, Gosavi S, Pawar T, Chaudhari G, Mahale H, Deshmukh P, et al. Seroprevalence of anti-SARS-CoV-2 of IgG antibody by ELISA: Community-based, cross-sectional study from urban area of Malegaon, Maharashtra. J Family Med Prim Care 2021;10:1453-8.
12. 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.
13. Ghose A, Bhattacharyya S, Karthikeyan AS, Kudale AM, Monteiro JM, Joshi A, et al. Community prevalence of antibodies to SARS-CoV-2 and correlates of protective immunity in an Indian metropolitan city. medRxiv. 2020. doi: 10.1101/2020.11.17.20228155.
14. Ioannidis JPA. Infection fatality rate of COVID-19 inferred from seroprevalence data. Bull World Health Organ 2021;99:19-33F.
15. Le Bert N, Tan AT, Kunasegaran K, Tham CYL, Hafezi M, Chia A, et al. SARS-CoV-2-specific T cell immunity in cases of COVID-19 and SARS, and uninfected controls. Nature 2020;584:457-62.