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A Descriptive Study of Community based Seroprevalence of SARS-CoV2 antibodies among adult population in Mumbai, India using an ELISA based assay

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Review Article

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Abstract

Background: Mumbai, with over 12 million residents, is one of the largest cities in India and the capital of the state of Maharashtra that accounted for close to 20% of the total COVID-19 cases in India. Regular serosurveys in Mumbai have shown stark differences in seroprevalence between slum and non-slum areas. The present study aimed to evaluate the prevalence of SARS-CoV-2 antibodies in Mumbai residents and assess the impact of the second wave and ongoing vaccination campaign on the population antibodies. By the start of the study period, 63% of Mumbai residents were partially vaccinated and 21% were fully vaccinated for COVID-19.

Methods: We conducted a cross-sectional seroprevalence study in all 24 wards of Mumbai between August 12 and September 08, 2021. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) antibody seropositivity was detected using an ELISA based assay. Sociodemographic and exposure related data was collected via a verbal questionnaire to analyse risk factors and association with COVID-19 vaccination.

Findings: Of the 8,674 participants recruited, 7,516 were positive for IgG SARS-COV-2, resulting in a crude seroprevalence of 86.6%. Using residence type based on the recruitment location (municipal dispensaries for slum residents and general practitioners for non-slum residents), the difference in prevalence between slum and non-slum is not significant (87.0% vs. 86.2%; RR: 1.009, CI: 0.992-1.026). Seroprevalence was higher in females (88.3%) than in males (85.1%) (RR: 096, CI 95%: 0.94-0.97)

Conclusion: Our results suggest that the levels of immunity are high in the Mumbai population across residence types. These findings highlight the extent of virus transmission during the second wave and point to the susceptible population to guide the vaccination strategy and better understand transmission dynamics in urban settings.

Keywords: Public Health; SARS CoV-2 Prevalence; COVID-19 Vaccination; India

Introduction

As of May 2022, the Indian Ministry of Health and Family Welfare reported over 42 million COVID-19 cases since the beginning of the pandemic of which close to 8 million were reported in the state of Maharashtra. Although there are significant regional variations, India's COVID-19 disease trend was marked by three distinct waves. The first, second and third waves occurred respectively between July and November 2020, March and May 2021 and December 2021 and February 2022. While reported cases are a good indicator of disease trends, they generally significantly underestimate the true burden of disease due to the high number of asymptomatic and mildly symptomatic cases. In order to overcome this challenge, WHO and others have recommended population-based sero-epidemiological studies to generate data and inform pandemic response policies. These surveys also can give us an estimation of the proportion of the population still susceptible to the infection as it is assumed that antibodies provide immunity. The protective role of antibodies against SARS-CoV-2 is unknown, but these antibodies are usually a reasonable correlate of antiviral immunity, and anti–receptor-binding domain antibody levels correspond to plasma viral neutralizing activity.

In Mumbai, a city of over 12 million residents in Maharashtra, the health authorities of the Municipal Corporation of Greater Mumbai (MCGM) have conducted regular SARS CoV-2 serosurveys since the beginning of the pandemic. The first survey, conducted in July 2020, found a prevalence of 57% in slums and 16% in non-slums areas. This first study showed the significant difference in virus transmission between slums-where over half of Mumbai dwellers live - and non-slum areas [1]. The second serosurvey, conducted in August, 2020, estimated the prevalence at around 44.9% in slums and 17.5% in non-slums. The third round, conducted in March 2021, showed a further reduction in the gap between slums and non-slum areas with an estimated seroprevalence of respectively 41.6% and 28.5%. An additional survey was conducted in the paediatric population in June 2021, immediately after the second wave. The study estimated a seroprevalence of 51.42%. The COVID-19 vaccination campaign in India started in January 20221 for priority groups and opened to all adults by May 2021. As of May 2022, 72% of the population is partially vaccinated and 62% is fully vaccinated.

Materials and Methods

Study Design and Participants

A city-wide population-based serosurveillance study was conducted in all 24 wards of the city of Mumbai between August 12 and September 08, 2021. All individuals above the age of 18 residing in the Greater Mumbai area for at least 6 months were eligible to participate. The exclusion criteria included being part of the same household as another participant and refusing to give informed consent.

The minimum sample size of 8,117 was calculated based on the following assumptions:

$$N = [\mathrm{NP}(1-\mathrm{P})] / [(\mathrm{D}\,2 / \mathrm{Z}\,21 - A / 2 * (N-1) + P * (1-P)] \quad (10)$$

Where N is the population size, Z is the 95% confidence interval, P is the estimated proportion of 30.26 based on pilot study and D is the absolute precision of 1% we then adopted a population probability sampling method to identify the number of samples to be collected from each of the 24 wards based on the projected mid-year population of the MCGM. The primary outcome was seropositivity (seroprevalence in the target groups) and the secondary outcomes were symptoms and risk factors associated with seropositivity.

Sample and Data Collection

Participants were randomly selected in health facilities. Recruitment took place in both municipal dispensaries (for the slum population) and in general practitioners' practices (for non-slum population). All municipal dispensaries were included in the study and the sample size was equally distributed within the dispensaries in a ward. The general practitioners were selected at ward level by systematic random sampling based on the list of practitioners registered with the municipal authorities. Fieldwork was conducted by teams from the MCGM and from a private laboratory. During the visit, the interviewer explained the purpose of the study to potential participants. After obtaining informed consent, the interviewers used a mobile-based survey to collect data on sociodemographic characteristics, history of positive PCR testing for SARS-CoV-2 and COVID-19 vaccination status. Upon sample collection, trained laboratory personnel analyzed the serological test, and the participants were informed about the test results thereafter.

About 05ml of blood was collected through venepuncture from each participant in a plain vacutainer and transported in cold chain to the microbiology department of the Lokmanya Tilak Municipal Medical College and General Hospital. Serological testing was conducted with the Indian Council of Medical research approved Covid Kawach IgG Microlisa test. The manufacturer reported a sensitivity of 96.3% and a specificity of 100%. Samples collected were marked with a unique identification number for processing by the department of microbiology. A second team was in charge of regular data monitoring and data analysis.

Ethical Statement

The protocol of the study was approved in August 2021 by the Ethics Committee of the Lokmanya Tilak Municipal Medical College and General Hospital (Reference number: IEC/68/21). Participation in the study was voluntary and an informed consent was obtained from each participant.

Statistical Analysis

Data analyses were performed using the statistical software SPSS version 26.0. The seroprevalence of IgG antibodies against SARS-COV-2 with 95% CI was estimated as the proportion of individuals who had a positive result in the IgG ELISA test. We also calculated seroprevalences by age group, sex, area of residence and SARS-CoV-2 infection-related characteristics of study participants.

Results

A total of 8,701 participants were recruited between 12th August, 2021 and 8th September, 2021 in municipal dispensaries and general practitioners' practices in all 24 wards of Mumbai. After data cleaning and results consolidation, 8,674 people were included in the analysis. More than half of study participants were recruited in municipal dispensaries (4,608 of 8,674, 53%) while the rest were recruited in private practices. Over 20% (1,799 of 8,674) of participants reported living in a kacca house - these are generally made of easily available material like mud, straw or stones and are typically owned or occupied by the lowest socio-economic classes. The remaining participants lived in pucca houses made of steel, cement or bricks that form a concrete structure. The majority of participants reported having a separate toilet (4,933 of 8,674, 56%) while the rest shared a common toilet with their building or neighbors.

Most study participants were partially or fully vaccinated (5,660 of 8,674, 65%; 3,014 unvaccinated, 35%). Among vaccinated individuals, 95% reported being vaccinated with Covishield and 4% with Covaxin. Among unvaccinated individuals, the most common reasons for not being vaccinated were unavailability of COVID-19 vaccine (51%), fear of side effects (14%) and technical difficulties to book a vaccine slot (11%). Participant recruitment occurred in healthcare facilities by an external team and our sample included a large number of healthcare workers. A total of 1,867 (22%) healthcare workers were included in the study.

Characteristics	N	Risk	Risk Ratio
Overall seropositive	**7516**		
Age groups, years			1.051 (CI 95% 1.036, 1.065)
18-44	3804	85.18%	
45-59	2465	89.60%	
60 and above	1247	85.60%	
Sex			0.9635 (CI 95% 0.9477, 0.9795)
Male	3773	85.10%	
Female	3742	88.30%	
Others	1		
Tested Positive for COVID-19			1.099 (CI 95% 1.07, 1.128)
Yes	313	94.90%	
No	7203	86.30%	
Vaccination			1.13(CI 95% 1.108, 1.153)
Yes	5109	90.30%	
No	2407	79.90%	
Residence			1.009 (CI 95% 0.9926, 1.026)
Slum	4010	87.00%	
Non-slum	3506	86.20%	
Type of house			1.025 (CI 95% 1.005, 1.044)
Kacha	1589	88.33%	
Pucca	5927	86.21%	
N number; % percentage			

Table 2: SARS CoV-2 seroprevalence.

The prevalence of SARS CoV-2 antibodies in the population was 86.6% with, for the first time, only a marginal difference between slums and non-slum residents. Using residence type based on the recruitment location (municipal dispensaries for slum residents and general practitioners for non-slum residents), the difference between slum and non-slum is not significant (87.0% vs. 86.2%; RR: 1.009, CI: 0.992-1.026). The seroprevalence was also higher in women than in men (88.3% vs. 85.1%; CI 95%: 0.94-0.97). The younger (18-44 years old) and older population (60 years and above) had a lower seroprevalence than the middle-aged group (45-59 years old). The overall COVID-19 vaccination coverage was 65% across the city. It was similar across gender but it was lower for the younger age group (59%) than for the "45-59" and "60 and above" age group (at respectively 72% and 70%). Major gaps in vaccination coverage were observed by location. Slum dwellers had vaccination coverage of 58% while it was 74% for non-slum dwellers. The vaccination coverage was 69% for Hindus, 27% for Muslims, 74% for Christians, and 88% for others.

Discussion

This study represents the first serosurvey conducted in Mumbai after the second wave and the launch of the vaccination campaign in the general population. It shows a high level of seropositivity in the community. In particular, this is the first survey to show a similar seroprevalence in slum and non-slum population. Serosurveys conducted at the same period in Delhi showed a similar seropositivity of 89.5% [2].

Due to recruitment biases, we over-recruited health care workers in the study. Our study shows a similar prevalence rate in the health-care worker and non-health care worker population. While they are generally considered to be more at risk, this could be due to higher vaccination rates in this population or better protection against the virus through effective and regular use of personal protective equipment. The seroprevalence is higher in women; this was already the case in previous studies and requires further investigation. Some possibilities would be that women tend to stay indoors most times and this represents a higher infection risk. Our findings on vaccination coverage highlight major inequalities in vaccination. The proportion of vaccination in non-slum areas is significantly higher than in slum areas. This could be due to the difficulties to get an appointment using the government application, Co-WIN that initially was the only medium to access the vaccination. In addition, research on routine immunisation in India (Ministry of Health and Family Welfare, 2017) [3] shows the poorest quintile has a lower vaccination rate. This is further enhanced for the COVID-19 vaccination campaign with a low 27% coverage in the Muslim community, well below the average of 65%.

Conclusion

Our findings show the high level of virus transmission and uptake of the vaccination campaign has significantly increased the levels of seropositivity in Mumbai. While the disparities between slums and non-slum areas have reduced, this research has highlighted some pockets of lower seroprevalence that should be the target of public health interventions. This research provides insightful understanding of the potential impact of future waves as well as transmission dynamics in urban settings.

Conflicts of Interest

We declare no conflict of interest

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