

Sero-epidemiological survey of SARS-Cov2 in urban slums of a capital city: A cross-sectional study

Santosh K. Nirala¹, Bijaya N. Naik¹, Neha Chaudhary¹, Alok Ranjan¹, Mala Mahto², Sanjay Pandey¹, Chandra Mani Singh¹, Prabhat K. Singh³

Departments of ¹Community and Family Medicine, ²Biochemistry and ³Anaesthesiology and Critical Care, AIIMS, Patna, Bihar, India

ABSTRACT

Introduction: Slums are the most vulnerable settlements for COVID-19 infection due to overcrowding and unsanitary conditions. Thus, this study was undertaken to determine the level of seroprevalence for SARS-CoV-2 infection among slum dwellers. **Material and Methods:** A community-based cross-sectional seroepidemiological survey was conducted at several slums of Patna over four weeks, that is, January 20–February 20, 2021. A total of 650 participants were recruited in the study by applying a two-stage random sampling technique. **Results:** Seroprevalence for SARS-CoV-2-specific IgG antibody was found to be 31.5% (95% Confidence Interval (CI): 27.9–35.1). The seropositivity prevalence was found to be statistically higher among participants belonging to the age group of 18–30 years (41.1%), male gender (67.9%), high-risk occupation (70%), below poverty line (BPL) economic status (62.1%), and residing in a hut (51.2%) and kutch house (42.4%). Further, 262 participants reported having COVID-like symptoms in the preceding 1 month of the survey, which was found to be significantly associated with the seropositivity status. **Conclusion:** The finding of the study reflects that a moderate seroprevalence level of COVID-19 infection was acquired in the slum settings of Bihar. Unchecked spread in these informal communities will pose a serious threat to the rest of the bigger sections of urban populations. This indirectly calls for early intervention in the form of preference in the roadmap of COVID-19 vaccination.

Keywords: COVID-19, herd immunity, IgG antibody, pandemic, serosurvey, slum

Introduction

The COVID-19 (coronavirus disease) crisis has shown that humans are assailable and are not undecipherable.^[1] Thus, communities need to be prepared against the threat of unforeseen pandemics. This public health emergency of the century has crossed over 2 million deaths globally.^[2] At present, India stands second in position, next to the USA, with a total number of confirmed cases reported being more than 10 million to date.^[2] As far as the state of Bihar is concerned, which is one of the most densely populated states, the first severe acute respiratory

syndrome 2 (SARS CoV-2) infection was identified in March 2020, followed by more than 2.5 lakh cases confirmed till now.^[3] Further, Bihar remained severely affected and the virus diffused across all 38 districts of Bihar, among which the capital city, Patna, has witnessed the highest number of cases.^[4] SARS-CoV-2 virus arouses a rapid immune response in the form of IgM and IgG antibodies in individuals with symptomatic and asymptomatic infection.^[5] The development of IgG antibodies indicates the likelihood of potential protection against subsequent infection and also contributes toward herd protection. It is estimated that in the case of SARS-CoV-2, herd immunity will be achieved when approximately 60%–80% of the community develops immunity. Attaining herd immunity will leave only a meager susceptible population in the community, thus leading to a decline in the outbreak.^[6] In view of this, the seroprevalence

Address for correspondence: Dr. Neha Chaudhary, Senior Resident, Department of Community and Family Medicine, First Floor, AIIMS Phulwarisharif, Patna, Bihar - 801507, India. E-mail: madhuchaudhary9@gmail.com

Received: 25-10-2021

Revised: 02-01-2022

Accepted: 13-01-2022

Published: 30-06-2022

Access this article online

Quick Response Code:



Website:
www.jfmpc.com

DOI:
10.4103/jfmpc.jfmpc_2127_21

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.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Nirala SK, Naik BN, Chaudhary N, Ranjan A, Mahto M, Pandey S, et al. Sero-epidemiological survey of SARS-Cov2 in urban slums of a capital city: A cross-sectional study. J Family Med Prim Care 2022;11:2709-16.

survey for SARS-CoV-2 antibodies in a community delivers the rational measurement of the extent of exposure and spread of infection.^[5] Moreover, slums are the most vulnerable settlement for COVID-19 infection due to overcrowding and unsanitary conditions.^[7,8] Inadequate medical facilities and illiteracy further paint them more susceptible to infections.^[7,8] Consequently, insight into the actual extent of infection in the slum population is crucial to recognize the trend and dynamics of infection to plan a competent public health response. Thus, this study was undertaken to determine the level of seroprevalence for SARS-CoV-2 infection among slum dwellers. Our study also intended to determine the clinical-social risk factors for SARS-CoV-2 infection. Furthermore, this research also addresses the health-seeking behavior of individuals with flu-like symptoms from such communities in the present situation.

Methodology

Study design and study setting

A community-based cross-sectional seroepidemiological survey was conducted at several slums of Patna over four weeks, that is, January 20–February 20, 2021. Patna is the capital city of the state of Bihar in eastern India. According to census 2011, 4.5% of the population of Patna resides in 110 slum colonies.^[9] Individuals aged >18 years were recruited as study participants as they are at higher risk of exposure to COVID-19 infection.

Ethical consideration

The Institutional Ethics Committee of AIIMS Patna approved the research protocol (IEC/2020/636). The study purpose and procedure were explained to the participants. Written informed consent was obtained from the participants who agreed to take part in the study, and the test results were communicated to them by providing a printed test report copy.

Sample size

A serosurvey done in Mumbai reported that 57%^[10] of the slum population had developed antibodies. Taking this prevalence into account and a 5% absolute margin of error with a 95% level of significance, the sample size was estimated to be 377. Furthermore, to adjust for the nature of sampling, a design effect of 1.5 was used and the sample size was increased further by considering 10% non-sampling error, yielding an effective sample size of 621. However, it was decided to target 650 participants for the study.^[11]

Sampling technique

A multi-stage random sampling technique was applied for selecting households in slum colonies. First, the entire city was divided into five zones, that is, East, West, North, South, and Central. Then, in the first stage of sampling, the two largest slums (population-wise) were selected from each zone. A total of 10 slums were selected to cover the sample of 650 (65 from each slum) [Figure 1]. In the second stage, households were selected in each slum. The first household was randomly selected from

any landmark of the slum and a convention of sticking to the left was followed for selecting households till the desired number was achieved. Lastly, convenience sampling was applied to recruit one eligible individual from each household.

Inclusion criteria

Individuals aged 18–60 years who were willing to participate and give written consent for the same.

Exclusion criteria

Any contraindication to venepuncture.

Study procedure

A single team comprising one medico-social service officer, one intern, one junior resident, and one senior resident was formed to conduct the survey. In each selected slum, a local leader was approached and the study purpose was briefed to him and his support was sought for carrying out the survey. The flowchart for the recruitment of participants is shown in Figure 2. Face-to-face interview of consenting individuals was conducted using a well-designed questionnaire to collect the relevant information. Each selected participant was allocated a three-digit unique identification number. After completing the interview, blood sampling was performed under aseptic precautions and 3 mL of venous blood was collected in a yellow top serum tube with a clot activator. The total collected samples of each day were sent to the central laboratory (Biochemistry) of the institute. In the laboratory, serum was separated from the blood samples by centrifugation and tested for Anti-SARS-CoV-2 IgG antibody. However, out of a total of 650 collected samples, five samples were rejected on the ground of “quantity not sufficient” (QNS) and name mismatch. Printed reports were handed over to the participants by revisiting the area after 2–3 days of surveying each slum.

Laboratory procedure

The qualitative and semi-quantitative estimation of IgG antibodies to SARS-CoV-2 was done using the “ADVIA Centaur SARS-CoV-2 IgG assay,” which is a chemiluminescent immunoassay (CLIA). The reported sensitivity and specificity of the assay are 100% and 99.8%, respectively. The measuring interval of the assay is 0.50–20.00 index. The samples with <1.00 index were considered non-reactive and reported negative for SARS-CoV-2 IgG antibodies, whereas the samples with ≥1.00 index were considered reactive and reported positive for SARS-CoV-2 IgG antibodies.

Study tool

Face-to-face interviews were conducted using a pretested, semi-structured questionnaire that consisted of a series of questions to extract information pertaining to sociodemographic details of the participants (age, gender, occupation, and housing condition), smoking history, contact history, past history of a confirmed diagnosis of COVID-19 or symptoms suggestive

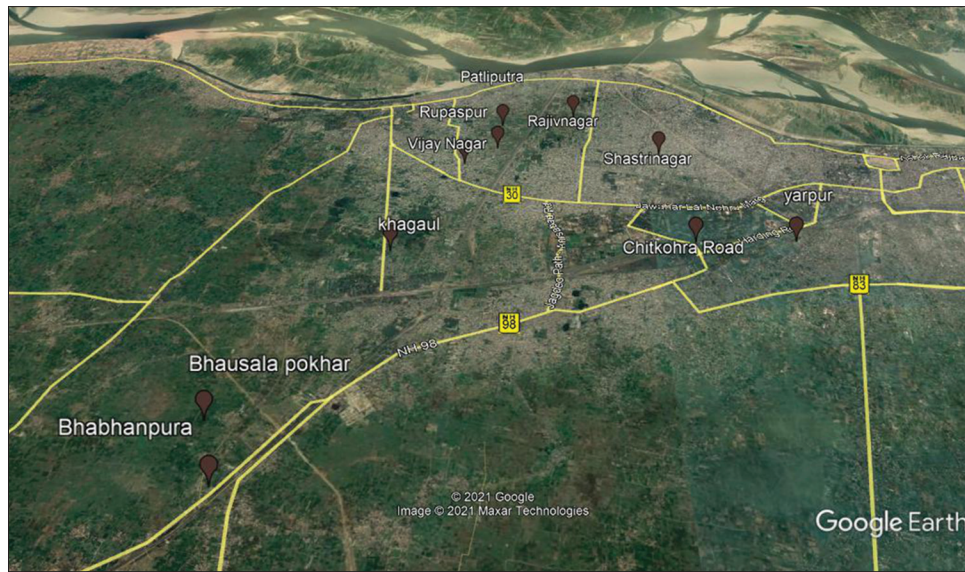


Figure 1: Location of selected slums across Patna (zoomed-in view)

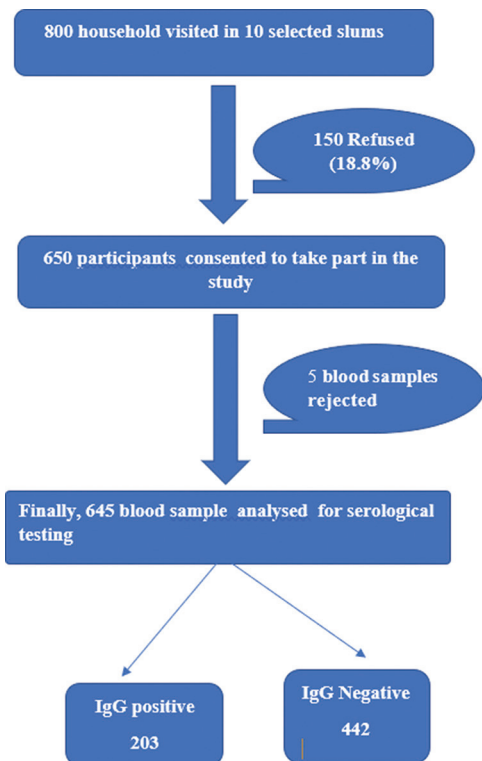


Figure 2: Flowchart depicting the recruitment of participants in the study

of COVID-19 in the preceding 1 month of the survey, health-seeking behavior, and any comorbidity.

Statistical analysis plan

The collected data were entered, cleaned, and coded in MS Excel. For analysis, age was summarized into three categories: 18–30, 31–44, and 45–60 years. Similarly, occupation was also summarized into three categories based on the risk of exposure: high risk (autorickshaw drivers, rickshaw pullers, street vendors,

etc.), low risk (shopkeepers, laborers, housemaids, etc.), and no risk (housewife, retired, unemployed, etc.). Frequency and percentages were used to present the categorical data, whereas mean and standard deviation were used to present the continuous data. Pearson’s Chi-square test and independent *t* test were used to test the association between the categorical and continuous data, respectively. $P < 0.05$ was considered statistically significant. All the variables having significant univariate analysis ($P < 0.05$) were selected for inclusion in the multiple logistic regression. STATA version 13 software was used for the analysis of data. In addition, considering the nature of the sampling technique, the cluster analysis command was used in STATA.

Results

Over 800 households were visited across the 10 selected slums. As many as 150 (18.8%) households refused to take part in the study. In total, 650 blood samples were collected, but five samples were rejected due to the quantity not being sufficient. Finally, 645 samples were analyzed [Figure 3]. Seroprevalence for SARS-CoV-2-specific IgG antibody was found to be 31.5% [95% Confidence Interval (CI): 27.9–35.1]. Table 1 displays the seroprevalence of IgG positivity according to the baseline characteristics of the participants. The mean age of participants in the study was 39.5 (11.2) years, with the majority belonging to the 31–44-years age group (36.6%) followed by 45–60 years (38.1%). More than half of the participants were male (55.7%), and approximately two-thirds of the participants (67.1%) were literate. More than half of the slum dwellers (59.7%) were engaged in occupations with a low risk of exposure to COVID-19, and only 18.3% had occupations with a high risk of exposure. The majority of participants were Hindu by religion (94.4%). Moreover, the seropositivity prevalence was found to be statistically higher among participants belonging to the age group of 18–30 years (41.1%), male gender (67.9%), and high-risk occupation (70%). However, no significant difference

in serological status was noted for the educational and religious status of participants. There was almost equal representation from both APL (51.9%) and BPL (48.1%) economic levels.

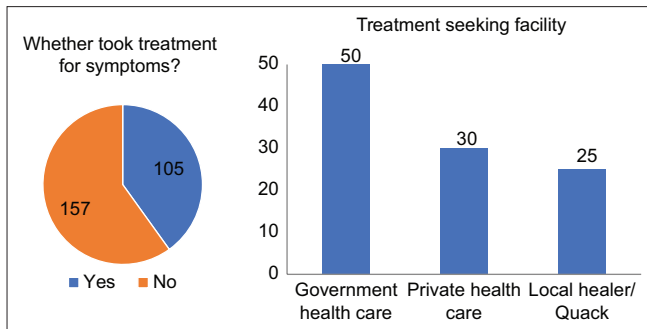


Figure 3: Distribution of participants according to the health-seeking behavior (n = 262)

More than half of the slum participants (56.4%) lived in a house; among those, 364 participants residing in a house; a maximum (37.1%) lived in a pucca house, followed by a semi pucca house (33%). The majority of participants (67.6%) denied smoking or chewing tobacco. Adding to it, higher antibody positivity was noted among individuals belonging to BPL economic status (62.1%). Furthermore, the participants residing in a hut (51.2%) and kutcha house (42.4%) were reported to have a higher prevalence of seropositivity. However, tobacco chewing/smoking habit and family type were not found to be associated with seropositivity. Regarding comorbidities, surprisingly, diabetes was found to be significantly associated with IgG positive test rate (17%). Relevant past history was inquired from the participants, which are shown in Table 2. On inquiring about the past history, only 1.3% among seropositive and 0.5% among seronegative disclosed having suffered from COVID

Table 1: Seroprevalence of COVID IgG antibodies by sociodemographic and other characteristics of participants (n=645)

Characteristics	n (%)	IgG positive n [% (95% CI)]	P (Chi-square test)
Age (years)			
18-30	163 (25.3)	84 [41.4 (34.7-48.3)]	<0.001*
31-44	236 (36.6)	72 [35.5 (29.1-2.3)]	
45-60	246 (38.1)	47 [23.1 (17.8-29.4)]	
Gender			
Female	286 (44.3)	65 [32.1 (25.9-38.7)]	0.02*
Male	359 (55.7)	138 [67.9 (61.2-74.1)]	
Education			
Illiterate	212 (32.9)	69 [34 (27.8-40.8)]	0.639
Literate	433 (67.1)	134 [66 (59.1-72.2)]	
Occupation			
Low risk	385 (59.7)	142 [70 (63.2-5.8)]	<0.001*
High risk	118 (18.3)	35 [17.2 (12.6-23.1)]	
No risk	142 (22.0)	26 [12.8 (8.8-18.1)]	
Religion			
Hindu	609 (94.4)	187 [92.1 (87.4-95.1)]	0.08
Muslim	27 (4.2)	14 [6.9 (4.1-11.3)]	
Others	9 (1.4)	2 [1 (0.2-6.4)]	
Family type			
Nuclear	296 (45.9)	86 [42.4 (35.7-49.3)]	0.223
Joint	349 (54.1)	117 [57.6 (50.7-4.2)]	
Economic level			
APL	335 (51.9)	77 [37.9 (31.4-44.8)]	<0.001*
BPL	310 (48.1)	126 [62.1 (55.2-68.5)]	
Dwelling			
House	364 (56.4)	99 [48.8 (41.9-55.6)]	0.008*
Hut	281 (43.6)	104 [51.2 (44.3-8.1)]	
House			
Kutcha	106 (29.1)	42 [42.4 (33.1-52.4)]	0.01*
Semi-pucca	123 (33.8)	27 [27.3 (19.3-6.9)]	
Pucca	135 (37.1)	30 [30.3 (22-40.1)]	
Smoking/tobacco chewing			
Yes	209 (32.4)	61 [30 (24.1-36.7)]	0.418
Comorbidities			
DM (yes)	81 (12.6)	17 [8.4 (5.3-13.1)]	0.03*
HTN (yes)	97 (15)	26 [12.8 (8.8-18.1)]	0.283
Others (yes)	66 (10.2)	16 [7.9 (4.8-12.5)]	0.18

*Significant, CI=confidence interval, APL=Above poverty line, BPL=Below poverty line, DM=Diabetes Mellitus, HTN=Hypertension

Table 2: Relevant past history of participants according to SARS-CoV-2 seropositivity (n=645)

Characteristics	IgG negative	IgG positive	P
Past history of covid infection			
Yes	2 (0.5)	3 (1.3)	0.489
No	196 (44.3)	82 (40.3)	
Don't Know	244 (55.2)	119 (58.4)	
Past history of contact with covid patient			
Yes	17 (3.8)	8 (3.9)	0.461
No	245 (55.4)	102 (50.3)	
Don't Know	180 (40.8)	93 (45.8)	
Past history of COVID-like symptoms (yes)	136 (30.8)	126 (62.1)	<0.01*
ILI symptoms (yes)	122 (27.6)	99 (48.8)	<0.001*
Loss of taste (yes)	9 (2.1)	28 (13.8)	<0.01*
Loss of smell (yes)	9 (2.1)	26 (12.9)	<0.001*
Others (yes)	26 (5.9)	14 (6.9)	0.62

*Significant, ILI=Influenza-like illness, Others=Headache, myalgia, nausea, vomiting, loose stools, etc.

infection or having contact with confirmed COVID cases in the past. As many as 262 participants reported having COVID-like symptoms in the preceding 1 month of the survey, and it was found to be significantly associated with the seropositivity status. Furthermore, among the different COVID-like symptoms inquired from the participants, influenza-like illness (ILI) symptoms (48.8%), loss of taste (13.8%), and loss of smell (12.9%) were significantly associated with increased prevalence of IgG antibody as compared to the other COVID-like symptoms. As far as health-seeking behavior is concerned, of those 262 participants who had suffered from COVID-like symptoms in the past, only 40.1% took treatment, and among those who seek treatment, approximately half of them went to a government health facility (47.6%), followed by a private health facility (28.6%), and almost one fourth went to a quack/local healer (23.8%) [Figure 3]. On applying logistic regression, age; male gender; BPL economic status; residing in a kutch house; occupation with a high risk of exposure; and symptoms such as ILI, loss of taste, and loss of smell in the past emerged as significant independent predictors of seropositivity among slum population [Table 3]. Overall, 24.2% variability of IgG seropositivity rate for SARS-CoV-2 among slum populations was explained by the independent variable in the regression model.

Discussion

The analysis of seroprevalence of SARS-CoV-2 antibodies from a citywide sample representative of the slum population indicated that despite the state of Bihar reporting a high number of unprecedented clinically diagnosed COVID cases during the first wave of the pandemic, overall, roughly one-third (31.5%) of the slum inhabitant showed evidence of seroconversion, thus reflecting that a substantial magnitude of the population is still susceptible to the risk of COVID infection. This documented prevalence is in striking contrast from the different surveys conducted by Malani *et al.*^[12] at Mumbai and George *et al.*^[13] at Bangalore slums, which reported that 54.1% and 57.9%, respectively, had evident past exposure

to COVID-19. Yet, the seroconversion rate across different slums in Patna surpassed the positive test rates reported by the nationwide first^[6] (0.73%) and second seroprevalence study^[14] (7.1%) conducted during May–June 2020 and August–September 2020. These instances of lower prevalence might be due to variations in the magnitude of COVID-19 disease burden across Indian states. Also, the first and second national-wide household surveys were conducted in an early phase of immunity, thus explaining the lower seropositivity rate. Another prior study conducted by Mahto *et al.*^[15] among health care workers of Patna, India, also documented a notably lower seroprevalence of 13.3%. Thus, the relatively higher antibody positivity rate in slums is expected out of overcrowding and unfeasible social distancing norm there. Further, the poor practice of hand washing and face mask contribute to spreading the infection.^[16–19] Moreover, we found higher antibody positivity among the age group of 18–30 years; male sex; and participants who engaged in occupational categories involving persistent public interaction, such as drivers/rickshaw pullers, and street vendors/shopkeepers. As these subgroups are more active and mobile, they exhibit a difference in the risk of exposure. Moreover, studies have suggested that females have a more responsive attitude toward the COVID pandemic, hence justifying the gender gap.^[20] In support of our finding, Murhekar *et al.*^[14] and Khan *et al.*^[21] also reported that young males and those with a higher risk of exposure were more likely to be IgG antibody positive.

Association of antibody positivity with BPL economic level and dwelling in a hut and kutch/semi-pucca house was another interesting finding in the current study. The hygiene hypothesis and immune hypothesis extend viable support to this paradoxical finding. This hypothesis advocates that chronic microbial exposure in poor communities as a result of their environment leads to the evolution of immunity training among them.^[22,23] Consequently, the severity of COVID infection appeared to be limited in such communities, whereas developed countries suffered higher mortality rates as compared to the developing countries during the pandemic.

Table 3: Independent predictors for SARS-CoV-2 seropositivity

Characteristics	COR (95% CI)	P	AOR (95% CI)	P
Age (years)				
18-30	1	<0.001	1	
31-44	0.41 (0.27-0.62)		0.41 (0.21-0.78)	0.007*
45-0	0.22 (0.14-0.34)		0.14 (0.06-0.32)	<0.001*
Gender				
Female	1	<0.001	1	
Male	2.12 (1.49-3)		2.09 (1.11-3.93)	0.02*
Economic level				
APL	1	<0.001	1	
BPL	2.29 (1.63-3.22)		2.93 (1.23-6.99)	0.01*
Dwelling				
House	1	0.008	1	
Hut	1.57 (1.12-2.19)		1	
House				
Kutchha	1		1	
Semipucca	0.39 (0.21-0.71)	0.002	0.33 (0.16-0.69)	0.033*
Pucca	0.43 (0.24-0.77)	0.004	0.53 (0.27-1.04)	0.06
Occupation				
No risk	1		1	
High risk	2.6 (1.62-4.18)	0.002	2.56 (1.22-5.41)	0.01*
Low risk	1.88 (1.05-3.36)	0.03	1.64 (0.65-4.13)	0.28
ILI				
No	1		1	
Yes	3.49 (2.45-4.98)	<0.001	2.51 (1.4-4.47)	0.002*
Loss of taste				
No	1		1	
Yes	6.91 (3.28-14.53)	<0.001	6.06 (1.96-18.68)	0.002*
Loss of smell				
No	1		1	
Yes	6.34 (2.99-13.43)	<0.001	6.15 (1.66-22.75)	0.006*
Diabetes				
No	1		1	
Yes	0.53 (0.3-0.94)	0.03	2.27 (0.80-6.44)	0.12
Pseudo R ²				0.242
Hosmer-Lemeshow test				0.81

*Significant, COR=crude odds ratio, ILI=Influenza-like illness, AOR=adjusted odds ratio, CI=confidence interval

Diabetes mellitus is an acknowledged risk factor for increased severity of coronavirus disease and worse prognosis, even leading to death.^[24] Surprisingly, our study found that among the comorbidities, diabetes mellitus was associated with IgG antibody positivity, suggesting recent subclinical COVID infection and highlighting the susceptibility of slum inhabitants suffering from diabetes, thus necessitating prioritizing them for COVID vaccination. A similar association was reported by Sharma *et al.*^[25] in a repeated population-based study conducted in Delhi. Out of all COVID-like symptoms inquired in the interview, loss of taste, loss of smell, and ILI symptoms experienced by people had higher statistical odds for the development of IgG antibodies. Similarly, Murhekar *et al.*,^[14] Khan *et al.*,^[21] and Makaronidis *et al.*^[26] also reported the association of antibody positivity with a past history of ILI symptoms, loss of taste, and loss of smell. Moreover, among all who suffered, only less than half took treatment for their illness. This indirectly implies that low level of literacy and poor awareness among slum dwellers inculcates poor health-seeking behavior and ultimately leads

to underutilization of existing health facilities.^[27] To add to it, another terrifying finding that came to light from our study was the misdirected health-seeking practices as a substantial proportion approached local quacks or unqualified persons for their symptoms. In consensus with our finding, Das *et al.*^[28] also documented poor health-seeking behavior of the slum population and their reliance on unqualified practitioners. Besides this, Burra and Chandrashekhara have also mentioned in their study that ignorant individuals believe in the wait-and-watch method on the pretext that minor symptoms would go away with time, neglecting the certainty that progression of disease toward severity can be abandoned by taking prompt action.^[28,29] Although the current study addressed and probed various determinants for IgG antibody positivity against SARS-CoV2 virus, few limitations remained in the study. First, geriatrics were not included in the study as the fragile blood vessels possess challenges in withdrawing blood for blood sample collection. Second, to avoid recall bias, the participants were asked regarding the recent history of COVID-like symptoms in the preceding

1 month of the survey. Thus, the true estimation regarding the total IgG-positive individuals who had apparent COVID-19 symptoms could not be made. Lastly, we did not test the blood samples for IgM antibodies nor the RT-PCR testing was done for the participants. Thus, the possibility of missing out on active cases cannot be ruled out, leading to a slight underestimation of seroprevalence.

Conclusion

The study was conducted across 10 different slums in Patna after the first wave of the pandemic slackened off. The results revealed that a moderate seroprevalence level of COVID-19 infection was acquired in these settings. Among all subpopulations, slum dwellers are most vulnerable to the spread of COVID-19 infection. A one-size-fits-all approach for controlling the spread is not likely to succeed as it overpasses the prevailing huge difference between the living conditions, economic level, and practices of slum settlements and the other general population. Thus, it is crucial to recognize that specific consideration and intervention are imperative for these settlements to curb the pandemic. Otherwise, unchecked spread in these informal communities will pose a serious threat to the rest of the bigger sections of urban populations. Thus, they should receive an early preference in the roadmap of COVID-19 vaccination. Moreover, repeated serosurvey in the same geographic location is recommended to demonstrate the trend of the emerging pandemic.

Acknowledgements

The authors are thankful to Dr. Manisha, Dr. Rajath, Dr. Neha Sachan, Dr. Anuvarshini, Dr. Monica, Dr. Arun Mani Babu, Dr. Nilanjan, Dr. Robin, and Dr. Venkatesh for putting up their immense efforts in this research.

Financial support and sponsorship

This research was funded by the institute as an Intramural Project.

Conflicts of interest

There are no conflicts of interest.

References

- Bavel JJV, Baicker K, Boggio PS, Capraro V, Cichocka A, Cikara M, *et al.* Using social and behavioural science to support COVID-19 pandemic response. *Nat Hum Behav* 2020;4:460-71.
- Coronavirus Update (Live): 88,618,548 Cases and 1,908,982 Deaths from COVID-19 Virus Pandemic-Worldometer. Available from: <https://www.worldometers.info/coronavirus/>. [Last accessed on 2021 Mar 10].
- Corona India tracker/Bihar/Patna. Available from: <https://coronaclusters.in/bihar>. [Last accessed on 2021 Mar 10].
- Available from: <https://www.hindustantimes.com/india-news/patna-tops-bihar-s-districts-with-316-covid-19-cases-bhagalpur-gaya-take-tally-near-40-000/story-TqdS1oTNqdZuSN1PTQJ0EL.html>. [Last accessed on 2021 Mar 10].
- Anand S, Montez-Rath M, Han J, Bozeman J, Kerschmann R, Beyer P, *et al.* Prevalence of SARS-CoV-2 antibodies in a large nationwide sample of patients on dialysis in the USA: A cross-sectional study. *Lancet* 2020;396:1335-44.
- Murhekar MV, Bhatnagar T, Selvaraju S, Rade K, Saravanakumar V, 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.
- Chen J, Chu S, Chungbaek Y, Khan M, Kuhlman C, Marathe A, *et al.* Effect of modelling slum populations on influenza spread in Delhi. *BMJ Open* 2016;6:e011699.
- Adiga A, Chu S, Eubank S, Kuhlman CJ, Lewis B, Marathe A, *et al.* Disparities in spread and control of influenza in slums of Delhi: Findings from an agent-based modelling study. *BMJ Open* 2018;8:e017353.
- Tiwari R, Sharma N. Patna: City profile. 2016. Available from: <https://idl-bnc-idrc.dspacedirect.org/handle/10625/55689>. [Last accessed on 2021 Mar 10].
- News. National. Coronavirus | 57% of Mumbai slum population has developed antibodies: Study. Available from: <https://www.thehindu.com/news/national/coronavirus-57-of-mumbai-slum-population-has-developed-antibodies-study/article32216939.ece>. [Last accessed on 2021 Mar 09].
- Dhand NK, Khatkar MS. Statulator: An online statistical calculator. Sample Size Calculator for Estimating a Single Proportion. 2014. Available from: <http://statulator.com/SampleSize/ss1P.html>. [Last accessed on 2021 Mar 09].
- Malani A, Shah D, Kang G, Lobo GN, Shastri J, Mohanan M, *et al.* Seroprevalence of SARS-CoV-2 in slums and non-slums of Mumbai, India, during June 29–July 19, 2020. *Lancet Glob Health* 2021;9:e110-1.
- George CE, Inbaraj LR, Chandrasingh S, de Witte LP. High seroprevalence of COVID-19 infection in a large slum in South India; What does it tell us about managing a pandemic and beyond? *Epidemiol Infect* 2021;149:e39.
- Murhekar MV, Bhatnagar T, Selvaraju S, Saravanakumar V, Thangaraj JW, Shah N, *et al.* SARS-CoV-2 antibody seroprevalence in India, August–September, 2020: Findings from the second nationwide household serosurvey. *Lancet Glob Health* 2021;9:e257-66.
- Mahto M, Banerjee A, Biswas B, Kumar S, Agarwal N, Singh PK. Seroprevalence of IgG against SARS-CoV-2 and its determinants among healthcare workers of a COVID-19 dedicated hospital of India. *Am J Blood Res* 2021;11:44-52.
- Islam S, Emran GI, Rahman E, Banik R, Sikder T, Smith L, *et al.* Knowledge, attitudes and practices associated with the COVID-19 among slum dwellers resided in Dhaka City: A Bangladeshi interview-based survey. *J Public Health (Oxf)* 2021;43:13-25.
- Islam SD, Mondal PK, Ojong N, Bodrud-Doza M, Siddique MA, Hossain M, *et al.* Water, sanitation, hygiene and waste disposal practices as COVID-19 response strategy: Insights from Bangladesh. *Environ Dev Sustain* 2021:1-22. doi: 10.1007/s10668-020-01151-9.
- Corburn J, Vlahov D, Mberu B, Riley L, Caiiffa WT, Rashid SF, *et al.* Slum health: Arresting COVID-19 and improving well-being in urban informal settlements. *J Urban Health* 2020;97:348-57.
- Sahasranaman A, Jensen HJ. Spread of COVID-19 in urban neighbourhoods and slums of the developing world. *J R*

- Soc Interface 2021;18:20200599.
20. Bwire GM. Coronavirus: Why men are more vulnerable to Covid-19 than women? *SN Compr Clin Med* 2020;2:874-6.
 21. Khan SM, Qurieshi MA, Haq I, Majid S, Bhat AA, Nabi S, *et al.* Seroprevalence of SARS-CoV-2 specific IgG antibodies in District Srinagar, northern India-A cross-sectional study. *PLoS One* 2020;15:e0239303.
 22. Sehrawat S, Rouse BT. Opinion: Does the hygiene hypothesis apply to COVID-19 susceptibility? *Microbes Infect* 2020;22:400-2.
 23. Chinnaswamy S. SARS-CoV-2 infection in India bucks the trend: Trained innate immunity? *Am J Hum Biol* 2020;33:e23504.
 24. Lim S, Bae JH, Kwon HS, Nauck MA. COVID-19 and diabetes mellitus: From pathophysiology to clinical management. *Nat Rev Endocrinol* 2020;17:11-30.
 25. Sharma N, Sharma P, Basu S, Saxena S, Chawla R, Dushyant K, *et al.* The seroprevalence of severe acute respiratory syndrome coronavirus 2 in Delhi, India: a repeated population-based seroepidemiological study. *Transactions of The Royal Society of Tropical Medicine and Hygiene.* 2022; 116:242–51.
 26. Makaronidis J, Mok J, Balogun N, Magee CG, Omar RZ, Carnemolla A, *et al.* Seroprevalence of SARS-CoV-2 antibodies in people with an acute loss in their sense of smell and/or taste in a community-based population in London, UK: An observational cohort study. *PLoS Med* 2020;17:e1003358.
 27. Reddy PM, Rineetha T, Sreeharshika D, Jothula KY. Health care seeking behaviour among rural women in Telangana: A cross sectional study. *J Family Med Prim Care* 2020;9:4778-83.
 28. Das M, Angeli F, Krumeich AJSM, van Schayck OCP. Patterns of illness disclosure among Indian slum dwellers: A qualitative study. *BMC Int Health Human Rights* 2018;18:1-7.
 29. Burra KC, Chandrashekhar VD. A comparative study on health seeking behaviour of parents towards their child's illness in rural and urban field practice area of a medical college. *Int J Community Med Public Health* 2019;6:3413-7.