

Household Transmission of SARS-CoV-2 in the Third Wave of the Pandemic with Special Reference to Clinico-epidemiological Characteristics

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Abstract

Background: Coronavirus disease 2019 (COVID-19) pandemic began in India in 2020. Despite successful vaccination, cases again started increasing from mid-December 2021. Therefore, this study was undertaken to find out the clinico-epidemiological characteristics and effectiveness of vaccination in the household transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in and around Pune. **Material and Methods:** All samples received from December 15, 2021, till February 15, 2022, were included in the study. Samples received in viral transport medium (VTM) were extracted by the MagMAX RNA Extraction Kit, and reverse transcriptase–polymerase chain reaction (RT–PCR) was performed by the CoviPath Kit as per kit guidelines. Values of nucleocapsid (N) gene and open reading frame (ORF) less than 37 were considered positive. Clinico-epidemiological data were analyzed from the sample referral form (SRF). **Results:** A total of 712 of 1032 household contacts of 271 families were positive. When geographical areas were compared, it was found that rural areas were affected more (63.76%) as compared to urban areas (36.24%). Males were more affected than females. The most commonly affected age group was 41–50 years (26.54%). Small families were found to have more household transmission. Mild symptoms were present in 97.89%. Among 271 infected individuals, seven were admitted to hospital, of which one patient died due to pneumonia. Two doses of vaccination were completed in 93.95%, and 3.79% had taken booster dose. **Conclusions:** Data from this study showed that a high rate of transmission was observed in household contact despite two doses of vaccination. However, these vaccinated individuals had mild symptoms, maybe due to the effect of vaccination and infecting variant omicron.

Keywords: Clinico-epidemiological characteristics, COVID-19, household transmission, N gene, ORF, third wave

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is an acute infection of the respiratory tract that emerged in December 2019 in Wuhan, China.^[1] India's first known COVID-19 case documented on January 30, 2020, was an Indian national evacuated from China.^[2] The symptoms may appear two to 14 days after exposure to the virus^[2] that include fever, cough, sputum production, shortness of breath, dyspnea, anorexia, and muscle pain.^[3] India has experienced three waves of the COVID-19 pandemic. The peak of the first wave of the pandemic was in mid-September when there were more than 10 lakhs active cases in the country, with the highest single-day spike of 97,894 new cases recorded on September 16, 2020, with predominant index virus lineages (L strain).^[4] Cases started decreasing in a couple of months. By the end of February 2021, there was a sharp rise

in the number of daily reported cases, which culminated in the second wave of the pandemic.^[5] Relaxation of interventions, negligence in public behavior, waning immunity, some super spreader religious and political events, and the emergence of more transmissible kappa and delta variants (B.1.617 lineage) are various reasons that led to the onset of the second wave.^[6] The second wave of COVID-19 ended around June in most parts of the country. Thereafter, cases decreased steadily, vaccination moved at a fast pace, and it was speculated that the pandemic

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was largely over unless some immunity-escaping mutants arose. Cases in India started increasing by the end of December 2021 with the emergence of the omicron variant of the virus. The third wave of the pandemic by omicron variant waned by March 2022 in India.^[5] Vaccinations in India began in January 2021 and were expanded in a phase-wise manner. After the frontline workers and the elderly, the third phase of vaccination targeting the 18- to 44-year-old age group was launched on May 1, 2021, which coincided with the peak of the second wave in most Indian states.^[5] Then, a booster dose was introduced. Even though high positivity was seen in the third wave, the first and second waves of the pandemic were responsible for more mortality and morbidity. This study aimed to determine the severity and attack rate in household transmission in and around the Pune District, highlighting rural and urban distribution in positive families and clinical symptoms of positive household contacts during the third wave of the pandemic.

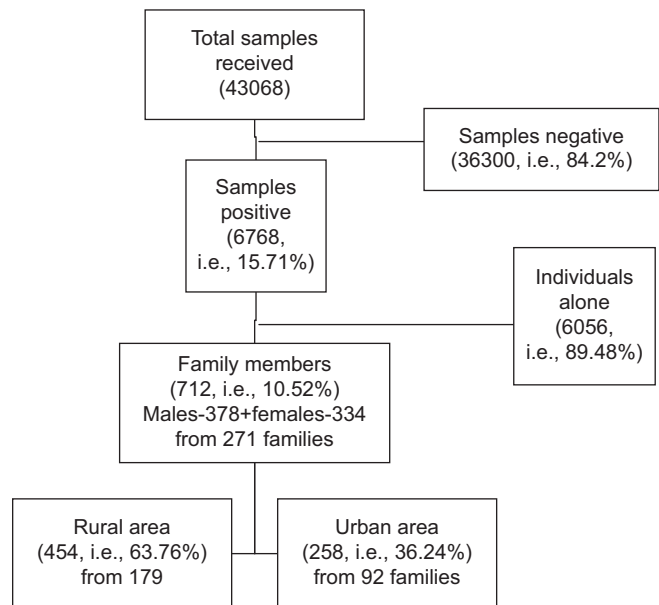
MATERIAL AND METHODS

A retrospective (observational epidemiological) study was conducted for the third wave of the pandemic of COVID-19 at a tertiary care hospital, in Pune (IEC no. ND-Dept 0121004-004), date was 22.1.2021. For inclusion of family criteria, at least one positive member from the family was excluded, and if no member was positive from family, that individual and their family were excluded from the study. The procedure performed was as follows: Nasopharyngeal swabs collected from COVID-19 suspected patients were received from various urban and rural COVID-19 swab collection centers of Pune District. The urban area includes Bhavani Peth, Pune Station Area, SNTD Warje, Shivajinagar, Kothrud, Khadki, Aundh, Yerwada, Sanas, KLVs, Cantonment, Camp, Bopodi, Market Yard, Dhankawadi, Wanawadi and Kondhwa. The rural area included Shirur (Talegaon, Mandavgan, Rajnandgaon, Karde, Kawathe, Nimone, and Takali), Junnar, Jejuri, Saswad, Loni Kalbhor, Manchar, and Narayangaon. Samples in viral transport medium (VTM) were vortexed before putting in a lysis buffer. Ribonucleic acid (RNA) extraction was performed using the MagMAX Viral/Pathogen II Nucleic Acid Isolation Kit manufactured by Thermo Fisher India Scientific Pvt. Ltd. Thermo Fisher Flex Automated Nucleic Acid Extractor was used for the extraction of RNA. Nuclease-free water was used as a negative control for the extraction reaction. One known positive sample was run in every cycle as a known positive control (KPC). Reverse transcriptase-polymerase chain reaction (RT-PCR) testing was performed using CoviPath COVID-19 RT-PCR Kits. As per instructions from the manufacturer, the master mix was prepared, 15 µL of the master mix was dispensed in each well of microtiter plate, and 10 µL of sample RNA was added. 10 µL of positive control was added to the positive control well. Protocol was set on RT-PCR machines as per the manufacturer’s instructions given in the kit literature. The results were taken as per the kit protocols. Samples and extracted RNA were stored at -70°C. As per Indian Council of Medical Research (ICMR) guidelines, Ct values less than or equal to 35 were considered positive.

This study was conducted during the third wave of the COVID-19 pandemic (December 15, 2021, to February 15, 2022). A total of 43068 samples (26750 males + 16318 females) were received during this period, of which 6768 (3829 males + 2939 females) were positive by RT-PCR for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. Among 6768 positive individuals, only one sample from 6056 was positive (with no other positive family member) so was not included in the study. The remaining 712 were samples from 271 families. Of 271 families, 179 were from rural area and 92 were from urban area [Flowchart].

RESULTS

In this study, individuals from rural areas (66.05%) were affected more than in urban areas (33.95%). Within affected families, males were affected more than females in both rural and urban areas (1.40:1) [Table 1].



Flowchart: Total number of families affected by COVID-19 in the third wave and their geographical distribution

Table 1: Age and gender-wise distribution of index cases of affected families during the third wave of COVID-19

Age (years)	Rural (n=179)		Urban (n=92)	
	Male (%)	Female (%)	Male (%)	Female (%)
1–10 years	01 (0.37)	00 (00)	00 (00)	00 (00)
11–20 years	07 (2.58)	06 (2.21)	04 (1.48)	00 (00)
21–30 years	10 (3.70)	07 (2.58)	07 (2.58)	02 (0.73)
31–40 years	26 (9.59)	24 (8.56)	16 (5.90)	12 (4.42)
41–50 years	32 (11.80)	29 (10.70)	25 (9.23)	12 (4.42)
51–60 years	10 (3.70)	14 (5.17)	07 (2.58)	02 (0.73)
61–70 years	5 (1.85)	04 (1.48)	03 (1.11)	00 (00)
>70 years	3 (1.11)	01 (0.37)	02 (0.73)	00 (00)
Total (271)	94 (34.69)	85 (31.36)	64 (23.62)	28 (10.33)

There are a total of 712 household-positive contacts, 454 were from rural areas and 258 were from urban areas. 63.76% of positive families were from rural areas. Males were more affected than females (53.09% vs. 46.91%), and the 41- to 50-year age group was most affected (26.54%). In urban areas, 35.65% of household contacts were positive, while 39.08% of household contacts were positive in rural areas [Table 2].

All household contacts (100%) were affected in a family consisting of two members. Secondary attack rate among

families affected in the third wave = number of new cases among contacts/total contact at risk*100. In our study, it came out to be = 712/1032*100 = 68.99%. Mild symptoms, such as fever, body ache, headache, cough, and cold, were seen in 697 (97.89%) positive patients, seven (0.98%) were asymptomatic, and seven (0.98%) were admitted to the hospital. One positive patient succumbed to death [Table 3].

Among the seven admitted patients, comorbidities were present in four of them. All of them have taken two doses of vaccination [Table 4].

In this study, 669 (93.95%) had two doses of vaccination, single dose was taken by six (0.84%), and non-vaccinated were three adults and seven pediatric patients (1.40%). A booster dose was taken only by 3.79% of cases.

Table 2: Age and gender-wise distribution of COVID-19 RT-PCR-positive household contacts

Age (years)	Rural (n=458)		Urban (n=258)	
	Male (%)	Female (%)	Male (%)	Female (%)
1-10 years	02 (0.28)	01 (0.14)	00 (00)	02 (0.28)
11-20 years	18 (2.52)	20 (2.81)	08 (1.12)	17 (2.34)
21-30 years	41 (5.76)	45 (6.32)	27 (3.79)	18 (2.52)
31-40 years	62 (8.71)	37 (5.20)	34 (4.78)	29 (4.07)
41-50 years	75 (10.53)	59 (8.29)	27 (3.79)	28 (3.93)
51-60 years	26 (3.65)	28 (3.93)	23 (3.23)	23 (3.23)
61-70 years	19 (2.67)	15 (2.11)	13 (1.82)	07 (0.98)
>70 years	02 (0.28)	04 (0.56)	01 (0.14)	01 (0.14)
Total (712)	245 (34.10)	209 (29.35)	133 (18.68)	125 (17.56)

DISCUSSION

As there were reports everywhere that there is a high transmission rate of SARS-CoV-2 in the third wave, this study was conducted to assess the household transmission rate of this virus in the Pune District. In the present study, a total of 271 families were positive in the third wave of the COVID-19 pandemic in the Pune District of Maharashtra. This included 712 positive members from various families.

Table 3: Rate of COVID-19 transmission in household contacts

Total no. of members in a family (families) Total members (no. of families)	<25% of family affected n (%)	25-50% family affected n (%)	50-75% family affected n (%)	76-99% family affected n (%)	100% family affected n (%)
2 (163)	00 (00)	00 (00)	00 (00)	00 (00)	163 (60.15)
3 (59)	00 (00)	07 (2.58)	07 (2.58)	13 (4.79)	32 (11.81)
4 (22)	00 (00)	00 (00)	03 (1.11)	11 (4.06)	8 (2.95)
5 (16)	00 (00)	02 (0.73)	1 (0.37)	5 (1.85)	8 (2.95)
6 (5)	00 (00)	00 (00)	00 (00)	05 (1.85)	00 (00)
7 (0)	00 (00)	00 (00)	00 (00)	00 (00)	00 (00)
8 (2)	00 (00)	01 (0.37)	00 (00)	01 (0.37)	00 (00)
9 (0)	00 (00)	00 (00)	00 (00)	00 (00)	00 (00)
10 (2)	00 (00)	00 (00)	00 (00)	02 (0.73)	00 (00)
>10 (2)	02 (0.73)	00 (00)	00 (00)	00 (00)	00 (00)
Total	02 (0.73)	10 (3.70)	11 (4.06)	37 (13.65)	211 (77.86)

Table 4: Details of COVID-19-positive hospitalized patients

Geographical area	Age/gender	Comorbidity	Cyclic threshold		Vaccination
			N Gene	ORF Gene	
Rural	38F	-	19	21	2 doses
Urban	67M	Asthma	24	26	2 doses
Urban	59M	Hypertension	32	32	2 doses
Rural	64M	Diabetes and hypertension	32	33	2 doses
Urban	53F	-	28	26	2 doses
Urban	46F	Allergic	24	26	2 doses
Rural	35M	-	32	33	2 doses

*M=male, F=female

In the present study, total positives were more in rural areas as compared to urban areas (63.76% vs 36.24%). Even the index cases were 66.05% in rural areas as compared to urban areas (33.95%) [Tables 1 and 2]. In the study conducted by Huang *et al.* (2021), they found that, in South Carolina, the spatial and temporal patterns were different. Initially, cases were concentrated in small parts within metro counties and then diffused to centralized urban and rural areas. Rural counties and rural areas were highly involved in their study.^[7] In the study conducted by Mohammad Abouzid M *et al.* (2022), urban transmission was much more than rural transmission (74% urban and 26% rural).^[8] This study was conducted in the Middle East and North Africa during the third wave of the COVID-19 pandemic.^[8] The difference in samples received from urban and rural areas could be due to samples from rural areas that had high positivity than in urban areas. After experiencing a high death rate in the second wave, people in rural areas may be fearful and may have been given samples for testing. The probable reason for the higher caseload in rural areas may be attributed to nonadherence to COVID-19 preventive measures and the high transmissibility of the omicron variant. This study was conducted in the third wave of the pandemic; people in urban areas were reluctant to do testing for COVID-19, maybe due to milder symptoms.

In our study, male preponderance was noted in both rural and urban areas (53.09%) and females (46.91%). In the study conducted by Jian Wu *et al.* (2021), males infected were 54.3% and females were 45.7%.^[9] In studies conducted by Wi Li *et al.* (2020), males affected were 57.1% while females were 43.1%, which is comparable to our study.^[10] Males were affected more as compared to females because in a male-dominated society, the major population going out for work is male, so the chances of contracting infection are more in males.

The most common affected age group for both household contacts and index cases was 41–50 years, followed by 31–40 years and 51–60 years. The least affected were pediatric and geriatric populations [Tables 1 and 2]. The median age group in the study conducted by Wi Li was 47 years, which is relatable to our study.^[10] In the study conducted by Dutta *et al.* (2020),^[11] the mean age of the patients was 30.12 years. In their study, around one-third (28.3%) of these patients were young adulthood (19–29 years). The majority of affected children were teenaged (13–18 years), while 67.3% of COVID-19-positive cases were in the age group (19–49 years).^[11] The majority of the working population falls between 31 and 50 years of age, and this could be the reason for more number of cases in that particular age.

In this study, more than 75% of household contacts were affected in the majority (91.51%) of families [Table 3]. One hundred and sixty-three families consisted only of two members, and all of them were positive. This is due to the nuclear family pattern of metro cities. Here, couples or children move out of their hometown and stay for better job opportunities. The reason could be that their study was

conducted during the second wave, while ours was in their wave, and the third wave has more widespread transmission as compared to the second wave. This could be due to immune escape and an increase in transmissibility.^[12] Initial modeling suggested that omicron shows a 13-fold increase in viral infectivity and is 2.8 times more infectious than the delta variant.^[13] The difference in samples received from urban and rural areas could be due to samples from rural areas that have higher positivity than in urban areas. The receipt of more samples from rural areas in the study cannot be explained, but probably, after the second pandemic wave, people were less panicked about COVID-19 infection; in addition to this, after taking the vaccine many people thought that they would not be affected by COVID-19 again. This led to not following social distancing and not wearing mask even in public places. Festival gatherings and religious activities continued during the third wave. In contrast to this, lockdown and social distancing restrictions made people follow all the rules during the first and second waves.

In the current study, clinico-epidemiological characteristics revealed that mild symptoms were present in 97.89%. These included fever, cough, sore throat, headache, and body pain for 2–3 days. Admission to the hospital was needed only in 0.98%, and one (0.14%) patient died due to pneumonia. Asymptomatic cases were 0.98%, and most of them were found accidentally positive when they wanted to have international travel or their close contacts were infected, for example, neighbors.

Only seven of 712 patients needed hospitalization. Major comorbidities requiring hospitalization were hypertension (two patients), diabetes, asthma, and allergy (one patient) [Table 4]. In a study conducted by Chua *et al.* (2021), in the third wave, 35.5% of cases were found to be asymptomatic. As compared to the first two waves, more household contacts were positive in the third wave.^[14] The government of India launched the Ayushman Bharat Yojana in 2018 with the aim of having easy access to patient's health record to healthcare workers for their better management, including early diagnosis of long or post-COVID-19. In our study, it would have been useful to identify infected household contacts of infected individual and their vaccination status added.^[15]

In our study, 94.94% of people had milder symptoms and had completed two dosages of vaccination. The milder symptoms seen in the majority of the population could be due to the effect of vaccination and infecting variant omicron. The omicron variant had shown a reduced risk of hospitalization relative to the delta variant (B.1.617.2) of SARS-CoV-2 despite its more transmissibility because of milder flu-like symptoms. In an article in the Times of India (October 7, 2022), it was mentioned that a majority of new infections—up to 80 percent to 90 percent confirmed cases—are asymptomatic or mildly symptomatic.^[16] It also mentioned that COVID-19 vaccines are very effective in modifying the outcome of infections and continue to prevent an individual from suffering severe disease, hospitalization, and death.^[16] In the study conducted by Sumit Malhotra *et al.* (2022), it was found that unvaccinated

were 14.5%, partial vaccination was performed in 17.1%, and complete vaccination was performed in 23.1%. This study was conducted in New Delhi.^[17] Thus, this could be the reason for protective immunity. The omicron variant had shown a reduced risk of hospitalization relative to the delta variant (B.1.617.2) of SARS-CoV-2 despite its more transmissibility because of milder flu-like symptoms.^[18,19]

Therefore, further genetic study is required to find out which mutations make the current strain of SARS-CoV-2 less virulent compared with the first two waves. A detailed immunological study of infected cases who had infection even after two doses of vaccination is required to find out whether they had developed immune responses after vaccination or whether they are cases of immunological failure.

CONCLUSION

This study highlights a high rate (68.99%) of household transmission in the third wave with male preponderance in and around Pune. In the present study, families from rural area had more transmissibility as compared to families from urban area. However, the study with a larger sample size is required to confirm this finding. Despite receiving two doses of vaccine against COVID-19, household transmission was observed in 94% of family members, but symptoms were milder in maximum cases of household contact, which may be due to the effect of vaccination. Emphasis on the adoption of COVID-19-related preventive measures and compliance with it is needed, especially in rural area for the prevention of transmission of infection in household contacts. Adherence to the World Health Organization (WHO) protocol (2020) for household transmission investigation for COVID-19 and continuous updates on citizen's health record in the Ayushman Bharat card will help in the eradication of the disease.

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Conflicts of interest

There are no conflicts of interest.

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