Original Article

Household secondary attack rate in SARS-CoV-2 infection during the second wave of the COVID-19 pandemic in South India

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Abstract

Background: Coronavirus disease 2019 (COVID-19) has become a major public health problem since its inception disrupting public life and crippling health systems. The mutated variant of the causative virus, Delta, has been notorious in causing rapid upsurge in cases compared to the Alpha variant. The current study tries to find out the household secondary attack rate (HSAR) of COVID-19 and factors associated with it during the second wave of cases in Kerala. **Methodology:** A retrospective cohort study was performed among 313 household contacts of 76 COVID-19 patients who had been admitted in Government Medical College, Thrissur, in the southern state of India, Kerala. Data from the participants were collected via phone using a semi-structured interview schedule, and analysis was performed with SPSS software. **Results:** The HSAR among household contacts was 59.1% (53.4–64.6%). The risk of acquiring COVID infection among household contacts was higher among contacts of symptomatic index cases with a *P* value of 0.001 and an odds ratio of 11 (3.7–32.4). index cases were having a home isolation *P* value of 0.001 and an odds ratio of 3.2 (2–5.1), with delay in COVID-19 testing for index cases with a *P* value of 0.006. Regarding characteristics of household contacts, higher age groups (p = 0.048), groups living in the same room with an index case *P* value of 0.021 and an odds ratio of [1.71 (1-2.8)], groups having physical contact with an index case *P* value of 0.001 and an odds ratio of [3.7 (2.1-7)], groups with touched or cleaned linen/articles with an index case *P* value of 0.02 and an odds ratio of [1.8 (1-3.1)], and groups having co-morbidities, especially diabetes mellitus (p = 0.0020), were significantly associated with chances of acquiring infection. However, the history of previous COVID positivity in household contacts was a protective factor against the infection *P* value of 0.009 with an odds ratio of [0.09 (0.01-0.78)]. **Conclusion:** The study concludes that the second wave of COVID-19 in Kerala was primarily caused by a high SAR, especially among household contacts, and this could have been the reason for the difficulty in control measures during the wave.

Keywords: COVID-19, Delta variant, household secondary attack rate, household contacts, HSAR, Kerala

Introduction

The COVID-19 (coronavirus disease 2019) pandemic is the worst of its kind faced by the humanity after the 'Spanish Flu.'[1] As the disease spread across the globe, the World Health Organization (WHO) declared COVID-19 as a Public Health Emergency of International Concern (PHEIC) on January 30, 2020 and a pandemic on March 11, 2020.[2] As of December 2021, there had been approximately over 273 million cases and over 5.3 million deaths globally.[3] A few of the worst affected countries were the USA, United Kingdom, Italy, Brazil, Russia, France, and India. However, in varying proportions, this deadly disease has affected almost the whole world.[4]

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In early August–September 2020, India experienced a surge of cases and crossed the 5 million mark on September 16, 2020 ('first wave'). There was a steady decline in the number of cases reported from the end of September 2020. However, from the middle of February 2021, a massive upsurge started ('second wave'), with the number of cases and deaths reported daily showing a very steep climb. During the second wave, more than 4 lakh new cases and 4000 deaths were reported per day.[5,6] COVID cases started declining from mid-May, but India continued to simmer with approximately 34,746,838 cases and 477,554 deaths till December 2021.[7] Thus, India has already seen two waves of COVID-19, with the second wave more devastating than the first.

In the past few months, several severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) variants have emerged from various countries worldwide.[8] Among them, the SARS-CoV-2 Delta variant (B.1.617.2) was first detected in India and has rapidly become the dominant variant in India. In Kerala, results from genome sequencing also indicate that Delta is the predominant variant circulating in the state.[9] It has been classified as a variant of concern (VOC) and is believed to be 60% more transmissible than the Alpha variant (B.1.17). The Delta variant is a serious public health threat because of its association with the higher transmissibility at the household level and potential immune escape.[8,10] Households are high-risk settings for transmission of COVID-19[11] and are an important factor in wider community spread.[12] By assessing the extent to which the Delta variant results in transmission among household members in comparison to the Alpha variant, we can assess the role of increased transmissibility in the rise in COVID-19 infection and provide information vital to the national and international pandemic response.

Some preliminary contact-tracing studies have shown that the highest-risk exposure setting of COVID-19 transmission was the household contacts of the infected cases.[13] Even after stringent measures for control, some countries still experience escalation in COVID-19 cases that may have been substantially contributed by household transmission. The control of this pandemic, especially in a country such as India, where 70% of the population is rural, lies in the hands of primary care physicians, family physicians, and public health personnel working in the field. The knowledge about the factors that determine transmission will vastly help personnel working in the peripheral level to take appropriate actions. The current study aims to study the secondary attack rate (SAR) of COVID-19 among household contacts of COVID-19 cases admitted in a tertiary COVID hospital in Kerala and identify its determinants, transmission triggers, and epidemiological characteristics during the second wave and after the emergence of the Delta variant. This may contribute in designing and developing infection control and prevention policies for COVID-19 that can limit further spread/transmission of the disease.

Materials and Methods

The current retrospective cohort study was conducted in Government Medical College, Thrissur, a tertiary care institution in the southern state of India. The data collection was performed between July 2021 and August 2021. The study was approved by the Institutional Ethics Committee as per letter B6-155/2019 MCTCR dated 18.06.2020.

Sample size

The study conducted by Oon Tek Ng *et al*. in Singapore showed that the SAR among household contacts was found to be 25.8%.[14] Applying it to the formula 4pq/d2 taking 25.8% as p, Q = 1-p, an Alpha of 0.05, and an absolute precision of 5%, the sample size was calculated to be 295.

Data collection: The details of all COVID-19 patients admitted in the hospital including the mobile number are collected as a hospital policy. Those admitted during the above-mentioned time period were contacted over phone. After doing a preliminary contact tracing, details of all the household contacts were taken, including their phone number, to be included in the study. A household contact was defined as a group of persons who normally live together and take their meals from a common kitchen unless the exigencies of work prevent any of them from doing so.[15] The basic demographic and clinical details of patients admitted were taken after taking a telephonic consent. Later, their household contacts were contacted over phone, and details regarding their socio-demographic features, clinical features, and outcome along with factors associated with transmission were taken after taking a telephonic consent. Those who were not willing were excluded. The data collection was performed using a semi-structured interview schedule.

Statistical analysis

The data were properly coded and were entered into Excel sheets and analyzed using SPSS software 16.0 version. SAR was defined as the proportion of exposed persons developing the disease within the incubation period (14 days) following exposure to a primary case. For finding out association with transmission of infection to secondary cases, Chi-square test was used. Those factors which were found to be significantly associated in univariate analysis were also analyzed using binary logistic regression. The final COVID status of secondary cases was taken as the dependent variable, and the risk factors were taken as independent variables. The results were expressed as adjusted odds ratios and their confidence intervals. A *P* value less than 0.05 was considered as significant.

Results

Socio-demography

The current study was conducted among 313 household contacts of 76 COVID-19-positive index patients admitted in Government Medical College, Thrissur. The mean age of the 76 index COVID-positive cases was 45.01 ± 18.27 years. The age of the index cases ranged from 3 to 85 years. Of them, 36 (47.36%) were males and 40 (52.64%) were females. The preliminary demographic details of the household contacts are depicted in Tables 1 and 2.

The maximum number of household contacts included in the study was from the age group of 30–45 (25.3%) years, followed by 0–15 years (22.8%). Among the household contacts in the current study, there was a female preponderance (55.6%).

The majority of the study population had studied up to high school/higher secondary (42.8%). 32.9% of the study sample were unemployed.

Out of the 313 household contacts that were studied, 185 were diagnosed as COVID-19-positive within 14 days after their last day of exposure. Thus, the household secondary attack rate (HSAR) as per the current study is 59.1% (53.4–64.6%).

Table 1: Age and gender classification of household contacts

	Gender		Total
	Male	Female	
Age			
0-15 years			
Number	31	40	71
% within age group	43.7%	56.3%	100.0%
16-30 years			
Number	27	41	68
% within age group	39.7%	60.3%	100.0%
31-45 years			
Number	39	40	79
% within age group	49.4%	50.6%	100.0%
46-60 years			
Number	23	30	53
% within age group	43.4%	56.6%	100.0%
More than 60 years			
Number	19	23	42
% within age group	45.2%	54.8%	100.0%
Total			
Number	139	174	313
% within age group	44.4%	55.6%	100.0%

Table 2: Socio-demographic characteristics of household contacts (*n*=313)

Variable	Frequency	Percentage
Educational status		
Graduate/PG	41	13.1
High school/Higher secondary	134	42.8
Middle	82	26.2
Primary	16	5.1
Illiterate	4	1.3
Not applicable (Children <7 years)	36	11.5
Occupational status		
Professional/Semi-professional	23	7.3
Clerk/Shopkeeper/Farmer	8	2.6
Skilled/Semi-skilled	51	16.3
Unskilled	45	14.4
Unemployed	103	32.9
Not applicable (Children <18 years)	83	26.5

The factors that were found to be statistically significant in univariate analysis are given in Table 3. The factors that were included but were not found to be significantly associated with COVID-19 positivity in household contacts were age, gender, co-morbidity, COVID-19 category, and vaccination status of the index case and gender, vaccination status, and family members per room in the household contacts.

The factors that were found to be significantly associated with COVID positivity in household contacts were also assessed using binary logistic regression. The method of regression used was the enter method. The r square value of the model was 0.33. The results of logistic regression are given in Table 4

Discussion

Socio-demography

It can be seen from Table 1 that all age groups and both genders have an adequate representation in the study. It was seen that the majority of people in the study were of the middle or low socio-economic classes and one-third were unemployed and had an education of up to high school or higher secondary. This can be because of the fact that the study was conducted among family members of the COVID-19 patients admitted in a government medical college. The majority of people, especially from the middle or low socio-economic strata, depend on government hospitals for their health care. This could be because of the fact that the cost of health care in a private institution may not be affordable to them. The 75th round of National Sample Survey (NSS) carried out in the year 2017 reported that the average medical expenditure incurred during hospitalization was more than seven-fold in a private hospital compared to a government hospital.[16]

Secondary attack rate

The overall SAR among household contacts as per the current study was 59.1%. This is similar to the study conducted by Hari Hwang *et al*. in South Korea among patients infected by the Delta variant, where the SAR among household contacts was 63%.[17] However, in another study conducted by Anika Singanayagam *et al*. in UK among cases who were identified as having COVID -19 infection with the Delta variant, the HSAR was found to be 26%.[18] Yet another study from England performed as a case control design reported that the odds ratio of transmission was 1.7 times among Delta-infected cases compared to Alpha after adjusting for confounding factors.[19] In another study from Singapore performed as a retrospective cohort, it was found that the HSAR of unvaccinated household contacts infected with the Delta variant was 25.8% compared to 12.9% among those infected with other variants.[14] This higher HSAR among those who were infected with the Delta variant could be because of the high viral loads in the respiratory tract of those infected with Delta compared to the earlier variants.[20] These results show why India had a huge surge in cases when the Delta variant was in circulation. Such a high HSAR among

Tablet 3: Association of COVID-19 positivity based on clinico-demographic factors

	COVID + ve household contact	COVID -ve household contact	Chi-square	*P*	Odds ratio (95% C.I)
Based on clinico-demographic characteristics of index cases					
Symptom status of index cases (*n*=313)					
Symptomatic	181 (63.7%)	103 (36.3%)	27.1	0.001	11 (3.7-32.4)
Asymptomatic	4 (13.8%)	25 (86.2%)			
Delay in COVID-19 testing in index patients (*n*=284)*30 were contacts of asymptomatic index cases					
0-2 days	115 (60.5%)	75 (39.5%)	10.34	0.006	NA
3-4 days	51 (79.7%)	13 (20.3%)			
>4 days	15 (50%)	15 (50%)			
Type of isolation of index patients (*n*=313)					
Home	132 (70.2%)	56 (29.8%)	24.02	0.001	3.2 (2-5.1)
Institutional	53 (42.4%)	72 (57.6%)			
Based on the clinico-demographic characteristics of household contacts					
Age group of household contacts (*n*=313)					
0-15 years	35 (49.3%)	36 (50.7%)	9.6	0.048	NA
16-30 years	35 (51.5%)	33 (48.5%)			
31-45 years	51 (64.6%)	28 (35.4%)			
45-60 years	33 (62.3%)	20 (37.7%)			
>60 years	31 (73.8%)	11 (26.2%)			
Living in the same room as the index case (*n*=313)					
Yes	69 (67.6%)	33 (32.4%)	4.58	0.021	1.71 (1-2.8)
No	116 (55%)	95 (45)			
Direct physical contact with the index case (*n*=313)					
Yes	167 (64.7%)	91 (35.3%)	19.2	0.001	3.7 (2.1-7)
No	18 (32.7%)	37 (67.3%)			
Touched or cleaned linen/articles used by the index case (*n*=313)					
Yes	58 (69%)	26 (31%)	4.7	0.02	1.8 (1-3.1)
No	127 (55.5%)	102 (44.5%)			
Previous COVID-19 positivity in household contacts (*n*=313)					
Yes	1 (12.5%)	7 (87.5%)	7.38	0.009	0.09 (0.01-0.78)
No	184 (60.3%)	121 (39.7%)			
Co-morbidity in household contacts					
No co-morbidity	116 (62.4%)	70 (37.6%)	17.4	0.002	NA
Pregnancy	12 (41.4%)	17 (58.6%)			
Diabetes mellitus	36 (76.6%)	11 (23.4%)			
Hypertension	10 (43.5%)	13 (56.5%)			
Other co-morbidities	11 (39.3%)	17 (60.7%)			

Table 4: Factors associated with COVID-19 positivity among household contacts in logistic regression

Factor	*P*	Odds ratio	95% Confidence interval of odds ratio
Symptomatic index case	0.001	15.02	3.99-56.65
Index case home isolated	0.001	2.66	1.46-4.86
Had direct physical contact with the index case	0.001	3.49	1.66-7.35

household contacts and a high population density could have been important factors associated with the second wave in India.

Factors associated with secondary attack rate

In the current study, it was seen that the majority of infections among household contacts were from symptomatic index cases (HSAR 63.7%) with very few from asymptomatic index cases (HSAR 13.8%), and the risk of COVID-19 in household contacts was 11 times if the index was symptomatic. As per the meta-analysis conducted by Zachary J.*et al.*, the HSAR was more than 18 times in symptomatic index cases compared to asymptomatic cases (18% vs 0.7%).[21] In another study conducted in Pakistan, it was seen that the risk of infection in contacts was very less from pre-symptomatic and asymptomatic index cases with transmission risks of 1.12% and 0.06%, respectively.[22] Even though many studies have shown that the viral load in an asymptomatic COVID-19 patient is similar to that of a person with symptoms,[23,24] transmission seems to be lower in this group. This could have major implications in control of the cases where focus could be given to symptomatic index cases in control of the COVID-19 pandemic compared to asymptomatic cases.

In the current study, it was seen that delay in COVID-19 testing in the index patient was associated with an increase in HSAR. In the case of a delay up to 2 days, the HSAR was 60.5% compared to 79.7% if the delay was more than 2 days but less than 4 days. In the study conducted by Tsuyoshi Ogata in Japan, it was found that the HSAR was higher for non-spousal household contacts of index patients with ≥3 days of diagnostic delay (26.0%) compared to those with ≤2 days' delay (12.5%).[25] As per the mathematical model performed by Mirjam E Kretzschmar, it was found that with a testing and tracing delay of 0 days, the onward transmission of COVID-19 from an index case can be reduced by 79.9% and by 41.8% with a 3-day testing delay.[26] When there is delay in testing, there is a high probability of index cases interacting with the family members without isolating themselves. Thus, early testing, especially in those who are symptomatic, could be a key factor in controlling the outbreak.

The present study showed high HSAR among those who were isolated at home after getting diagnosed as COVID-19 compared to those who were isolated in institutions (70.2% vs 42.4%). This shows that those who were isolated at home were not really practicing room isolation. In a study from Israel, it was seen that the compliance rate for self-quarantine dropped from 94% to less than 57% when monetary compensation for lost wages was removed.[27] In a study from Istanbul in Turkey, it was found that only 56.2% of COVID-19 patients used masks in common areas during isolation and 21.2% even left their homes during isolation at least once.[28] In a mathematical model by Borame L Dickens comparing the effectiveness of home isolation to that of institutional isolation in curtailing cases during an outbreak, it was found that the strategy of home-based isolation could result in an 8-day delay in the epidemic peak, whereas Institution-based isolation could create a peak delay of 18 days.[29] Thus, failure of compliance of strict room isolation could be one of the major factors that could have triggered the huge surge in cases during the second wave.

The SAR among people above 60 years was the highest in the current study (73.8%) compared to 49.3% in the 0–15 years category. Similar findings have been obtained in a study conducted by Qin-Long Jing *et al.* in China where the risk of household infection was lower in the youngest age group <20 years compared to those above 60 years of age (odds ratio 0·23).[30] In another study conducted by Daphne F M Reukers *et al.* in the Netherlands, HSARs were high among older groups (51%) compared to 35% in younger groups.[31] This high SAR among the older population with the higher probability of complications and death in COVID-19 puts them as the highest priority group for reverse quarantine.

The current study showed that closer the contact to the index case, that is, living in the same room or washing the linen used by the patient or in contact with body fluids, the higher the risk of contracting COVID-19 from the index case. In a study in Brunei on analysis of SARS-CoV-2 transmission in different settings, it was seen that close contact was significantly associated with COVID-19 infection and spouses have an adjusted risk ratio of 45.2 compared to non-spousal contacts.[32] Spouses are always in constant contact with the partner and have a high chance of being in the same room and having contact with body fluids and hence the high risk of infection.

As per the current study, the highest HSAR was found among those with co-morbidities, especially with diabetes mellitus. Diabetes mellitus patients have been proven to have a higher susceptibility to infections both viral and bacterial because of multiple reasons.[33,34] A study form Korea has shown that people with diabetes have an adjusted odds ratio of 1.25 compared to non-diabetic patients in getting COVID infection.[31] Thus, diabetes is an important factor for both prognosis of COVID-19 infection and the risk factor for contacting it.

Conclusions

The study concludes the HSAR of COVID-19 when Delta was the predominant COVID-19 variant in Kerala to be high. The major factors related with HSAR were found to be higher age, close contact with the index case, and co-morbidities, especially diabetes, in the contacts. Among the index cases, delay in getting tested and isolating the case at home were found to be risk factors for transmission.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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