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Secondary attack rate of COVID-19 among contacts and risk factors, Tamil Nadu, April-May 2020: A retrospective Cohort Study

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3 **Secondary attack rate of COVID-19 among contacts and risk factors, Tamil**
4 **Nadu, April-May 2020: A retrospective Cohort Study**
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Abstract:

Objective: To describe the characteristics of contacts of COVID-19 case-patients in terms of time, place, and person, to calculate the secondary attack rate and factors associated with COVID-19 infection among contacts

Design: Retrospective cohort study

Setting and participants: Contacts of cases identified by the health department from March 14 to May 5, 2020, in nine of 38 administrative districts of Tamil Nadu

Outcome measure: Attack rate among the contacts and factors associated with COVID-19 positivity.

Results:

We listed 15,702 contacts of 931 primary cases. Of the contacts, 89% (n=14002) were tested for COVID-19. The overall SAR was 4% (599/14002), with higher among the household contacts (13%) than the community contacts (1%). SAR among the contacts of primary cases with congregation exposure were five times higher than the contacts of non-congregation primary cases (10% Vs 2%). Being a household contact of a primary case with congregation exposure had a four-fold increased risk of getting COVID-19 (RR=16.4; 95%CI:13-20) than contact of primary case without congregation exposure. Among the symptomatic primary cases, household contacts of congregation primaries had higher RR than household contacts of other cases [(RR=25.3; 95%CI:10.2-63) Vs (RR=14.6; 95%CI:5.7-37.7)]. Among asymptomatic primary case, RR was increased among household contacts (RR=16.5; 95%CI:13.2–20.7) of congregation primaries compared to others

Conclusion:

Our study showed an increase in disease transmission among household contacts than community contacts. Also, symptomatic primary cases and primary cases with exposure to the congregation had more secondary cases than others.

Strengths and Limitations:**• Strengths**

- We documented the secondary attack rate of COVID-19 in a large cohort of more than 15,000 contacts in India.

- Majority of the contacts were tested with RT-PCR, therefore the estimates of secondary attack rate were reliable.
- We documented high transmission among household contacts and contacts of symptomatic primary cases which guided the testing policy early in the pandemic in Tamil Nadu, India.

- **Limitations:**

- We did not have confirmation of the COVID-19 status of 11% of the contacts,
- Contact tracing was prioritised for household contacts during lockdown as the community interactions were limited.

Background

The novel coronavirus outbreak due to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection reported from China in December 2019 was declared a Public Health Emergency of International Concern (PHEIC) by WHO on January 30, 2020¹. At the early stages of COVID-19, international travel was the most common exposure. Subsequently, clusters emerged in various settings, including community gatherings, hospital settings, and commercial gatherings. Investigating such clusters provided clues for disease transmission and guided intervention strategies for pandemic response². Contact tracing is one of the key strategies to interrupt the chain of transmission of SARS-CoV-2. The aim of the contact tracing strategy is to reduce secondary cases of COVID-19. In this context, the secondary attack rate of SARS-CoV-2 denotes the probability that infection occurs among susceptible contacts within a reasonable incubation period following contact with the infectious person(s) or that of the source³ and represents infectiousness of the agent. The secondary attack rate among contacts thus is a useful indicator to track the viral transmission potential⁴ and thereby guides control strategies. The secondary attack rate of SARS-CoV-2 differs from the nature of the setting and that of the symptomatic status of the primary cases.^{5 6 7 8} Understanding the dynamics of transmission of COVID-19 for specific settings will help in preventing the spread of the infection⁹.

India reported the first laboratory-confirmed case on January 30, 2020, from a Southern state Kerala. In early March, most reported cases had a history of international travel or contact with the traveller¹⁰. Tamil Nadu, the southern State of India, reported the first case of COVID-19 on March 18 2020¹¹. At the initial stages, COVID-19 cases were reported among international travellers and subsequently among travellers from other states. On March 13, the media reported a cluster of cases linked to a religious congregation in New Delhi.^{12 13} According to the reports, the event started on February 9, 2020, with more than 4000 participants from various Indian states and abroad gathered in groups to attend the meeting.¹⁴ As the participants returned to their respective states, clusters emerged in several states.¹⁵ People from Tamil Nadu also participated in the meeting, predominantly during 21-23 March, 2020¹⁶. After returning from the event, attendees travelled to many parts

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3 of the State. Public health authorities initiated a massive search for potential cases
4 and their contact in various districts.
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7 Due to the novelty of the pandemic, the transmission dynamics of the diseases were
8 not fully understood. In the early phase, knowledge on the spread of the disease in
9 various settings and in different geographical was not known. Knowing this
10 information was crucial in preventing the disease's spread from the primary case to
11 the contacts. In this context, we conducted a study to estimate the secondary attack
12 rate in terms of time, place, and person and determined risk factors for COVID-19
13 infection among contacts during March-May 2020 in Tamil Nadu, India.
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19 **Methods:**

20 **Study design**

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22 We conducted a retrospective cohort study of all contacts of COVID-19 cases
23 between March 14 to May 5, 2020, of Tamil Nadu, Southern India.
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28 **Study setting and the COVID-19 context:**

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30 We studied nine of 38 administrative districts reporting maximum cases during the
31 study period (Figure 1). The study districts varied in a population density ranging
32 from 28,553 persons per square Kilometre in the State capital city of Chennai to 367
33 in Erode district, located southwest of Chennai (Table 1). The average family size
34 was similar (3.5 to 4.3 persons per family) across these study districts.
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39 The COVID-19 response strategies implemented by the State included surveillance
40 for case identification, confirmation with Reverse Transcriptase-Polymerase Chain
41 Reaction (RT-PCR) test for COVID-19, contact tracing, isolation, and quarantine, in
42 addition to community-based interventions. The district officials hospitalised the
43 COVID-19 patients, and quarantined COVID-19 tested negatives at home or facility.
44 By contact tracing, the officials identified the household and the community contacts
45 and tested them for COVID-19. We included all COVID-19 confirmed cases in the
46 study period from these districts.
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54 **Sampling and sample size**

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56 We listed all the identified confirmed COVID-19 cases in the study districts from
57 March 1 to May 30, 2020. We included all the contacts of the identified COVID-19
58 positive individuals.
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Operational definitions:

Primary case: We defined a primary case as any person with a laboratory-confirmed COVID-19 case with no established contact history.

Confirmed Case: Any person who is positive for COVID-19 using RT-PCR

Contact: Contact is any person exposed to COVID-19 positive individuals¹⁷.

Household contact: It is defined as any person living in the same household and comes in contact with the COVID-19 case

Community contact: It is defined as any person other than living in the same household and comes in contact with the COVID-19 case

Cluster: An unusual aggregation of health events grouped in time and space and reported to a health agency¹⁸

Secondary attack rate: The secondary attack rate is the proportion of COVID-19 positive individuals among the tested contacts minus the primary cases of the contacts.

Data collection and analysis:

We collected data from district surveillance records and classified the contacts as household and community contacts. We abstracted the information on sociodemographic characteristics, residence location, symptom status and congregation exposure of the primary case from the district surveillance records.

We described the total number of contacts and the median number of contacts per case by the district. We calculated the overall secondary attack rate (SAR) for COVID-19 and by age, gender, symptom status and congregation exposure of the primary case. We estimated the SAR by symptom status and congregation exposure of the primary case in two subgroups, namely household and community contacts. We determined the risk factors associated with COVID-19 infection among contacts based on the household vs community exposure, congregation vs non-congregation exposure of primary case and symptom status of the primary case. We estimated the unadjusted and age/sex-adjusted relative risk (RR) and 95% confidence intervals

(CI) for the four categories of contacts. The community contacts of the non-congregation primary case were the reference category. The other categories were community contacts of congregation primary, household contacts of non-congregation and household contacts of congregation primary cases. We also estimated the unadjusted and age/sex-adjusted RR and 95% CI after stratifying the four categories by symptom status of the primary case.

Human participation protection:

We obtained the approval of the Institutional Ethics Committee of the ICMR-National Institute of Epidemiology. No primary information was collected from the participants. We maintained complete confidentiality and anonymity of the participants during data abstraction.

Results:

Description of the cases and contacts

We identified 931 COVID-19 primary cases and 15,702 contacts during the study period. The median number of contacts identified per COVID-19 case was 17 (IQR: 9, 18) in the selected nine districts. The duration, from the reporting of the first COVID-19 case to the time of data abstraction, ranged from 51 days for Chennai and 15 days in the Karur district. (Table 1).

Of the identified 15,702 contacts, 14,002 (89%) contacts were tested for COVID-19. Apart from household contacts, most community contacts (98%) were cab-drivers, vegetable sellers, co-workers, or co-passengers in public transport. The majority of the household contacts (99%) were tested. There is no difference between tested and not-tested by age and gender (data not shown).

Information on age was available for 99.7% (13,969/14,002) of the contacts (Table 2). The contacts were predominantly aged 21-40 years (41%) and 41 to 59 years (27%). Over half of the contacts were males (53%). About one-fourth (28%) of the contacts were traced from primary cases with congregation exposure, and 25% of the contacts had household COVID-19 exposure. Healthcare providers contributed to less than 1% of the contacts identified for the primary cases.

Secondary attack rate by selected characteristics

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3 Among tested contacts (n=14002), 599 (4.3%) tested positive for COVID-19 based
4 on RT PCR. The overall secondary attack rate was 4% (599 of 14,002). The
5 secondary attack rate was similar across the age groups and gender, ranging from
6 4% to 5%. The secondary attack rate among the contacts of primary cases with
7 congregation exposure was five times higher (10%) than contacts of non-
8 congregation primary cases (2%). Of the 598 contacts who tested positive, more
9 than three-fourths (78%) were household contacts.

10 The overall secondary attack rate was 4%, with 13% among the household contacts
11 compared to 1% among the community contacts. The secondary attack among
12 household contacts of primary cases with exposure to congregation was higher
13 (21%) than the contacts of primary cases without congregation exposure (6%) (Table
14 3). The primary cases' symptomatic status was available for 95% (13,338) of the
15 tested contacts. The overall secondary attack among contacts of the primary cases
16 with COVID -19 symptoms was 6% compared to 4% among the contacts of
17 asymptomatic cases. The household contacts exposed to the symptomatic primary
18 case had two times higher attack rate as compared to contacts of asymptomatic
19 primary cases (25% vs 12%). Secondary attack among the community contacts was
20 similar irrespective of the symptomatic status of the primary case.

21 ***Risk factors for secondary cases***

22 We estimated the risk of acquiring infection for contacts by type of contact and
23 congregation participation of the primary cases. There was no significant risk among
24 the community contacts of the primary cases irrespective of the participation in the
25 congregation. The relative risk of household contacts of primary cases with
26 congregation participation was four times higher (RR=16.4; 95% CI: 13.3 to 20.2) in
27 getting COVID-19 compared to household contacts of other primary cases (RR=4.9;
28 95% CI: 3.81 to 6.38). The association did not change even after adjusting for age
29 and gender. (Table 4)

30 We estimated the RR stratified by the symptomatic status of the primary cases. In
31 the strata where the primary case was symptomatic, there was an eight-fold increase
32 in RR for household contacts of congregation participants when compared to the
33 household contacts of other cases [RR=25.3,95% CI: 10.2 to 63) vs RR= 14.6, 95%
34 CI: 5.7 to 37.7)]. If the primary case was asymptomatic, there was no increase in RR
35 for community contacts of congregation participants, but RR was increased among
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3 household contacts of primary cases with congregation exposure. The change in RR
4 among household contacts of the symptomatic primary case was several folds
5 higher as compared to household contacts of the asymptomatic primary case (Table
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10 **Discussion:**

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13 Our study showed an increase in disease transmission among household contacts
14 than community contacts. The transmission was further accentuated if the primary
15 case had symptoms or exposure to a congregation. The high risk of infection among
16 family members was consistent with the pooled analysis of 43 studies which
17 estimated an SAR of 18% among household contacts¹⁹. We observed very low SAR
18 (1%) among non-household contacts, possibly due to the State's lockdown situation
19 during the study period.
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25 Contact tracing is one of the core public health strategies for COVID-19 control, and
26 our study assessed if districts implemented this strategy. Although the median
27 number of contacts per case was 17, there was a high variation between districts
28 due to limiting the contact tracing to only household contacts in several cases. A
29 study in the UK measuring the efficacy of contact tracing for COVID-19 suggested an
30 average of 36 contacts must be traced per case²⁰. Another study in the Republic of
31 Korea shows a range of 15-649 contacts traced per case²¹. Once the number of
32 cases increases, extensive contact tracing may not be feasible unless we deploy
33 dedicated human resources and train the contact tracers. There was limited capacity
34 in the initial phase of the epidemic; however, the public health department added
35 human resources, especially in the capital city of Chennai, to sustain the contact
36 tracing as cases started increasing.
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46 We observed a higher attack rate among household contacts (25%) of symptomatic
47 primary cases when compared to asymptomatic. Our observations were similar to a
48 pooled analysis of three studies from Wei et al.²², Part et al.²³, Chaw et al.²⁴, which
49 reported 20% SAR among household contacts of symptomatic primary cases²⁵. This
50 observation guided the testing policy in the context of limited resources at the peak
51 of the pandemic. We prioritised the testing of household contacts of symptomatic
52 primary cases. Although the attack rate was lower among contacts of asymptomatic
53 primary, the transmission did take place especially in the household setting. Our
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3 findings support the rationale of isolation of all cases irrespective of the symptoms
4 and testing of all household contacts to break the chain of transmission²⁶.

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7 The congregation clusters were one of the sources which led to COVID-19
8 transmission in various communities²⁷. Similar to our setting, many countries
9 experienced clusters emerging from congregation settings. In South Korea, an
10 explosive outbreak happened following a social event held at a Church and is
11 attributable to 84% of the total confirmed cases of South Korea reported till mid-
12 March²⁸. Another study in Jordan among the wedding attendees reported a higher
13 attack rate of 22%²⁹. Similar clusters had been reported in different parts of South
14 Korea³⁰, and in the USA, a secondary attack of 53.3% was estimated among one
15 such event attendees³¹. Avoiding any type of gathering is one of the essential
16 mitigation measures to be followed strictly. Government actions to ban mass
17 gatherings are essential, as are good diagnostic facilities and remotely accesses
18 health advice, together with specialised treatment for people with severe disease³².

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21 Our study has several limitations. We did not have confirmation of the COVID-19
22 status of 11% of the contacts, who were mostly community contacts. Hence, this
23 may have over-estimated the overall secondary attack rate by 0.3%. Contact tracing
24 was prioritised for household contacts due to restricted mobility and limited
25 interactions at the community level. Therefore, secondary attack among non-
26 household contacts may not reflect the real transmission potential. Information
27 regarding symptoms was retrieved from district surveillance records. The symptom
28 status was collected at the time of diagnosis. We could not verify if the primary case
29 developed symptoms later in the course of illness. Hence, there was a chance of
30 misclassification of symptom status.

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33 We conclude that COVID-19 transmission was higher among household contacts,
34 contacts of symptomatic primary case, and contacts of primary cases exposed to the
35 congregation. Based on the findings, we informed the testing policy and contact
36 tracing strategy in the early stages of the COVID-19 epidemic in Tamil Nadu. We
37 recommend testing all household contacts irrespective of the symptoms and
38 extensive contact tracing and testing in case of super spreader events. In resource-
39 constrained settings, all contacts of symptomatic primary cases should be prioritised
40 for testing. The gatherings should be restricted to prevent significant clusters.

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3 **Author Contributions:** KK, RM, MP, and PK designed the study, supervised
4 fieldwork, did primary data collection, planned data analysis and wrote the first draft
5 of the manuscript. VV, PR, MS, PS, PG and MS did primary data collection and did
6 data analysis. VV, IS, and KI supervised fieldwork and data management. JM, RG,
7 SS, SR, SKST, VM, MT, JK, VG, and SK supervised fieldwork and supported data
8 collection. PV, YN, SP, STS, MR, BR and MM conceptualised the study and gave
9 critical comments in finalising the manuscript. All authors approved the final
10 manuscript
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29 **Data availability statement:** Data are available upon reasonable request

30 **Patient and Public Involvement in research:** Not involved in the conduct of
31 research

32 **Trial registration:** Not applicable

33 **Figure 1:** Map of Tamil Nadu included in the epidemiological study of COVID-19.
34 There are nine of the 38 districts included in the study.
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Table 1: Frequency of contacts traced per COVID-19 primary case by district, Tamil Nadu, India, April-May, 2020

District	Demographic characteristics		# Primary Cases	Frequency of contacts		Days since reporting of the first case in the district
	Population density (Per Sq KM)*	Family size*		# Contacts identified	Median (Range) contacts per Primary case	
Chennai	26553	3.9	530	9731	18 (1 to 151)	51
Coimbatore	731	3.9	151	3257	22 (1 to 274)	33
Erode	391	3.5	56	1032	18 (3 to 141)	46
Karur	367	3.7	42	416	10 (1 to 86)	15
Ranipet	648	4.3	29	273	9 (1 to 68)	25
Tirunelveli	460	3.8	35	166	5 (1 to 21)	23
Tirupathur	648	4.3	12	312	26 (1 to 100)	20
Tiruppur	478	3.6	66	279	5 (1 to 10)	24
Vellore	648	4.3	10	236	24 (6 to 79)	23
Overall			931	15,702	17(5 to 26)	

*- Census 2011

Table 2: Secondary Attack Rate (%) by selected characteristics among the contacts traced per COVID-19 primary case, Tamil Nadu, India, April- May 2020

Selected characteristics		Number of contacts (%)	# COVID-19 Positive	Secondary attack rate (%)
Overall		14002(100%)	599	4
Age in Years (N=13,379)	≤20	3203 (24%)	138	4
	21-40	5511 (41%)	237	4
	41-59	3364 (25%)	155	5
	60+	1301 (10%)	65	5
Gender (N=13,969)	Male	7443 (53%)	280	4
	Female	6526 (47%)	318	5
Congregation exposure of primary case (N=14,002)	Yes	3884 (28%)	377	10
	No	10,118 (72%)	222	2
Contact type (N=14,002)	Household	3474 (25%)	464	13
	Community	10,417 (74%)	134	1
	Healthcare personnel	111 (1%)	0	0
Symptom status of Primary case (N=13338)	Symptomatic	607(5%)	37	6
	Asymptomatic	12,731(95%)	464	4

Table 3: Secondary Attack Rate among household and non-household contacts of COVID-19 individuals by type of exposure and symptom status of primary cases, Tamil Nadu, April-May, 2020 (N=14002)

Type of exposure or symptom status of the primary case	The secondary attack rate (%) (# cases / # contacts of the case)		
	Household	Community contacts	Overall
<u>N = 14,002</u>			
Congregation	21% (352/1686)	1% (25/2198)	10% (377/3884)
No congregation	6% (112/1788)	1% (110/8330)	2% (222/10118)
<u>N= 13,338</u>			
Symptomatic	25% (26/104)	2% (11/503)	6% (37/607)
Asymptomatic	12% (341/2930)	1% (123/9801)	4% (464/12731)

Table 4: Factors associated with COVID-19 among the contacts of Tamil Nadu, India April – May 2020

Risk factors	Crude RR (95% CI)	RR with age-adjusted (95% CI)	RR with age and sex-adjusted (95% CI)
Community contacts of non-congregation Primary cases	Ref	Ref	Ref
Community contact of Congregation Primary cases	1.0 (0.7-1.5)	0.9 (0.6-1.4)	0.9 (0.6-1.4)
Household contacts of non-congregation Primary cases	4.9 (3.8-6.4)	4.7 (3.7 – 6.2)	4.7 (36.4-6.1)
Household contacts of Congregation Primary cases	16.4 (13.3–20.2)	16.2 (13.1-20.0)	16.1 (13.0-20.0)

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Table 5: Factors associated with COVID-19 among the contacts stratified by the symptomatic status of the primary cases of Tamil Nadu, India April – May 2020

Symptomatic Primary	Type of contacts	Crude RR (95% CI)	Adjusted RR with Age and Sex (95% CI)
Yes	Community contacts of non-congregation Primary cases	Ref	Ref
	Community contact of Congregation Primary cases	10.5 (6.0-33.0)	8.6 (2.6 – 29.1)
	Household contacts of non-congregation Primary cases	15.5 (6.0-39.8)	14.6 (5.7 – 37.7)
	Household contacts of Congregation Primary cases	26.7 (10.8-65.9)	25.3 (10.2 – 63.0)
No	Community contacts of non-congregation Primary cases	Ref	Ref
	Community contact of Congregation Primary cases	0.9 (0.6-1.4)	0.9 (0.5 – 1.3)
	Household contacts of non-congregation Primary cases	4.6 (3.5-6.0)	4.4 (3.4 – 5.8)
	Household contacts of Congregation Primary cases	16.48 (13.17-20.63)	16.52 (13.16 – 20.74)

Reference:

1, World Health Organization. Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). [https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov)) (2020).

² WHO; Coronavirus disease (COVID-19): Contact tracing 2020 [Available from: <https://www.who.int/news-room/q-a-detail/coronavirus-disease-covid-19-contact-tracing>.

³ Halloran ME. Secondary Attack Rate. In: Peter A, Theodore C, editors. Encyclopedia of Biostatistics. New York: John Wiley & Sons Ltd; 2005

⁴ Li W, Zhang B, Lu J, Liu S, Chang Z, Cao P, et al. The characteristics of household transmission of COVID-19. *Clinical Infectious Diseases*. 2020.

⁵ Liu Y, Eggo RM, Kucharski AJ. Secondary attack rate and superspreading events for SARS-CoV-2. *The Lancet*. 2020 Mar 14;395(10227):e47

⁶ Luo L, Liu D, Liao X, Wu X, Jing Q, Zheng J, Liu F, Yang S, Bi H, Li Z, Liu J. Contact settings and risk for transmission in 3410 close contacts of patients with COVID-19 in Guangzhou, China: a prospective cohort study. *Annals of internal medicine*. 2020 Aug 13

⁷ Yang J, Zheng Y, Gou X, Pu K, Chen Z, Guo Q, et al. Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis. *International Journal of Infectious Diseases*. 2020; 94:91-5

⁸ Cheng HY, Jian SW, Liu DP, Ng TC, Huang WT, Lin HH. High transmissibility of COVID-19 near symptom onset. *medRxiv*. 2020 Jan 1

⁹ Wilder-Smith A, Chiew CJ, Lee VJ. Can we contain the COVID-19 outbreak with the same measures as for SARS?. *The Lancet Infectious Diseases*. 2020 Mar 5

¹⁰ Jahan N, Rubeshkumar P, Karuppiyah M, Sambath I, Sendhilkumar M, Ilangovan K, et al. Entry and initial spread of COVID-19 in India: Epidemiological analysis of media surveillance data, India, 2020. *Clinical Epidemiology and Global Health*. 2020.

¹¹ MediaBulletin180320COVID19.pdf [Internet]. [cited 2020 May 31]. Available from: <https://stopcorona.tn.gov.in/wp-content/uploads/files/MediaBulletin180320COVID19.pdf>

¹² Ali, A. (2020, April 1). Coronavirus was a test of secular nationalism. Then Tablighi Jamaat became the scapegoat. *The Print*. <https://theprint.in/opinion/coronavirus-test-of-secular-nationalism-tablighi-jamaat-became-scapegoat/392764/>

¹³ Gathering at Nizamuddin a highly irresponsible act, says Kejriwal. (2020, March 31). *The Hindu*. <https://www.thehindu.com/news/cities/Delhi/gathering-at-nizamuddin-a-highly-irresponsible-act-says-kejriwal/article31221982.ece>

¹⁴ Chandna, H. (2020, April 18). 30% of India's Covid-19 positive caseload linked to Tablighi Jamaat meet, says govt. *The Print*. <https://theprint.in/health/30-of-indias-covid-19-positive-caseload-linked-to-tablighi-jamaat-meet-says-govt/404426/>

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54
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56
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- ¹⁵ Of 14,378 total Covid-19 cases in India, 4,291 linked to Delhi's Markaz event: Health ministry. (2020, April 18). *India Today*. <https://www.indiatoday.in/india/story/coronavirus-india-total-cases-linked-tablighi-jamaat-markaz-nizamuddin-event-health-ministry-1668456-2020-04-18>
- ¹⁶ NDTV. 1,023 COVID-19 Cases Linked To Mosque Event, Tamil Nadu Leads: 10 Points: NDTV; [Available from: <https://www.ndtv.com/india-news/coronavirus-tablighi-jamaat-1-023-of-2-902-covid-19-cases-linked-to-mosque-event-tamil-nadu-leads-2206193>
- ¹⁷ National Centre for Disease Control Directorate General of Health Services MoH&FW, GOI, New Delhi The updated case definitions and contact-categorisation [internet]. [cited 2020 Jun 2]. Available from https://nirth.res.in/virology/Revised_case_definitions_for_COVID_19.pdf
- ¹⁸ US Department of Health and Human Services. Guidelines for investigating clusters of health events. *Mort Morb Wkly Rep*. 1990;39:1-23.
- ¹⁹ Koh WC, Naing L, Chaw L, Rosledzana MA, Alikhan MF, et al. (2020) What do we know about SARS-CoV-2 transmission? A systematic review and meta-analysis of the secondary attack rate and associated risk factors. *PLOS ONE* 15(10): e0240205. <https://doi.org/10.1371/journal.pone.0240205>
- ²⁰ Keeling MJ, Hollingsworth TD, Read JM. The Efficacy of Contact Tracing for the Containment of the 2019 Novel Coronavirus (COVID-19). *medRxiv*. 2020.
- ²¹ COVID-19 National Emergency Response Center Epidemiology and case management team, Korea Centers for disease Control and prevention. Coronavirus disease-19: summary of 2,370 contact investigations of the first 30 cases in the Republic of Korea. *Public Health Res Perspect*. 2020;11(2):81–84. doi: 10.24171/j.phrp.2020.11.2.04
- ²² Wei L, Lv Q, Wen Y, Feng S, Gao W, Chen Z, Cao B, Wu X, Lu Y, Zhao J, Zou X. Household transmission of COVID-19, Shenzhen, January-February 2020. *medRxiv*. 2020 Jan 1
- ²³ Park SY, Kim YM, Yi S, Lee S, Na BJ, Kim CB, Kim JI, Kim HS, Kim YB, Park Y, Huh IS. Coronavirus disease outbreak in call center, South Korea. *Emerging infectious diseases*. 2020 Aug;26(8):1666.
- ²⁴ Chaw, L., Koh, W., Jamaludin, S., Naing, L., Alikhan, M., & Wong, J. (2020). Analysis of SARS-CoV-2 Transmission in Different Settings, Brunei. *Emerging Infectious Diseases*, 26(11), 2598-2606. <https://dx.doi.org/10.3201/eid2611.202263>
- ²⁵ Koh WC, Naing L, Chaw L, Rosledzana MA, Alikhan MF, et al. (2020) What do we know about SARS-CoV-2 transmission? A systematic review and meta-analysis of the secondary attack rate and associated risk factors. *PLOS ONE* 15(10): e0240205. <https://doi.org/10.1371/journal.pone.0240205>
- ²⁶ MOHFW. Revised guidelines for Home Isolation of very mild/pre-symptomatic/asymptomatic COVID-19 cases. MOHFW 2020 July 2 [Available from [RevisedHomeIsolationGuidelines.pdf \(mohfw.gov.in\)](https://www.mohfw.gov.in/RevisedHomeIsolationGuidelines.pdf)]
- ²⁷ Quadri SA. COVID-19 and religious congregations: Implications for spread of novel pathogens. *International Journal of Infectious Diseases*. 2020 Jul 1;96:219-21.

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²⁸ Choi JY. COVID-19 in South Korea. *Postgraduate Medical Journal*. 2020;96(1137):399-402.

²⁹ Yusef D, Hayajneh W, Awad S, Momany S, Khassawneh B, Samrah S, Obeidat B, Raffee L, Al-Faouri I, Issa AB, Al Zamel H. Large outbreak of coronavirus disease among wedding attendees, Jordan. *Emerging infectious diseases*. 2020 Sep;26(9):2165.

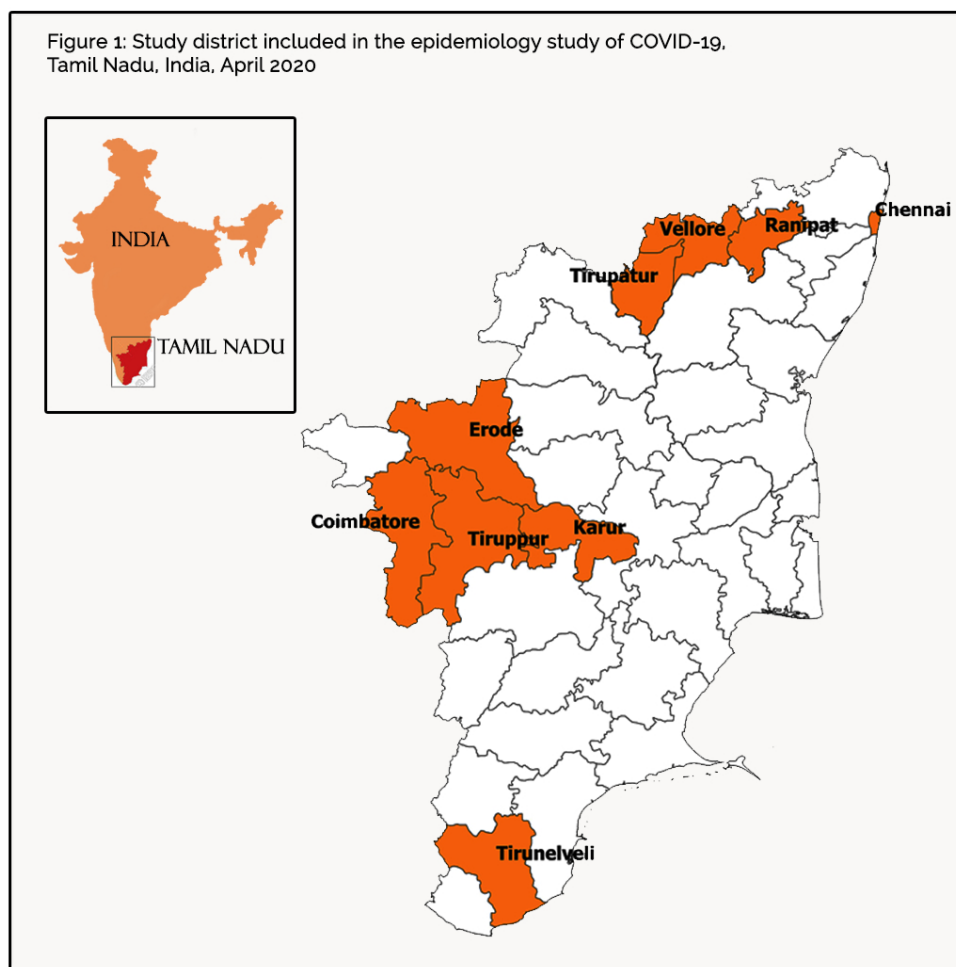
³⁰ Shim E, Tariq A, Choi W, Lee Y, Chowell G. Transmission potential and severity of COVID-19 in South Korea. *International Journal of Infectious Diseases*. 2020;93:339-44.

³¹ Hamner L, Dubbel P, Capron I, Ross A, Jordan A, Lee J, et al. High SARS-CoV-2 Attack Rate Following Exposure at a Choir Practice - Skagit County, Washington, March 2020. *MMWR Morbidity and mortality weekly report*. 2020;69(19):606-10

³² The Times of India; Avoid mass gatherings, says govt as corona cases hit 31: [Available from: http://timesofindia.indiatimes.com/articleshow/74520610.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst]

peer review only

Figure 1: Study district included in the epidemiology study of COVID-19,
Tamil Nadu, India, April 2020



Map of Tamil Nadu included in the epidemiological study of COVID-19. There are nine of the 38 districts included in the study.

90x90mm (300 x 300 DPI)

Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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In your methods section, say that you used the STROBE cohort reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Page
	Reporting Item	Number
Title and abstract		
Title	#1a Indicate the study's design with a commonly used term in the title or the abstract	1

1	Abstract	#1b	Provide in the abstract an informative and balanced	2
2			summary of what was done and what was found	
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6	Introduction			
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10	Background /	#2	Explain the scientific background and rationale for the	3
11	rationale		investigation being reported	
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15	Objectives	#3	State specific objectives, including any prespecified	4
16			hypotheses	
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20	Methods			
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23	Study design	#4	Present key elements of study design early in the paper	4
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26	Setting	#5	Describe the setting, locations, and relevant dates,	4
27			including periods of recruitment, exposure, follow-up, and	
28			data collection	
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34	Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of	5
35			selection of participants. Describe methods of follow-up.	
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39	Eligibility criteria	#6b	For matched studies, give matching criteria and number of	n/a
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45	Variables	#7	Clearly define all outcomes, exposures, predictors,	5
46			potential confounders, and effect modifiers. Give	
47			diagnostic criteria, if applicable	
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53	Data sources /	#8	For each variable of interest give sources of data and	5
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more than one group. Give information separately for for
exposed and unexposed groups if applicable.

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6	Bias	#9	Describe any efforts to address potential sources of bias n/a
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9	Study size	#10	Explain how the study size was arrived at 4
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12	Quantitative	#11	Explain how quantitative variables were handled in the 5
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14	variables		analyses. If applicable, describe which groupings were
15			chosen, and why
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19	Statistical	#12a	Describe all statistical methods, including those used to 5
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21	methods		control for confounding
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25	Statistical	#12b	Describe any methods used to examine subgroups and n/a
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27	methods		interactions
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30	Statistical	#12c	Explain how missing data were addressed n/a
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36	Statistical	#12d	If applicable, explain how loss to follow-up was addressed n/a
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41	Statistical	#12e	Describe any sensitivity analyses n/a
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43	methods		
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46	Results		
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49	Participants	#13a	Report numbers of individuals at each stage of study—eg 5
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52			confirmed eligible, included in the study, completing follow-
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up, and analysed. Give information separately for for
exposed and unexposed groups if applicable.

Participants	#13b	Give reasons for non-participation at each stage	n/a
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	5
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	5
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	6
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6
Main results	#16b	Report category boundaries when continuous variables were categorized	n/a
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a

1	Other analyses	#17	Report other analyses done—eg analyses of subgroups	6
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6	Discussion			
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9	Key results	#18	Summarise key results with reference to study objectives	7
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12	Limitations	#19	Discuss limitations of the study, taking into account	8
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14			sources of potential bias or imprecision. Discuss both	
15			direction and magnitude of any potential bias.	
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17	Interpretation	#20	Give a cautious overall interpretation considering	8
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19			objectives, limitations, multiplicity of analyses, results from	
20			similar studies, and other relevant evidence.	
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22	Generalisability	#21	Discuss the generalisability (external validity) of the study	n/a
23			results	
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27	Other Information			
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29	Funding	#22	Give the source of funding and the role of the funders for	10
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31			the present study and, if applicable, for the original study	
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BMJ Open

Secondary attack rate of COVID-19 among contacts and risk factors, Tamil Nadu, March-May 2020: A retrospective Cohort Study

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	Department Murhekar, Manoj; National Institute of Epidemiology
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3 **Secondary attack rate of COVID-19 among contacts and risk factors, Tamil**
4 **Nadu, March-May 2020: A retrospective Cohort Study**
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43 transmission, Cluster
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Abstract:

Objective: To describe the characteristics of contacts of COVID-19 case-patients in terms of time, place, and person, to calculate the secondary attack rate and factors associated with COVID-19 infection among contacts

Design: Retrospective cohort study

Setting and participants: Contacts of cases identified by the health department from March 14 to May 30, 2020, in nine of 38 administrative districts of Tamil Nadu.

Significant proportion of cases attended a religious congregation.

Outcome measure: Attack rate among the contacts and factors associated with COVID-19 positivity.

Results: We listed 15,702 contacts of 931 primary cases. Of the contacts, 89% (n=14002) were tested for COVID-19. The overall SAR was 4% (599/14002), with higher among the household contacts (13%) than the community contacts (1%). SAR among the contacts of primary cases with congregation exposure were five times higher than the contacts of non-congregation primary cases (10% Vs 2%). Being a household contact of a primary case with congregation exposure had a four-fold increased risk of getting COVID-19 (RR=16.4; 95%CI:13-20) than contact of primary case without congregation exposure. Among the symptomatic primary cases, household contacts of congregation primaries had higher RR than household contacts of other cases [(RR=25.3; 95%CI:10.2-63) Vs (RR=14.6; 95%CI:5.7-37.7)]. Among asymptomatic primary case, RR was increased among household contacts (RR=16.5; 95%CI:13.2–20.7) of congregation primaries compared to others

Conclusion: Our study showed an increase in disease transmission among household contacts than community contacts. Also, symptomatic primary cases and primary cases with exposure to the congregation had more secondary cases than others.

Strengths and Limitations:

- **Strengths**

- We documented the secondary attack rate of COVID-19 in a large cohort of more than 15,000 contacts in India
- All the contacts were tested with RT-PCR, therefore the estimates of secondary attack rate were reliable.
- We documented high transmission among household contacts and contacts of symptomatic primary cases which guided the testing policy of the state in the early phase of the pandemic,

- **Limitations:**

- We did not have confirmation of the COVID-19 status of 11% of the contacts
- Contact tracing was prioritised for household contacts during lockdown as the community interactions were limited

Background

The novel coronavirus outbreak due to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection reported from China in December 2019 was declared a Public Health Emergency of International Concern (PHEIC) by WHO on January 30, 2020¹. At the early stages of COVID-19, international travel was the most common exposure. Subsequently, clusters emerged in various settings, including community gatherings, hospital settings, and commercial gatherings. Investigating such clusters provided clues for disease transmission and guided intervention strategies for pandemic response². Contact tracing is one of the key strategies to interrupt the chain of transmission of SARS-CoV-2. The aim of the contact tracing strategy is to reduce secondary cases of COVID-19. In this context, the secondary attack rate of SARS-CoV-2 denotes the probability that infection occurs among susceptible contacts within a reasonable incubation period following contact with the infectious person(s) or that of the source³ and represents infectiousness of the agent. The secondary attack rate among contacts thus is a useful indicator to track the viral transmission potential⁴ and thereby guides control strategies. The secondary attack rate of SARS-CoV-2 differs from the nature of the setting and that of the symptomatic status of the primary cases.^{5 6 7 8} Understanding the dynamics of transmission of COVID-19 for specific settings will help in preventing the spread of the infection⁹.

India reported the first laboratory-confirmed case on January 30, 2020, from a Southern state Kerala. In early March, most reported cases had a history of international travel or contact with the traveller¹⁰. Tamil Nadu, the southern State of India, reported the first case of COVID-19 on March 18 2020¹¹. At the initial stages, COVID-19 cases were reported among international travellers and subsequently among travellers from other states. On March 13, the media reported a cluster of cases linked to a religious congregation in New Delhi.^{12 13} According to the reports, the event started on February 9, 2020, with more than 4000 participants from various Indian states and abroad gathered in groups to attend the meeting.¹⁴ As the participants returned to their respective states, clusters emerged in several states.¹⁵ People from Tamil Nadu also participated in the meeting, predominantly during 21-23 March, 2020¹⁶. After returning from the event, attendees travelled to many parts

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3 of the State. Public health authorities initiated a massive search for potential cases
4 and their contact in various districts.
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7 From February 2020, the health department of Tamil Nadu state practised testing
8 and quarantine of international travellers and enhanced the voluntary testing of
9 symptomatic individuals with h/o travel or h/o contact with a traveller. When the
10 congregation cluster was reported, all the persons who attended the congregation
11 were traced, quarantined and tested. The persons tested for COVID-19 were
12 isolated and treated. The persons who tested negative were quarantined for 14 days.
13 Also, the COVID-19 test was repeated after 5th day of the first testing. The household
14 members of the attendees were immediately tested for COVID-19, if any person is
15 tested positive.
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18 After the information of COVID outbreak in the Delhi congregation setting, Govt of
19 Tamil Nadu collected the line list of participants from the appropriate authority
20 involved in the outbreak control in the congregation. The district collected additional
21 information from the local leaders.
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24 At the time this investigation was undertaken, there was no wide spread community
25 transmission. Most of the infection were among travelers and health care workers,
26 and they did not mingle with the community due to restrictions. Unlike international
27 travelers, congregation participants travelled with other local travelers and after
28 attending the congregation, all resumed social and work-related activities after
29 arrival. Therefore, they are more likely to transmit to the community.
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32 Due to the novelty of the pandemic, the transmission dynamics of the diseases were
33 not fully understood. In the early phase, knowledge on the spread of the disease in
34 various settings and in different geographical was not known. Also, the contribution
35 of the congregation cluster in driving the pandemic is not known. Knowing this
36 information was crucial in preventing the disease's spread from the primary case to
37 the contacts. In this context, we conducted a study to estimate the secondary attack
38 rate in terms of time, place, and person and determined risk factors for COVID-19
39 infection among contacts during March-May 2020 in Tamil Nadu, India.
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56 **Methods:**

57 **Study design**

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3 We conducted a retrospective cohort study of all contacts of COVID-19 cases
4 between March 14 to May 30, 2020, of Tamil Nadu, Southern India.

7 **Study setting and the COVID-19 context:**

9 We studied nine of 38 administrative districts reporting maximum cases during the
10 study period (Figure 1). The study districts varied in a population density ranging
11 from 28,553 persons per square Kilometre in the State capital city of Chennai to 367
12 in Erode district, located southwest of Chennai. The average family size was similar
13 in Erode district, located southwest of Chennai. The average family size was similar
14 (3.5 to 4.3 persons per family) across these study districts.
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18 The COVID-19 response strategies implemented by the State included surveillance
19 for case identification, confirmation with Reverse Transcriptase-Polymerase Chain
20 Reaction (RT-PCR) test for COVID-19, contact tracing, isolation, and quarantine, in
21 addition to community-based interventions. The confirmation with RT-PCR was done
22 by identifying two or more target genes (E / RdRp / ORF1ab / N / S) using multiplex
23 PCR kits The district officials hospitalised the COVID-19 patients, and quarantined
24 COVID-19 tested negatives at home or facility. By contact tracing, the officials
25 identified the household and the community contacts and tested them for COVID-19.
26 We included all COVID-19 confirmed cases in the study period from these districts.
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35 ***Sampling and sample size***

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37 We listed all the identified confirmed COVID-19 cases in the study districts from
38 March 1 to May 30, 2020. We included all the contacts of the identified COVID-19
39 positive individuals.
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44 ***Operational definitions:***

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46 Primary case: Any individual with a laboratory-confirmed COVID-19 case with no
47 reported history of contact with COVID-19 case
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51 Symptomatic Cases: Any individual with H/O Fever, cough, Sore throat or
52 breathlessness from 5 days before the date of testing
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55 Confirmed Case: Any individual who is tested positive for COVID-19 using RT-PCR
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58 Contact: Any individual comes in proximity with COVID-19 positive individuals¹⁷.
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60 High risk contacts is defined as any person who was in proximity with COVID-19

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3 positive individual within 2 metres of proximity for 15 minutes. Low risk contact is
4 defined as any person who was in proximity with COVID-19 positive individual and
5 sharing same environment but not having high exposure.
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9 Household contact: Any individual living in the same household and comes in
10 proximity with the COVID-19 confirmed individual
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14 Community contact: Any individual other than living in the same household and
15 comes in proximity with the COVID-19 confirmed individual
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19 Cluster: An unusual aggregation of two or more COVID-19 cases grouped in time
20 and space and reported to a health agency¹⁸
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23 Congregation exposure: Individual who have attended the religious congregation
24 event held during February and March 2020 (News paper reference)
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27 Secondary attack rate: The secondary attack rate is the proportion of COVID-19
28 positive individuals among the tested contacts.
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30 31 **Data collection and analysis:**

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33 We collected data from district surveillance records and classified the contacts as
34 household and community contacts. We abstracted the information on
35 sociodemographic characteristics, residence location, symptom status and
36 congregation exposure of the primary case from the district surveillance records.
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40 We described the total number of contacts and the median number of contacts per
41 case by the district. We calculated the overall secondary attack rate (SAR) for
42 COVID-19 and by age, gender, symptom status and congregation exposure of the
43 primary case. We estimated the SAR by symptom status and congregation exposure
44 of the primary case in two subgroups, namely household and community contacts.
45 We determined the risk factors associated with COVID-19 infection among contacts
46 based on the household vs community exposure, congregation vs non-congregation
47 exposure of primary case and symptom status of the primary case. We estimated the
48 unadjusted and age/sex-adjusted relative risk (RR) and 95% confidence intervals
49 (CI) for the four categories of contacts. The community contacts of the non-
50 congregation primary case were the reference category. The other categories were
51 community contacts of congregation primary, household contacts of non-
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3 congregation and household contacts of congregation primary cases. We also
4 estimated the unadjusted and age/sex-adjusted RR and 95% CI after stratifying the
5 four categories by symptom status of the primary case.
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8 9 **Human participation protection:**

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11 We obtained the approval of the Institutional Ethics Committee of the ICMR-National
12 Institute of Epidemiology. No primary information was collected from the participants.
13 We maintained complete confidentiality and anonymity of the participants during data
14 abstraction.
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19 **Patient and Public Involvement in research:** Not involved in the conduct of
20 research
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23 **Results:**

24 ***Description of the cases and contacts***

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26 We identified 931 COVID-19 primary cases and 15,702 contacts during the study
27 period. The median number of contacts identified per COVID-19 case was 17 (IQR:
28 9, 18) in the selected nine districts. Around 11% (n=102) of the cases did not have
29 household contacts. The duration from the reporting of the first COVID-19 case to
30 the time of data abstraction ranged from 51 days for Chennai and 15 days for Karur
31 district. (Table 1).
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38 Of the identified 15,702 contacts, 14,002 (89%) contacts were tested for COVID-19.
39 Apart from household contacts, most community contacts (98%) were cab-drivers,
40 vegetable sellers, co-workers, or co-passengers in public transport. The majority of
41 the household contacts (99%) were tested. There is no difference between tested
42 and not-tested by age and gender (data not shown).
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48 Information on age was available for 99.7% (13,969/14,002) of the contacts (Table
49 2). The contacts were predominantly aged 21-40 years (41%) and 41 to 59 years
50 (27%). Over half of the contacts were males (53%). About one-fourth (28%) of the
51 contacts were traced from primary cases with congregation exposure, and 25% of
52 the contacts had household COVID-19 exposure. Healthcare providers contributed
53 to less than 1% of the contacts identified for the primary cases.
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58 ***Secondary attack rate by selected characteristics***

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3 Among tested contacts (n=14002), 599 (4.3%) tested positive for COVID-19 based
4 on RT PCR. The overall secondary attack rate was 4% (599 of 14,002). The
5 secondary attack rate was similar across the age groups and gender, ranging from
6 4% to 5%. The secondary attack rate among the contacts of primary cases with
7 congregation exposure was five times higher (10%) than contacts of non-
8 congregation primary cases (2%). Of the 599 contacts who tested positive, more
9 than three-fourths (78%) were household contacts.

10 The overall secondary attack rate was 4%, with 13% among the household contacts
11 compared to 1% among the community contacts. The secondary attack among
12 household contacts of primary cases with exposure to congregation was higher
13 (21%) than the contacts of primary cases without congregation exposure (6%) (Table
14 3). The primary cases' symptomatic status was available for 95% (13,338) of the
15 tested contacts. The overall secondary attack among contacts of the primary cases
16 with COVID -19 symptoms was 6% compared to 4% among the contacts of
17 asymptomatic cases. The household contacts exposed to the symptomatic primary
18 case had two times higher attack rate as compared to contacts of asymptomatic
19 primary cases (25% vs 12%). Secondary attack among the community contacts was
20 similar irrespective of the symptomatic status of the primary case.

21 ***Risk factors for secondary cases***

22 We estimated the risk of acquiring infection for contacts by type of contact and
23 congregation participation of the primary cases. There was no significant risk among
24 the community contacts of the primary cases irrespective of the participation in the
25 congregation. The relative risk of household contacts of primary cases with
26 congregation participation was four times higher (RR=16.4; 95% CI: 13.3 to 20.2) in
27 getting COVID-19 compared to household contacts of other primary cases (RR=4.9;
28 95% CI: 3.81 to 6.38). The association did not change even after adjusting for age
29 and gender. (Table 4)

30 We estimated the RR stratified by the symptomatic status of the primary cases. In
31 the strata where the primary case was symptomatic, there was an eight-fold increase
32 in RR for household contacts of congregation participants when compared to the
33 household contacts of other cases [RR=25.3,95% CI: 10.2 to 63) vs RR= 14.6, 95%
34 CI: 5.7 to 37.7)]. If the primary case was asymptomatic, there was no increase in RR
35 for community contacts of congregation participants, but RR was increased among
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3 household contacts of primary cases with congregation exposure. The change in RR
4 among household contacts of the symptomatic primary case was several folds
5 higher as compared to household contacts of the asymptomatic primary case (Table
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10 **Discussion:**

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12 Our study showed an increase in disease transmission among household contacts
13 than community contacts. The transmission was further accentuated if the primary
14 case had symptoms or exposure to a congregation. The high risk of infection among
15 family members was consistent with the pooled analysis of 43 studies which
16 estimated an SAR of 18% among household contacts¹⁹. Other systematic reviews
17 demonstrated a secondary attack rate of 16.6%²⁰ and 27%²¹ compared to our study.
18 This may probably due to the timeline of our study in early part of the pandemic. We
19 also observed very low SAR (1%) among non-household contacts, possibly due to
20 the State's lockdown situation during the study period. Contact tracing is one of the
21 core public health strategies for COVID-19 control, and our study assessed if
22 districts implemented this strategy. Although the median number of contacts per
23 case was 17, there was a high variation between districts due to limiting the contact
24 tracing to only household contacts in several cases. A study in the UK measuring the
25 efficacy of contact tracing for COVID-19 suggested an average of 36 contacts must
26 be traced per case²². Another study in the Republic of Korea shows a range of 15-
27 649 contacts traced per case²³. Once the number of cases increases, extensive
28 contact tracing may not be feasible unless we deploy dedicated human resources
29 and train the contact tracers. There was limited capacity in the initial phase of the
30 epidemic; however, the public health department added human resources, especially
31 in the capital city of Chennai, to sustain the contact tracing as cases started
32 increasing.
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35 We observed a higher attack rate among household contacts (25%) of symptomatic
36 primary cases when compared to asymptomatic. Our observations were similar to a
37 pooled analysis of three studies from Wei et al.²⁴, Part et al.²⁵, Chaw et al.²⁶, which
38 reported 20% SAR among household contacts of symptomatic primary cases²⁷. This
39 observation guided the testing policy in the context of limited resources at the peak
40 of the pandemic. We prioritised the testing of household contacts of symptomatic
41 primary cases in the subsequent phases of pandemic at times of resource
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3 constraints. Although the attack rate was lower among contacts of asymptomatic
4 primary, the transmission did take place especially in the household setting. Our
5 findings support the rationale of isolation of all cases irrespective of the symptoms
6 and testing of all household contacts to break the chain of transmission²⁸.
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10 The congregation clusters were one of the sources which led to COVID-19
11 transmission in various communities²⁹. Similar to our setting, many countries
12 experienced clusters emerging from congregation settings. In South Korea, an
13 explosive outbreak happened following a social event held at a Church and is
14 attributable to 84% of the total confirmed cases of South Korea reported till mid-
15 March³⁰. Another study in Jordan among the wedding attendees reported a higher
16 attack rate of 22%³¹. Similar clusters had been reported in different parts of South
17 Korea³², and in the USA, a secondary attack of 53.3% was estimated among one
18 such event attendees³³. In addition to the effect of disease spread within the cluster,
19 the attendees returned from the congregation involved themselves in the routine
20 duties and social activities, which led to further spread of the disease in the
21 community. Avoiding any type of gathering is one of the essential mitigation
22 measures to be followed strictly. Government actions to ban mass gatherings are
23 essential, as are good diagnostic facilities and remotely accesses health advice,
24 together with specialised treatment for people with severe disease³⁴.
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37 Our study has several limitations. We did not have confirmation of the COVID-19
38 status of 11% of the contacts, who were mostly community contacts. Hence, this
39 may have over-estimated the overall secondary attack rate by 0.3%. Contact tracing
40 was prioritised for household contacts due to restricted mobility and limited
41 interactions at the community level. Therefore, secondary attack among non-
42 household contacts may not reflect the real transmission potential. Information
43 regarding symptoms was retrieved from district surveillance records. The symptom
44 status was collected at the time of diagnosis. We could not verify if the primary case
45 developed symptoms later in the course of illness. Hence, there was a chance of
46 misclassification of symptom status.
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54 We conclude that COVID-19 transmission was higher among household contacts,
55 contacts of symptomatic primary case, and contacts of primary cases exposed to the
56 congregation. Based on the findings, we informed the testing policy and contact
57 tracing strategy in the early stages of the COVID-19 epidemic in Tamil Nadu. We
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3 recommend testing all household contacts irrespective of the symptoms and
4 extensive contact tracing and testing in case of super spreader events. In resource-
5 constrained settings, all contacts of symptomatic primary cases should be prioritised
6 for testing. The gatherings should be restricted to prevent significant clusters.
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12 **Author Contributions:** KK, RMK, MP, and PK designed the study, supervised
13 fieldwork, did primary data collection, planned data analysis and wrote the first draft
14 of the manuscript. VV, PRK, MS, PS, PG and MSK did primary data collection and
15 did data analysis. SM, VV, IS, and KI supervised fieldwork and data management.
16 JM, RG, SS, SR, SKST, VM, MT, JK, VG, and SK supervised fieldwork and
17 supported data collection. PV, YN, SP, STS, MR, BR and MM conceptualised the
18 study and gave critical comments in finalising the manuscript. All authors approved
19 the final manuscript
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33 **Award/Grant number:** Not applicable
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35 **Competing interests:** None declared
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38 **Patient consent for publication:** Not required
39

40 **Ethics approval:** Institutional Ethics Committee of ICMR-National Institute of
41 Epidemiology, Chennai, approved the study. Written consent was not required for
42 this study
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45 **Provenance and peer review:** Not commissioned; externally peer-reviewed.
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48 **Data availability statement:** Data are available upon reasonable request
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50 **Trial registration:** Not applicable
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Figure 1: Map of Tamil Nadu included in the epidemiological study of COVID-19

For peer review only

Table 1: Frequency of contacts traced per COVID-19 primary case by district, Tamil Nadu, India, March-May, 2020

District	Days since reporting of the first case in the district	# Primary Cases	Frequency of contacts				No. of contacts tested	No of contacts tested positive	SAR
			# Contacts identified	Household contacts	Community Contacts	Median (Range) contacts per Primary case			
Chennai	51	530	9731	1795	7936	18 (1 to 151)	9724	261	3 (2.4-3.0)
Coimbatore	33	151	3257	570	2687	22 (1 to 274)	1585	151	10(8.2-11.1)
Erode	46	56	1032	246	786	18 (3 to 141)	1032	38	4 (2.7-5.0)
Karur	15	42	416	271	145	10 (1 to 86)	416	18	4(2.8-6.7)
Ranipet	25	29	273	153	120	9 (1 to 68)	273	11	4(2.3-7.1)
Tirunelveli	23	35	166	157	9	5 (1 to 21)	145	20	14(9.1-20.0)
Tirupathur	20	12	312	61	251	26 (1 to 100)	312	5	2(0.7-3.7)
Tiruppur	24	66	279	241	38	5 (1 to 10)	279	80	29(23.7-34.0)
Vellore	23	10	236	51	185	24 (6 to 79)	236	15	6(3.9-10.0)
Overall		931	15,702	3545	12157	17(5 to 26)	14002	599	4(4.0-4.6)

Table 2: Secondary Attack Rate (%) by selected characteristics among the contacts traced per COVID-19 primary case, Tamil Nadu, India, March- May 2020

Selected characteristics	Number of contacts (%)	# COVID-19 Positive	Secondary attack rate % (95% CI)
Overall	14002(100%)	599	4 (4.0-4.6)
Age in Years (N=13,379)	≤20	3203 (24%)	4 (3.7-5.1)
	21-40	5511 (41%)	4(3.8-4.9)
	41-59	3364 (25%)	5(4.0-5.4)
	60+	1301 (10%)	5 (4.0-6.4)
Gender (N=13,969)	Male	7443 (53%)	4 (3.4-4.2)
	Female	6526 (47%)	5 (4.4-5.4)
Congregation exposure of primary case (N=14,002)	Yes	3884 (28%)	10 (8.8-10.7)
	No	10,118 (72%)	2 (1.9-2.5)
Contact type (N=14,002)	Household	3474 (25%)	13 (12.3-14.5)
	Community	10,417 (74%)	1 (1.0 – 1.5)
	Healthcare personnel	111 (1%)	0
Symptom status of Primary case (N=13338)	Symptomatic	607(5%)	6 (4.5-8.3)
	Asymptomatic	12,731(95%)	4 (3.3-4.0)

Table 3: Secondary Attack Rate among household and non-household contacts of COVID-19 individuals by type of exposure and symptom status of primary cases, Tamil Nadu, March-May, 2020 (N=14002)

Type of exposure or symptom status of the primary case	The secondary attack rate (%) (95% CI) (# cases / # contacts of the case)		
	Household	Community contacts	Overall
N = 14,002	21 (19.0 – 22.9)	1 (0.6-1.5)	10 (8.8-10.7)
Congregation	(352/1686)	(25/2198)	(377/3884)
No congregation	6 (5.2-7.5)	1 (1.0-1.6)	2 (1.9-2.5)
	(112/1788)	(110/8330)	(222/10118)
N= 13,338	25 (17.6-34.1)	2 (1.2-3.9)	6 (4.5-8.3)
Symptomatic	(26/104)	(11/503)	(37/607)
Asymptomatic	12 (10.5-12.9)	1 (1.0-1.5)	4 (3.3-4)
	(341/2930)	(123/9801)	(464/12731)

Table 4: Factors associated with COVID-19 among the contacts of Tamil Nadu, India March – May 2020

Risk factors	Crude RR (95% CI)	RR with age-adjusted (95% CI)	RR with age and sex- adjusted (95% CI)
Community contacts of non-congregation Primary cases	Ref	Ref	Ref
Community contact of Congregation Primary cases	1.0 (0.7-1.5)	0.9 (0.6-1.4)	0.9 (0.6-1.4)
Household contacts of non-congregation Primary cases	4.9 (3.8-6.4)	4.7 (3.7 – 6.2)	4.7 (36.4-6.1)
Household contacts of Congregation Primary cases	16.4 (13.3–20.2)	16.2 (13.1-20.0)	16.1 (13.0-20.0)

Table 5: Factors associated with COVID-19 among the contacts stratified by the symptomatic status of the primary cases of Tamil Nadu, India March – May 2020

Symptomatic Primary	Type of contacts	Crude RR (95% CI)	Adjusted RR with Age and Sex (95% CI)
Yes	Community contacts of non-congregation Primary cases		Ref
	Community contact of Congregation Primary cases	10.5 (6.0-33.0)	8.6 (2.6 – 29.1)
	Household contacts of non-congregation Primary cases	15.5 (6.0-39.8)	14.6 (5.7 – 37.7)
	Household contacts of Congregation Primary cases	26.7 (10.8-65.9)	25.3 (10.2 – 63.0)
No	Community contacts of non-congregation Primary cases		Ref
	Community contact of Congregation Primary cases	0.9 (0.6-1.4)	0.9 (0.5 – 1.3)
	Household contacts of non-congregation Primary cases	4.6 (3.5-6.0)	4.4 (3.4 – 5.8)
	Household contacts of Congregation Primary cases	16.48 (13.17-20.63)	16.52 (13.16 – 20.74)

Reference:

¹ World Health Organization. Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). [https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov)) (2020).

² WHO; Coronavirus disease (COVID-19): Contact tracing 2020 [Available from: <https://www.who.int/news-room/q-a-detail/coronavirus-disease-covid-19-contact-tracing>.

³ Halloran ME. Secondary Attack Rate. In: Peter A, Theodore C, editors. Encyclopedia of Biostatistics. New York: John Wiley & Sons Ltd; 2005

⁴ Li W, Zhang B, Lu J, Liu S, Chang Z, Cao P, et al. The characteristics of household transmission of COVID-19. *Clinical Infectious Diseases*. 2020.

⁵ Liu Y, Eggo RM, Kucharski AJ. Secondary attack rate and superspreading events for SARS-CoV-2. *The Lancet*. 2020 Mar 14;395(10227):e47

⁶ Luo L, Liu D, Liao X, Wu X, Jing Q, Zheng J, Liu F, Yang S, Bi H, Li Z, Liu J. Contact settings and risk for transmission in 3410 close contacts of patients with COVID-19 in Guangzhou, China: a prospective cohort study. *Annals of internal medicine*. 2020 Aug 13

⁷ Yang J, Zheng Y, Gou X, Pu K, Chen Z, Guo Q, et al. Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis. *International Journal of Infectious Diseases*. 2020; 94:91-5

⁸ Cheng HY, Jian SW, Liu DP, Ng TC, Huang WT, Lin HH. High transmissibility of COVID-19 near symptom onset. *medRxiv*. 2020 Jan 1

⁹ Wilder-Smith A, Chiew CJ, Lee VJ. Can we contain the COVID-19 outbreak with the same measures as for SARS?. *The Lancet Infectious Diseases*. 2020 Mar 5

¹⁰ Jahan N, Rubeshkumar P, Karuppiyah M, Sambath I, Sendhilkumar M, Ilangovan K, et al. Entry and initial spread of COVID-19 in India: Epidemiological analysis of media surveillance data, India, 2020. *Clinical Epidemiology and Global Health*. 2020.

¹¹ MediaBulletin180320COVID19.pdf [Internet]. [cited 2020 May 31]. Available from: <https://stopcorona.tn.gov.in/wp-content/uploads/files/MediaBulletin180320COVID19.pdf>

¹² Ali, A. (2020, April 1). Coronavirus was a test of secular nationalism. Then Tablighi Jamaat became the scapegoat. *The Print*. <https://theprint.in/opinion/coronavirus-test-of-secular-nationalism-tablighi-jamaat-became-scapegoat/392764/>

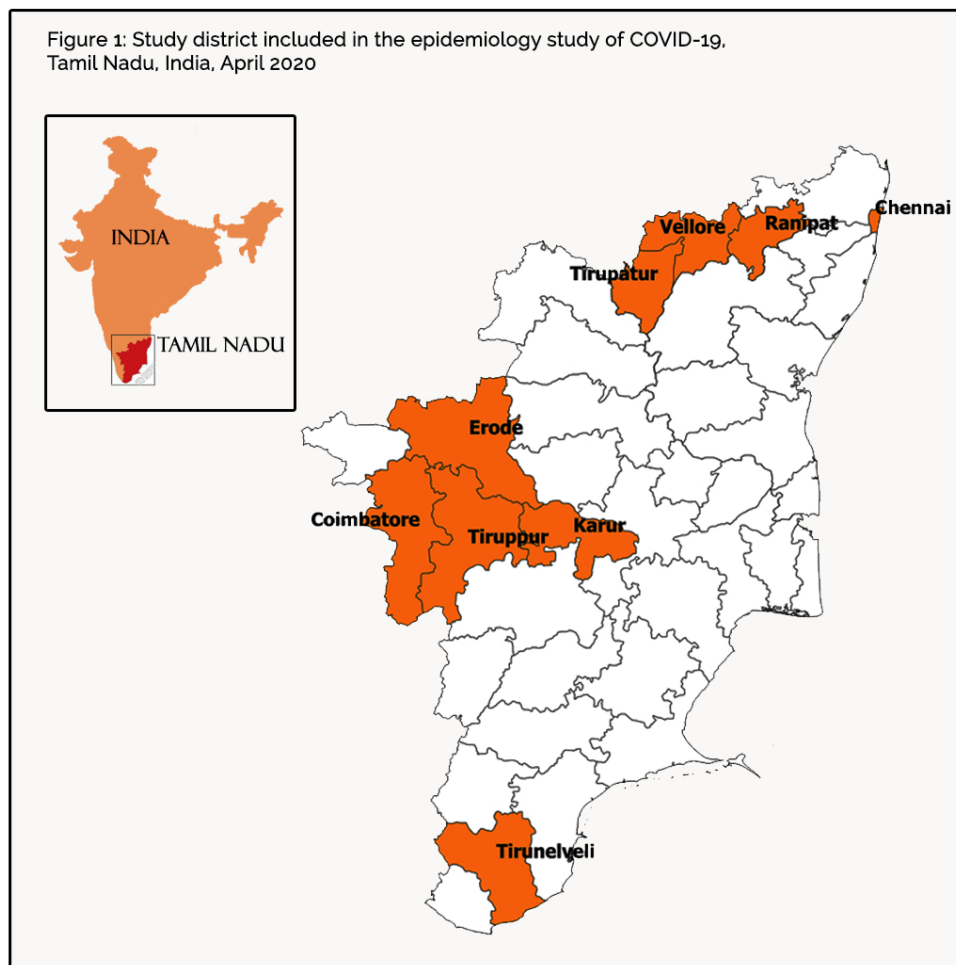
¹³ Gathering at Nizamuddin a highly irresponsible act, says Kejriwal. (2020, March 31). *The Hindu*. <https://www.thehindu.com/news/cities/Delhi/gathering-at-nizamuddin-a-highly-irresponsible-act-says-kejriwal/article31221982.ece>

¹⁴ Chandna, H. (2020, April 18). 30% of India's Covid-19 positive caseload linked to Tablighi Jamaat meet, says govt. *The Print*. <https://theprint.in/health/30-of-indias-covid-19-positive-caseload-linked-to-tablighi-jamaat-meet-says-govt/404426/>

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- ¹⁵ Of 14,378 total Covid-19 cases in India, 4,291 linked to Delhi's Markaz event: Health ministry. (2020, April 18). *India Today*. <https://www.indiatoday.in/india/story/coronavirus-india-total-cases-linked-tablighi-jamaat-markaz-nizamuddin-event-health-ministry-1668456-2020-04-18>
- ¹⁶ NDTV. 1,023 COVID-19 Cases Linked To Mosque Event, Tamil Nadu Leads: 10 Points: NDTV; [Available from: <https://www.ndtv.com/india-news/coronavirus-tablighi-jamaat-1-023-of-2-902-covid-19-cases-linked-to-mosque-event-tamil-nadu-leads-2206193>
- ¹⁷ National Centre for Disease Control Directorate General of Health Services MoH&FW, GOI, New Delhi The updated case definitions and contact-categorisation [internet]. [cited 2020 Jun 2]. Available from https://nirth.res.in/virology/Revised_case_definitions_for_COVID_19.pdf
- ¹⁸ Guidelines for investigating clusters of health events. *MMWR Recomm Rep*. 1990 Jul 27;39(RR-11):1-23. PMID: 2117247. .
- ¹⁹ Koh WC, Naing L, Chaw L, Rosledzana MA, Alikhan MF, et al. (2020) What do we know about SARS-CoV-2 transmission? A systematic review and meta-analysis of the secondary attack rate and associated risk factors. *PLOS ONE* 15(10): e0240205. <https://doi.org/10.1371/journal.pone.0240205>
- ²⁰ Madewell ZJ, Yang Y, Longini IM Jr, Halloran ME, Dean NE. Household Transmission of SARS-CoV-2: A Systematic Review and Meta-analysis. *JAMA Netw Open*. 2020 Dec 1;3(12):e2031756. doi: 10.1001/jamanetworkopen.2020.31756. PMID: 33315116; PMCID: PMC7737089.
- ²¹ Lei H, Xu X, Xiao S, Wu X, Shu Y. Household transmission of COVID-19-a systematic review and meta-analysis. *J Infect*. 2020;81(6):979-997. doi:10.1016/j.jinf.2020.08.033
- ²² Keeling MJ, Hollingsworth TD, Read JM. The Efficacy of Contact Tracing for the Containment of the 2019 Novel Coronavirus (COVID-19). *medRxiv*. 2020.
- ²³ COVID-19 National Emergency Response Center Epidemiology and case management team, Korea Centers for disease Control and prevention. Coronavirus disease-19: summary of 2,370 contact investigations of the first 30 cases in the Republic of Korea. *Public Health Res Perspect*. 2020;11(2):81–84. doi: 10.24171/j.phrp.2020.11.2.04
- ²⁴ Wei L, Lv Q, Wen Y, Feng S, Gao W, Chen Z, Cao B, Wu X, Lu Y, Zhao J, Zou X. Household transmission of COVID-19, Shenzhen, January-February 2020. *medRxiv*. 2020 Jan 1
- ²⁵ Park SY, Kim YM, Yi S, Lee S, Na BJ, Kim CB, Kim JI, Kim HS, Kim YB, Park Y, Huh IS. Coronavirus disease outbreak in call center, South Korea. *Emerging infectious diseases*. 2020 Aug;26(8):1666.
- ²⁶ Chaw, L., Koh, W., Jamaludin, S., Naing, L., Alikhan, M., & Wong, J. (2020). Analysis of SARS-CoV-2 Transmission in Different Settings, Brunei. *Emerging Infectious Diseases*, 26(11), 2598-2606. <https://dx.doi.org/10.3201/eid2611.202263>
- ²⁷ Koh WC, Naing L, Chaw L, Rosledzana MA, Alikhan MF, et al. (2020) What do we know about SARS-CoV-2 transmission? A systematic review and meta-analysis of the secondary attack rate and associated risk factors. *PLOS ONE* 15(10): e0240205. <https://doi.org/10.1371/journal.pone.0240205>

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3
4 28 MOHFW. Revised guidelines for Home Isolation of very mild/pre-
5 symptomatic/asymptomatic COVID-19 cases. MOHFW 2020 July 2 [Available from
6 [RevisedHomelsolationGuidelines.pdf \(mohfw.gov.in\)](#)
7
8 29 Quadri SA. COVID-19 and religious congregations: Implications for spread of novel
9 pathogens. *International Journal of Infectious Diseases*. 2020 Jul 1;96:219-21.
10
11 30 Choi JY. COVID-19 in South Korea. *Postgraduate Medical Journal*. 2020;96(1137):399-
12 402.
13
14 31 Yusef D, Hayajneh W, Awad S, Momany S, Khassawneh B, Samrah S, Obeidat B, Raffee
15 L, Al-Faouri I, Issa AB, Al Zamel H. Large outbreak of coronavirus disease among wedding
16 attendees, Jordan. *Emerging infectious diseases*. 2020 Sep;26(9):2165.
17
18 32 Shim E, Tariq A, Choi W, Lee Y, Chowell G. Transmission potential and severity of
19 COVID-19 in South Korea. *International Journal of Infectious Diseases*. 2020;93:339-44.
20
21 33 Hamner L, Dubbel P, Capron I, Ross A, Jordan A, Lee J, et al. High SARS-CoV-2 Attack
22 Rate Following Exposure at a Choir Practice - Skagit County, Washington, March 2020.
23 *MMWR Morbidity and mortality weekly report*. 2020;69(19):606-10
24
25 34 The Times of India; Avoid mass gatherings, says govt as corona cases hit 31: [Available
26 from:
27 [http://timesofindia.indiatimes.com/articleshow/74520610.cms?utm_source=contentofinterest](http://timesofindia.indiatimes.com/articleshow/74520610.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst)
28 [&utm_medium=text&utm_campaign=cppst](http://timesofindia.indiatimes.com/articleshow/74520610.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst)
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Figure 1: Study district included in the epidemiology study of COVID-19,
Tamil Nadu, India, April 2020



Map of Tamil Nadu included in the epidemiological study of COVID-19. There are nine of the 38 districts included in the study.

90x90mm (300 x 300 DPI)

Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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	Reporting Item	Page Number
Title and abstract		
Title	#1a Indicate the study's design with a commonly used term in the title or the abstract	1

1	Abstract	#1b	Provide in the abstract an informative and balanced	2
2			summary of what was done and what was found	
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6	Introduction			
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10	Background /	#2	Explain the scientific background and rationale for the	3
11	rationale		investigation being reported	
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15	Objectives	#3	State specific objectives, including any prespecified	4
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20	Methods			
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23	Study design	#4	Present key elements of study design early in the paper	4
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26	Setting	#5	Describe the setting, locations, and relevant dates,	4
27			including periods of recruitment, exposure, follow-up, and	
28			data collection	
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34	Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of	5
35			selection of participants. Describe methods of follow-up.	
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45	Variables	#7	Clearly define all outcomes, exposures, predictors,	5
46			potential confounders, and effect modifiers. Give	
47			diagnostic criteria, if applicable	
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53	Data sources /	#8	For each variable of interest give sources of data and	5
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more than one group. Give information separately for for
exposed and unexposed groups if applicable.

Bias	#9	Describe any efforts to address potential sources of bias	n/a
Study size	#10	Explain how the study size was arrived at	4
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	5
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	5
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	n/a
Statistical methods	#12c	Explain how missing data were addressed	n/a
Statistical methods	#12d	If applicable, explain how loss to follow-up was addressed	n/a
Statistical methods	#12e	Describe any sensitivity analyses	n/a
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-	5

up, and analysed. Give information separately for for
exposed and unexposed groups if applicable.

Participants	#13b	Give reasons for non-participation at each stage	n/a
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	5
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	5
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	6
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6
Main results	#16b	Report category boundaries when continuous variables were categorized	n/a
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a

1	Other analyses	#17	Report other analyses done—eg analyses of subgroups	6
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6	Discussion			
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10	Key results	#18	Summarise key results with reference to study objectives	7
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13	Limitations	#19	Discuss limitations of the study, taking into account	8
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17			direction and magnitude of any potential bias.	
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20	Interpretation	#20	Give a cautious overall interpretation considering	8
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24			similar studies, and other relevant evidence.	
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28	Generalisability	#21	Discuss the generalisability (external validity) of the study	n/a
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33	Other Information			
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36	Funding	#22	Give the source of funding and the role of the funders for	10
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38			the present study and, if applicable, for the original study	
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40			on which the present article is based	
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BMJ Open

Secondary attack rate of COVID-19 among contacts and risk factors, Tamil Nadu, March-May 2020: A retrospective Cohort Study

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3 1 **Secondary attack rate of COVID-19 among contacts and risk factors, Tamil**
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41 23 **Word count:** 4389

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43 24 **Keywords:** Secondary Attack Rate, COVID-19, Contact investigation, Disease
44 25 transmission, Cluster
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3 27 **Abstract:**
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5 28 Objective: To describe the characteristics of contacts of COVID-19 case-patients in
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7 29 terms of time, place, and person, to calculate the secondary attack rate and factors
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9 30 associated with COVID-19 infection among contacts

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11 31 Design: Retrospective cohort study
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13 32 Setting and participants: Contacts of cases identified by the health department from
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15 33 March 14 to May 30, 2020, in nine of 38 administrative districts of Tamil Nadu.

16 34 Significant proportion of cases attended a religious congregation.
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19 35 Outcome measure: Attack rate among the contacts and factors associated with
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21 36 COVID-19 positivity.
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23 37 Results: We listed 15,702 contacts of 931 primary cases. Of the contacts, 89%
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25 38 (n=14002) were tested for COVID-19. The overall SAR was 4% (599/14002), with
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27 39 higher among the household contacts (13%) than the community contacts (1%).
28
29 40 SAR among the contacts of primary cases with congregation exposure were five
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31 41 times higher than the contacts of non-congregation primary cases (10% Vs 2%).
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33 42 Being a household contact of a primary case with congregation exposure had a four-
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35 43 fold increased risk of getting COVID-19 (RR=16.4; 95%CI:13-20) than contact of
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37 44 primary case without congregation exposure. Among the symptomatic primary
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39 45 cases, household contacts of congregation primaries had higher RR than household
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41 46 contacts of other cases [(RR=25.3; 95%CI:10.2-63) Vs (RR=14.6; 95%CI:5.7-37.7)].
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43 47 Among asymptomatic primary case, RR was increased among household contacts
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45 48 (RR=16.5; 95%CI:13.2–20.7) of congregation primaries compared to others

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47 49 Conclusion: Our study showed an increase in disease transmission among
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49 50 household contacts than community contacts. Also, symptomatic primary cases and
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51 51 primary cases with exposure to the congregation had more secondary cases than
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52 others.

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3 53 **Strengths and Limitations:**
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5 54 • **Strengths**

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8 55 ○ We documented the secondary attack rate of COVID-19 in a large
9 56 cohort of more than 15,000 contacts in India
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11 57 ○ All the contacts were tested with RT-PCR; therefore, the estimates of
12 58 secondary attack rate were reliable.
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14 59 ○ The state updated the testing policy in the early phase of this pandemic
15 60 based on the findings from this study.

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19 61 • **Limitations:**

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22 62 ○ We did not have confirmation of the COVID-19 status of 11% of the
23 63 contacts
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25 64 ○ Contact tracing was prioritised for household contacts during lockdown
26 65 as the community interactions were limited
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66 **Background**

67 The novel coronavirus outbreak due to Severe Acute Respiratory Syndrome
68 Coronavirus 2 (SARS-CoV-2) infection reported from China in December 2019 was
69 declared a Public Health Emergency of International Concern (PHEIC) by WHO on
70 January 30, 2020¹. At the early stages of COVID-19, international travel was the
71 most common exposure. Subsequently, clusters emerged in various settings,
72 including community gatherings, hospital settings, and commercial gatherings.
73 Investigating such clusters provided clues for disease transmission and guided
74 intervention strategies for pandemic response². Contact tracing is one of the key
75 strategies to interrupt the chain of transmission of SARS-CoV-2. The aim of the
76 contact tracing strategy is to reduce secondary cases of COVID-19. In this context,
77 the secondary attack rate of SARS-CoV-2 denotes the probability that infection
78 occurs among susceptible contacts within a reasonable incubation period following
79 contact with the infectious person(s) or that of the source³ and represents
80 infectiousness of the agent. The secondary attack rate among contacts thus is a
81 useful indicator to track the viral transmission potential⁴ and thereby guides control
82 strategies. The secondary attack rate of SARS-CoV-2 differs from the nature of the
83 setting and that of the symptomatic status of the primary cases.^{5 6 7 8} Understanding
84 the dynamics of transmission of COVID-19 for specific settings will help in preventing
85 the spread of the infection⁹.

86 India reported the first laboratory-confirmed case on January 30, 2020, from a
87 Southern state Kerala. In early March, most reported cases had a history of
88 international travel or contact with the traveller¹⁰. Tamil Nadu, the southern State of
89 India, reported the first case of COVID-19 on March 18 2020¹¹. At the initial stages,
90 COVID-19 cases were reported among international travellers and subsequently
91 among travellers from other states. On March 13, the media reported a cluster of
92 cases linked to a religious congregation in New Delhi.^{12 13} According to the reports,
93 the event started on February 9, 2020, with more than 4000 participants from various
94 Indian states and abroad gathered in groups to attend the meeting.¹⁴ As the
95 participants returned to their respective states, clusters emerged in several states.¹⁵
96 People from Tamil Nadu also participated in the meeting, predominantly during 21-
97 23 March, 2020¹⁶. After returning from the event, attendees travelled to many parts

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3 98 of the State. Public health authorities initiated a massive search for potential cases
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5 99 and their contact in various districts.
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7 100 From February 2020, the health department of Tamil Nadu state practised testing
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9 101 and quarantine of international travellers and enhanced the voluntary testing of
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11 102 symptomatic individuals with h/o travel or h/o contact with a traveller. When the
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13 103 congregation cluster was reported, all the persons who attended the congregation
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15 104 were traced, quarantined and tested. The persons tested for COVID-19 were
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17 105 isolated and treated. The persons who tested negative were quarantined for 14 days.
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19 106 Also, the COVID-19 test was repeated after 5th day of the first testing. The household
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21 107 members of the attendees were immediately tested for COVID-19, if any person is
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23 108 tested positive.

24 109 After the information of COVID outbreak in the Delhi congregation setting, Govt of
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26 110 Tamil Nadu collected the line list of participants from the appropriate authority
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28 111 involved in the outbreak control in the congregation. The district collected additional
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30 112 information from the local leaders.

31 113 At the time this investigation was undertaken, there was no wide spread community
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33 114 transmission. Most of the infection were among travelers and health care workers,
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35 115 and they did not mingle with the community due to restrictions. Unlike international
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37 116 travelers, congregation participants travelled with other local travelers and after
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39 117 attending the congregation, all resumed social and work-related activities after
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41 118 arrival. Therefore, they are more likely to transmit to the community.

42 119 Due to the novelty of the pandemic, the transmission dynamics of the diseases were
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44 120 not fully understood. In the early phase, knowledge on the spread of the disease in
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46 121 various settings and in different geographical was not known. Also, the contribution
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48 122 of the congregation cluster in driving the pandemic is not known. Knowing this
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50 123 information was crucial in preventing the disease's spread from the primary case to
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52 124 the contacts. In this context, we conducted a study to estimate the secondary attack
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54 125 rate in terms of time, place, and person and determined risk factors for COVID-19
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56 126 infection among contacts during March-May 2020 in Tamil Nadu, India.

57 127 **Methods:**

58 128 **Study design**

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3 129 We conducted a retrospective cohort study of all contacts of COVID-19 cases
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5 130 between March 14 to May 30, 2020, of Tamil Nadu, Southern India.
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7 131 **Study setting and the COVID-19 context:**
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9 132 We studied nine of 38 administrative districts reporting maximum cases during the
10 133 study period (Figure 1). These nine districts reported higher number of cases during
11 134 the study period. The study districts varied in a population density ranging from
12 135 28,553 persons per square Kilometre in the State capital city of Chennai to 367 in
13 136 Erode district, located southwest of Chennai. The average family size was similar
14 137 (3.5 to 4.3 persons per family) across these study districts.
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20 138 The COVID-19 response strategies implemented by the State included surveillance
21 139 for case identification, confirmation with Reverse Transcriptase-Polymerase Chain
22 140 Reaction (RT-PCR) test for COVID-19, contact tracing, isolation, and quarantine, in
23 141 addition to community-based interventions. The confirmation with RT-PCR was done
24 142 by identifying two or more target genes (E / RdRp / ORF1ab / N / S) using multiplex
25 143 PCR kits The district officials hospitalised the COVID-19 patients, and quarantined
26 144 COVID-19 tested negatives at home or facility. By contact tracing, the officials
27 145 identified the household and the community contacts and tested them for COVID-19.
28 146 We included all COVID-19 confirmed cases in the study period from these districts.
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37 147 **Sampling and sample size**
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39 148 We listed all the identified confirmed COVID-19 cases in the study districts from
40 149 March 1 to May 30, 2020. We included all the contacts of the identified COVID-19
41 150 positive individuals.
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46 151 **Operational definitions:**
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48 152 Primary case: Any individual with a laboratory-confirmed COVID-19 case with no
49 153 reported history of contact with COVID-19 case
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52 154 Symptomatic Cases: Any individual with H/O Fever, cough, Sore throat or
53 155 breathlessness from 5 days before the date of testing Confirmed Case: Any individual
54 156 who is tested positive for COVID-19 using RT-PCR
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59 157 Contact: Any individual comes in proximity with COVID-19 positive individuals¹⁷.
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158 High risk contacts is defined as any person who was in proximity with COVID-19

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3 159 positive individual within 2 metres of proximity for 15 minutes. Low risk contact is
4 defined as any person who was in proximity with COVID-19 positive individual and
5 160 sharing same environment but not having high exposure.
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9 162 Household contact: Any individual living in the same household and comes in
10 proximity with the COVID-19 confirmed individual
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13 164 Community contact: Any individual other than living in the same household and
14 comes in proximity with the COVID-19 confirmed individual
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17 166 Cluster: An unusual aggregation of two or more COVID-19 cases grouped in time
18 and space and reported to a health agency¹⁸
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20 168 Congregation exposure: Individual who have attended the religious congregation
21 event held during February and March 2020 (News paper reference)
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24 170 Secondary attack rate: The secondary attack rate is the proportion of COVID-19
25 positive individuals among the tested contacts.
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31 172 ***Data collection and analysis:***

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33 173 We collected data from district surveillance records and classified the contacts as
34 household and community contacts. We abstracted the information on
35 174 sociodemographic characteristics, residence location, symptom status and
36 175 congregation exposure of the primary case from the district surveillance records.
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39 177 The analysis is based on the information from nine identified districts. We described
40 the total number of contacts and the median number of contacts per case by the
41 178 district. We calculated the overall secondary attack rate (SAR) for COVID-19 and by
42 179 age, gender, symptom status and congregation exposure of the primary case. We
43 180 estimated the SAR by symptom status and congregation exposure of the primary
44 181 case in two subgroups, namely household and community contacts. We determined
45 182 the risk factors associated with COVID-19 infection among contacts based on the
46 183 household vs community exposure, congregation vs non-congregation exposure of
47 184 primary case and symptom status of the primary case. We estimated the unadjusted
48 185 and age/sex-adjusted relative risk (RR) and 95% confidence intervals (CI) for the
49 186 four categories of contacts. The community contacts of the non-congregation primary
50 187 case were the reference category. The other categories were community contacts of
51 188

189 congregation primary, household contacts of non-congregation and household
190 contacts of congregation primary cases. We also estimated the unadjusted and
191 age/sex-adjusted RR and 95% CI after stratifying the four categories by symptom
192 status of the primary case.

193 **Human participation protection:**

194 We obtained the approval of the Institutional Ethics Committee of the ICMR-National
195 Institute of Epidemiology. No primary information was collected from the participants.
196 We maintained complete confidentiality and anonymity of the participants during data
197 abstraction.

198 **Patient and Public Involvement in research:** Not involved in the conduct of
199 research

200 **Results:**

201 ***Description of the cases and contacts***

202 We identified 931 COVID-19 primary cases and 15,702 contacts during the study
203 period. The median number of contacts identified per COVID-19 case was 17 (IQR:
204 9, 18) in the selected nine districts. Around 11% (n=102) of the cases did not have
205 household contacts. The duration from the reporting of the first COVID-19 case to
206 the time of data abstraction ranged from 51 days for Chennai and 15 days for Karur
207 district. (Table 1). This is because the reporting of the first case varies across the
208 districts and the data collection was done in the same period across these districts
209 and hence the duration of the data collection period varies.

210 Of the identified 15,702 contacts, 14,002 (89%) contacts were tested for COVID-19.
211 Apart from household contacts, most community contacts (98%) were cab-drivers,
212 vegetable sellers, co-workers, or co-passengers in public transport. The majority of
213 the household contacts (99%) were tested. There is no difference between tested
214 and not-tested by age and gender (data not shown).

215 Information on age was available for 99.7% (13,969/14,002) of the contacts (Table
216 2). The contacts were predominantly aged 21-40 years (41%) and 41 to 59 years
217 (27%). Over half of the contacts were males (53%). About one-fourth (28%) of the
218 contacts were traced from primary cases with congregation exposure, and 25% of

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3 219 the contacts had household COVID-19 exposure. Healthcare providers contributed
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5 220 to less than 1% of the contacts identified for the primary cases.
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7 221 ***Secondary attack rate by selected characteristics***

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9 222 Among tested contacts (n=14002), 599 (4.3%) tested positive for COVID-19 based
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11 223 on RT PCR. The overall secondary attack rate was 4% (599 of 14,002). The
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13 224 secondary attack rate was similar across the age groups and gender, ranging from
14
15 225 4% to 5%. The secondary attack rate among the contacts of primary cases with
16
17 226 congregation exposure was five times higher (10%) than contacts of non-
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19 227 congregation primary cases (2%). Of the 599 contacts who tested positive, more
20
21 228 than three-fourths (78%) were household contacts.

22 229 The overall secondary attack rate was 4%, with 13% among the household contacts
23
24 230 compared to 1% among the community contacts. The secondary attack among
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26 231 household contacts of primary cases with exposure to congregation was higher
27
28 232 (21%) than the contacts of primary cases without congregation exposure (6%) (Table
29
30 233 3). The primary cases' symptomatic status was available for 95% (13,338) of the
31
32 234 tested contacts. The overall secondary attack among contacts of the primary cases
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34 235 with COVID -19 symptoms was 6% compared to 4% among the contacts of
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36 236 asymptomatic cases. The household contacts exposed to the symptomatic primary
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38 237 case had two times higher attack rate as compared to contacts of asymptomatic
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40 238 primary cases (25% vs 12%). Secondary attack among the community contacts was
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42 239 similar irrespective of the symptomatic status of the primary case.

43 240 ***Risk factors for secondary cases***

44 241 We estimated the risk of acquiring infection for contacts by type of contact and
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46 242 congregation participation of the primary cases. There was no significant risk among
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48 243 the community contacts of the primary cases irrespective of the participation in the
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50 244 congregation. The relative risk of household contacts of primary cases with
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52 245 congregation participation was four times higher (RR=16.4; 95% CI: 13.3 to 20.2) in
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54 246 getting COVID-19 compared to household contacts of other primary cases (RR=4.9;
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56 247 95% CI: 3.81 to 6.38). The association did not change even after adjusting for age
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58 248 and gender. (Table 4)

59 249 We estimated the RR stratified by the symptomatic status of the primary cases. In
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250 the strata where the primary case was symptomatic, there was an eight-fold increase

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3 251 in RR for household contacts of congregation participants when compared to the
4 252 household contacts of other cases [RR=25.3,95% CI: 10.2 to 63) vs RR= 14.6, 95%
5 253 CI: 5.7 to 37.7)]. If the primary case was asymptomatic, there was no increase in RR
6 254 for community contacts of congregation participants, but RR was increased among
7 255 household contacts of primary cases with congregation exposure. The change in RR
8 256 among household contacts of the symptomatic primary case was several folds
9 257 higher as compared to household contacts of the asymptomatic primary case (Table
10 258 5).

17 259 **Discussion:**

19 260 Our study showed an increase in disease transmission among household contacts
20 261 than community contacts. The transmission was further accentuated if the primary
21 262 case had symptoms or exposure to a congregation. The high risk of infection among
22 263 family members was consistent with the pooled analysis of 43 studies which
23 264 estimated an SAR of 18% among household contacts¹⁹. Other systematic reviews
24 265 demonstrated a secondary attack rate of 16.6%²⁰ and 27%²¹ compared to our study.
25 266 This may probably due to the timeline of our study in early part of the pandemic. We
26 267 also observed very low SAR (1%) among non-household contacts, possibly due to
27 268 the State's lockdown situation during the study period. Contact tracing is one of the
28 269 core public health strategies for COVID-19 control, and our study assessed if
29 270 districts implemented this strategy. Although the median number of contacts per
30 271 case was 17, there was a high variation between districts due to limiting the contact
31 272 tracing to only household contacts in several cases. A study in the UK measuring the
32 273 efficacy of contact tracing for COVID-19 suggested an average of 36 contacts must
33 274 be traced per case²². Another study in the Republic of Korea shows a range of 15-
34 275 649 contacts traced per case²³. Once the number of cases increases, extensive
35 276 contact tracing may not be feasible unless we deploy dedicated human resources
36 277 and train the contact tracers. There was limited capacity in the initial phase of the
37 278 epidemic; however, the public health department added human resources, especially
38 279 in the capital city of Chennai, to sustain the contact tracing as cases started
39 280 increasing.

40 281 Initially, testing was done among the individuals reported with symptoms. But due to
41 282 the clustering of cases among the congregation attendees, all the congregation
42 283 attendees were tested irrespective of symptom status, as there was lot of panic in

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3 284 the initial phase of the pandemic. It posed high risk of big outbreak. Similarly, all
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5 285 international travelers were tested irrespective of the symptom status. We observed
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7 286 a higher attack rate among household contacts (25%) of symptomatic primary cases
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9 287 when compared to asymptomatic. Our observations were similar to a pooled analysis
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11 288 of three studies from Wei et al.²⁴, Part et al.²⁵, Chaw et al.²⁶, which reported 20%
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13 289 SAR among household contacts of symptomatic primary cases²⁷. This observation
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15 290 guided the testing policy in the context of limited resources at the peak of the
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17 291 pandemic. We prioritised the testing of household contacts of symptomatic primary
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19 292 cases in the subsequent phases of pandemic at times of resource constraints.
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21 293 Although the attack rate was lower among contacts of asymptomatic primary, the
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23 294 transmission did take place especially in the household setting. Our findings support
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25 295 the rationale of isolation of all cases irrespective of the symptoms and testing of all
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27 296 household contacts to break the chain of transmission²⁸.

26 297 At the time when this investigation was undertaken, there was no widespread
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28 298 community transmission. Most of the infection were among international travellers
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30 299 and health care workers, and they were separated from the community, due to
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32 300 isolation and quarantine protocols. Unlike international travellers, congregation
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34 301 participants travelled with local people. After attending the congregation, all resumed
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36 302 their routine work and social activities after arrival. This posed threat to transmit to
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38 303 diseases in the community, as the congregation occurred before the lockdown.

36 304 The congregation clusters were one of the sources which led to COVID-19
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38 305 transmission in various communities²⁹. Similar to our setting, many countries
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40 306 experienced clusters emerging from congregation settings. In South Korea, an
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42 307 explosive outbreak happened following a social event held at a Church and is
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44 308 attributable to 84% of the total confirmed cases of South Korea reported till mid-
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46 309 March³⁰. Another study in Jordan among the wedding attendees reported a higher
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48 310 attack rate of 22%³¹. Similar clusters had been reported in different parts of South
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50 311 Korea³², and in the USA, a secondary attack of 53.3% was estimated among one
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52 312 such event attendees³³. In addition to the effect of disease spread within the cluster,
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54 313 the attendees returned from the congregation involved themselves in the routine
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56 314 duties and social activities, which led to further spread of the disease in the
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58 315 community. Avoiding any type of gathering is one of the essential mitigation
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60 316 measures to be followed strictly. Government actions to ban mass gatherings are
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318 317 essential, as are good diagnostic facilities and remotely accesses health advice,
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319 318 together with specialised treatment for people with severe disease³⁴.

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3 319 Our study has several limitations. We did not have confirmation of the COVID-19
4 320 status of 11% of the contacts, who were mostly community contacts. Hence, this
5 321 may have over-estimated the overall secondary attack rate by 0.3%. Contact tracing
6 322 was prioritised for household contacts due to restricted mobility and limited
7 323 interactions at the community level. Therefore, secondary attack among non-
8 324 household contacts may not reflect the real transmission potential. Information
9 325 regarding symptoms was retrieved from district surveillance records. The symptom
10 326 status was collected at the time of diagnosis. We could not verify if the primary case
11 327 developed symptoms later in the course of illness. Hence, there was a chance of
12 328 misclassification of symptom status. We abstracted the information from the records
13 329 of the district surveillance units. The information on the date of exposure and the
14 330 date of sample taken are not available for all the contacts. Hence we could not
15 331 calculate the time taken for the contacts to be tested from the date of contact.

16 332 We conclude that COVID-19 transmission was higher among household contacts,
17 333 contacts of symptomatic primary case, and contacts of primary cases exposed to the
18 334 congregation. Based on the findings, we informed the testing policy and contact
19 335 tracing strategy in the early stages of the COVID-19 epidemic in Tamil Nadu. We
20 336 recommend testing all household contacts irrespective of the symptoms and
21 337 extensive contact tracing and testing in case of super spreader events. In resource-
22 338 constrained settings, all contacts of symptomatic primary cases should be prioritised
23 339 for testing. The gatherings should be restricted to prevent significant clusters.

24 340

25 341 **Author Contributions:** KK, RMK, MP, and PK designed the study, supervised
26 342 fieldwork, did primary data collection, planned data analysis and wrote the first draft
27 343 of the manuscript. VV, PRK, MNS, PS, PG and MSK did primary data collection and
28 344 did data analysis. MS, VV, IS, and KI supervised fieldwork and data management.
29 345 JM, RG, SS, SR, SKST, VM, MT, JK, VG, and SK supervised fieldwork and
30 346 supported data collection. PV, YN, SP, STS, MR, BR and MM conceptualised the
31 347 study and gave critical comments in finalising the manuscript. All authors approved
32 348 the final manuscript

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7 353 **Competing interests:** None declared
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9 354 **Patient consent for publication:** Not required
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11 355 **Ethics approval:** Institutional Ethics Committee of ICMR-National Institute of
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14 356 Epidemiology, Chennai, approved the study. Written consent was not required for
15
16 357 this study

17 358 **Provenance and peer review:** Not commissioned; externally peer-reviewed.
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19 359 **Data availability statement:** Data are available upon reasonable request
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22 360 **Trial registration:** Not applicable
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3 361 **Figure 1:** Map of Tamil Nadu included in the epidemiological study of COVID-19
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Table 1: Frequency of contacts traced per COVID-19 primary case by district, Tamil Nadu, India, March-May, 2020

District	Days since reporting of the first case in the district	# Primary Cases	Frequency of contacts				No. of contacts tested	No of contacts tested positive	SAR
			# Contacts identified	Household contacts	Community Contacts	Median (Range) contacts per Primary case			
Chennai	51	530	9731	1795	7936	18 (1 to 151)	9724	261	3 (2.4-3.0)
Coimbatore	33	151	3257	570	2687	22 (1 to 274)	1585	151	10(8.2-11.1)
Erode	46	56	1032	246	786	18 (3 to 141)	1032	38	4 (2.7-5.0)
Karur	15	42	416	271	145	10 (1 to 86)	416	18	4(2.8-6.7)
Ranipet	25	29	273	153	120	9 (1 to 68)	273	11	4(2.3-7.1)
Tirunelveli	23	35	166	157	9	5 (1 to 21)	145	20	14(9.1-20.0)
Tirupathur	20	12	312	61	251	26 (1 to 100)	312	5	2(0.7-3.7)
Tiruppur	24	66	279	241	38	5 (1 to 10)	279	80	29(23.7-34.0)
Vellore	23	10	236	51	185	24 (6 to 79)	236	15	6(3.9-10.0)
Overall		931	15,702	3545	12157	17(5 to 26)	14002	599	4(4.0-4.6)

Table 2: Secondary Attack Rate (%) by selected characteristics among the contacts traced per COVID-19 primary case, Tamil Nadu, India, March- May 2020

Selected characteristics	Number of contacts (%)	# COVID-19 Positive	Secondary attack rate % (95% CI)
Overall	14002(100%)	599	4 (4.0-4.6)
Age in Years (N=13,379)	≤20	3203 (24%)	4 (3.7-5.1)
	21-40	5511 (41%)	4(3.8-4.9)
	41-59	3364 (25%)	5(4.0-5.4)
	60+	1301 (10%)	5 (4.0-6.4)
Gender (N=13,969)	Male	7443 (53%)	4 (3.4-4.2)
	Female	6526 (47%)	5 (4.4-5.4)
Congregation exposure of primary case (N=14,002)	Yes	3884 (28%)	10 (8.8-10.7)
	No	10,118 (72%)	2 (1.9-2.5)
Contact type (N=14,002)	Household	3474 (25%)	13 (12.3-14.5)
	Community	10,417 (74%)	1 (1.0 – 1.5)
	Healthcare personnel	111 (1%)	0
Symptom status of Primary case (N=13338)	Symptomatic	607(5%)	6 (4.5-8.3)
	Asymptomatic	12,731(95%)	4 (3.3-4.0)

Table 3: Secondary Attack Rate among household and non-household contacts of COVID-19 individuals by type of exposure and symptom status of primary cases, Tamil Nadu, March-May, 2020 (N=14002)

Type of exposure or symptom status of the primary case	The secondary attack rate (%) (95% CI) (# cases / # contacts of the case)		
	Household	Community contacts	Overall
N = 14,002	21 (19.0 – 22.9)	1 (0.6-1.5)	10 (8.8-10.7)
Congregation	(352/1686)	(25/2198)	(377/3884)
No congregation	6 (5.2-7.5)	1 (1.0-1.6)	2 (1.9-2.5)
	(112/1788)	(110/8330)	(222/10118)
N= 13,338	25 (17.6-34.1)	2 (1.2-3.9)	6 (4.5-8.3)
Symptomatic	(26/104)	(11/503)	(37/607)
Asymptomatic	12 (10.5-12.9)	1 (1.0-1.5)	4 (3.3-4)
	(341/2930)	(123/9801)	(464/12731)

Table 4: Factors associated with COVID-19 among the contacts of Tamil Nadu, India March – May 2020

Risk factors	Crude RR (95% CI)	RR with age-adjusted (95% CI)	RR with age and sex- adjusted (95% CI)
Community contacts of non-congregation Primary cases	Ref	Ref	Ref
Community contact of Congregation Primary cases	1.0 (0.7-1.5)	0.9 (0.6-1.4)	0.9 (0.6-1.4)
Household contacts of non-congregation Primary cases	4.9 (3.8-6.4)	4.7 (3.7 – 6.2)	4.7 (36.4-6.1)
Household contacts of Congregation Primary cases	16.4 (13.3–20.2)	16.2 (13.1-20.0)	16.1 (13.0-20.0)

Table 5: Factors associated with COVID-19 among the contacts stratified by the symptomatic status of the primary cases of Tamil Nadu, India March – May 2020

Symptomatic Primary	Type of contacts	Crude RR (95% CI)	Adjusted RR with Age and Sex (95% CI)
Yes	Community contacts of non-congregation Primary cases		Ref
	Community contact of Congregation Primary cases	10.5 (6.0-33.0)	8.6 (2.6 – 29.1)
	Household contacts of non-congregation Primary cases	15.5 (6.0-39.8)	14.6 (5.7 – 37.7)
	Household contacts of Congregation Primary cases	26.7 (10.8-65.9)	25.3 (10.2 – 63.0)
No	Community contacts of non-congregation Primary cases		Ref
	Community contact of Congregation Primary cases	0.9 (0.6-1.4)	0.9 (0.5 – 1.3)
	Household contacts of non-congregation Primary cases	4.6 (3.5-6.0)	4.4 (3.4 – 5.8)
	Household contacts of Congregation Primary cases	16.48 (13.17-20.63)	16.52 (13.16 – 20.74)

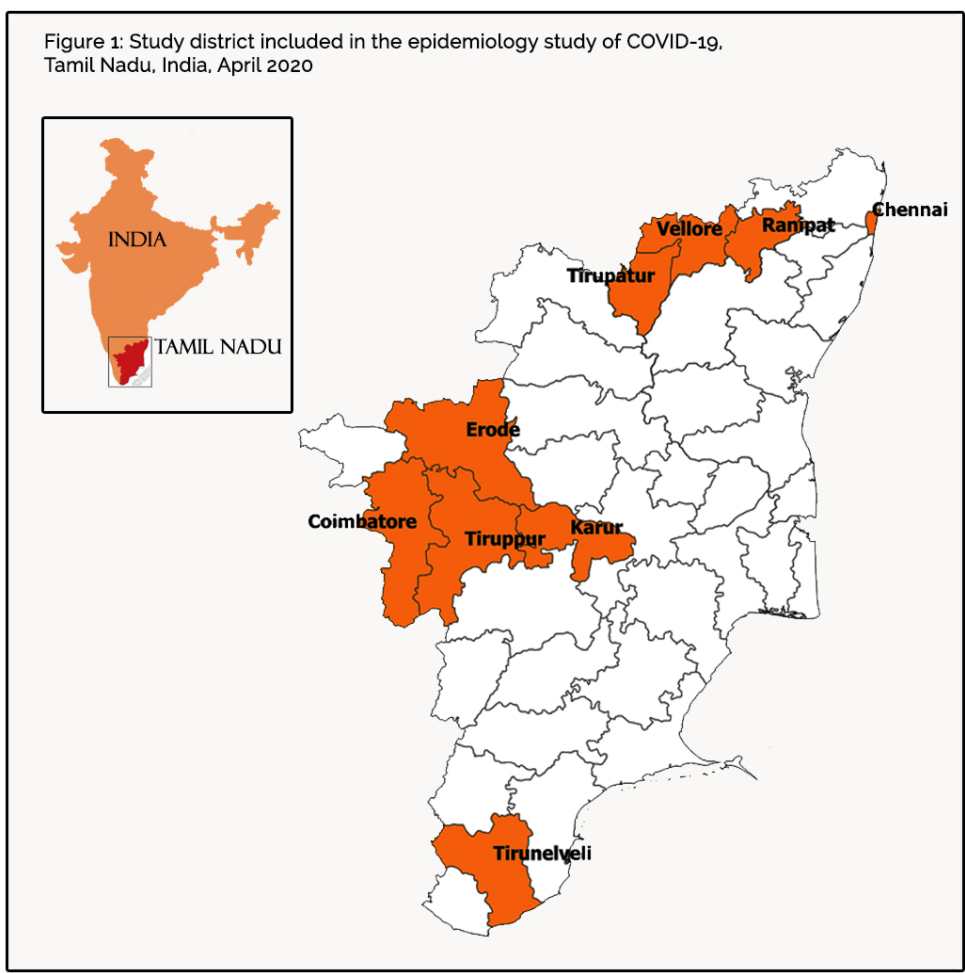
Reference:

-
- 1 World Health Organization. Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). [https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov)) (2020).
- 2 WHO; Coronavirus disease (COVID-19): Contact tracing 2020 [Available from: <https://www.who.int/news-room/q-a-detail/coronavirus-disease-covid-19-contact-tracing>.
- 3 Halloran ME. Secondary Attack Rate. In: Peter A, Theodore C, editors. Encyclopedia of Biostatistics. New York: John Wiley & Sons Ltd; 2005
- 4 Li W, Zhang B, Lu J, Liu S, Chang Z, Cao P, et al. The characteristics of household transmission of COVID-19. *Clinical Infectious Diseases*. 2020.
- 5 Liu Y, Eggo RM, Kucharski AJ. Secondary attack rate and superspreading events for SARS-CoV-2. *The Lancet*. 2020 Mar 14;395(10227):e47
- 6 Luo L, Liu D, Liao X, Wu X, Jing Q, Zheng J, Liu F, Yang S, Bi H, Li Z, Liu J. Contact settings and risk for transmission in 3410 close contacts of patients with COVID-19 in Guangzhou, China: a prospective cohort study. *Annals of internal medicine*. 2020 Aug 13
- 7 Yang J, Zheng Y, Gou X, Pu K, Chen Z, Guo Q, et al. Prevalence of comorbidities and its effects in patients infected with SARS-CoV-2: a systematic review and meta-analysis. *International Journal of Infectious Diseases*. 2020; 94:91-5
- 8 Cheng HY, Jian SW, Liu DP, Ng TC, Huang WT, Lin HH. High transmissibility of COVID-19 near symptom onset. *medRxiv*. 2020 Jan 1
- 9 Wilder-Smith A, Chiew CJ, Lee VJ. Can we contain the COVID-19 outbreak with the same measures as for SARS?. *The Lancet Infectious Diseases*. 2020 Mar 5
- 10 Jahan N, Rubeshkumar P, Karuppiyah M, Sambath I, Sendhilkumar M, Ilangovan K, et al. Entry and initial spread of COVID-19 in India: Epidemiological analysis of media surveillance data, India, 2020. *Clinical Epidemiology and Global Health*. 2020.
- 11 MediaBulletin180320COVID19.pdf [Internet]. [cited 2020 May 31]. Available from: <https://stopcorona.tn.gov.in/wp-content/uploads/files/MediaBulletin180320COVID19.pdf>
- 12 Ali, A. (2020, April 1). Coronavirus was a test of secular nationalism. Then Tablighi Jamaat became the scapegoat. *The Print*. <https://theprint.in/opinion/coronavirus-test-of-secular-nationalism-tablighi-jamaat-became-scapegoat/392764/>
- 13 Gathering at Nizamuddin a highly irresponsible act, says Kejriwal. (2020, March 31). *The Hindu*. <https://www.thehindu.com/news/cities/Delhi/gathering-at-nizamuddin-a-highly-irresponsible-act-says-kejriwal/article31221982.ece>
- 14 Chandna, H. (2020, April 18). 30% of India's Covid-19 positive caseload linked to Tablighi Jamaat meet, says govt. *The Print*. <https://theprint.in/health/30-of-indias-covid-19-positive-caseload-linked-to-tablighi-jamaat-meet-says-govt/404426/>

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- ¹⁵ Of 14,378 total Covid-19 cases in India, 4,291 linked to Delhi's Markaz event: Health ministry. (2020, April 18). *India Today*. <https://www.indiatoday.in/india/story/coronavirus-india-total-cases-linked-tablighi-jamaat-markaz-nizamuddin-event-health-ministry-1668456-2020-04-18>
- ¹⁶ NDTV. 1,023 COVID-19 Cases Linked To Mosque Event, Tamil Nadu Leads: 10 Points: NDTV; [Available from: <https://www.ndtv.com/india-news/coronavirus-tablighi-jamaat-1-023-of-2-902-covid-19-cases-linked-to-mosque-event-tamil-nadu-leads-2206193>
- ¹⁷ National Centre for Disease Control Directorate General of Health Services MoH&FW, GOI, New Delhi The updated case definitions and contact-categorisation [internet]. [cited 2020 Jun 2]. Available from https://nirth.res.in/virology/Revised_case_definitions_for_COVID_19.pdf
- ¹⁸ Guidelines for investigating clusters of health events. *MMWR Recomm Rep*. 1990 Jul 27;39(RR-11):1-23. PMID: 2117247. .
- ¹⁹ Koh WC, Naing L, Chaw L, Rosledzana MA, Alikhan MF, et al. (2020) What do we know about SARS-CoV-2 transmission? A systematic review and meta-analysis of the secondary attack rate and associated risk factors. *PLOS ONE* 15(10): e0240205. <https://doi.org/10.1371/journal.pone.0240205>
- ²⁰ Madewell ZJ, Yang Y, Longini IM Jr, Halloran ME, Dean NE. Household Transmission of SARS-CoV-2: A Systematic Review and Meta-analysis. *JAMA Netw Open*. 2020 Dec 1;3(12):e2031756. doi: 10.1001/jamanetworkopen.2020.31756. PMID: 33315116; PMCID: PMC7737089.
- ²¹ Lei H, Xu X, Xiao S, Wu X, Shu Y. Household transmission of COVID-19-a systematic review and meta-analysis. *J Infect*. 2020;81(6):979-997. doi:10.1016/j.jinf.2020.08.033
- ²² Keeling MJ, Hollingsworth TD, Read JM. The Efficacy of Contact Tracing for the Containment of the 2019 Novel Coronavirus (COVID-19). *medRxiv*. 2020.
- ²³ COVID-19 National Emergency Response Center Epidemiology and case management team, Korea Centers for disease Control and prevention. Coronavirus disease-19: summary of 2,370 contact investigations of the first 30 cases in the Republic of Korea. *Public Health Res Perspect*. 2020;11(2):81–84. doi: 10.24171/j.phrp.2020.11.2.04
- ²⁴ Wei L, Lv Q, Wen Y, Feng S, Gao W, Chen Z, Cao B, Wu X, Lu Y, Zhao J, Zou X. Household transmission of COVID-19, Shenzhen, January-February 2020. *medRxiv*. 2020 Jan 1
- ²⁵ Park SY, Kim YM, Yi S, Lee S, Na BJ, Kim CB, Kim JI, Kim HS, Kim YB, Park Y, Huh IS. Coronavirus disease outbreak in call center, South Korea. *Emerging infectious diseases*. 2020 Aug;26(8):1666.
- ²⁶ Chaw, L., Koh, W., Jamaludin, S., Naing, L., Alikhan, M., & Wong, J. (2020). Analysis of SARS-CoV-2 Transmission in Different Settings, Brunei. *Emerging Infectious Diseases*, 26(11), 2598-2606. <https://dx.doi.org/10.3201/eid2611.202263>
- ²⁷ Koh WC, Naing L, Chaw L, Rosledzana MA, Alikhan MF, et al. (2020) What do we know about SARS-CoV-2 transmission? A systematic review and meta-analysis of the secondary attack rate and associated risk factors. *PLOS ONE* 15(10): e0240205. <https://doi.org/10.1371/journal.pone.0240205>

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3
4 28 MOHFW. Revised guidelines for Home Isolation of very mild/pre-
5 symptomatic/asymptomatic COVID-19 cases. MOHFW 2020 July 2 [Available from
6 [RevisedHomeIsolationGuidelines.pdf \(mohfw.gov.in\)](#)
7
8 29 Quadri SA. COVID-19 and religious congregations: Implications for spread of novel
9 pathogens. *International Journal of Infectious Diseases*. 2020 Jul 1;96:219-21.
10
11 30 Choi JY. COVID-19 in South Korea. *Postgraduate Medical Journal*. 2020;96(1137):399-
12 402.
13
14 31 Yusef D, Hayajneh W, Awad S, Momany S, Khassawneh B, Samrah S, Obeidat B, Raffee
15 L, Al-Faouri I, Issa AB, Al Zamel H. Large outbreak of coronavirus disease among wedding
16 attendees, Jordan. *Emerging infectious diseases*. 2020 Sep;26(9):2165.
17
18 32 Shim E, Tariq A, Choi W, Lee Y, Chowell G. Transmission potential and severity of
19 COVID-19 in South Korea. *International Journal of Infectious Diseases*. 2020;93:339-44.
20
21 33 Hamner L, Dubbel P, Capron I, Ross A, Jordan A, Lee J, et al. High SARS-CoV-2 Attack
22 Rate Following Exposure at a Choir Practice - Skagit County, Washington, March 2020.
23 *MMWR Morbidity and mortality weekly report*. 2020;69(19):606-10
24
25 34 The Times of India; Avoid mass gatherings, says govt as corona cases hit 31: [Available
26 from:
27 [http://timesofindia.indiatimes.com/articleshow/74520610.cms?utm_source=contentofinterest](http://timesofindia.indiatimes.com/articleshow/74520610.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst)
28 [&utm_medium=text&utm_campaign=cppst](http://timesofindia.indiatimes.com/articleshow/74520610.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst)
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Map of Tamil Nadu included in the epidemiological study of COVID-19. There are nine of the 38 districts included in the study.

90x90mm (300 x 300 DPI)

Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cohort reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Page
	Reporting Item	Number
Title and abstract		
Title	#1a Indicate the study's design with a commonly used term in the title or the abstract	1

1	Abstract	#1b	Provide in the abstract an informative and balanced	2
2				
3			summary of what was done and what was found	
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5				
6	Introduction			
7				
8				
9	Background /	#2	Explain the scientific background and rationale for the	3
10				
11	rationale		investigation being reported	
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15	Objectives	#3	State specific objectives, including any prespecified	4
16				
17			hypotheses	
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20	Methods			
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23	Study design	#4	Present key elements of study design early in the paper	4
24				
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26	Setting	#5	Describe the setting, locations, and relevant dates,	4
27				
28			including periods of recruitment, exposure, follow-up, and	
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30			data collection	
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34	Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of	5
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36			selection of participants. Describe methods of follow-up.	
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39	Eligibility criteria	#6b	For matched studies, give matching criteria and number of	n/a
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41			exposed and unexposed	
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45	Variables	#7	Clearly define all outcomes, exposures, predictors,	5
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47			potential confounders, and effect modifiers. Give	
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49			diagnostic criteria, if applicable	
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53	Data sources /	#8	For each variable of interest give sources of data and	5
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55	measurement		details of methods of assessment (measurement).	
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57			Describe comparability of assessment methods if there is	
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more than one group. Give information separately for for exposed and unexposed groups if applicable.

Bias	#9	Describe any efforts to address potential sources of bias	n/a
Study size	#10	Explain how the study size was arrived at	4
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	5
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	5
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	n/a
Statistical methods	#12c	Explain how missing data were addressed	n/a
Statistical methods	#12d	If applicable, explain how loss to follow-up was addressed	n/a
Statistical methods	#12e	Describe any sensitivity analyses	n/a
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-	5

up, and analysed. Give information separately for for
exposed and unexposed groups if applicable.

Participants	#13b	Give reasons for non-participation at each stage	n/a
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	5
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	5
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	n/a
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	6
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6
Main results	#16b	Report category boundaries when continuous variables were categorized	n/a
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a

1	Other analyses	#17	Report other analyses done—eg analyses of subgroups	6
2			and interactions, and sensitivity analyses	
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6	Discussion			
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10	Key results	#18	Summarise key results with reference to study objectives	7
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13	Limitations	#19	Discuss limitations of the study, taking into account	8
14			sources of potential bias or imprecision. Discuss both	
15			direction and magnitude of any potential bias.	
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20	Interpretation	#20	Give a cautious overall interpretation considering	8
21			objectives, limitations, multiplicity of analyses, results from	
22			similar studies, and other relevant evidence.	
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28	Generalisability	#21	Discuss the generalisability (external validity) of the study	n/a
29			results	
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33	Other Information			
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36	Funding	#22	Give the source of funding and the role of the funders for	10
37			the present study and, if applicable, for the original study	
38			on which the present article is based	
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 46 made by the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)
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