

 Open access • Posted Content • DOI:10.1101/2021.02.23.21252287





Household secondary attack rate of COVID-19 by household size and index case characteristics — [Source link](#)

[Semra Tibebe](#), [Kevin A. Brown](#), [Nick Daneman](#), [Lauren A Paul](#) ...+1 more authors

Published on: 25 Feb 2021 - [medRxiv](#) (Cold Spring Harbor Laboratory)

Related papers:

- [\[Household structure in Barcelona: an analysis of the 1981 census\]](#).
- [Wealth status and sex differential of household head: implication for source of drinking water in Nigeria](#)
- [Magnitude and spatial distribution of food and nutrition security during the COVID-19 pandemic in Tucumán \(Argentina\)](#).
- [\[Single-parent households in Taiwan: estimation from one percent 1990 census data\]](#).
- [Method of Household Surveys and Characteristics of Surveyed Households: Comparison regarding Household Composition, Annual Income and Educational Attainment](#)

Share this paper:    

View more about this paper here: <https://typeset.io/papers/household-secondary-attack-rate-of-covid-19-by-household-ejwppmqmy7>

Title: Household secondary attack rate of COVID-19 by household size and index case characteristics

Authors:

Semra Tibebe, MPH ^a	semra.tibebe@oahpp.ca
Kevin A. Brown, PhD ^a	kevin.brown@oahpp.ca
Nick Daneman, MD ^a	nick.daneman@sunnybrook.ca
Lauren A. Paul, MSc ^a	lauren.paul@oahpp.ca
Sarah A. Buchan, PhD ^a	sarah.buchan@oahpp.ca

Affiliations:

^aHealth Protection, Public Health Ontario, 661 University Ave., Floor 17, Toronto, ON, M5G 1M1, Canada

Abstract

In this population-wide study in Ontario, Canada, we investigated the household secondary attack rate (SAR) to understand its relationship to household size and index case characteristics. We identified all patients with confirmed COVID-19 between July 1 and November 30, 2020. Cases within households were matched based on reported residential address; households were grouped based on the number of household contacts. The majority of households (68.2%) had a SAR of 0%, while 3,442 (11.7%) households had a SAR $\geq 75\%$. Overall household SAR was 19.5% and was similar across household sizes, but varied across index case characteristics. Households where index cases had longer delays between symptom onset and test seeking, households with older index cases, households with symptomatic index cases, and larger households located in diverse neighborhoods, were associated with greater household SAR. Our findings present characteristics associated with greater household SARs and proposes immediate testing as a method to reduce household transmission and incidence of COVID-19.

Introduction

Household secondary attack rate (SAR) is an important indicator of the transmission of COVID-19. Previous studies have reported household SARs of COVID-19 ranging from 4% to 55%¹. A majority of these studies were based on small cohort sizes, with few stratifying by number of household contacts². In this population-wide study in Ontario, Canada, we investigated the household SAR to understand its relationship to household size and index case characteristics.

Methods

We identified all patients with confirmed COVID-19 in Ontario's provincial reportable disease surveillance system between July 1 and November 30, 2020. Cases within households were matched based on reported residential address³ and the number of household contacts were determined using reported household size. Cases living alone were excluded, as were those living in congregate settings such as retirement homes and shelters. Households were grouped based on household size.

We defined index cases based on the symptom onset date in the household; specimen collection date was used when symptom onset date was missing. In households with 1 contact, secondary cases were defined as those with symptom onset dates 1-14 days after the index case; in households with 2 or more contacts, this interval was increased to 1-28 days to allow for chains of transmission. Households containing multiple cases with the same earliest symptom onset date were excluded. In sensitivity analyses, secondary cases were those with onset 2-14 days after the index case. We obtained ethics approval from Public Health Ontario's Research Ethics Board.

Results

In this study period 68.5% of cases reported a household size. From those, we identified 29,352 households with 84,125 household contacts and 16,404 secondary cases. The majority of households (68.2%) had a SAR of 0% (Figure 1), while 3,442 (11.7%) households had a SAR \geq 75%. Overall household SAR was 19.5% and was similar across household sizes, but varied across index case characteristics (Table 1). Households with index cases aged 20-30 years had the lowest SAR (16.5%) compared to other age groups. Households with symptomatic index cases had greater SAR compared to

households with asymptomatic index cases (22.1% vs 6.2%); this was consistent across household sizes. Larger households in the most ethnically diverse neighborhoods had greater SAR than those in the least ethnically diverse neighborhoods (15.0% vs 20.3%); this was not evident in smaller households. Index cases with longer delays between symptom onset and test seeking were associated with greater household SAR; each one-day increase in testing delay was associated with a 1.8% increase in SAR. When secondary case onset was 2-14 days after the index case, household SAR was 15.5%.

Discussion

Household SARs differed by index case characteristics. Our estimated household SAR (19.5%) aligns with a pooled estimate compiled by Koh et al. (18.1%, 95% CI: 15.7-20.6). Unlike our findings, studies have reported greater SARs in households with more contacts, though these studies utilized cohorts with fewer than 1000 participants and conducted enhanced contact follow-up^{2,4}. Asymptomatic index cases associated with lower SAR is consistent with previous findings^{1,2}. The increased SAR within larger households in more ethnically diverse neighborhoods reflects findings that visible minorities are less likely to work from home during the pandemic⁵ and that greater household crowding in these communities contribute to their increased risk of COVID-19⁶. Our findings propose the importance of immediate test seeking, as a confirmed case may motivate behavior to prevent household transmission. This analysis is limited by the absence of household contact information (including COVID-19 testing status), and by the potential misclassification of index cases, especially in households with asymptomatic cases. Our findings present characteristics associated with greater household SARs and proposes immediate testing as a method to reduce household transmission and incidence of COVID-19.

References

1. Koh WC, Naing L, Chaw L, et al. 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*. 2020;15(10):e0240205. doi:10.1371/journal.pone.0240205
2. Madewell ZJ, Yang Y, Longini IM, Halloran ME, Dean NE. Household transmission of SARS-CoV-2: a systematic review and meta-analysis. *JAMA Netw Open*. 2020;3(12):e2031756. doi:10.1001/jamanetworkopen.2020.31756
3. Paul LA, Daneman N, Brown KA, et al. Characteristics associated with household transmission of SARS-CoV-2 in Ontario, Canada. *MedRxiv* 20217802 [Preprint]. October 26, 2020 [cited February 4, 2021]. doi:10.1101/2020.10.22.20217802
4. Jing Q-L, Liu M-J, Zhang Z-B, et al. Household secondary attack rate of COVID-19 and associated determinants in Guangzhou, China: a retrospective cohort study. *Lancet Infect Dis*. 2020;20(10):1141-1150. doi:10.1016/S1473-3099(20)30471-0
5. Selden TM, Berdahl TA. COVID-19 and racial/ethnic disparities in health risk, employment, and household composition. *Health Aff*. 2020;39(9):1624-1632. doi:10.1377/hlthaff.2020.00897
6. van Ingen T, Akingbola S, Brown KA, Daneman N, Buchan SA, Smith BT. Neighbourhood-level risk factors of COVID-19 incidence and mortality. *MedRxiv* 21250618 [Preprint]. January 31, 2021 [cited February 4, 2021]. doi:10.1101/2021.01.27.21250618

Table 1. Number of secondary cases and household secondary attack rate by index case characteristics and the number of household contacts.

Index case characteristics	Index Cases	Households with 1 to 2 contacts N = 13,135		Households with 3 to 4 contacts N = 12,032		Households with 5 or more contacts N = 4,185		All households N = 29,352	
	N (%)	Secondary Cases	SAR (95% CI)	Secondary Cases	SAR (95% CI)	Secondary Cases	SAR (95% CI)	Secondary Cases	SAR (95% CI)
Total	29,352	3,720	19.2 (18.7 - 19.8)	7,828	19.3 (18.9 - 19.7)	4,856	20.1 (19.6 - 20.6)	16,404	19.5 (19.2 - 19.8)
Gender ^a									
Female	14,276 (48.6)	1,727	17.8 (17.0 - 18.6)	3,639	18.8 (18.2 - 19.3)	2,069	19.3 (18.6 - 20.1)	7,435	18.7 (18.3 - 19.1)
Male	14,980 (51.0)	1,989	20.8 (20.0 - 21.6)	4,173	19.8 (19.3 - 20.4)	2,772	20.7 (20.0 - 21.4)	8,934	20.3 (19.9 - 20.7)
Age group									
Median [IQR]	36 [25, 52]		44 [28, 59]		39 [24, 51]		36 [23, 51]		39 [25, 53]
0-10 years	800 (2.7)	63	17.6 (13.9 - 22.0)	291	19.3 (17.4 - 21.5)	170	18.8 (16.3 - 21.5)	524	18.9 (17.5 - 20.5)
10-20 years	2,436 (8.3)	149	14.7 (12.6 - 17.1)	803	18.2 (17.1 - 19.4)	571	17.8 (16.5 - 19.2)	1,523	17.7 (16.9 - 18.5)
20-30 years	7,596 (25.9)	817	15.7 (14.7 - 16.7)	1,633	16.2 (15.5 - 16.9)	1,114	17.5 (16.6 - 18.5)	3,564	16.5 (16.0 - 17.0)
30-40 years	5,435 (18.5)	658	17.1 (15.9 - 18.3)	1,192	17.1 (16.2 - 18.0)	884	20.2 (19.0 - 21.4)	2,734	18.0 (17.4 - 18.6)
40-50 years	4,782 (16.3)	478	19.0 (17.5 - 20.6)	1,689	20.3 (19.5 - 21.2)	783	19.6 (18.4 - 20.9)	2,950	19.9 (19.3 - 20.6)
50-60 years	4,553 (15.5)	696	21.7 (20.3 - 23.2)	1,491	23.5 (22.5 - 24.6)	704	24.7 (23.2 - 26.4)	2,891	23.3 (22.6 - 24.1)
60-70 years	2,541 (8.7)	520	24.3 (22.5 - 26.2)	525	23.9 (22.1 - 25.7)	410	24.4 (22.4 - 26.6)	1,455	24.2 (23.1 - 25.3)
70-80 years	843 (2.9)	222	29.8 (26.6 - 33.3)	122	23.8 (20.2 - 27.8)	136	22.9 (19.7 - 26.6)	480	25.9 (24.0 - 28.0)
≥80 years	365 (1.2)	117	36.8 (31.5 - 42.4)	82	32.2 (26.5 - 38.3)	84	34.3 (28.4 - 40.6)	283	34.6 (31.4 - 38.0)
Symptom status ^b									
Asymptomatic	2,245 (7.6)	98	6.7 (5.5 - 8.2)	195	6.3 (5.5 - 7.3)	116	5.6 (4.7 - 6.8)	409	6.2 (5.6 - 6.8)
Pre-symptomatic	1,247 (4.2)	61	7.3 (5.7 - 9.3)	156	8.7 (7.4 - 10.1)	65	8.0 (6.3 - 10.1)	282	8.2 (7.3 - 9.1)
Symptomatic	23,610 (80.4)	3,378	21.9 (21.3 - 22.6)	7,171	21.8 (21.4 - 22.3)	4,520	22.8 (22.2 - 23.4)	15,069	22.1 (21.8 - 22.4)
High Risk ^c									
Yes	3,749 (12.8)	859	26.9 (25.3 - 28.4)	729	24.6 (23.0 - 26.2)	630	25.0 (23.4 - 26.8)	2,218	25.6 (24.6 - 26.5)
No	25,603 (87.2)	2,861	17.7 (17.1 - 18.3)	7,099	18.9 (18.5 - 19.3)	4,226	19.5 (19.0 - 20.0)	14,186	18.8 (18.5 - 19.1)
Residential Neighbourhood Diversity ^d									
1 (least diverse)	1,182 (4.1)	174	18.2 (15.8 - 20.8)	182	14.2 (12.3 - 16.2)	86	12.1 (9.8 - 14.8)	442	15.0 (13.7 - 16.3)
2	1,774 (6.1)	214	15.6 (13.8 - 17.7)	321	15.8 (14.2 - 17.5)	216	18.3 (16.1 - 20.6)	751	16.4 (15.3 - 17.5)
3	3,184 (11.0)	461	19.8 (18.2 - 21.5)	717	17.2 (16.1 - 18.4)	305	17.2 (15.5 - 19.0)	1,483	17.9 (17.1 - 18.8)
4	5,799 (20.1)	802	19.3 (18.1 - 20.5)	1,474	19.3 (18.4 - 20.2)	776	20.1 (18.9 - 21.4)	3,052	19.5 (18.9 - 20.1)
5 (most diverse)	16,933 (58.6)	2,027	19.8 (19.0 - 20.6)	5,019	20.2 (19.7 - 20.7)	3,350	20.8 (20.1 - 21.4)	10,396	20.3 (20.0 - 20.7)

Table 1. Number of secondary cases and household secondary attack rate by index case characteristics and the number of household contacts (continued).

Index case characteristics	Index Cases	Households with 1 to 2 contacts N = 13,135		Households with 3 to 4 contacts N = 12,032		Households with 5 or more contacts N = 4,185		All households N = 29,352	
	N (%)	Secondary Cases	SAR (95% CI)	Secondary Cases	SAR (95% CI)	Secondary Cases	SAR (95% CI)	Secondary Cases	SAR (95% CI)
Testing delay ^e									
Median [IQR]	2 [0, 4]		3 [1, 5]		3 [1, 5]		3 [1, 6]		3 [1, 5]
No symptoms	2,245 (7.7)	98	6.7 (5.5 - 8.2)	195	6.3 (5.5 - 7.3)	116	5.6 (4.7 - 6.8)	409	6.2 (5.6 - 6.8)
<0 days	1,247 (4.3)	61	7.3 (5.7 - 9.3)	156	8.7 (7.4 - 10.1)	65	8.0 (6.3 - 10.1)	282	8.2 (7.3 - 9.1)
0 days	2,834 (9.7)	272	14.1 (12.6 - 15.7)	522	13.2 (12.2 - 14.3)	229	11.4 (10.1 - 12.9)	1,023	13.0 (12.2 - 13.7)
1 day	4,669 (16.0)	557	18.6 (17.2 - 20.0)	1,233	18.3 (17.4 - 19.3)	708	18.6 (17.4 - 19.9)	2,498	18.5 (17.8 - 19.1)
2 days	4,322 (14.8)	596	20.6 (19.1 - 22.1)	1,307	22.0 (21.0 - 23.1)	762	22.2 (20.9 - 23.7)	2,665	21.8 (21.0 - 22.5)
3 days	3,252 (11.1)	472	22.8 (21.0 - 24.6)	1,007	21.7 (20.5 - 22.9)	545	20.2 (18.7 - 21.8)	2,024	21.5 (20.7 - 22.4)
4 days	2,218 (7.6)	338	23.5 (21.4 - 25.8)	686	22.9 (21.4 - 24.5)	495	25.4 (23.5 - 27.4)	1,519	23.8 (22.8 - 24.9)
≥5 days	6,192 (21.2)	1,127	28.5 (27.1 - 29.9)	2,390	28.2 (27.2 - 29.2)	1,761	30.1 (29.0 - 31.3)	5,278	28.9 (28.2 - 29.5)

a This section does not include missing or other genders (96 index cases and associated 35 secondary cases and 299 contacts).

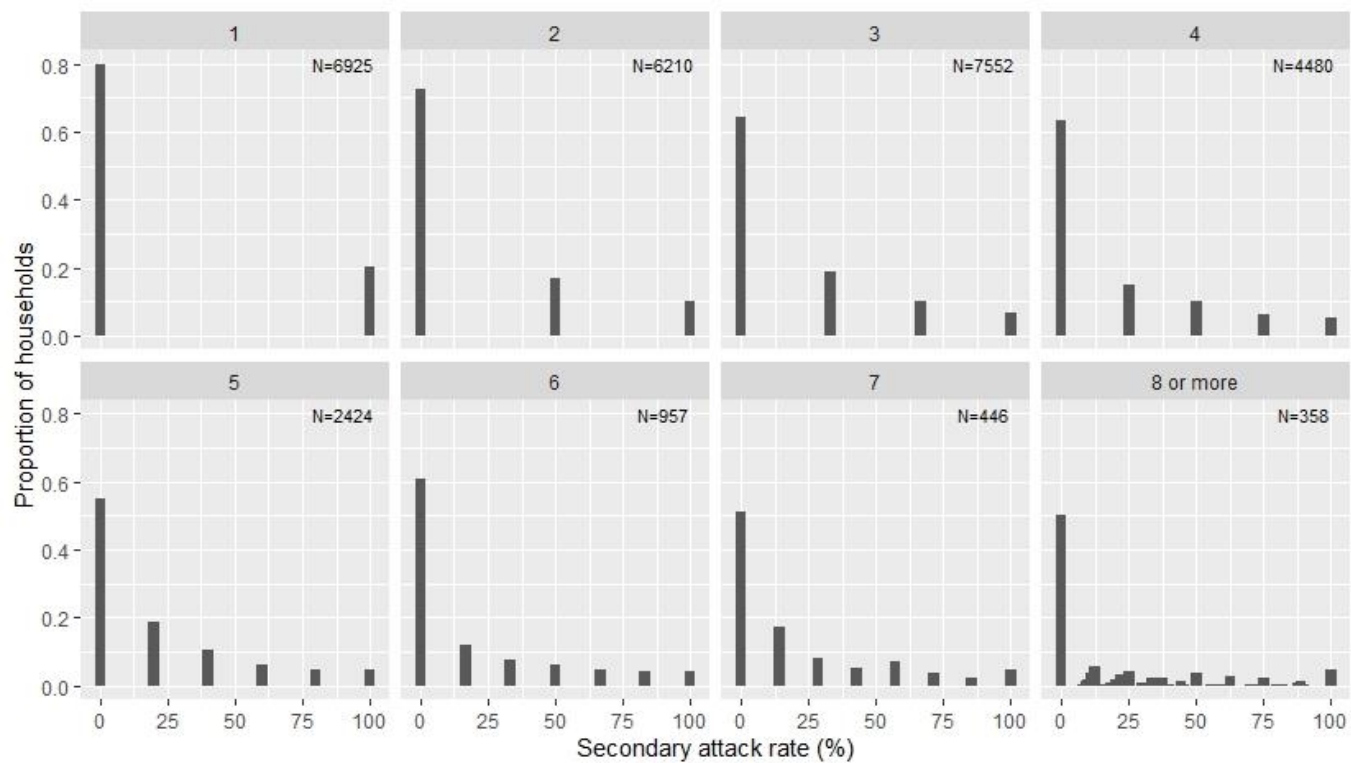
b Pre-symptomatic cases were those that were tested before they developed symptoms. Those that did not report a symptom or did not report a symptom onset date and were not asymptomatic were excluded from this section (2,250 index cases and associated 644 secondary cases and 5,987 contacts).

c High risk cases were those that either: were over the age of 60, were immunocompromised, had cardiovascular-related health issues, or had chronic obstructive pulmonary disease (COPD).

d Neighbourhood diversity is a composite measure of 1) the proportion of non-white and non-Indigenous residents and 2) the proportion of immigrants that arrived in Canada within the past five years, for each Dissemination Area (DA) in Ontario. A DA is a standard census geographic area, containing approximately 400 to 700 people. Quintiles are calculated by ranking scores for each DA and sorting all DAs into five equally sized groups, thus each quintile contains the same number of DAs. Those living in DAs that did not have this score were excluded from this section (480 index cases and associated 280 secondary cases and 1,459 contacts).

e Testing delay is the delay between the case's symptom onset and when their specimen was collected by a healthcare provider. Those that did not report a symptom or did not report a symptom onset date and were not asymptomatic, or, were missing a specimen collection date, were excluded from this section (2,373 index cases and associated 706 secondary cases and 6,340 contacts).

Figure 1. Distribution of household secondary attack rate (%) stratified by number of households contacts.



a. N is the total number of households with the specified number of contacts.