











RESEARCH NOTE

# Reported exposure to SARS-CoV-2 and relative perceived importance of different settings for SARS-CoV-2 acquisition in England and Wales: Analysis of the Virus Watch Community Cohort [version 1; peer review: awaiting peer review]

Sarah Beale <sup>1</sup>, Thomas Byrne<sup>1</sup>, Ellen Fragaszy <sup>1</sup>, Jana Kovar<sup>1</sup>, Vincent Nguyen<sup>1</sup>, Anna Aryee <sup>1</sup>, Wing Lam Erica Fong<sup>1</sup>, Cyril Geismar <sup>1</sup>, Parth Patel <sup>1</sup>, Madhumita Shrotri<sup>1</sup>, Nicholas Patni<sup>1,2</sup>, Isobel Braithwaite<sup>1</sup>, Annalan Navaratnam <sup>1</sup>, Anne M Johnson<sup>1</sup>, Robert W Aldridge <sup>1</sup>, Andrew C Hayward <sup>1</sup>, Virus Watch Collaborative

<sup>1</sup>University College London, London, UK

<sup>2</sup>University of Oxford, Oxford, UK

---

**V1** First published: 21 Sep 2021, 6:242  
<https://doi.org/10.12688/wellcomeopenres.17067.1>  
Latest published: 21 Sep 2021, 6:242  
<https://doi.org/10.12688/wellcomeopenres.17067.1>

---

## Abstract

We aimed to assess the relative importance of different settings for SARS-CoV-2 transmission in a large community cohort based on perceived location of infection for self-reported confirmed SARS-CoV-2 cases. We demonstrate the importance of home, work and education as perceived venues for transmission. In children, education was most important and in older adults essential shopping was of high importance. Our findings support public health messaging about infection control at home, advice on working from home and restrictions in different venues.

## Keywords

SARS-CoV-2; COVID-19; transmission; pandemic

## Open Peer Review

**Reviewer Status** *AWAITING PEER REVIEW*

Any reports and responses or comments on the article can be found at the end of the article.

**Corresponding author:** Sarah Beale ([sarah.beale.19@ucl.ac.uk](mailto:sarah.beale.19@ucl.ac.uk))

**Author roles:** **Beale S:** Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Visualization, Writing – Original Draft Preparation; **Byrne T:** Data Curation, Investigation, Project Administration, Validation, Writing – Original Draft Preparation, Writing – Review & Editing; **Fragaszy E:** Conceptualization, Methodology, Project Administration, Supervision, Writing – Review & Editing; **Kovar J:** Project Administration, Resources, Writing – Review & Editing; **Nguyen V:** Data Curation, Project Administration, Software, Writing – Review & Editing; **Aryee A:** Methodology, Writing – Review & Editing; **Fong WLE:** Data Curation, Writing – Review & Editing; **Geismar C:** Data Curation, Writing – Review & Editing; **Patel P:** Conceptualization, Writing – Review & Editing; **Shrotri M:** Conceptualization, Methodology, Writing – Review & Editing; **Patni N:** Project Administration, Writing – Review & Editing; **Braithwaite I:** Conceptualization, Writing – Review & Editing; **Navaratnam A:** Conceptualization, Writing – Review & Editing; **Johnson AM:** Conceptualization, Methodology, Supervision, Writing – Review & Editing; **Aldridge RW:** Conceptualization, Funding Acquisition, Methodology, Supervision, Writing – Review & Editing; **Hayward AC:** Conceptualization, Funding Acquisition, Methodology, Supervision, Writing – Review & Editing;

**Competing interests:** ACH serves on the UK New and Emerging Respiratory Virus Threats Advisory Group.

**Grant information:** The research costs for the Virus Watch study have been supported by the MRC Grant Ref: MC\_PC 19070 awarded to UCL on 30 March 2020 and MRC Grant Ref: MR/V028375/1 awarded on 17 August 2020. The study also received \$15,000 of Facebook advertising credit to support a pilot social media recruitment campaign on 18th August 2020. This study was supported by the Wellcome Trust through a Wellcome Clinical Research Career Development Fellowship to RA [206602]. SB and TB are supported by an MRC doctoral studentship (MR/N013867/1)

*The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.*

**Copyright:** © 2021 Beale S *et al.* This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

**How to cite this article:** Beale S, Byrne T, Fragaszy E *et al.* **Reported exposure to SARS-CoV-2 and relative perceived importance of different settings for SARS-CoV-2 acquisition in England and Wales: Analysis of the Virus Watch Community Cohort [version 1; peer review: awaiting peer review]** Wellcome Open Research 2021, 6:242 <https://doi.org/10.12688/wellcomeopenres.17067.1>

**First published:** 21 Sep 2021, 6:242 <https://doi.org/10.12688/wellcomeopenres.17067.1>

## Background

Risk of SARS-CoV-2 transmission is understood to be driven by the complex interplay of many factors that can be broadly classified into four main areas<sup>1</sup> viral load and infectiousness<sup>2</sup>, contact patterns<sup>3,4</sup>, environmental factors<sup>5</sup> and socioeconomic inequalities<sup>6–8</sup>. However, the relative contribution of different settings to overall transmission has proven difficult to quantify at a population level<sup>1</sup>. A lack of evidence on the fraction of infections occurring in different settings at different epidemic stages and intensities limits our ability to make evidence-based decisions about which settings should be the focus of control measures at different stages of the pandemic, as different public health and policy actions are required. In this analysis, we aimed to assess the perceived relative importance of different settings for SARS-CoV-2 transmission in a large community cohort (Virus Watch).

## Methods

Virus Watch is a household community cohort study which began recruitment in June 2020 and has recruited circa 50,000 individuals across England and Wales with weekly online follow up and self-reporting of any positive SARS-CoV-2 virological tests<sup>9</sup>. On the 17th of March 2021, participants were asked, “If you have had a positive COVID-19 swab test at any point in the pandemic, did you test positive after...?”. Possible responses were “Contact with confirmed COVID-19 case(s)”, “Contact with suspected COVID-19 case(s)”, “No known contact with confirmed or suspected COVID-19 case(s)”, or “I have not had a positive COVID-19 swab test during the pandemic”. Participants who responded anything other than “I have not had a positive COVID-19 swab test during the pandemic” were then asked: “Where do you think you may have caught COVID-19?”. Participants were allowed to select multiple setting categories and we classified these settings into the following groups: home, someone else’s home, work, place of education, public transport, essential shop, healthcare setting, leisure (comprising ‘bar, pub, or club’, ‘eating out in a restaurant, cafe, or canteen’, ‘gym/indoor sports facility’, ‘hairdresser, barber, nail salon, or similar location’, and ‘shop for non-essential items’), and other. Survey responses were linked to a previously reported date of laboratory-confirmed infection, where available. Virus Watch was approved by the Hampstead NHS Health Research Authority Ethics Committee: 20/HRA/2320.

Using these data, we described the perceived setting of SARS-CoV-2 acquisition by contact status and stratified these descriptive analyses by age of the case and by time period of infection (Jan-May 2020, Jun-Aug 2020, Sep 2020-Dec 2020, Jan-March 2021). The survey was sent to 21,444 households comprising 45,654 study participants on 17/03/2021, and 18,096 (40%) individual participants had completed the survey in full when data were extracted on 28/03/2021. Of these, 1142 participants had self-reported a positive SARS-CoV-2 test previously during follow-up and responded to the main question of interest.

## Results

Of the 1142 survey respondents, 499 (44%) reported known contact with a confirmed case, 120 (10%) contact with a suspected case and 523 (46%) reported no known contact. Amongst all cases, the perceived setting of acquisition was, in descending order of frequency, within the home (n=317, 33%), at work (n=259, 23%), in an essential shop (n=201, 18%), other venues (n=129, 11%), in a leisure venue (n=112, 10%), in a place of education (n=96, 8%), in healthcare settings (n=90, 8%), on public transport (n=75, 7%), and in someone else’s home (n=64, 6%; [Table 1](#)). This varied considerably depending whether or not the person was a contact of a known case ([Figure 1](#)).

For those with known contact with a confirmed case, the perceived venues for transmission in descending order of frequency were: home (n=234, 47%), work (n=116, 23%), education (n=44, 9%), someone else’s home (n=39, 8%), healthcare setting (n=35, 7%), essential shop (n=28, 6%), other venues (n=25, 5%), and leisure venue (n=17, 3%). For those with no recognized contact, the perceived venues for acquisition were: an essential shop (n=167, 32%), work (n=101, 19%), other venues (n=99, 19%), home (n=98, 19%), a leisure venue (n=86, 16%), transport (n=58, 11%), healthcare (n=48, 9%), education (n=42, 8%), and someone else’s home (n=13, 3%) ([Table 1](#) and [Figure 1](#)).

The most important perceived venue for transmission varied by age group: place of education was more important than home for children aged 0–17, home and workplace were of similar importance for working age adults, and home and essential shops were the most important settings for those aged over 65 years ([Table 1](#) and [Figure 1](#)). Young adults aged 18–34 were more likely than other age groups to perceive leisure venues and public transport as the venue of acquisition.

Home settings had a relatively stable level of perceived importance between Jan-May 2020 (n=21, 34%) and Jan-March 2021 (n=106, 30%; [Table 1](#)). The proportions who perceived that they were infected in someone else’s home increased over time (n=0, 0% Jan-May 2020 vs. n=27, 9% Jan-March 2021), as did place of education (n=0, 0% vs. n=12, 4%). The proportion who perceived that they were infected in a healthcare setting decreased over time (n=18, 26% vs. n=25, 8%). Caution should be used interpreting these time period changes because of small numbers for some groups, particularly in the Jun-Aug time period when levels of infection were low.

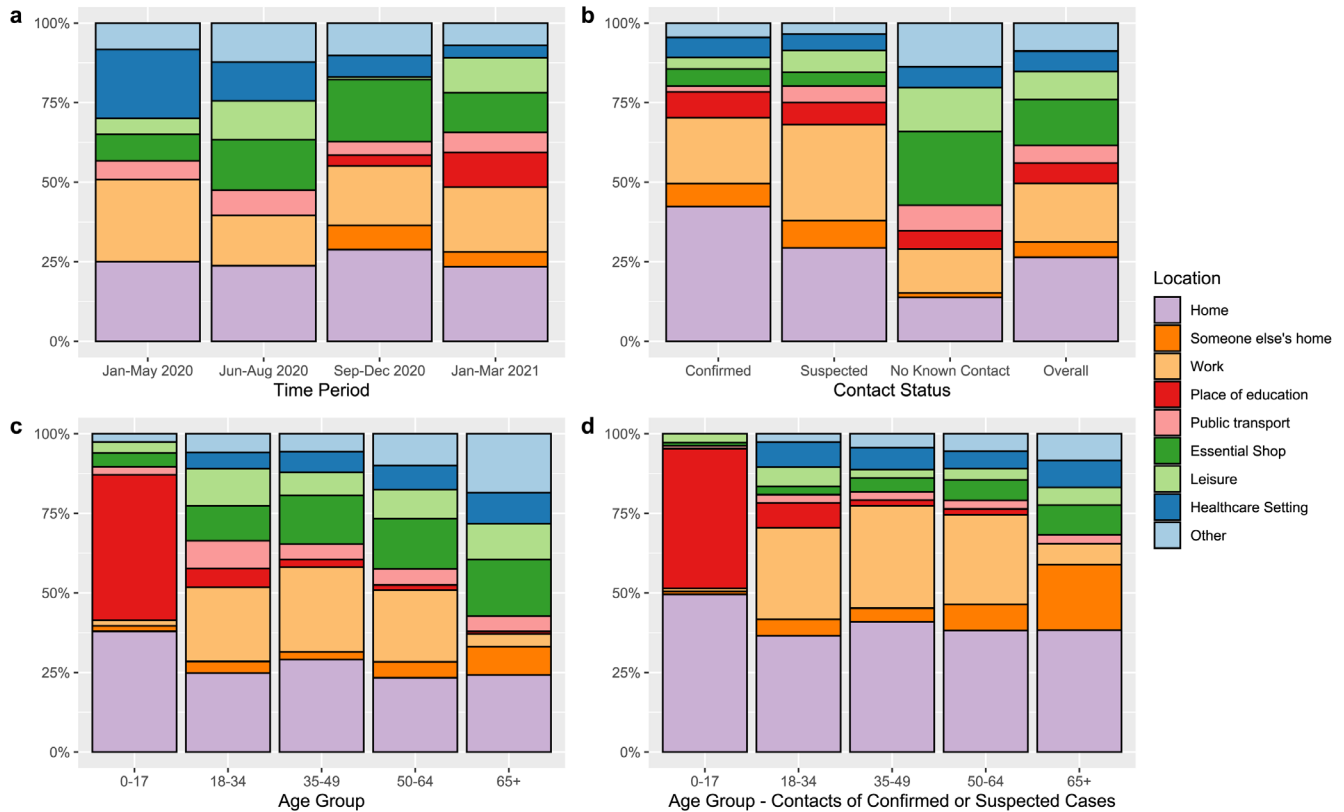
## Discussion

Our findings illustrate the central perceived importance of home, work and place of education as venues for transmission, although the relative importance of different settings is likely to change over time and with variation in restrictions. In children, place of education is most important, and in older adults essential shopping is of high importance. Home was

**Table 1. Perceived Setting of SARS-CoV-2 Acquisition by Contact Status, Age, and Time Period.**

	Contact Status				Age*						Time Period			
	Confirmed <sup>1</sup> , N=499	Suspected <sup>1</sup> , N=120	None <sup>1</sup> ,	Overall, N=1142	0 to 17 <sup>1</sup> , N = 120 <sup>1</sup>	18 to 34 <sup>1</sup> , N = 191 <sup>1</sup>	35 to 49 <sup>1</sup> , N = 262 <sup>1</sup>	50 to 64 <sup>1</sup> , N = 361 <sup>1</sup>	65+ <sup>1</sup> , N = 206 <sup>1</sup>	Mar-May 2020, N = 70 <sup>1</sup>	Jun-Aug 2020, N = 18 <sup>1</sup>	Sep-Dec 2020, N = 377 <sup>1</sup>	Jan-Mar 2021, N = 311 <sup>1</sup>	
Home	234 (46.9%)	41 (34.2%)	98 (18.7%)	373 (32.7%)	53 (44.2%)	64 (33.5%)	94 (35.9%)	100 (27.7%)	61 (29.6%)	21 (30.0%)	6 (33.3%)	113 (30.0%)	106 (34.1%)	
Someone else's home	39 (7.8%)	12 (10.0%)	13 (2.5%)	64 (5.6%)	2 (1.7%)	9 (4.7%)	9 (3.4%)	21 (5.8%)	23 (11.2%)	0 (0.0%)	0 (0.0%)	22 (5.8%)	27 (8.7%)	
Work	116 (23%)	42 (35.0%)	101 (19.3%)	259 (22.7%)	2 (1.7%)	61 (31.9%)	87 (33.2%)	98 (27.1%)	11 (5.3%)	22 (31.4%)	4 (22.2%)	97 (25.7%)	69 (22.2%)	
Place of education	44 (8.8%)	10 (8.3%)	42 (8.0%)	96 (8.4%)	63 (52.5%)	15 (7.9%)	8 (3.1%)	8 (2.2%)	1 (0.5%)	0 (0.0%)	0 (0.0%)	54 (14.3%)	12 (3.9%)	
Public transport	10 (2.0%)	7 (5.8%)	58 (11.1%)	75 (6.6%)	4 (3.3%)	22 (11.5%)	15 (5.7%)	22 (6.1%)	12 (5.8%)	5 (7.1%)	2 (11.1%)	30 (8.0%)	16 (5.1%)	
Essential shop	28 (5.6%)	6 (5.0%)	167 (31.9%)	201 (17.6%)	6 (5.0%)	28 (14.7%)	51 (19.5%)	70 (19.4%)	46 (22.3%)	7 (10.0%)	4 (22.2%)	62 (16.4%)	71 (22.8%)	
Healthcare setting	35 (7.0%)	7 (5.8%)	48 (9.2%)	90 (7.9%)	0 (0.0%)	14 (7.3%)	20 (7.6%)	32 (8.9%)	24 (11.7%)	18 (25.7%)	3 (16.7%)	17 (4.5%)	25 (8.0%)	
Leisure	17 (3.4%)	9 (7.5%)	86 (16.4%)	112 (9.8%)	5 (4.2%)	28 (14.7%)	19 (7.3%)	36 (10.0%)	24 (11.7%)	4 (5.7%)	3 (16.7%)	53 (14.1%)	4 (1.3%)	
Other	25 (5.0%)	5 (4.2%)	99 (18.9%)	129 (11.2%)	4 (3.3%)	15 (7.9%)	19 (7.3%)	43 (11.9%)	48 (23.3%)	7 (10.0%)	3 (16.7%)	34 (9.0%)	37 (11.9%)	

<sup>1</sup>n (%); \* Two cases excluded due to missing age; **Note:** Participants could select multiple locations so proportions are calculated from group n and may sum to >100.0%



**Figure 1.** Perceived Setting of SARS-CoV-2 Acquisition by (a) Time Period, (b) Contact Status, (c) Age and (d) Age – Contacts of Confirmed or Suspected Cases.

perceived as an important location across time periods and age groups – particularly for contacts of confirmed or suspected cases – and further research (particularly intervention research) and public health advice to reduce household transmission is recommended. Our estimates cover several periods of intense restrictions. As restrictions loosen, the relative importance of out-of-household transmission, including of workplaces and a wider range of leisure settings, is likely to increase.

Our study was reliant on community testing for case ascertainment so is most likely to represent infections acquired after the first UK lockdown following initiation of the Test, Trace and Isolate programme. Perceived venues of acquisition in those with known contact are likely biased toward venues such as home, work and education where contact tracing can readily lead to identification of known contact. Conversely those with no known contact may be more likely to conclude they acquired SARS-CoV-2 infection in settings where they are in contact with strangers (such as in shops). Judgments may also be affected by perceptions of the importance of factors such as proximity and ventilation in influencing transmission risk.

Considering these possible biases in reporting of the importance of these perceived settings by known or unknown contact status, our estimates provide useful upper and lower

ranges for the likely relative importance of acquisition of SARS-CoV-2 in England and Wales over our study period. In future waves of transmission, these findings can support public health efforts on guidance to prevent household transmission, advice on working from home, restrictions in different venues, and advice to vulnerable elderly to reduce exposure to shops, for example through online shopping.

## Data availability

### Underlying data

We aim to share aggregate data from this project on our website and via a “Findings so far” section on our website - <https://ucl-virus-watch.net/>. We will also be sharing individual record level data on a research data sharing service such as the Office of National Statistics Secure Research Service. In sharing the data we will work within the principles set out in the UKRI Guidance on best practice in the management of research data. Access to use of the data whilst research is being conducted will be managed by the Chief Investigators (AH and RWA) in accordance with the principles set out in the UKRI guidance on best practice in the management of research data. We will put analysis code on publicly available repositories to enable their reuse. Given the content of our dataset (information on exposure and activities in participants with SARS-CoV-2 infection) for this study, we currently cannot release the data at the individual level.

Data access requests to data can be made to the Virus Watch chief investigators (AH or RWA) at the following email address: [viruswatch@ucl.ac.uk](mailto:viruswatch@ucl.ac.uk).

#### Extended data:

Zenodo. UCL-Public-Health-Data-Science/VirusWatch\_Caught\_Covid: VirusWatch\_Caught\_Covid. DOI: <https://doi.org/10.5281/zenodo.5123386><sup>10</sup>

This project contains the following extended data:

- <exposure\_code\_deposit.R> (<source code>)
- <Contact with COVID survey question.pdf> (<original survey questions used for current analyses>)

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](https://creativecommons.org/licenses/by/4.0/) (CC-BY 4.0).

## References

1. Scientific Advisory Group for Emergencies: **PHE: Factors contributing to risk of SARS-CoV-2 transmission in various settings, 26 November 2020**. GOV.UK; 2020; [cited 9 Jun 2021]. [Reference Source](#)
2. Cevik M, Tate M, Lloyd O, *et al.*: **SARS-CoV-2, SARS-CoV, and MERS-CoV viral load dynamics, duration of viral shedding, and infectiousness: a systematic review and meta-analysis**. *Lancet Microbe*. 2021; 2(1): e13–e22. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
3. Sun K, Wang W, Gao L, *et al.*: **Transmission heterogeneities, kinetics, and controllability of SARS-CoV-2**. *Science*. 2021; 371(6526): eabe2424. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
4. Government Office for Science: **SARS-COV-2: Transmission Routes and Environments, 22 October 2020**. GOV.UK; 2020; [cited 10 Jun 2021]. [Reference Source](#)
5. Bulfone TC, Malekinejad M, Rutherford GW, *et al.*: **Outdoor Transmission of SARS-CoV-2 and Other Respiratory Viruses: A Systematic Review**. *J Infect Dis*. 2021; 223(4): 550–561. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
6. Public Health England: **COVID-19: review of disparities in risks and outcomes**. GOV.UK; 2020; [cited 10 Jun 2021]. [Reference Source](#)
7. Aldridge RW, Pineo H, Fragaszy E, *et al.*: **Household overcrowding and risk of SARS-CoV-2: analysis of the Virus Watch prospective community cohort study in England and Wales**. *medRxiv*. 2021. [Publisher Full Text](#)
8. Beale S, Braithwaite I, Navaratnam AMD, *et al.*: **Deprivation and exposure to public activities during the COVID-19 pandemic in England and Wales**. *medRxiv*. 2021. [Publisher Full Text](#)
9. Hayward A, Fragaszy E, Kovar J, *et al.*: **Risk factors, symptom reporting, healthcare-seeking behaviour and adherence to public health guidance: protocol for Virus Watch, a prospective community cohort study**. *bioRxiv*. 2021. [Publisher Full Text](#)
10. sarahbealeuc: **UCL-Public-Health-Data-Science/VirusWatch\_Caught\_Covid: VirusWatch\_Caught\_Covid (v1.0.0)**. Zenodo. 2021. <http://www.doi.org/10.5281/zenodo.5123386>