The impact of household physical distancing and its timing on the transmission of SARS-CoV-2: Insights from a household transmission evaluation study.

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Introduction

Detailed data on contacts among household members could inform the estimation of secondary attack rates and other transmission parameters. Here, we **characterize contact patterns** of relevance for the transmission of SARS-CoV-2 infections in households to **estimate the impact of physical distancing and its timing on secondary transmissions**.

Data and Methods

Data collection

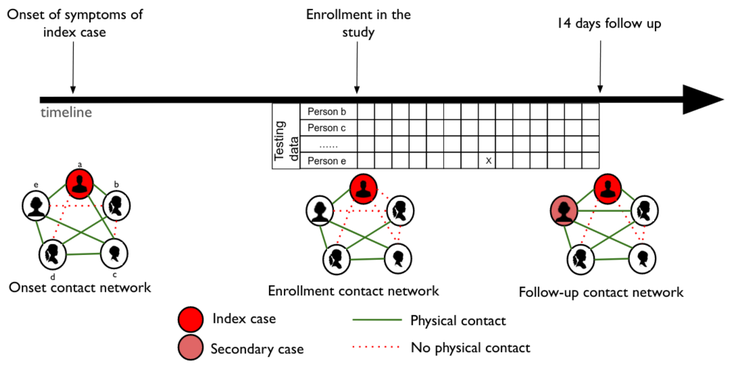


Figure 1: Schematic representation of the study design[1,2]. Individuals with a positive SARS-CoV-2 test result (index case) enrolled in the study, together with their household members.

We collected :

- Symptoms data and respiratory specimen (daily)
- Household interactions (three time points: *Onset* of symptoms of the index case, *enrollment* in the study, *follow-up*)
- Participant's and household members' demography and vaccination status

Contact data modelling

Using exponential family random graph modeling[3] (ERGM), we analyzed physical contact patterns and identified associated covariates. We included in our model:

- Household size effect (# contacts, # triangles, and # 2-stars)
- Age specific mixing
- Index case status
- COVID-19 vaccination status

Parameters' estimates were obtained fitting jointly all households[3].

Epidemic modelling and model calibration

The best-fit models for physical contacts (at Onset/Enrollment/Follow-up) are used to generate contact networks that inform a two-level SEIR mixing model for the spread of SARS-CoV-2. Individuals can acquire infection:

- From outside the household (with a constant probability β_c)
- From an infected household member with whom they reported a contacts (with a probability β_{hh})

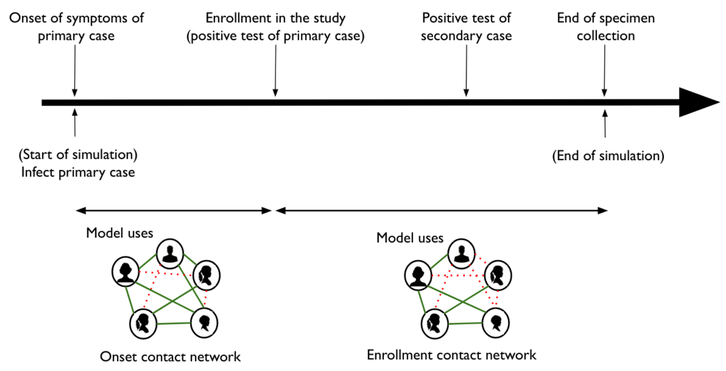
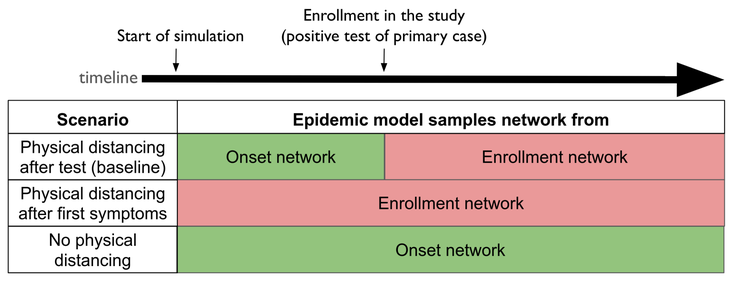


Figure 2: Timeline of the epidemic model

We calibrated the model maximising the likelihood of the observed secondary cases.

Impact of physical distancing

Different physical distancing strategies are evaluated varying the contact network



Scenario	Epidemic model samples network from	
Physical distancing after test (baseline)	Onset network	Enrollment network
Physical distancing after first symptoms	Enrollment network	
No physical distancing	Onset network	

Results

Household contact patterns

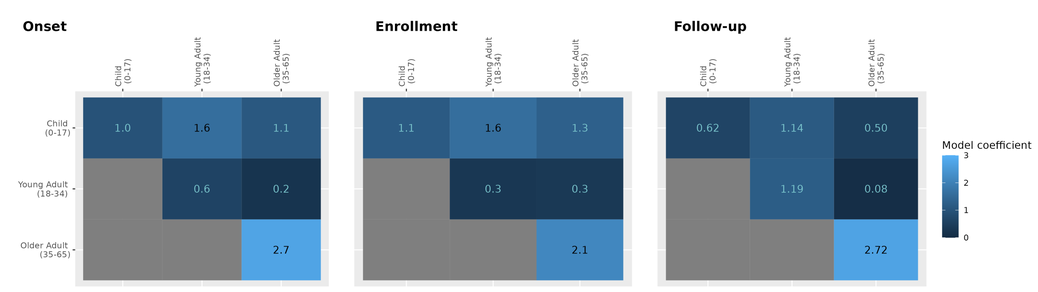


Figure 3: Model's estimates for physical contact between age categories.

The analysis of household physical contacts reveals:

- Reduction of contacts at enrollment (when positive test result)
- Strong age-specific mixing
- Avoidance to have physical contact with index case (only at enrollment)
- No impact of vaccination status

Epidemic modelling and impact of physical distancing

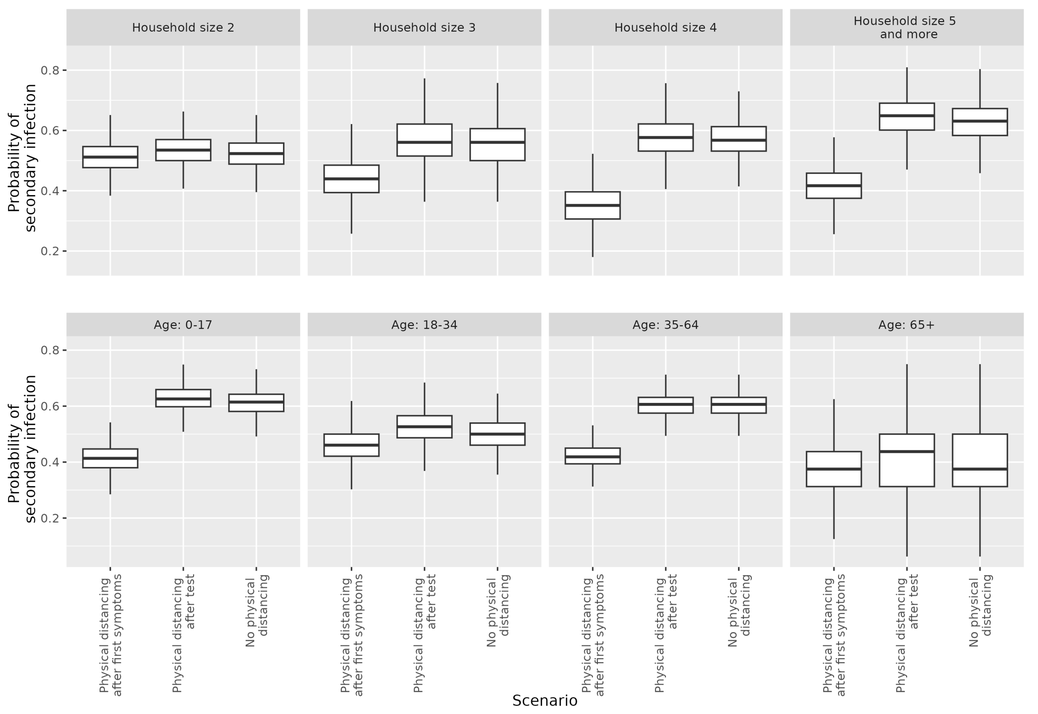


Figure 4: Probability of secondary infections after follow-up for the three scenarios, stratified by household size (top panel) and by age category of the secondary case (bottom panel).

Best fit parameters highlight higher probability of acquiring infection from infected household members than from the community ($\beta_{hh} = 0.16$, $\beta_c = 0.00118$).
There were no significant differences in secondary cases between *physical distancing after test* and when *no physical distancing* was adopted. The comparison of the *physical distancing after first symptoms* vs *physical distancing after test* shows significant reductions in secondary cases (22%, 39% and 35% for household sizes of 3, 4, and 5+, respectively). This reduction was highest for individuals aged 0-17 and 35-64.

Summary

- A laboratory-confirmed SARS-CoV-2 infection leads to a change in household physical contact patterns.
- Index case and household member physical contacts were reduced after becoming aware of a SARS-CoV-2 infection in the household.
- For prevention of secondary infections, reducing physical contacts after test results was similar to not implementing physical distancing at all
- If such a reduction in physical contacts would be implemented at first symptoms onset, a sizable number of secondary infections could be reduced.

References

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[2] H. Q. McLean, C. G. Grijalva et al. Pediatrics, 149(3), March 2022. DOI: 10.1542/peds.2021-054178.
[3] P. N. Krivitsky, P. Coletti & N. Hens (2023). Journal of the American Statistical Association, DOI: 10.1080/01621459.2023.2242627.