Understanding SARS-CoV-2using Contact Tracing and Household Data

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JOHNS HOPKINS
BLOOMBERG SCHOOL
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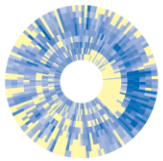

Infectious Disease
DYNAMICS
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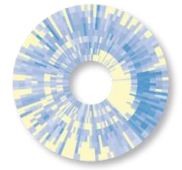
- **Theory** – How do disease systems likely behave under certain conditions?

- **Strategic Modeling** – How will intervention *X* work given conditions *Y*? Broadly, what are the critical scenarios we should be planning for?

- **Inference** – What do observed trends tell us about the nature of the disease and the effectiveness of our control measures?

- **Forecasting** – What is the likely future course of the epidemic?



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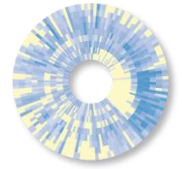
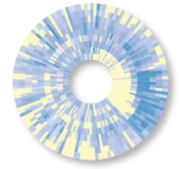


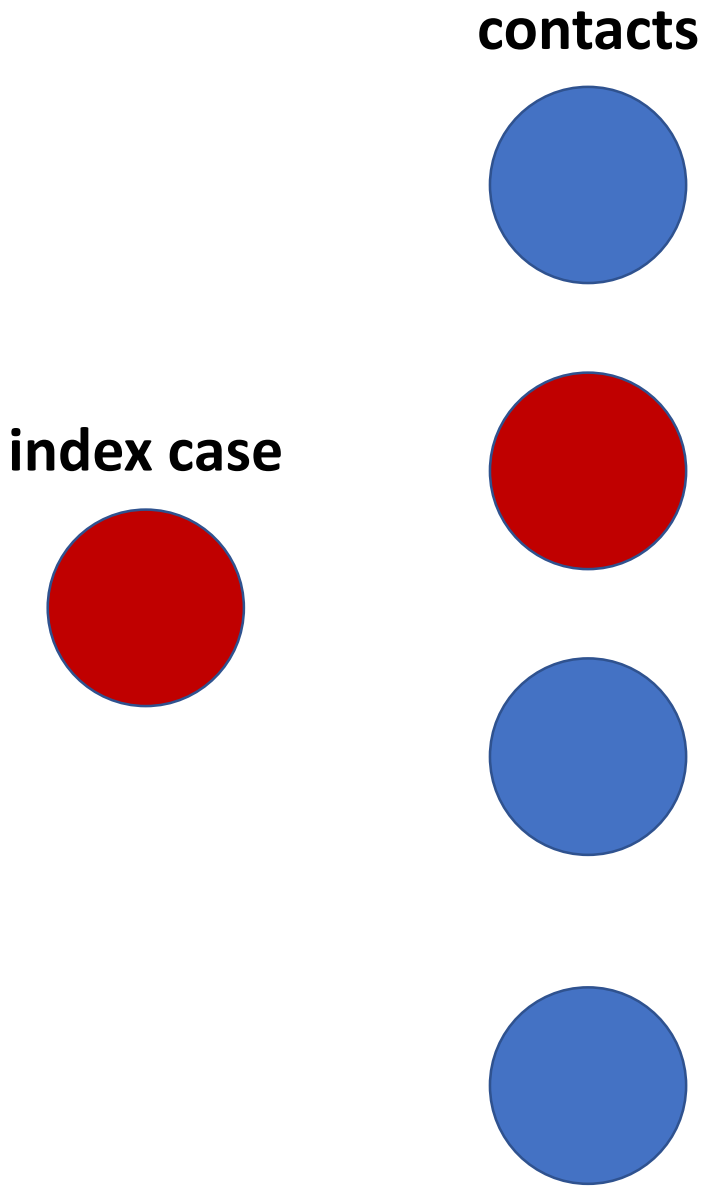
Inference for Policy

- **How long do should we quarantine/monitor potential cases?**
  - How long is it before cases show symptoms?
- **How quickly will the disease move and how intensely must we respond?**
  - How effectively does SARS-CoV-2 transmit?
  - How quickly does it move between individuals?
- **What types of interventions are likely to work and who should they target?**
  - Does risk differ by individual characteristics or exposure type?
  - What is the possibility of asymptomatic spread?

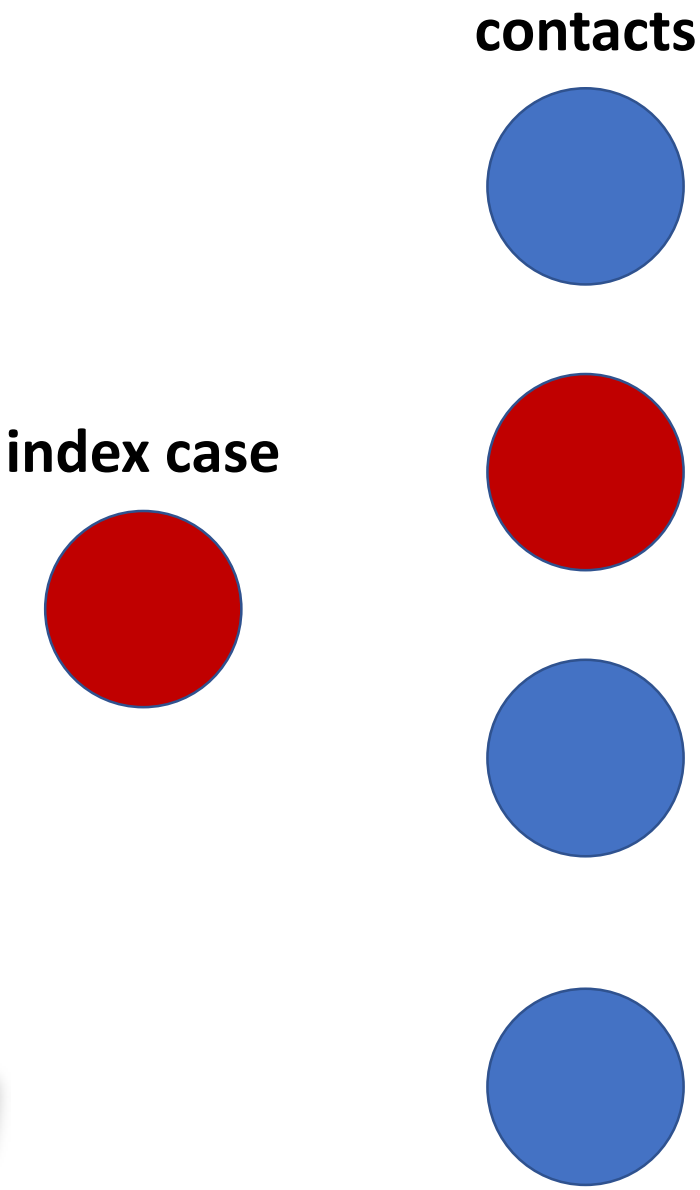


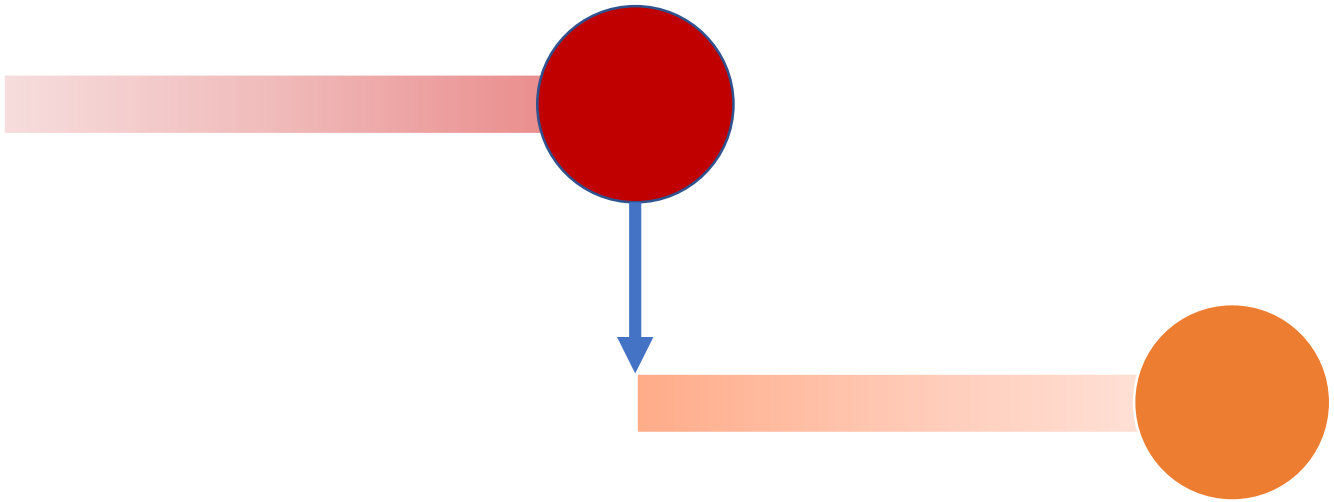
The Data: Contact Tracing Studies

- Conducted as part of the public health response.
- Finds people exposed to a particular index case.
- Defines clear risk sets and bound time of infection, particularly early in an epidemic.



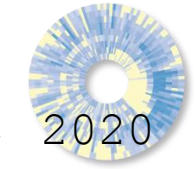
Models of Individual Transmission





Early Contact Tracing Data from Shenzen China

Contact type: household									
No	456	4	0·9% (0·3–2·2)	Ref	..	..	Ref	..	..
Yes	686	77	11·2% (9·1–13·8)	15·10	3·69	61·69	6·27	1·49	26·33
Contact type: travel									
No	824	63	7·6% (6·0–9·7)	Ref	..	..	Ref	..	..
Yes	318	18	5·7% (3·6–8·8)	9·13	1·85	45·08	7·06	1·43	34·91
Contact type: meal									
No	435	20	4·6% (3·0–7·0)	Ref	..	..	Ref	..	..
Yes	707	61	8·6% (6·8–10·9)	23·01	2·51	211·2	7·13	0·73	69·32
Contact frequency									
Rare	230	1	0·4% (0·02–2·4)	<0·0001	0	Inf	..	..	..
Moderate	305	9	3·0% (1·6–5·5)	Ref	..	..	..	..	..
Often	555	71	12·8% (10·3–15·8)	8·8	2·58	30·06	..	..	..



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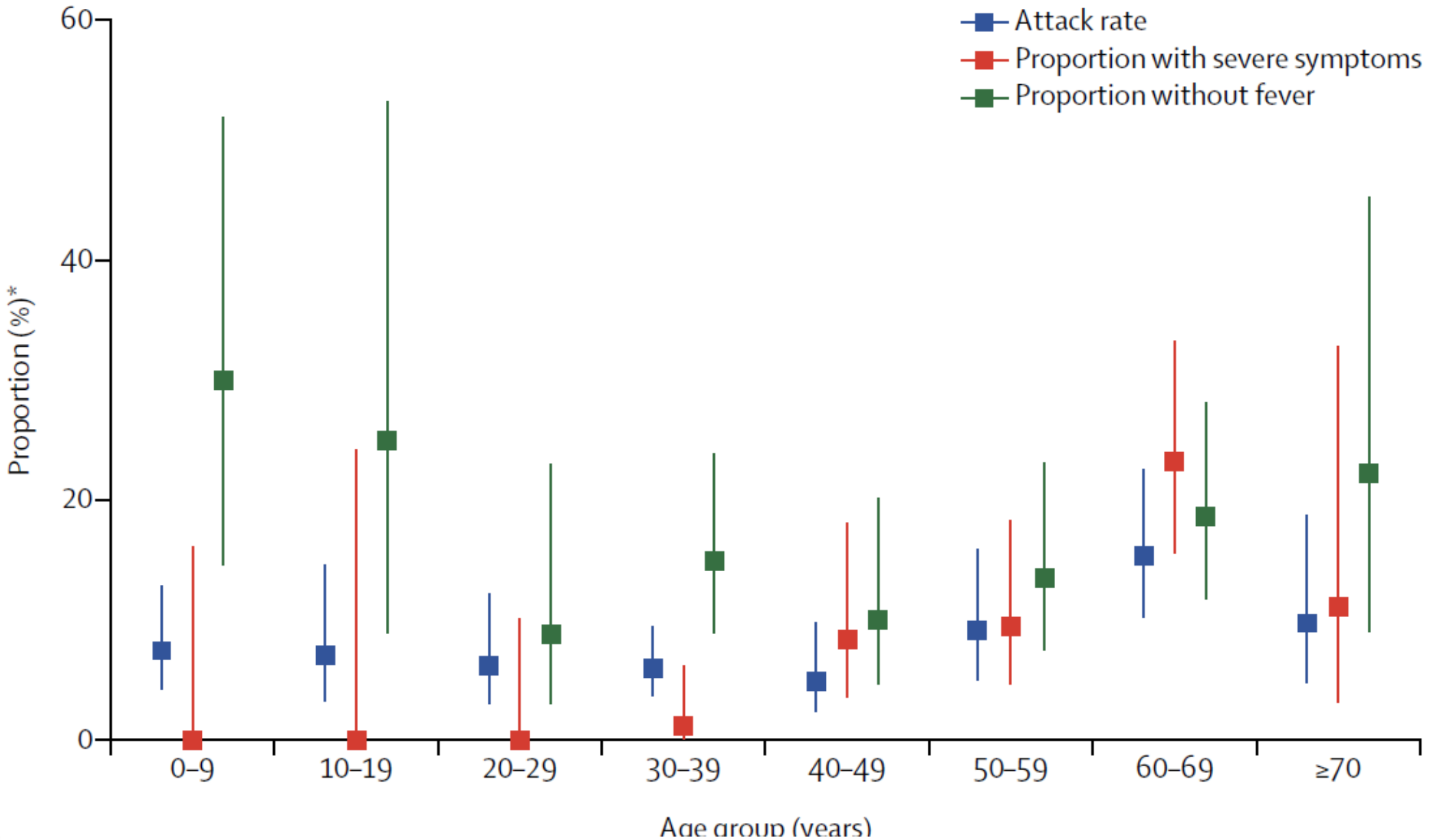
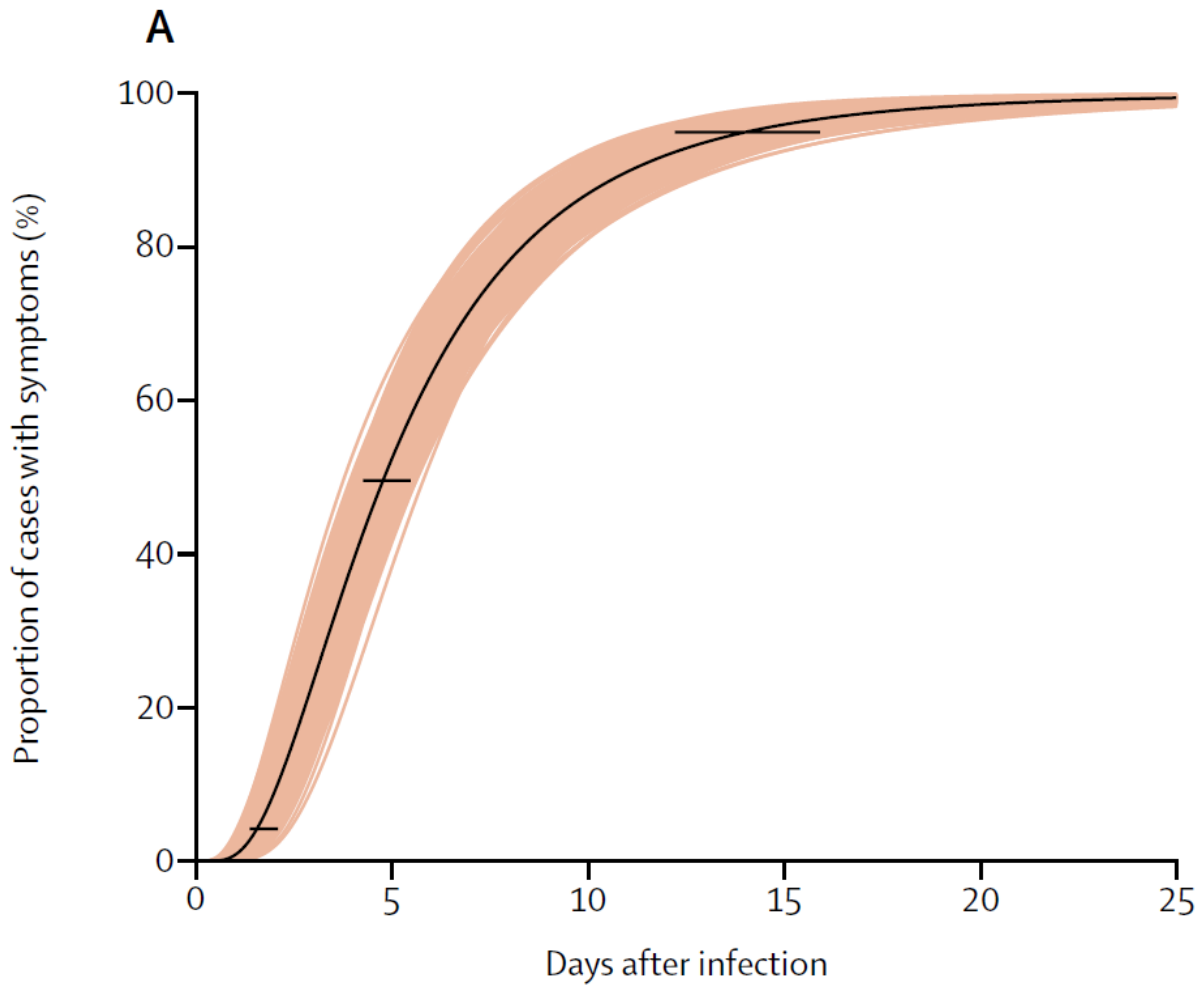
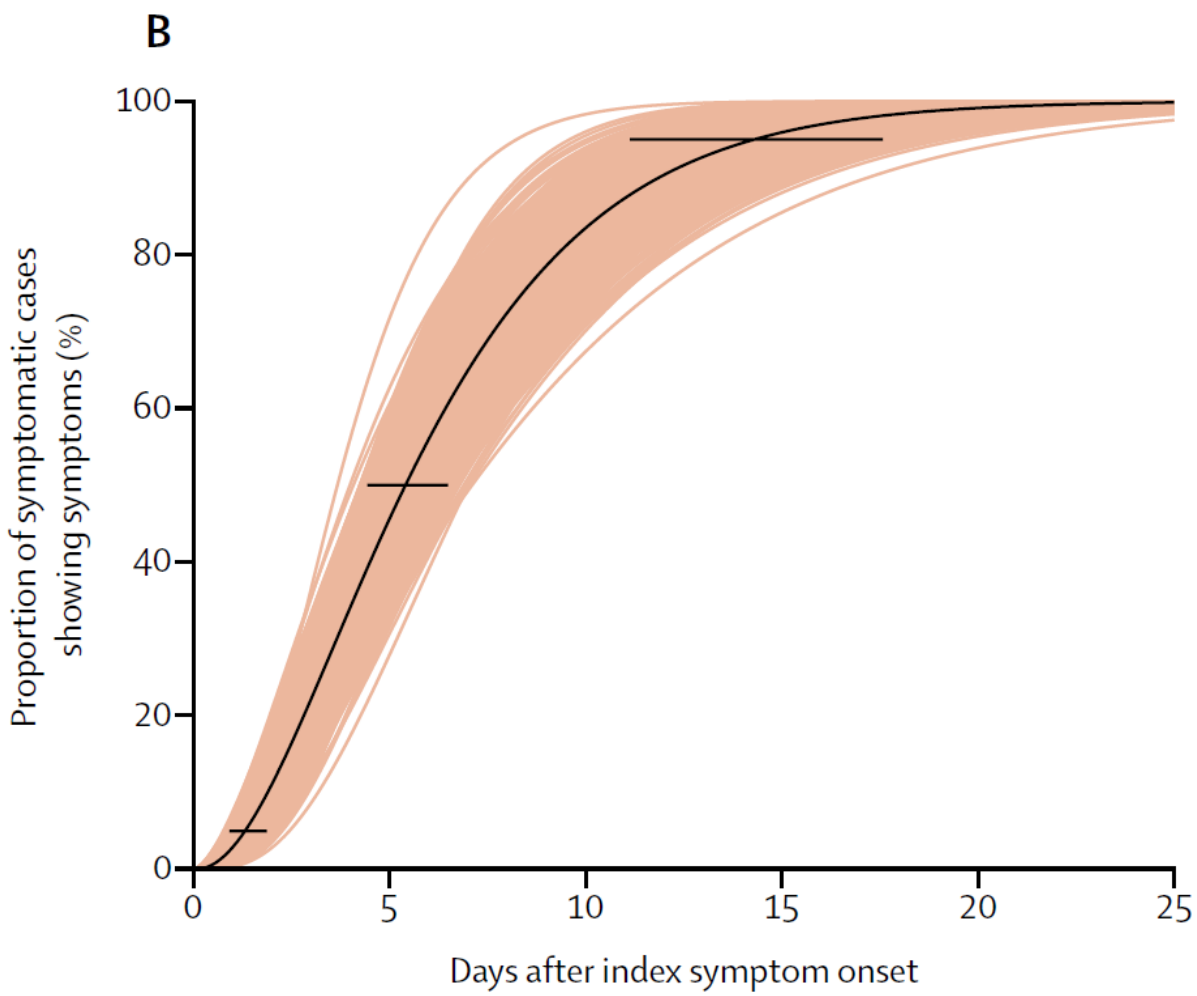

Attack rate
Proportion with severe symptoms
Proportion without fever
Proportion (%)*
60
40
20
0
0–9
10–19
20–29
30–39
40–49
50–59
60–69
≥70
Age group (years)

Bi et al., 2020





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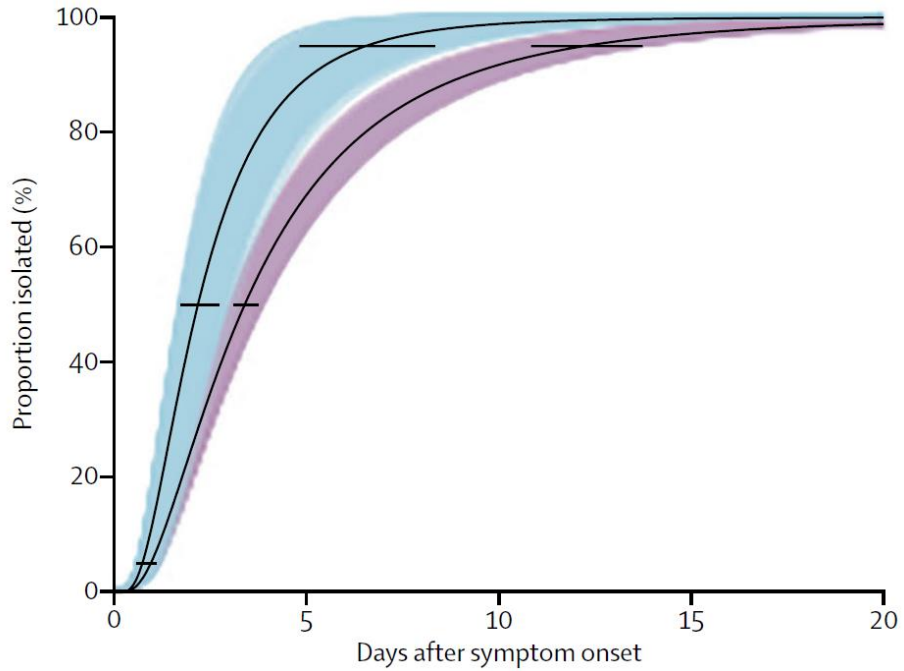

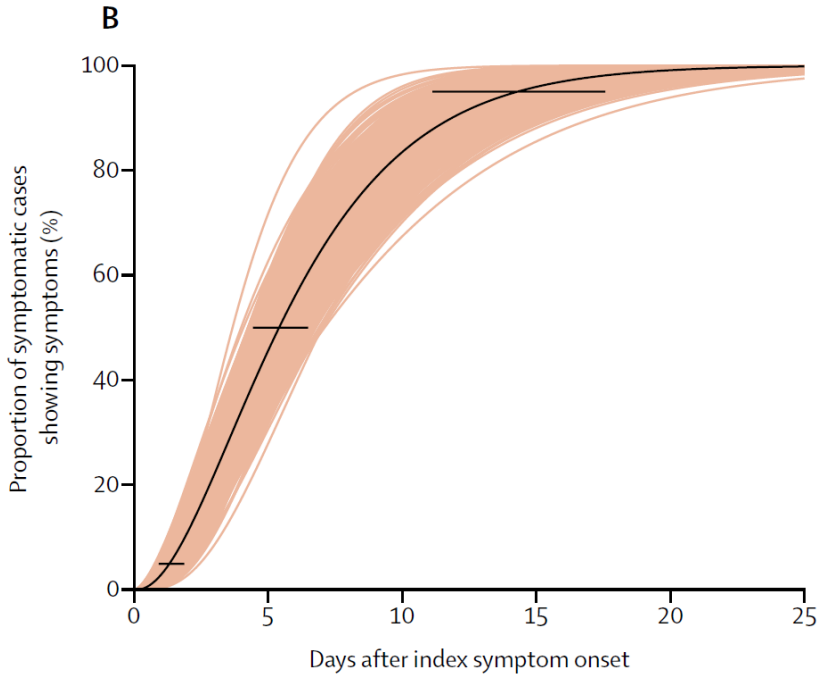

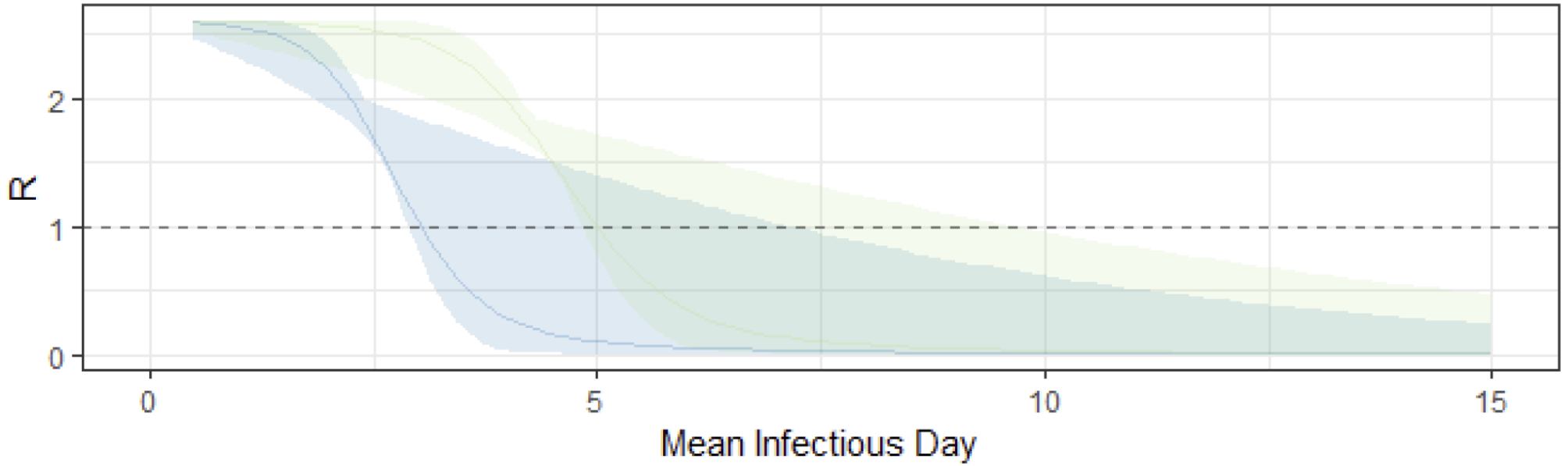

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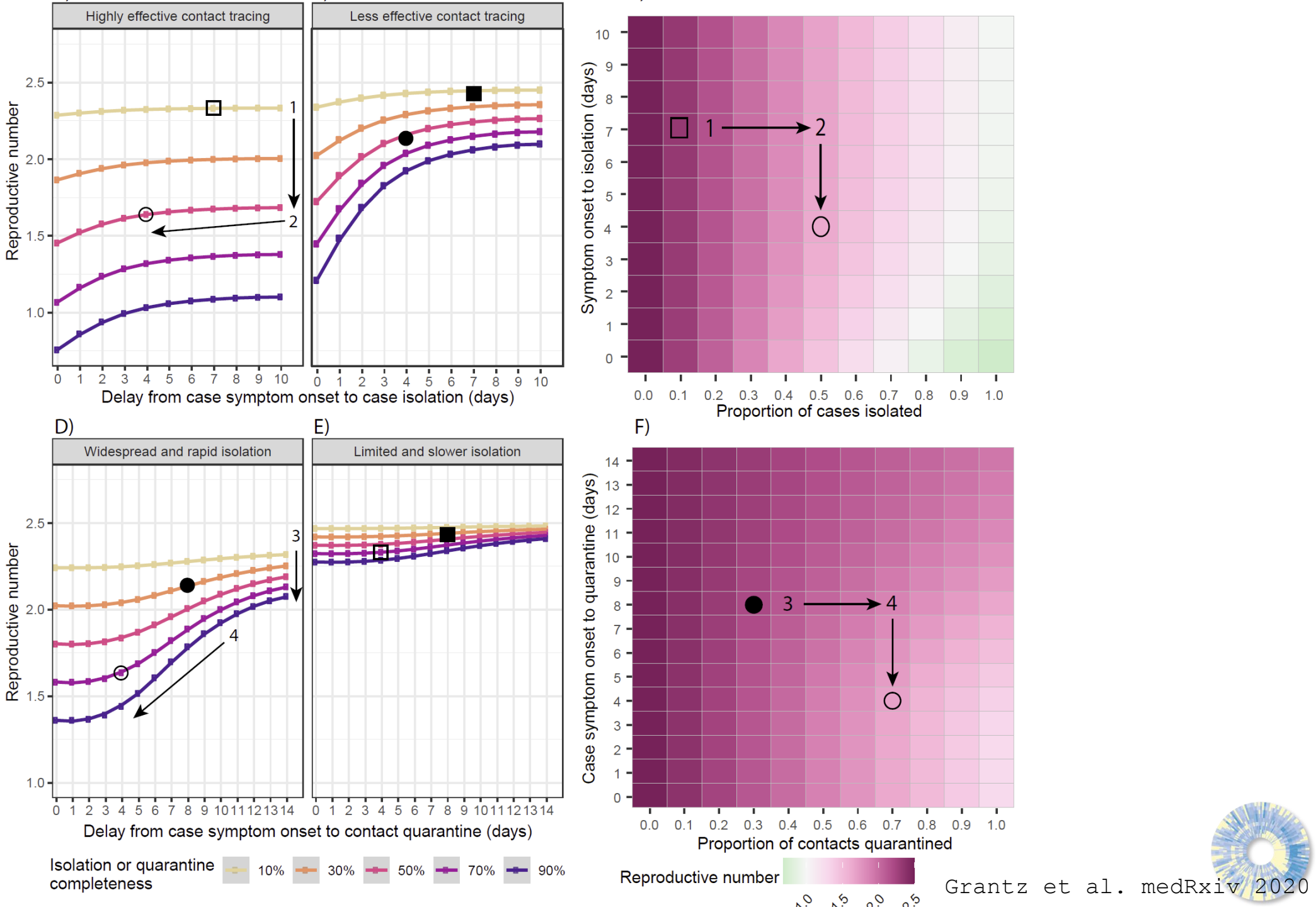

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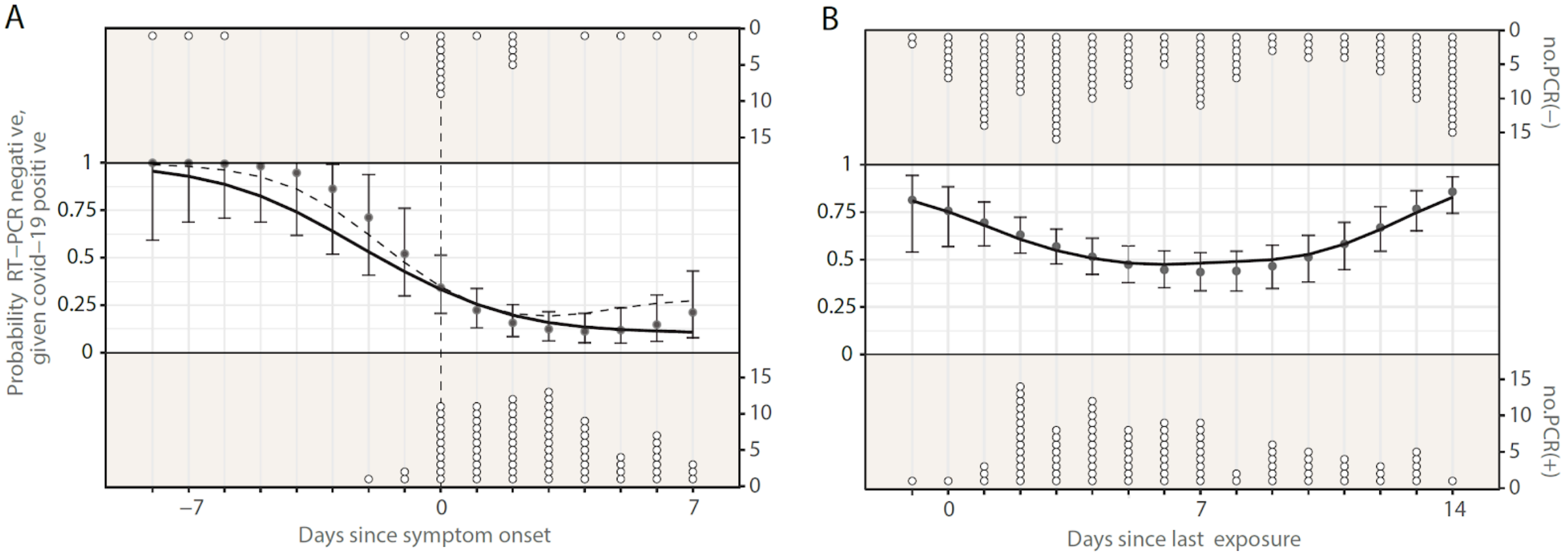
Advantages and shortcomings of contact tracing data

Advantages

- Temporal information
- Detailed and timely data collection
- Fast results and ongoing results

Shortcomings

- Index cases almost always symptomatic
- Sampling biased towards close contacts
- Missed infections (particularly asymptomatic)
- Lose utility as epidemic becomes widespread.



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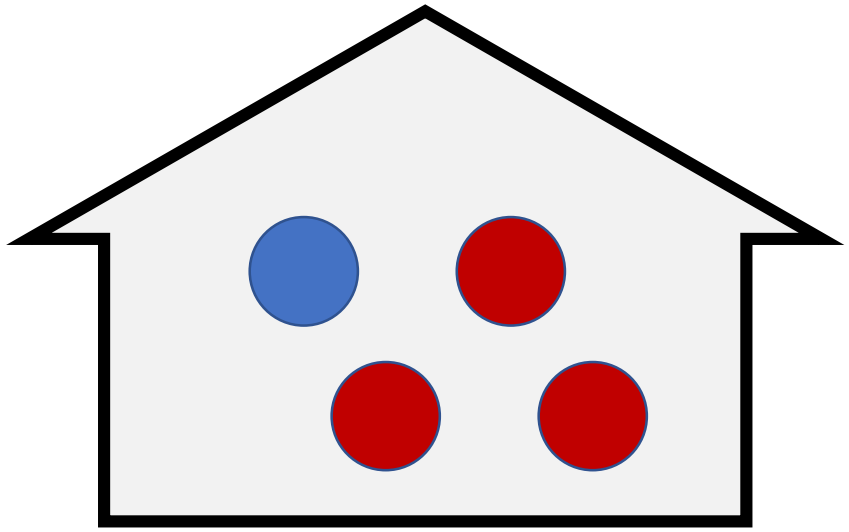
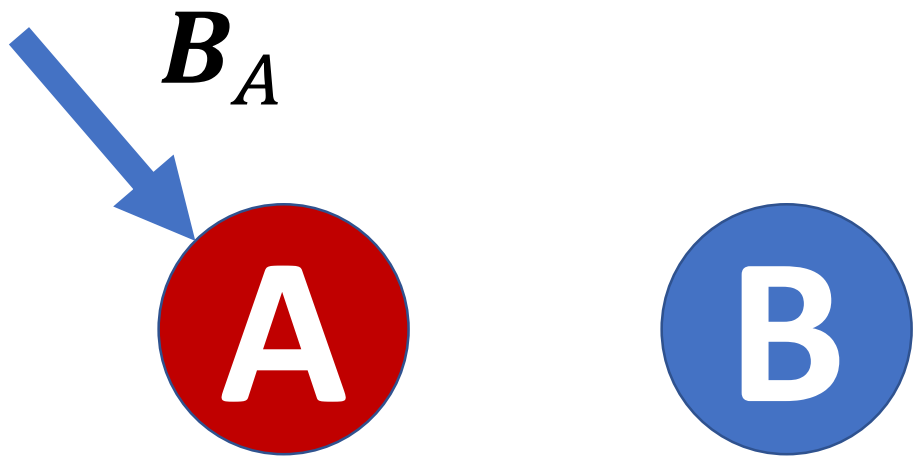
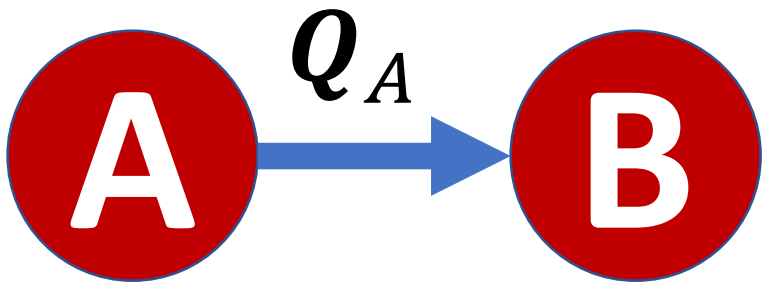
The Data: Household Serological Studies

- Serological tests of complete households late in or after an epidemic wave.
- In most cases gives more complete data on total attack rates than virologic or symptomatic information.
- Immunologic response may be heterogenous.
- No temporal information.
- Problems with recall bias.



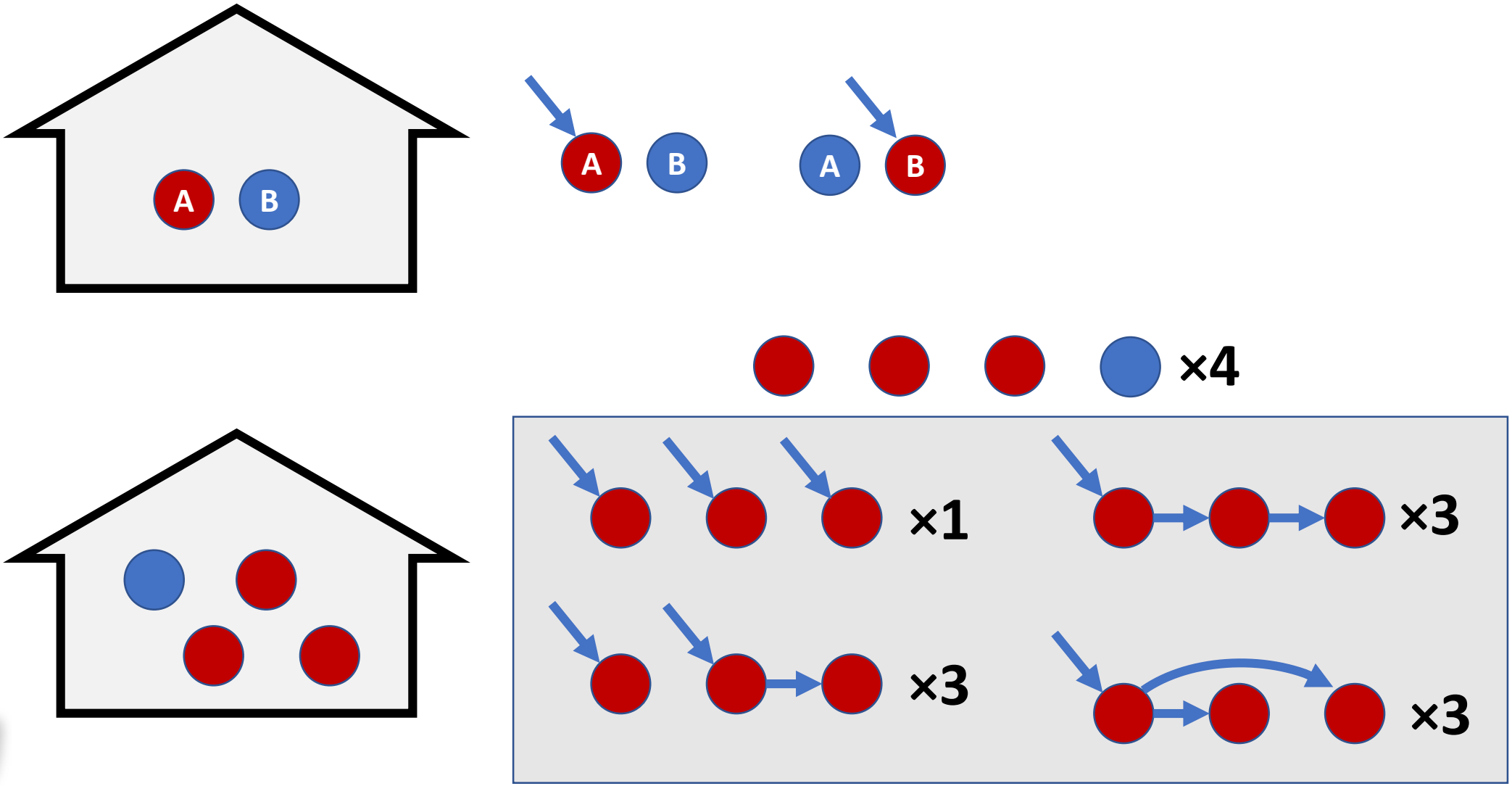
The Model: Chain Binomial Models

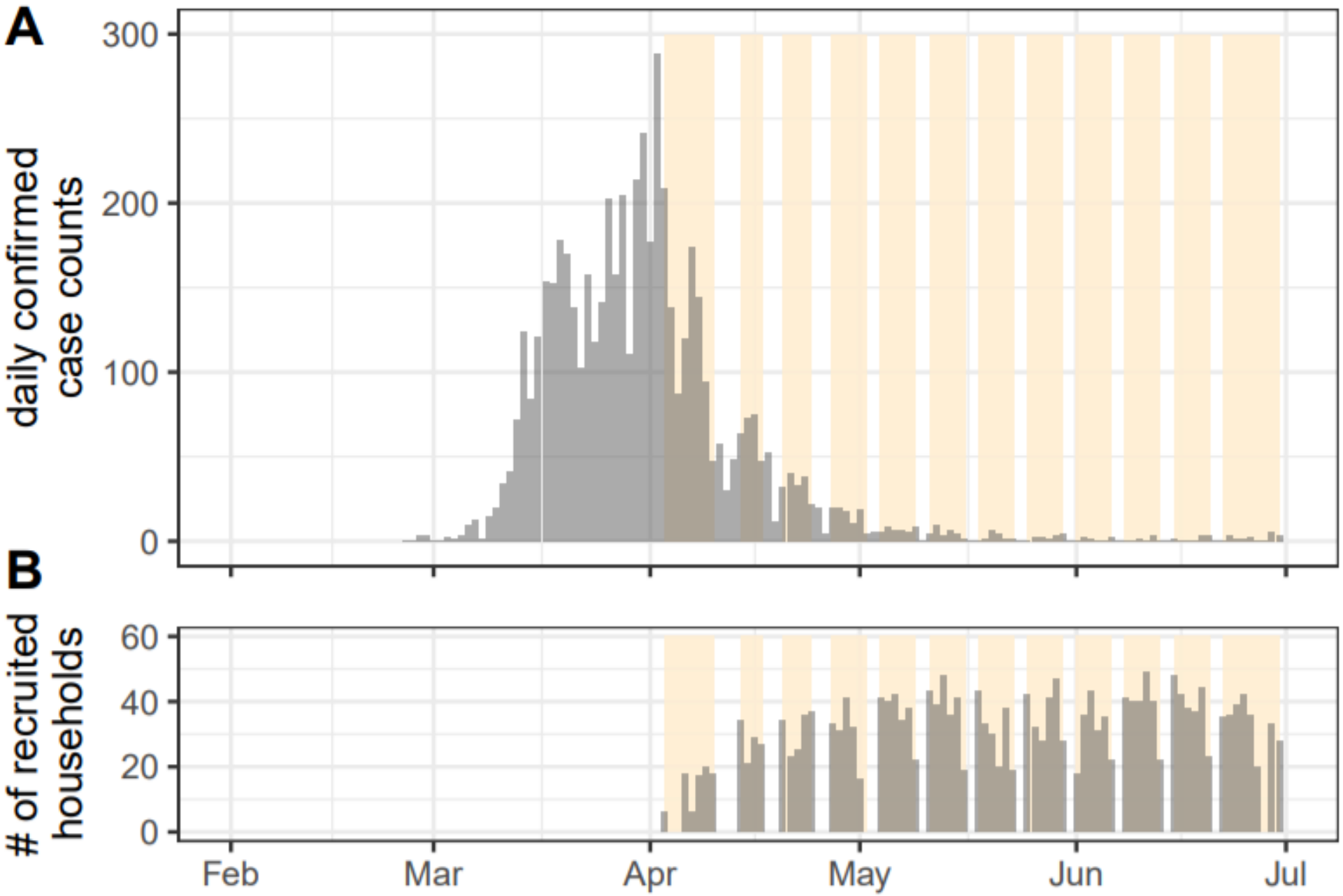




$$(1 - Q_{AC})(1 - Q_{BC})$$

The Model: Chain Binomial Models





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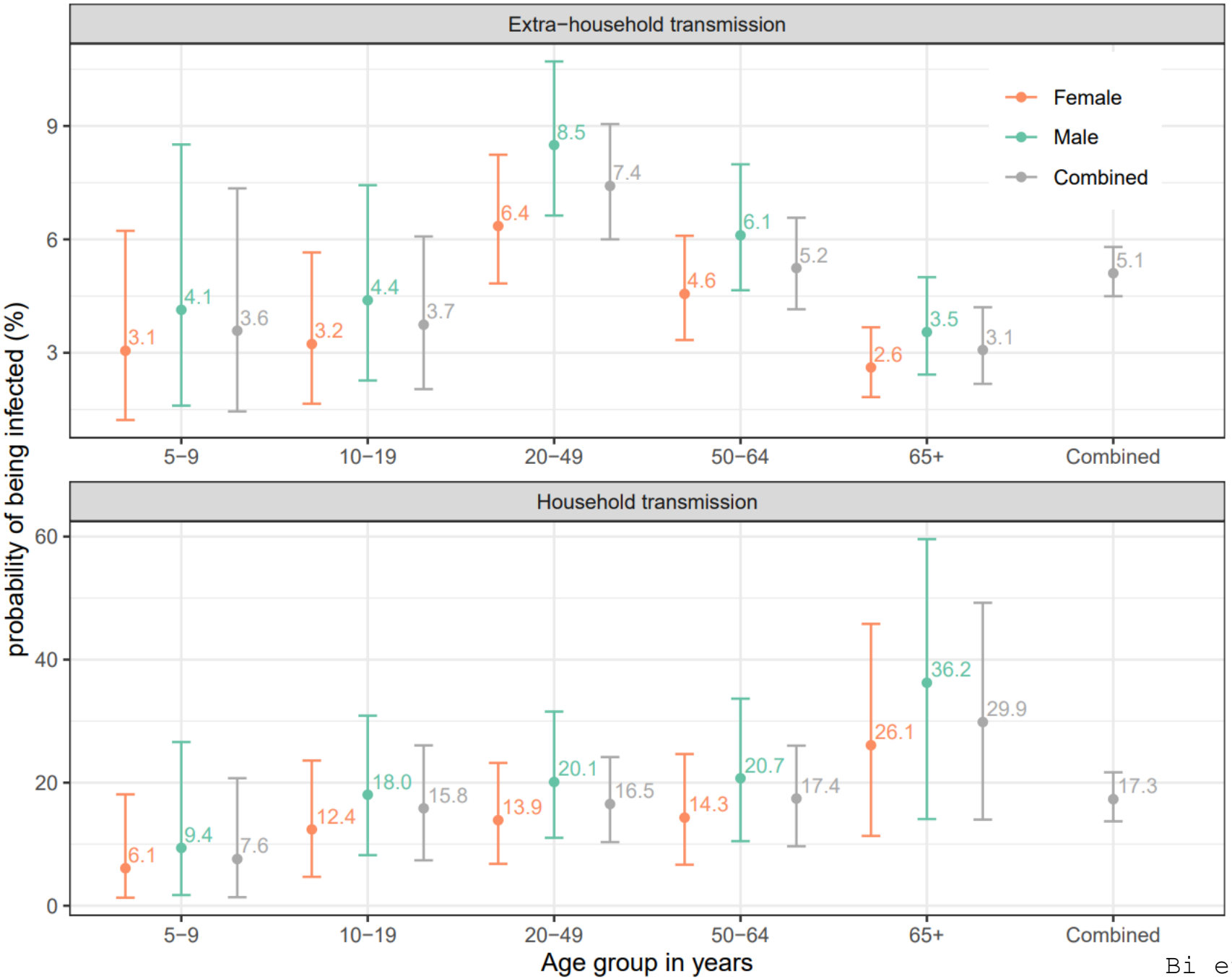

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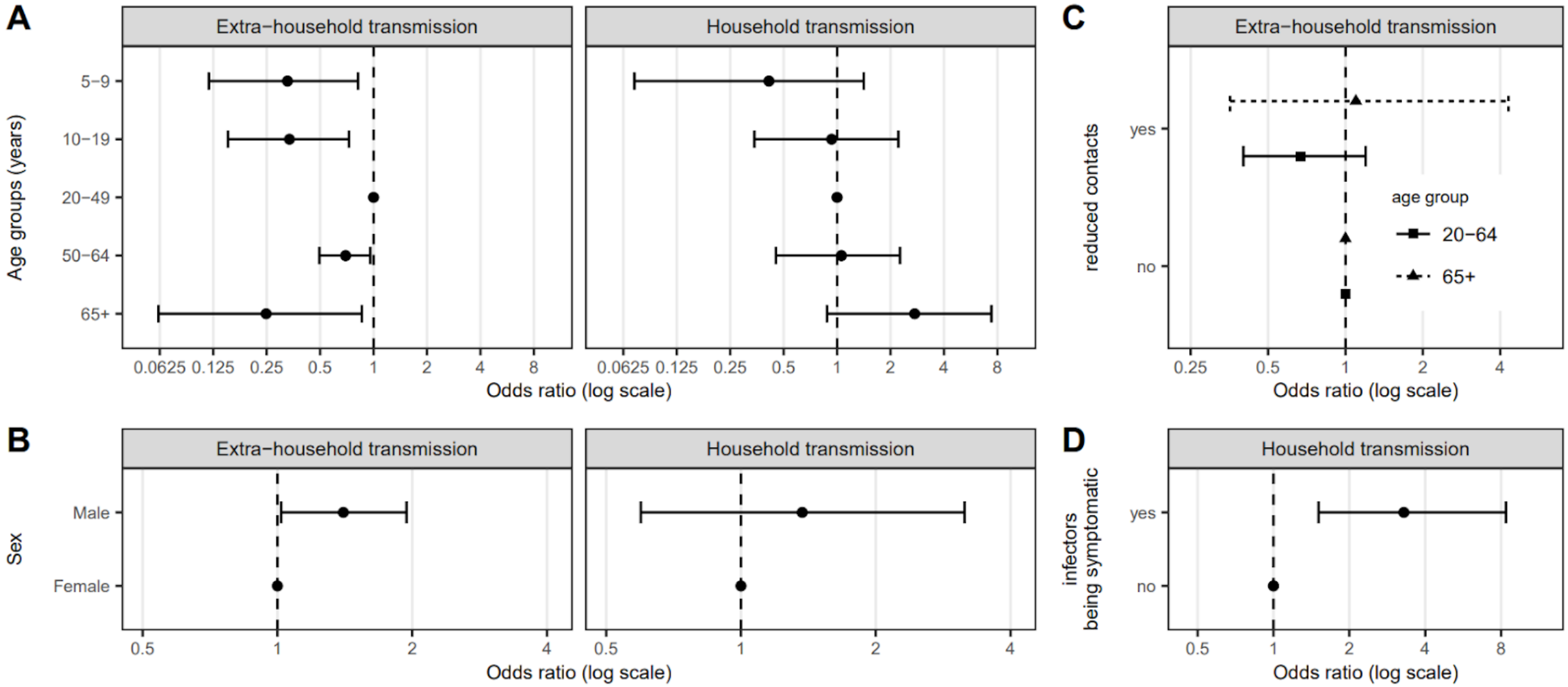

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Implications for Policy and Control

- Test-trace-isolate can have some impact on spread
  - Effects limited by speed and ability to test.
- Young children are less likely to be infected
  - But not by that much
  - High exposures in schools may overwhelm
- Asymptomatic individuals are less likely to infect others
  - But still cause 15% of household infections
  - Proportion like much higher across households
- Household contacts have the highest probability of transmission
  - But community HH structure may minimize attributable fraction

Thank You!

- **Shenzhen Close Contacts:** Qifang Bi, Yongsheng Wu, Shujiang Mei, Chenfei Ye, Xuan Zou, Zhen Zhang, Xiaojian Liu, Lan Wei, Shaun A. Truelove, Tong Zhang, Wei Gao, Cong Cheng, Xiujuan Tang, Xiaoliang Wu, Yu Wu, Binbin Sun, Suli Huang, Yu Sun, Juncen Zhang, Ting Ma, Tiejian Feng
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