HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH

Projecting the transmission dynamics of SARS-CoV-2 through the post-pandemic period

Marc Lipsitch

NISS-ASA Symposium

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Center for Communicable Disease Dynamics

MIDAS Models of Infectious Disease Agent Study

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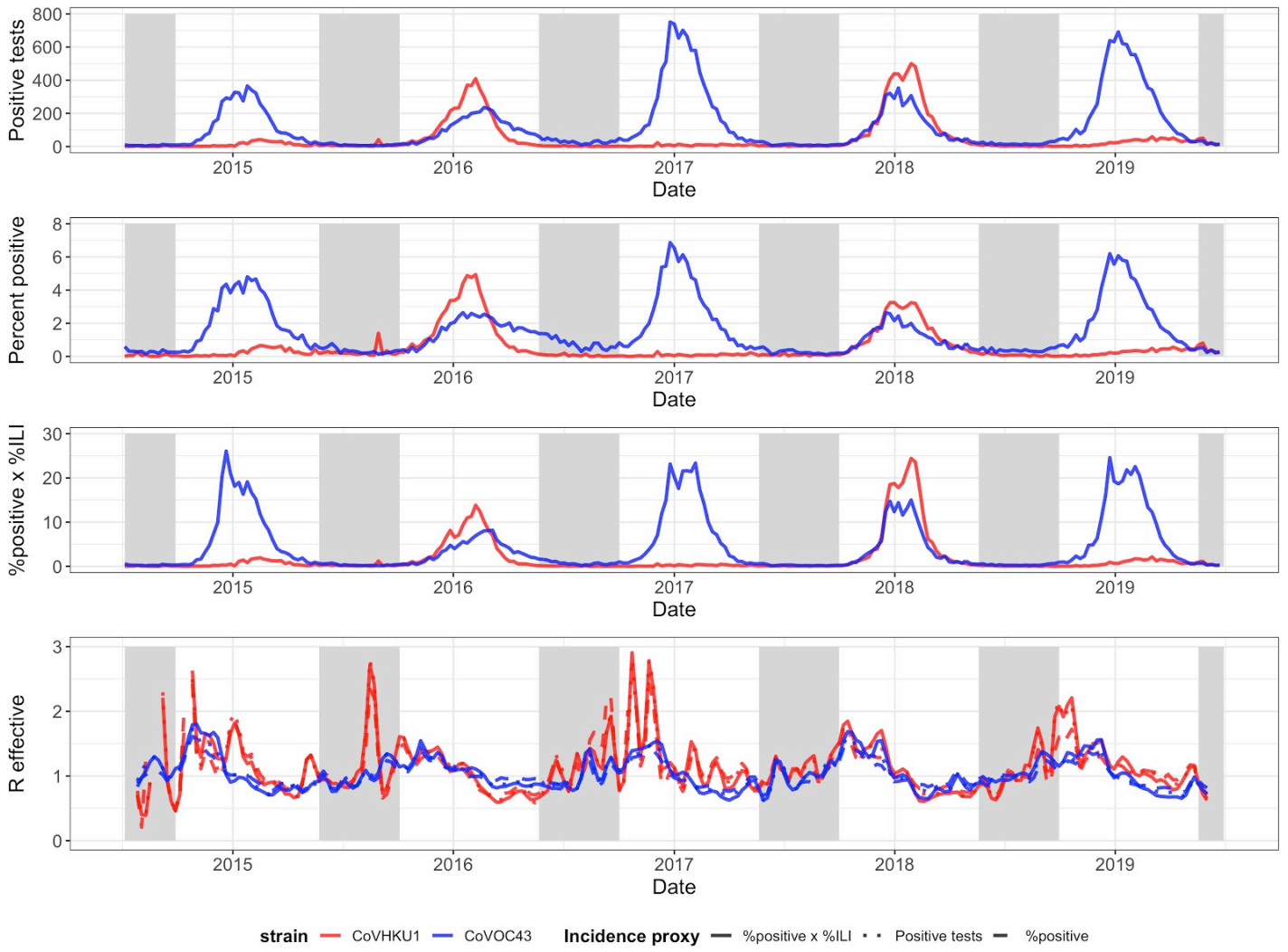
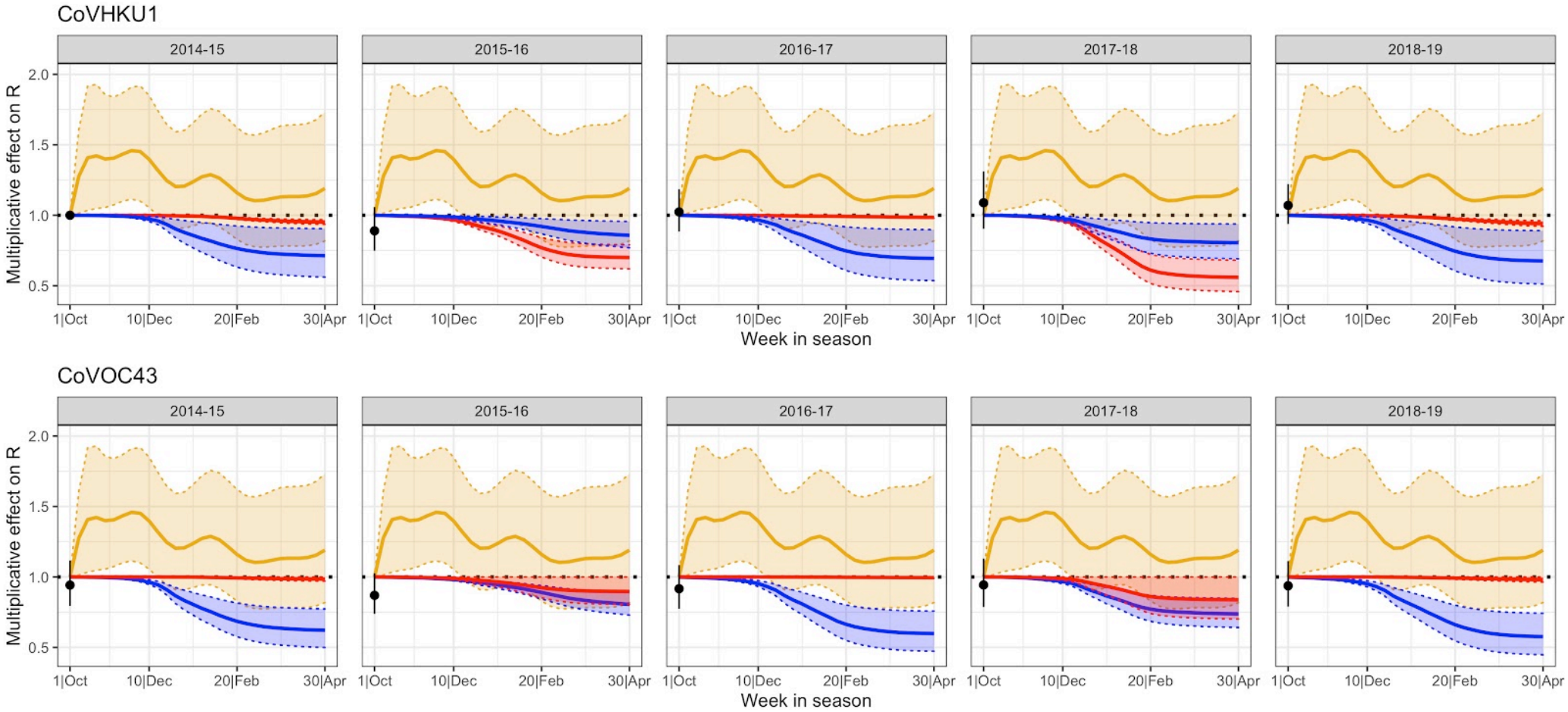
1. Estimating seasonality of betacoronaviruses

Beta coronavirus incidence in the US

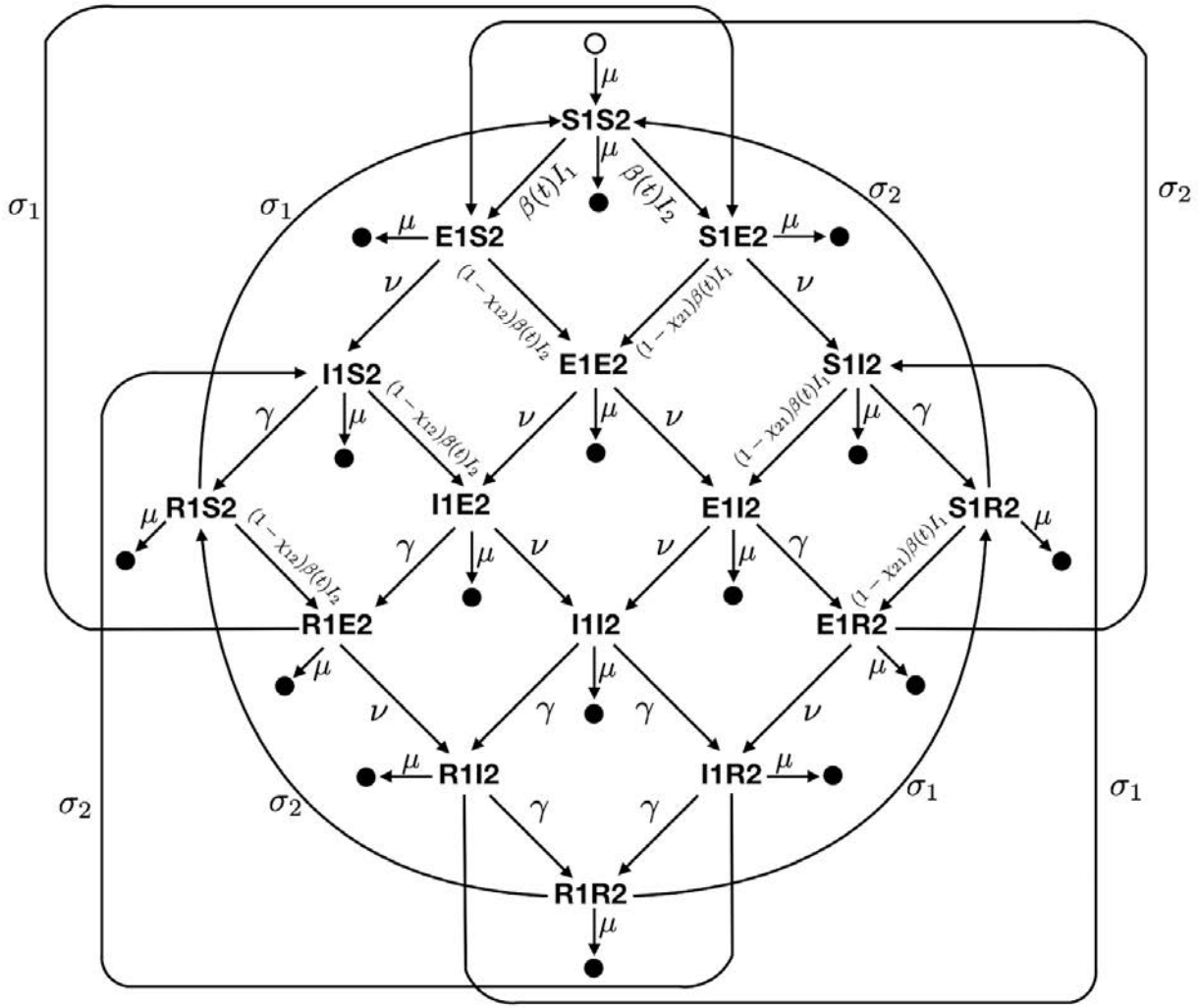


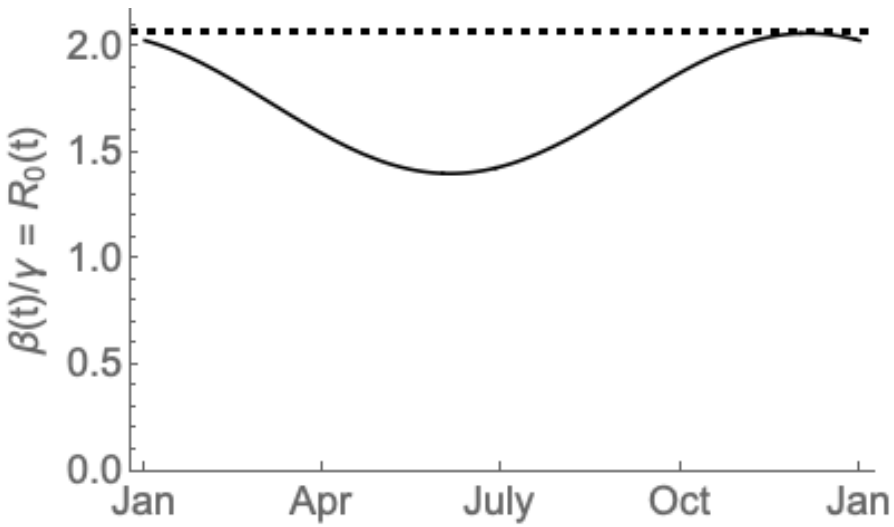
Decomposing R_e



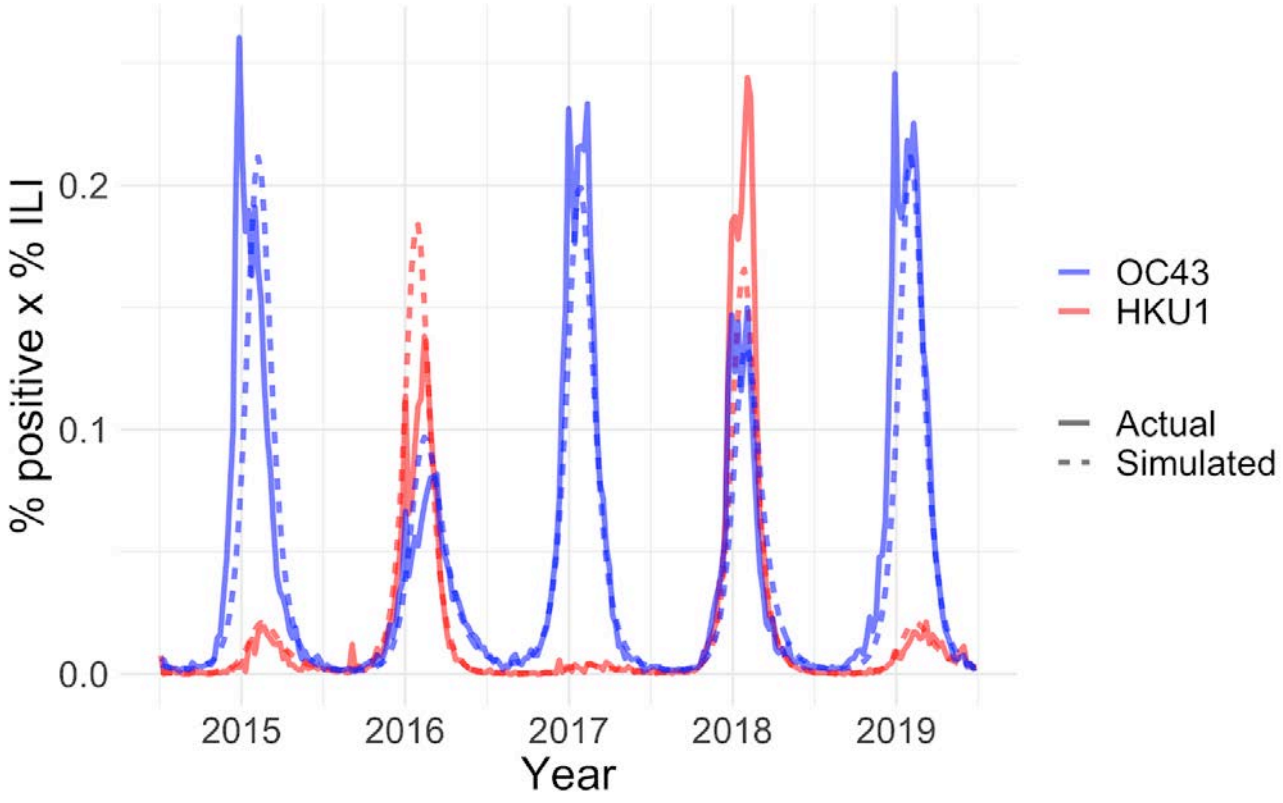
$$log(R_{sij}) = log(R_0 S_0) + \alpha_{sj} + \lambda_s d_{sij} + \delta_s d_{rij} + \sum_{n=1}^{10} \theta_n B_n(i) + \epsilon_{sij}$$

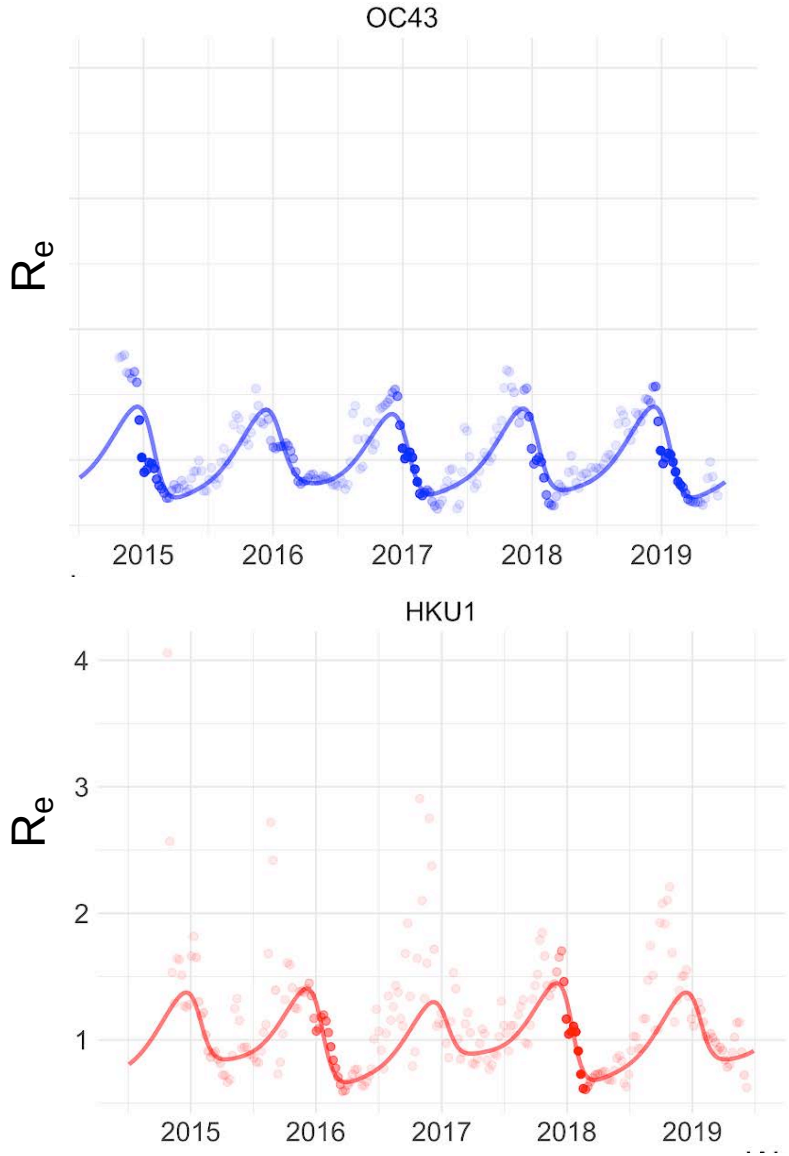
Transmission model





Model fit


% positive x % ILI
0.2
0.1
0.0
2015
2016
2017
2018
2019
Year
OC43
HKU1
Actual
Simulated


OC43
R_e
2015
2016
2017
2018
2019
HKU1
R_e
4
3
2
1
2015
2016
2017
2018
2019

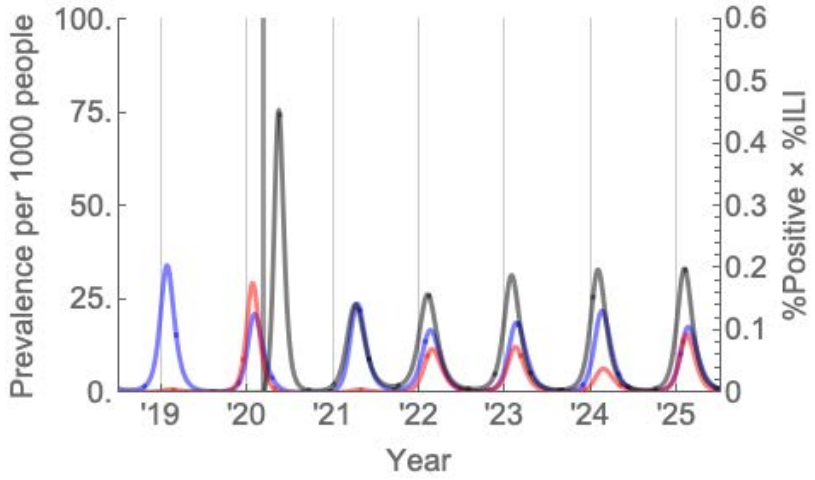
Seasonality of betacoronaviruses

- 21% best fit amplitude of seasonal forcing
- Rest is accounted for by depletion of susceptibles
- This would not be enough alone to control SARS-CoV-2 in summer
- Limitations: incidence proxy, national data, lack of mechanism
- For excellent work on early evidence of SARS-CoV-2 seasonality see preprings of Tamma Carleton (Chicago) and Mauricio Santillana (Harvard)

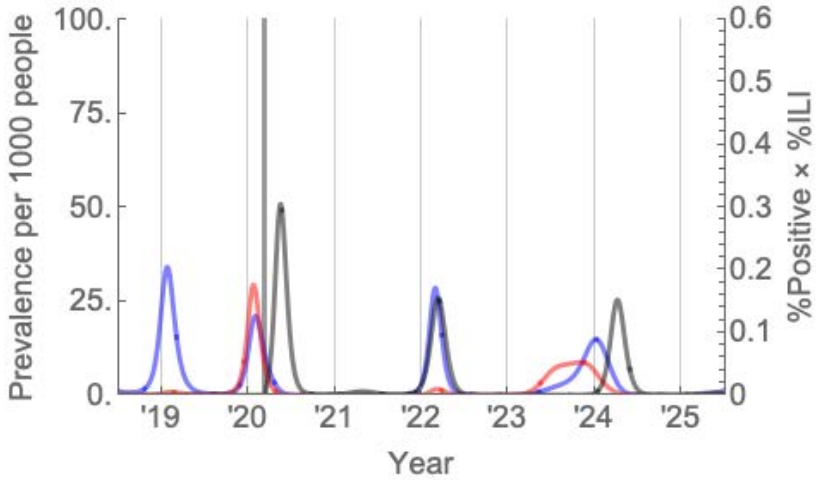
2. Projecting with and without intervention

Scenarios

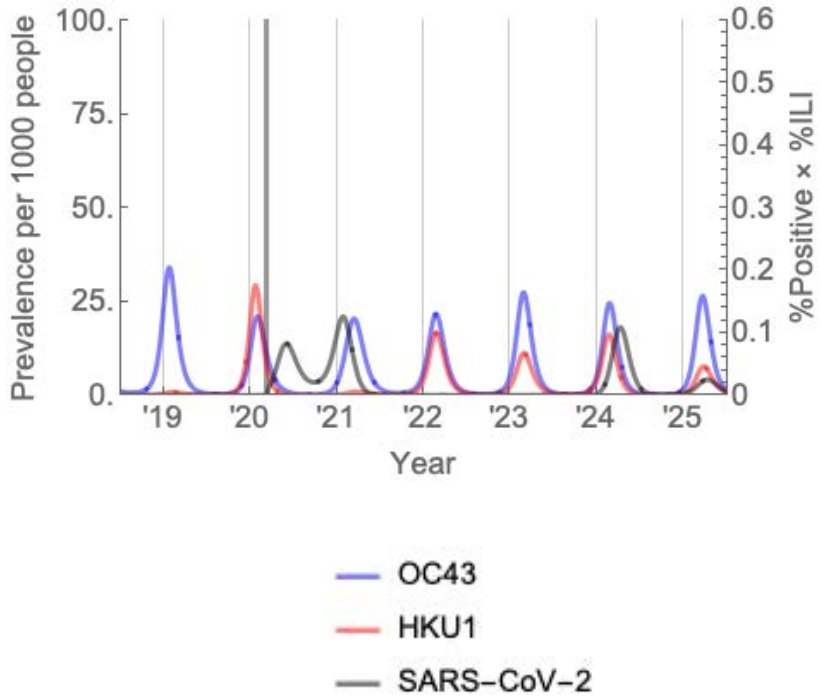
Short immunity: annual outbreaks



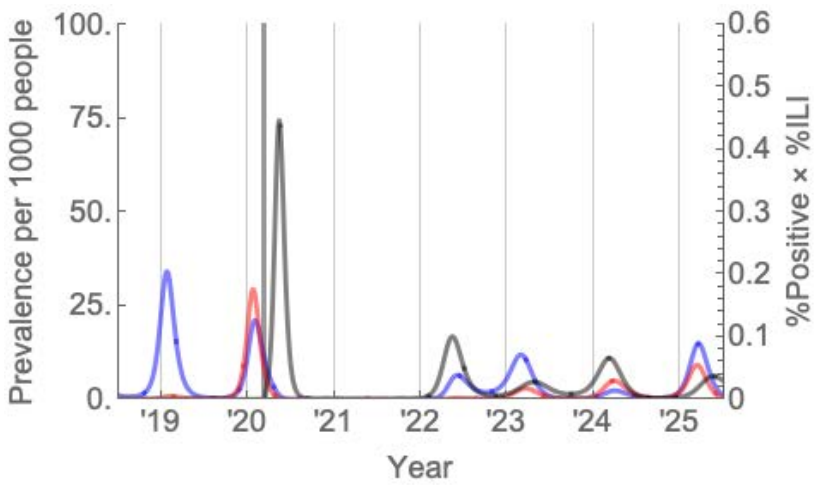
More seasonality: more punctuated outbreaks



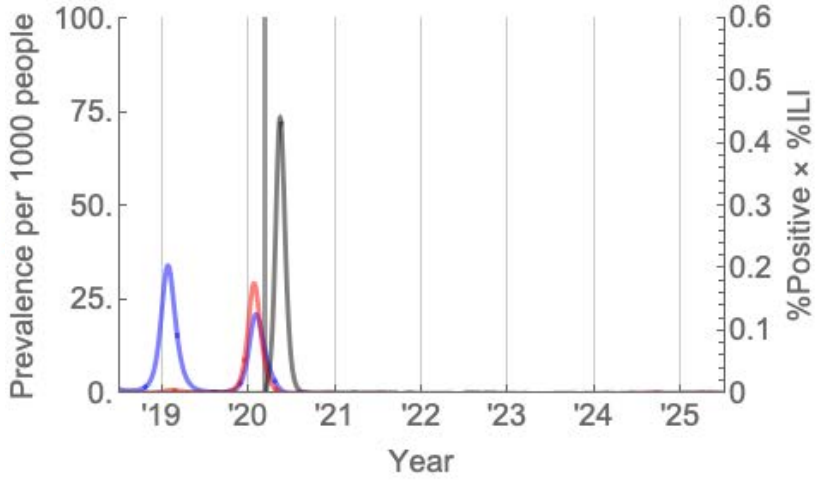
Cross immunity: possible resurgence



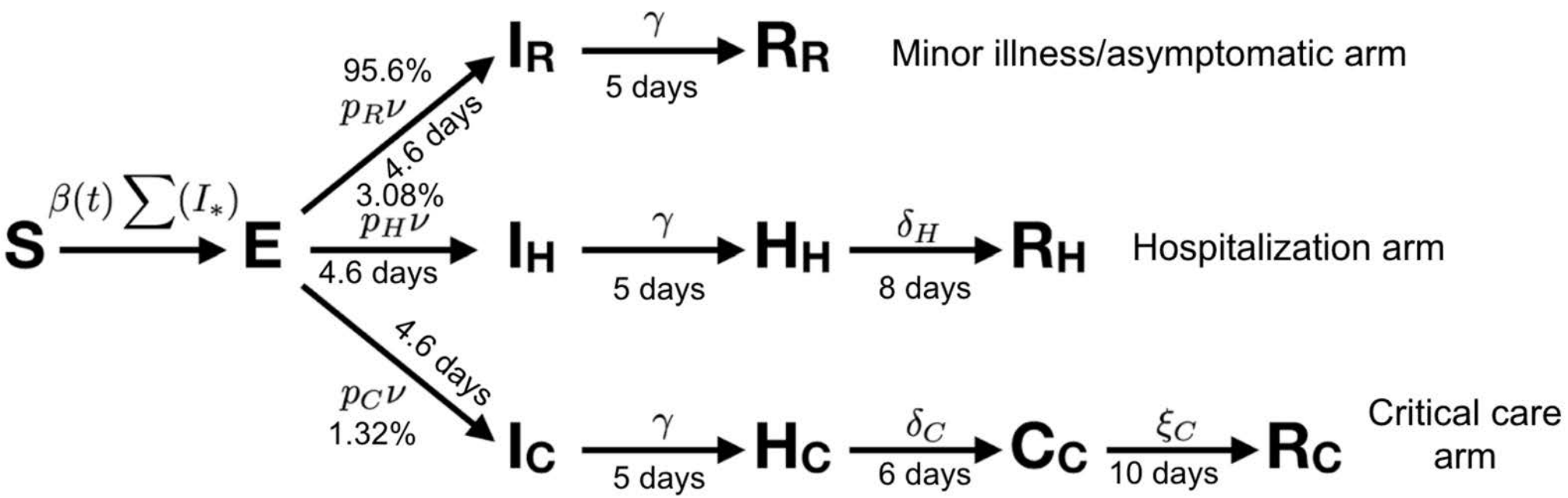
Longer immunity: sporadic outbreaks



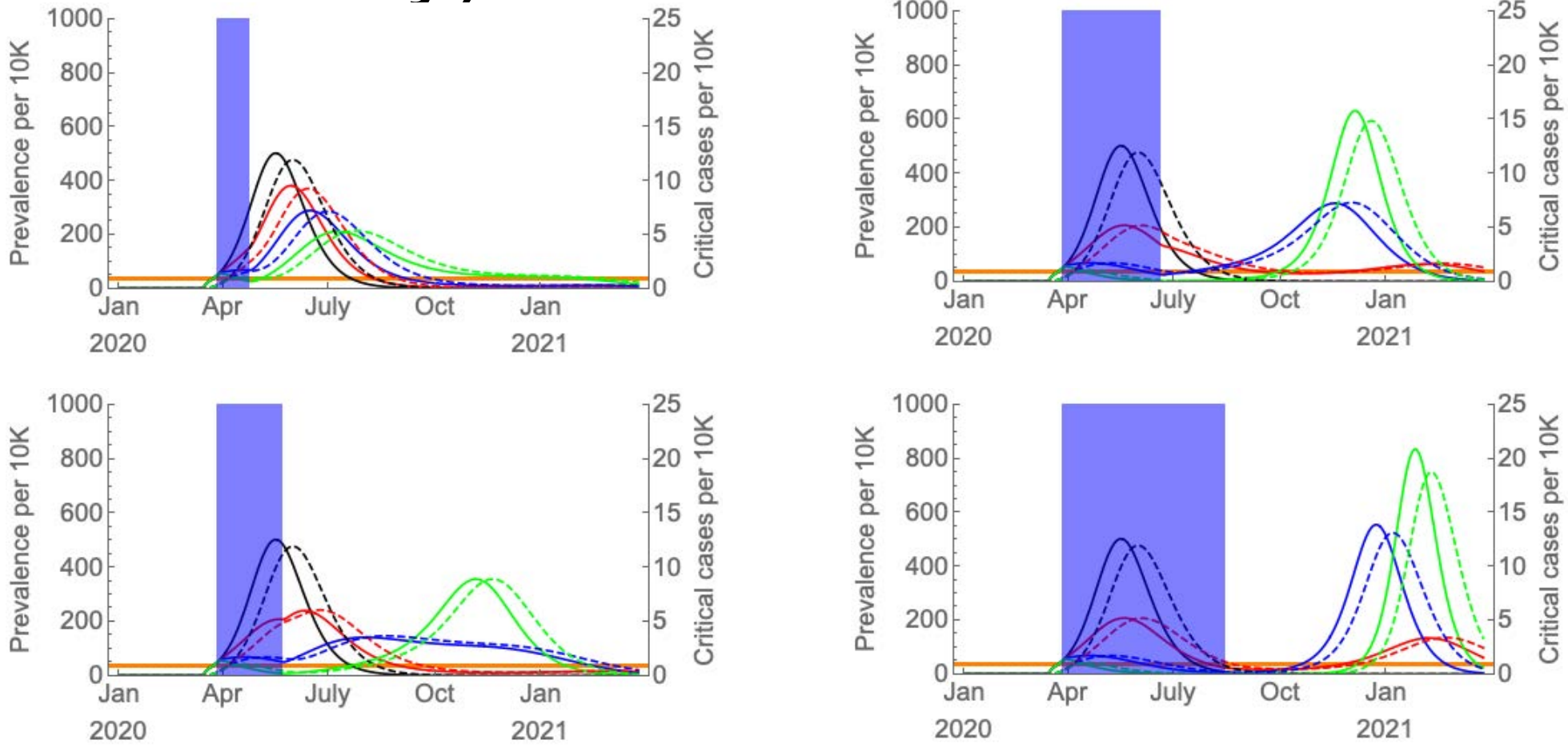
Permanent immunity: elimination



Interventions

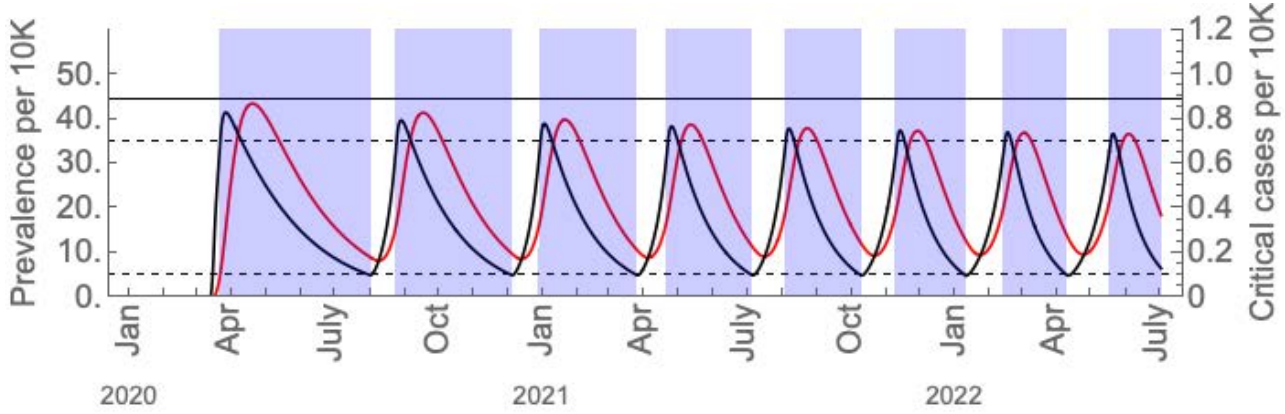


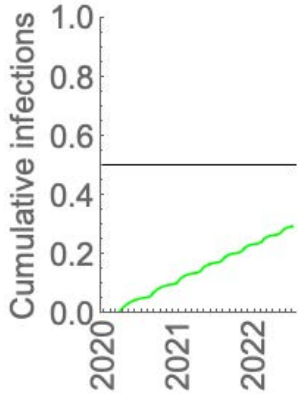
One-time social distancing (with seasonality)



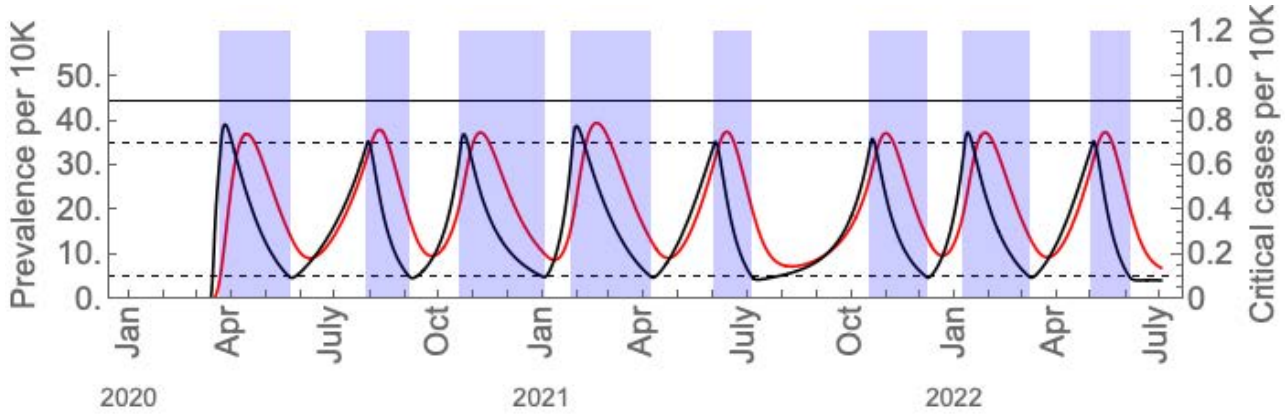
Intermittent social distancing

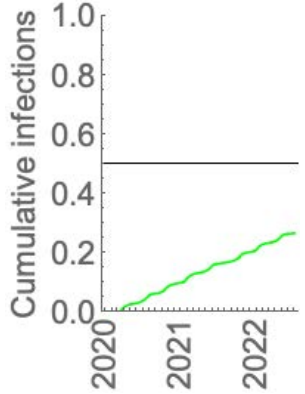
No seasonality:





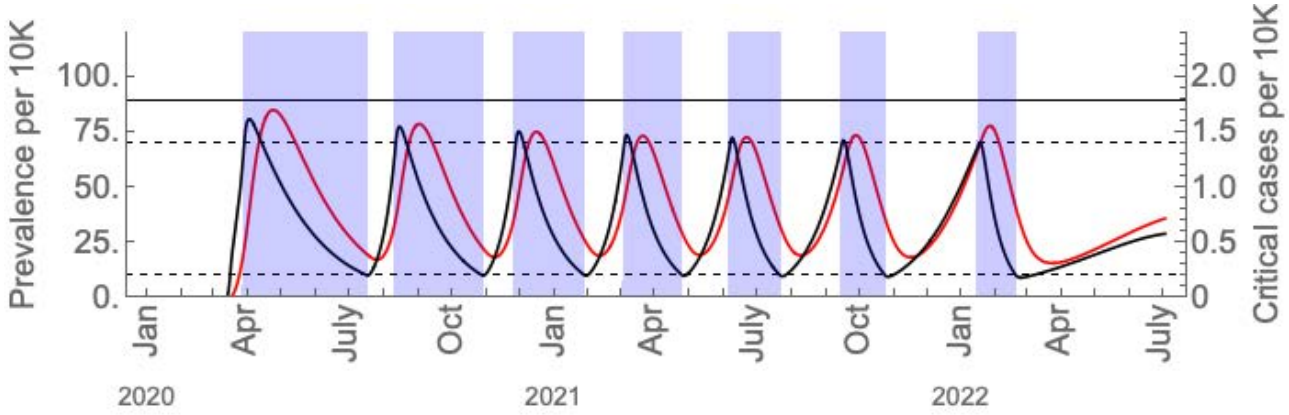
Seasonality:

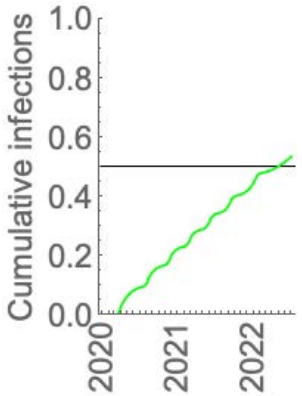




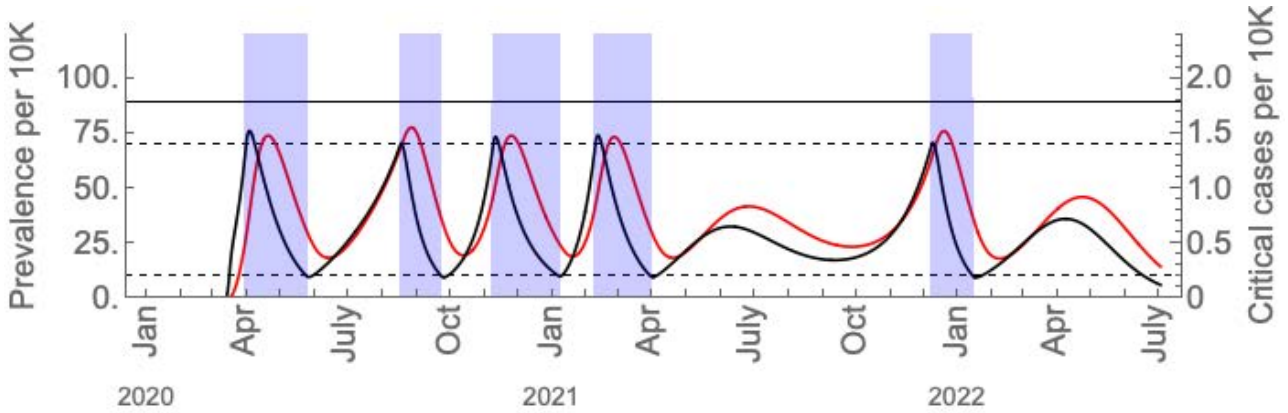
Intermittent social distancing, double ICU capacity (similar: treatment halves demand)

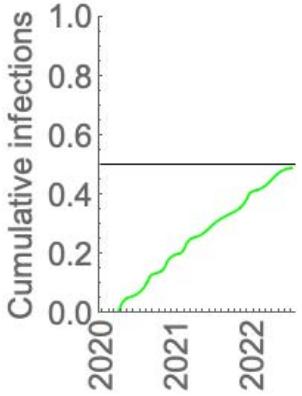
No seasonality:





Seasonality:





Key conclusions

- One time distancing not enough – impact not monotonic in duration or intensity
- If estimates are correct about proportion of cases mild vs severe/critical, then several years of intermittent distancing required to get to herd immunity without overwhelming ICU
- Seasonality can exacerbate or improve impact of one-time distancing, but improves outcome of multiple rounds

4. Design of seroprotection studies

Rebecca Kahn, Lee Kennedy-Shaffer, Yonatan Grad, James Robins, Marc Lipsitch.

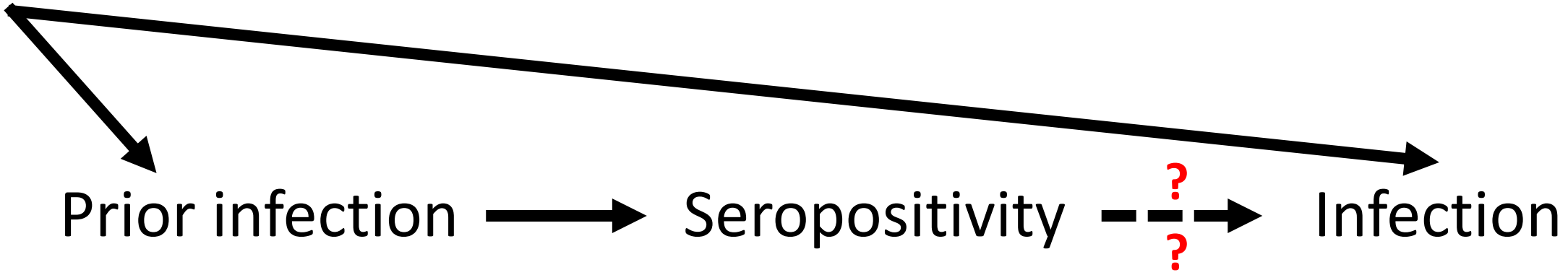
Potential biases arising from epidemic dynamics in observational seroprotection studies

To appear MedRxiv

Does past infection protect against future infection?

Geographic structure + epidemic dynamics

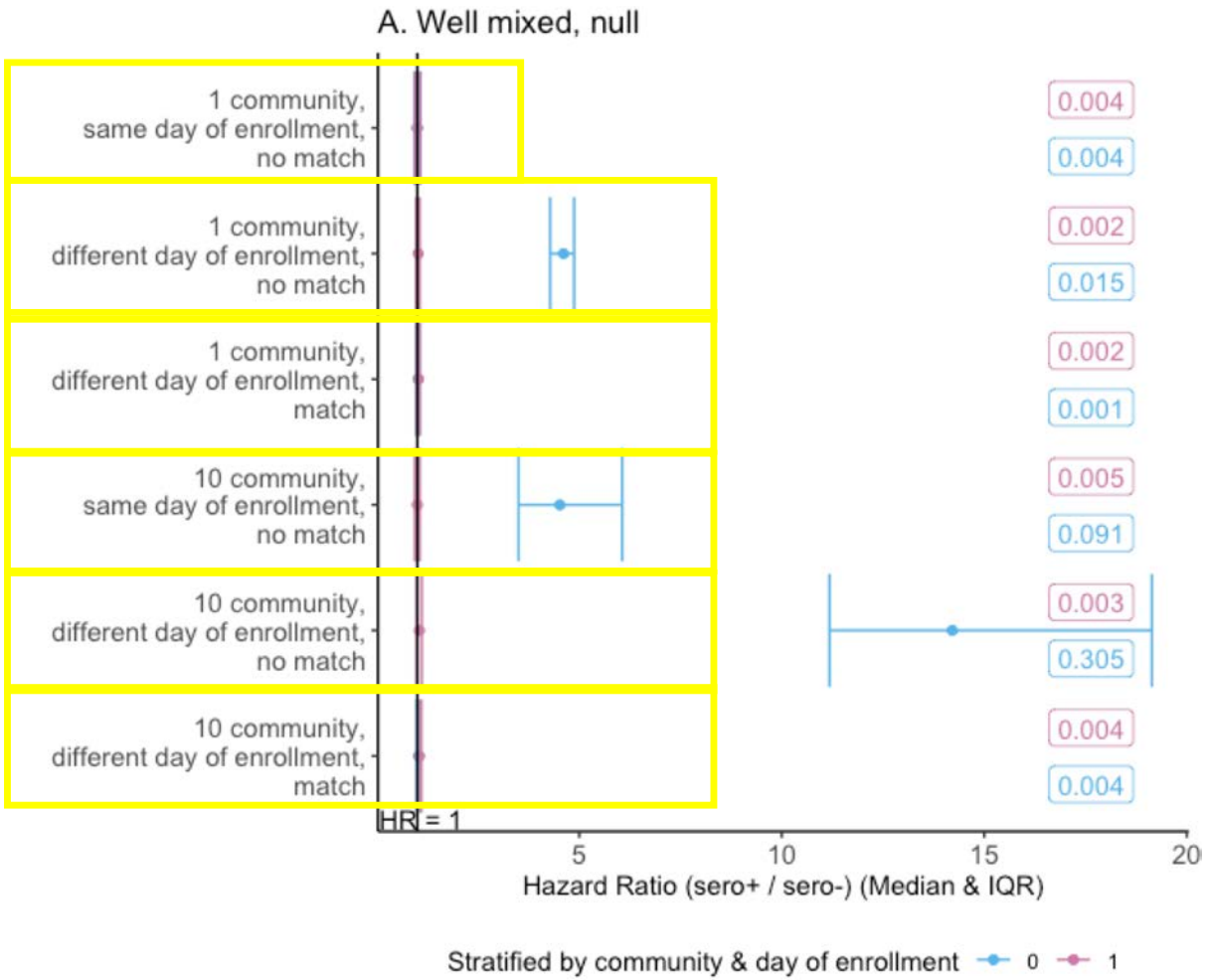
Job (healthcare worker)

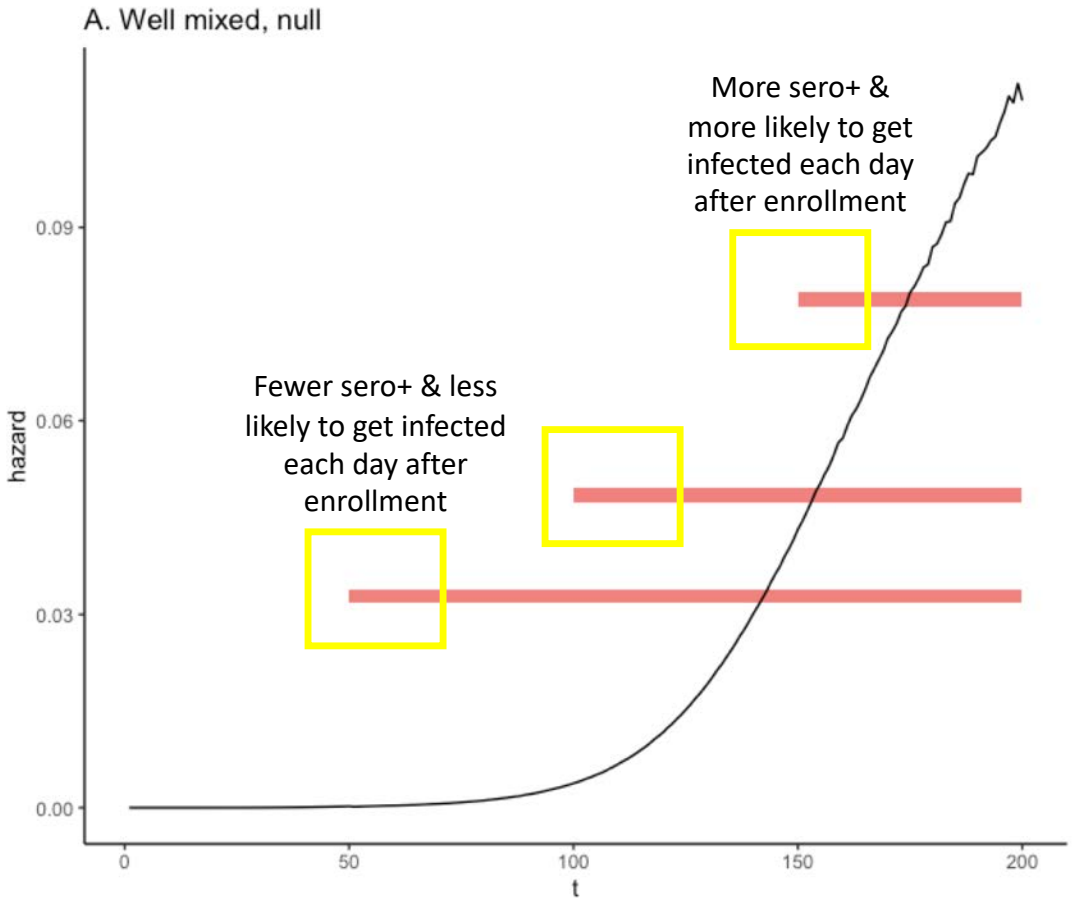


Methods overview

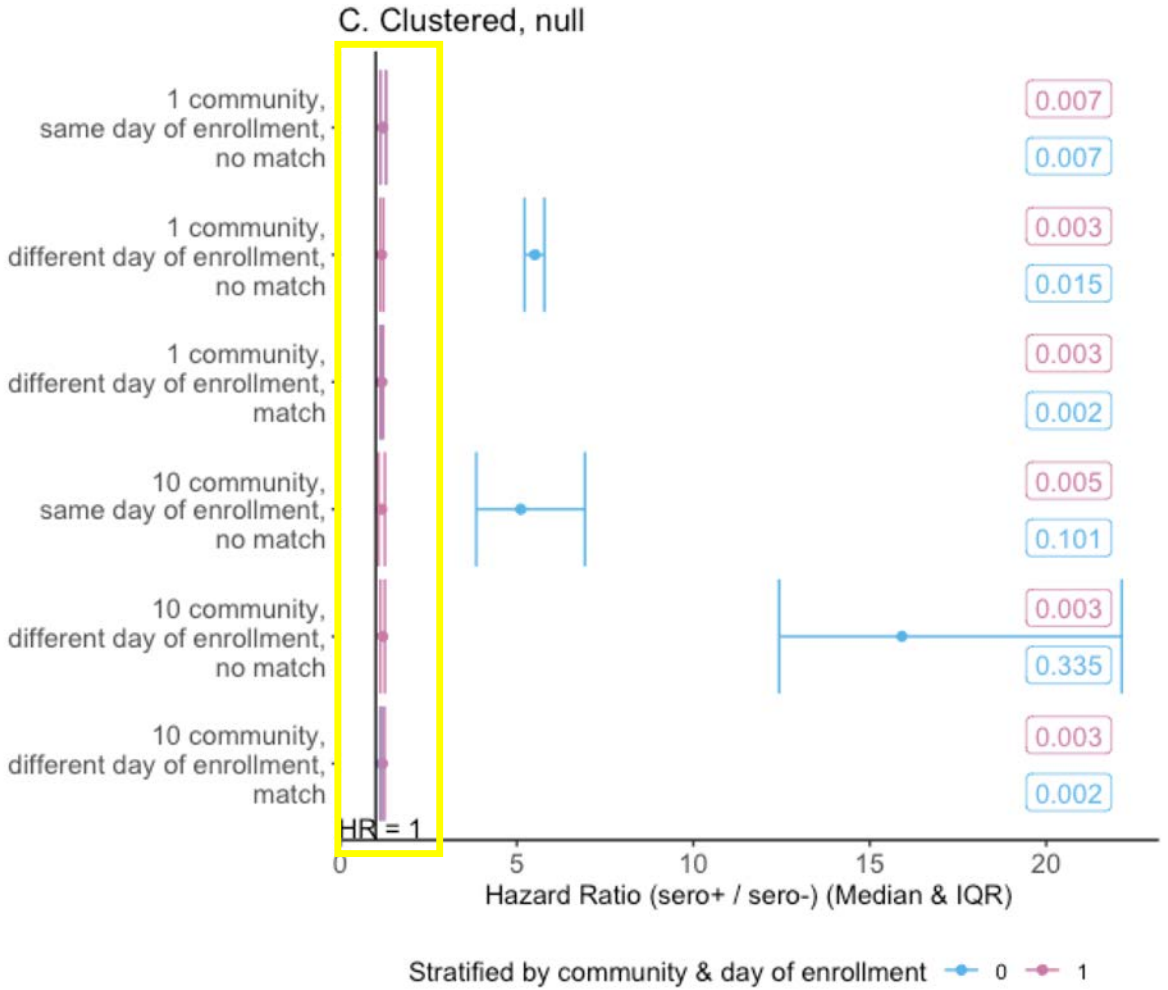
- Simulate an SEIS' outbreak in a network model
  - Control vs. no control
- Seroprotection
  - 0 (null)
  - 50% reduction in force of infection
  - 95% reduction in force of infection
- Communities
  - 1 vs. 10
  - Well mixed vs. clustered
- Enroll into observational study & assess serostatus
  - Random sample all on the same day
  - Random sample on different days
  - Matched enrollment (on communnity & day of enrollment)
- Cox proportional hazards comparing infection after enrollment in sero+ vs. sero-

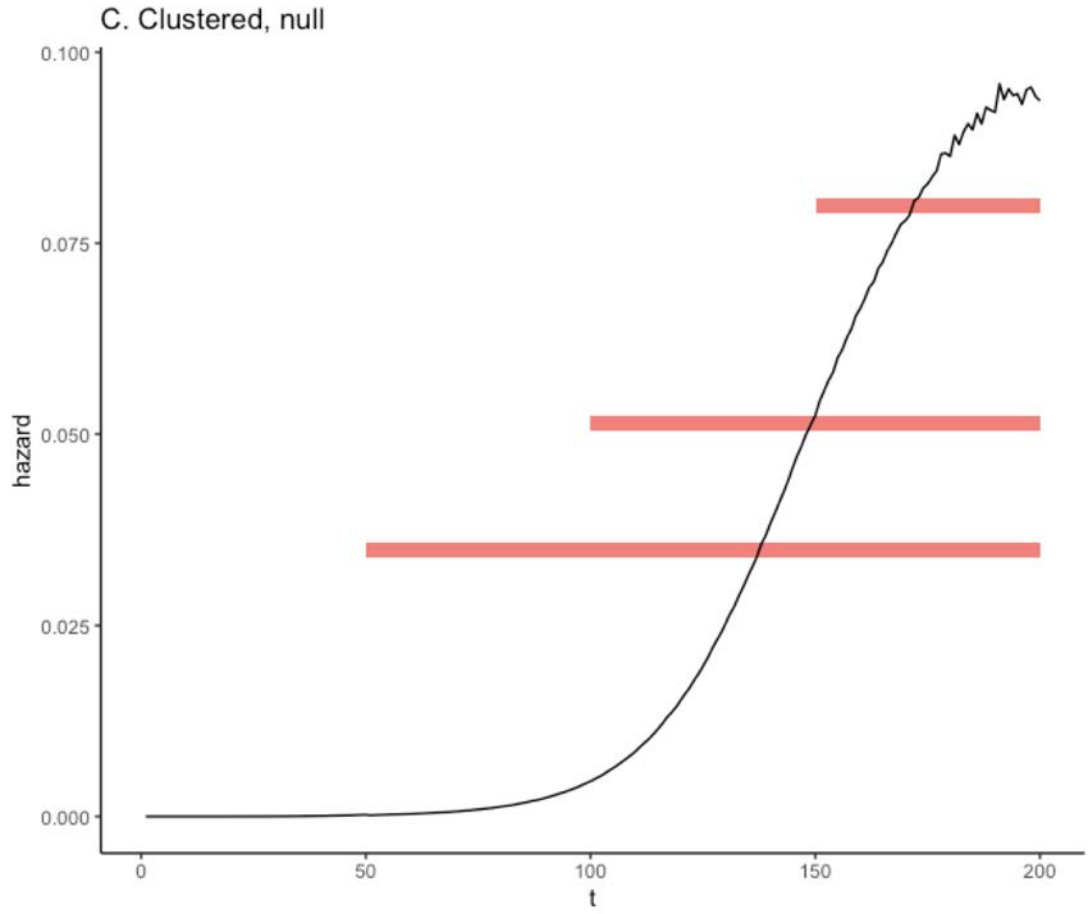
Well mixed, no control, null (HR =1)



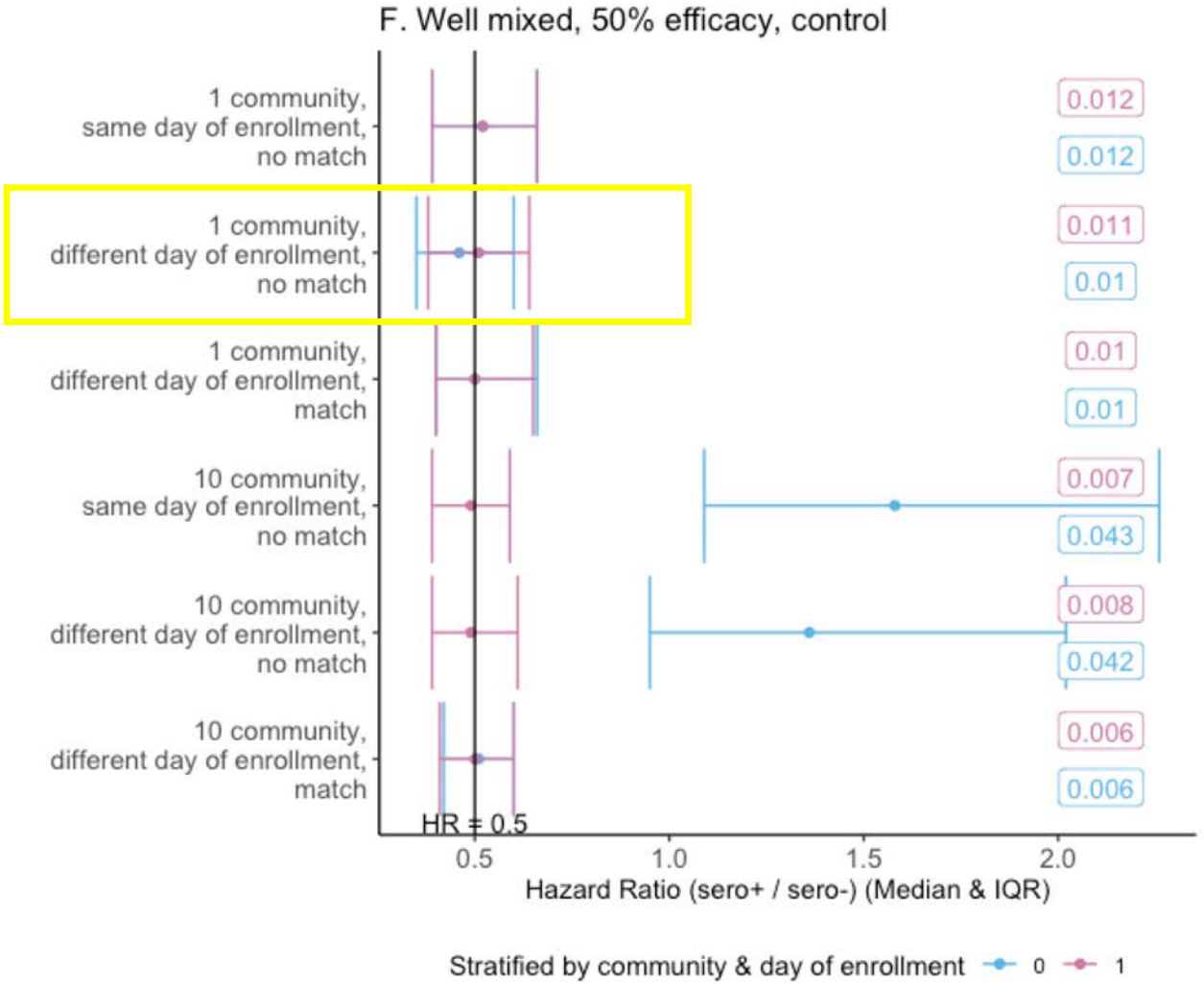


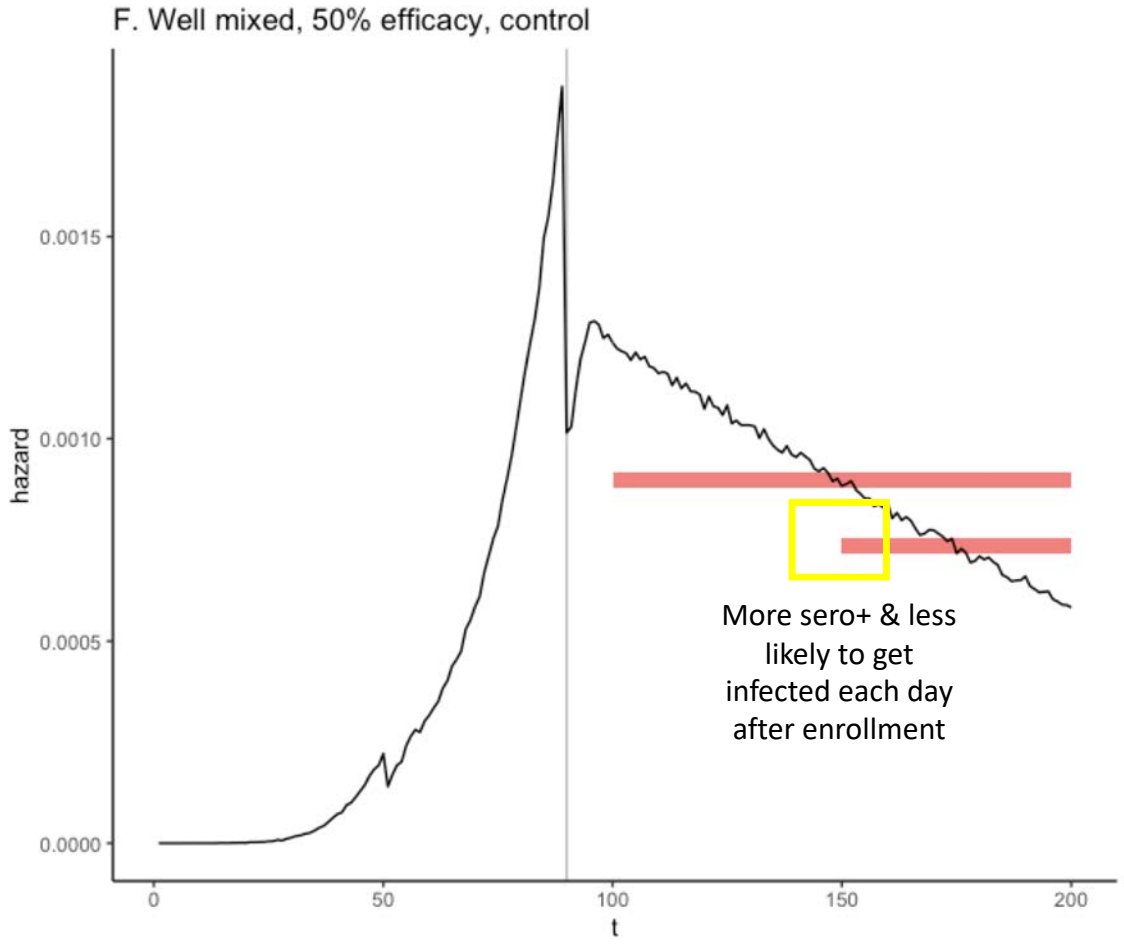
Well mixed, clustered, null (HR =1)



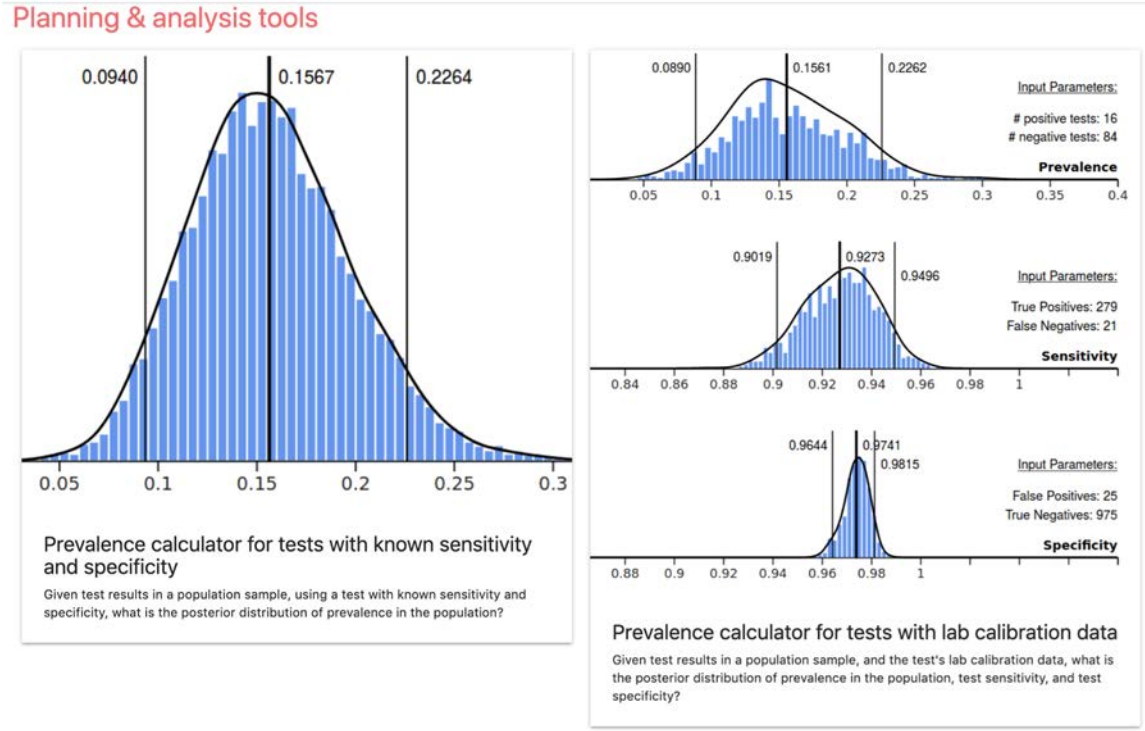


Well mixed, control, 50% efficacy (HR =0.5)





5. Infomercial: simple Bayesian stats for serosurveys



https://larremorelab.github.io/covid19testgroup

Estimating SARS-CoV-2 seroprevalence and epidemiological parameters with uncertainty from serological surveys

Daniel B. Larremore,[1,2*] Bailey K. Fosdick,[3] Kate M. Bubar[4,5],
Sam Zhang[4], Stephen M. Kissler[6], C. Jessica E. Metcalf,[7]
Caroline O. Buckee[8,9], Yonatan H. Grad[6*]

Extra slide

One-time social distancing (without seasonality)