Transmission dynamics of COVID-19

Ben Cowling

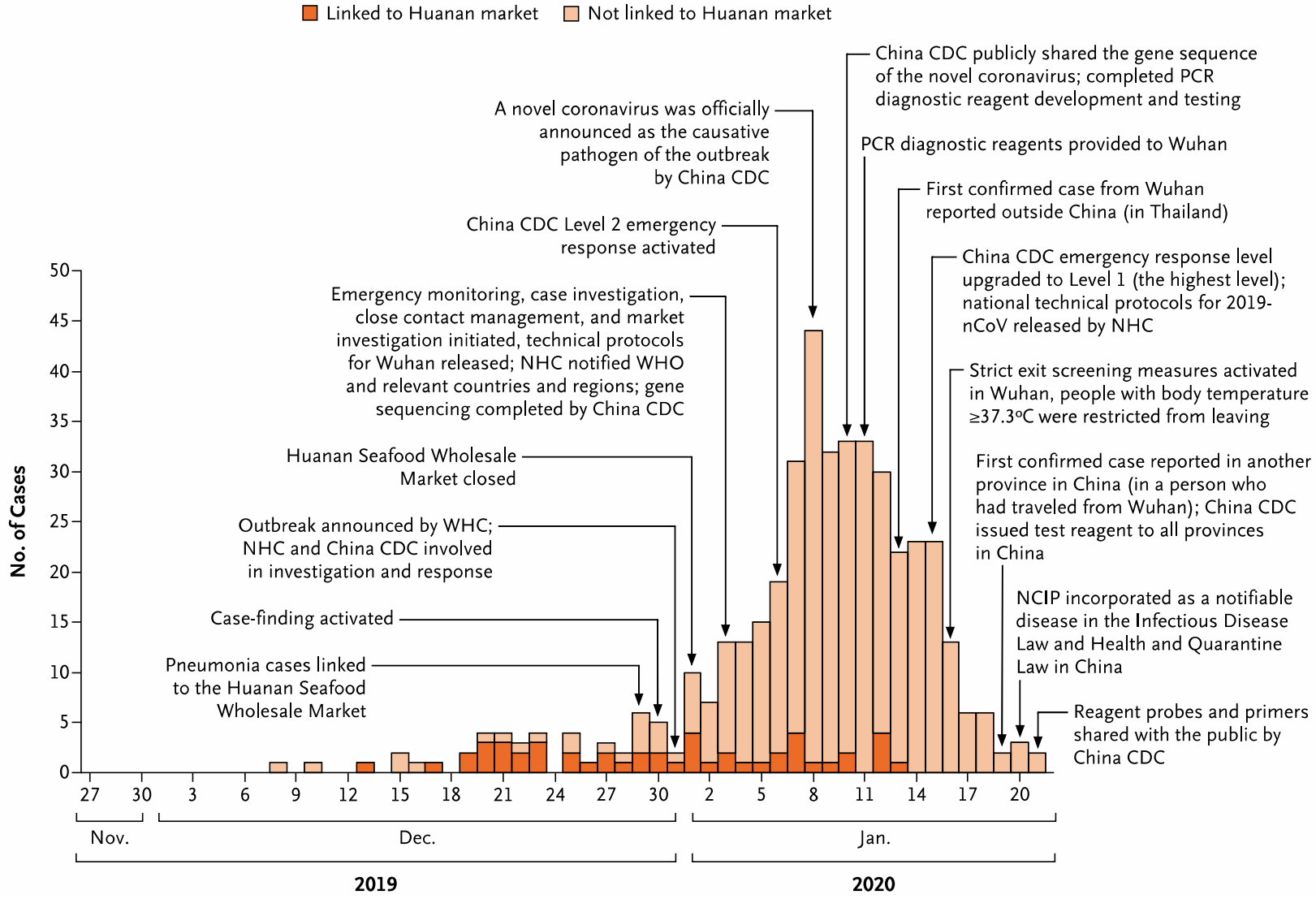
Co-Director, WHO Collaborating Centre for Infectious Disease Epidemiology and Control

School of Public Health, The University of Hong Kong, Hong Kong

8 December 2020

Early transmission dynamics in Wuhan

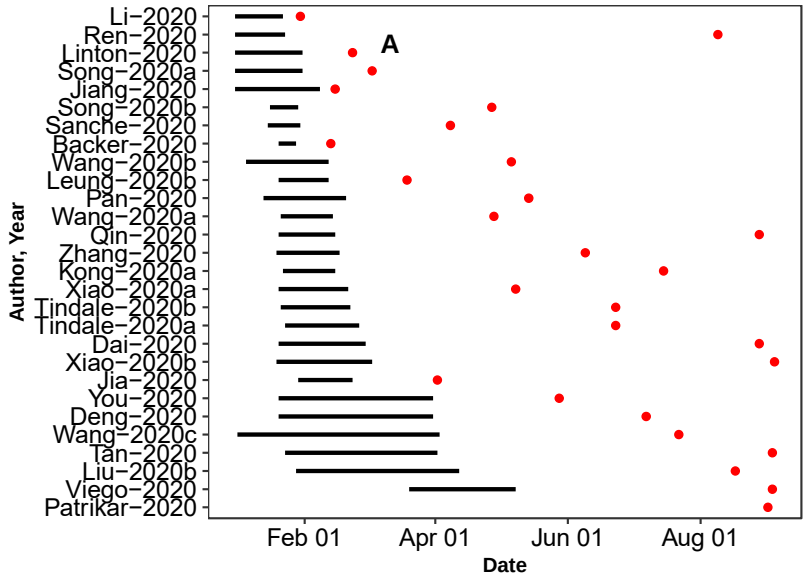
- Based on early exponential growth in non-linked cases (up to 3 January) case numbers doubled every 7.4 days
- Basic reproductive number (R_0) of 2.2

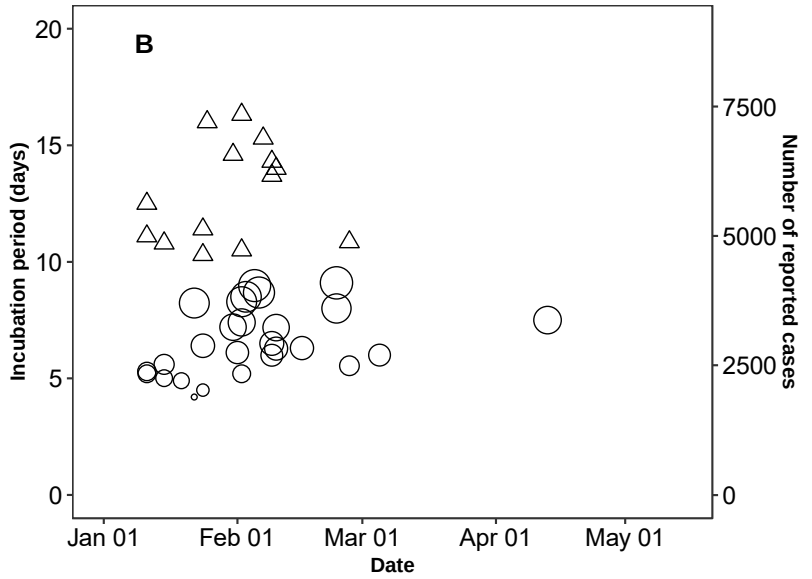


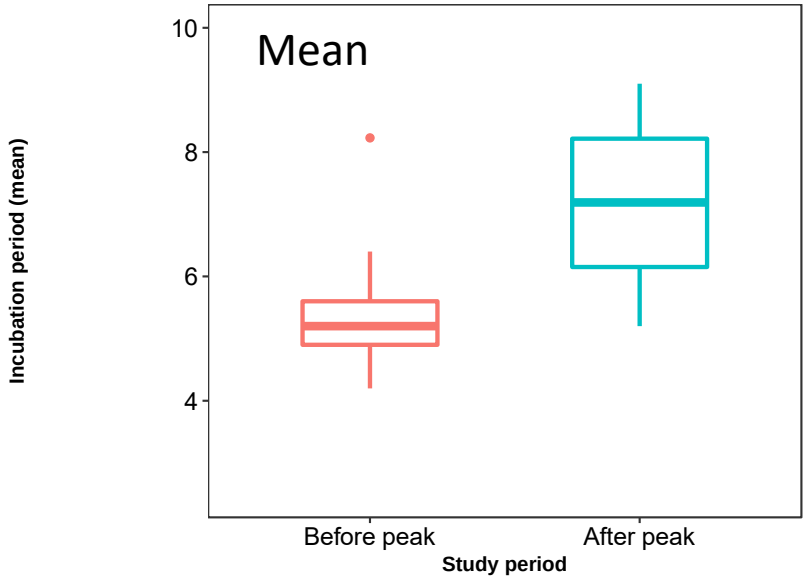
Li et al. 2020 NEJM

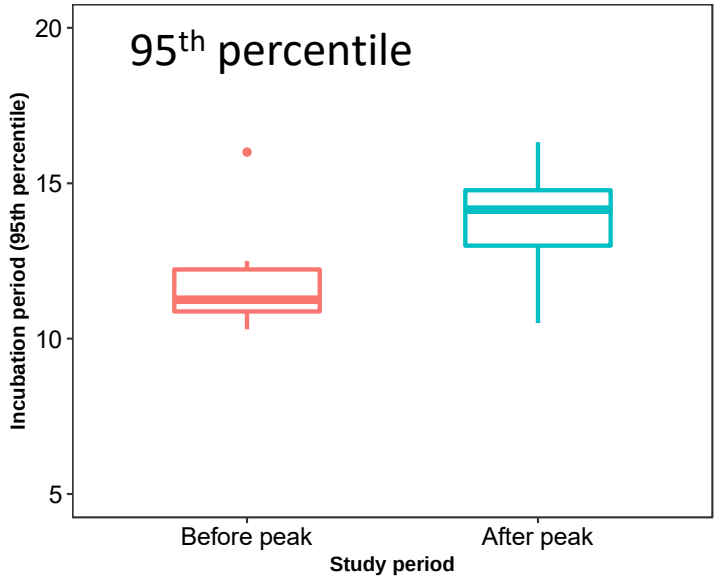
Incubation period

- Earliest estimates of the mean incubation period 5-6 days, 95th percentile 12 days
- But biased towards shorter incubation periods during rising epidemic



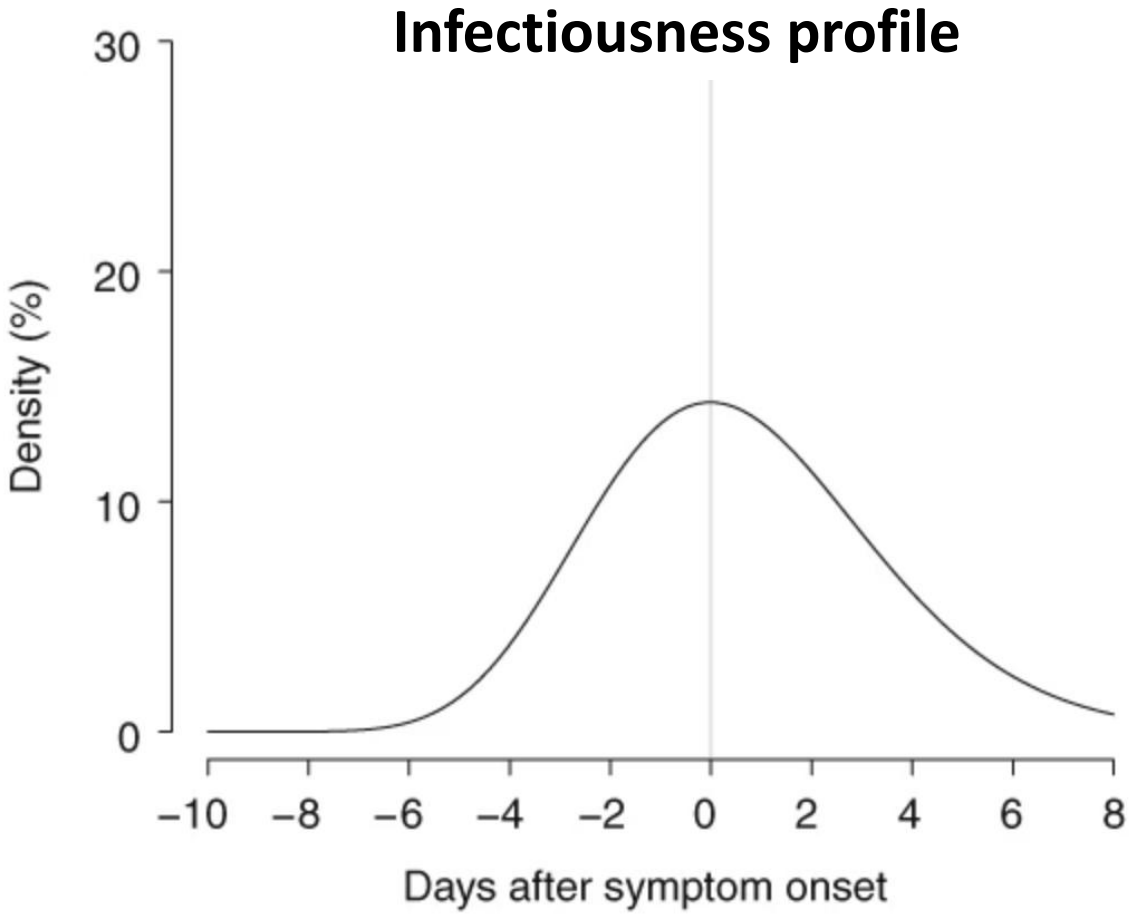






unpublished

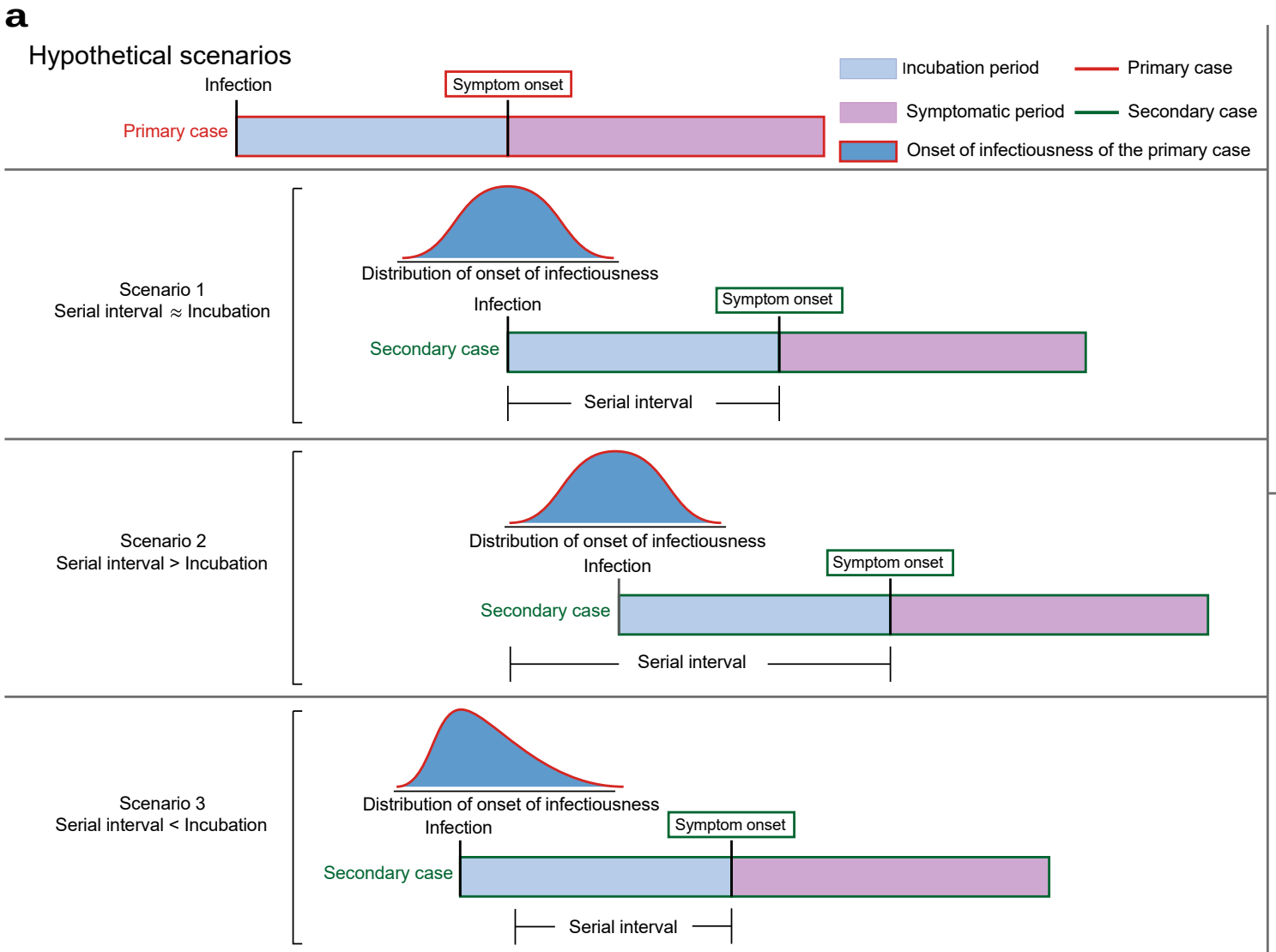
Pre-symptomatic infectiousness



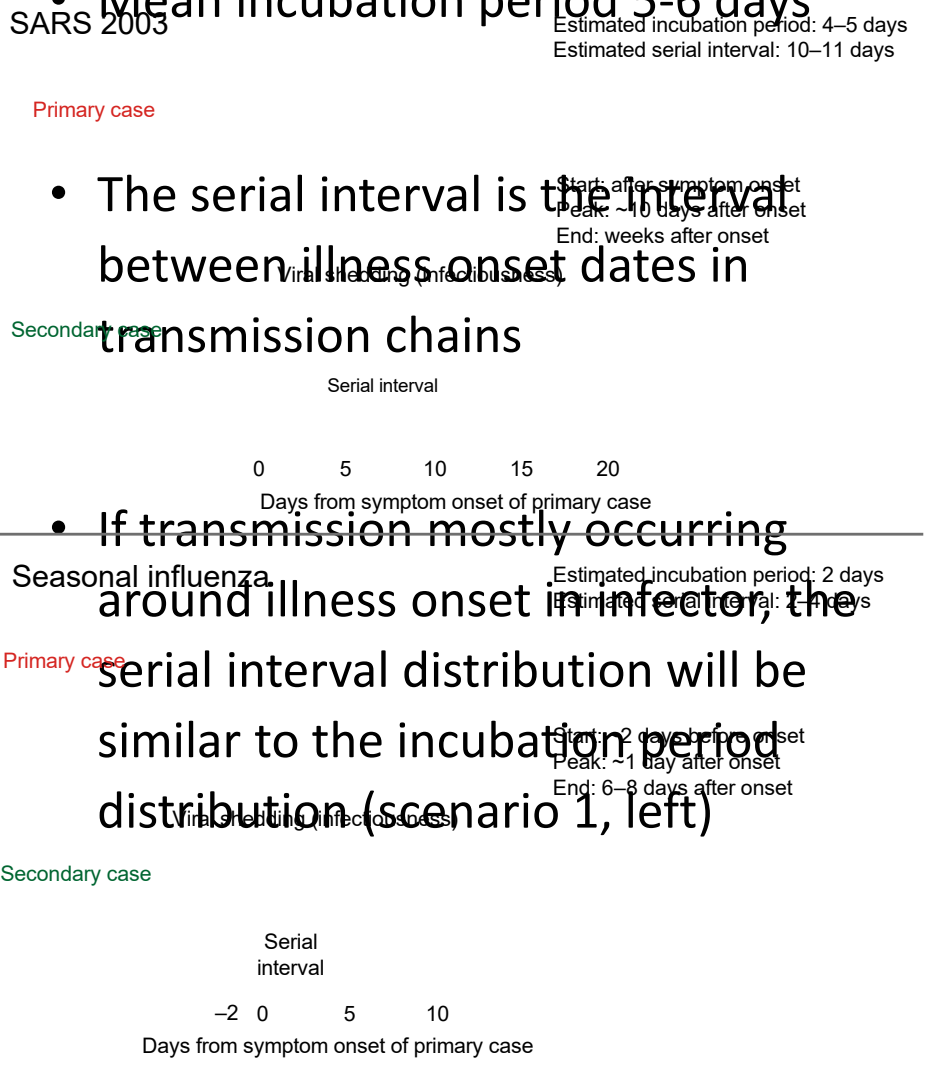
- We analyzed data on serial intervals between cases in transmission chains, and the incubation period distribution
- Estimated that most infectiousness occurred within a few days before and after symptom onset
- Caveat – this study used data from China during containment efforts, and post-symptomatic infectiousness may have been reduced by public health measures

He et al. 2020 Nat Med (corrected)

Serial interval vs incubation period

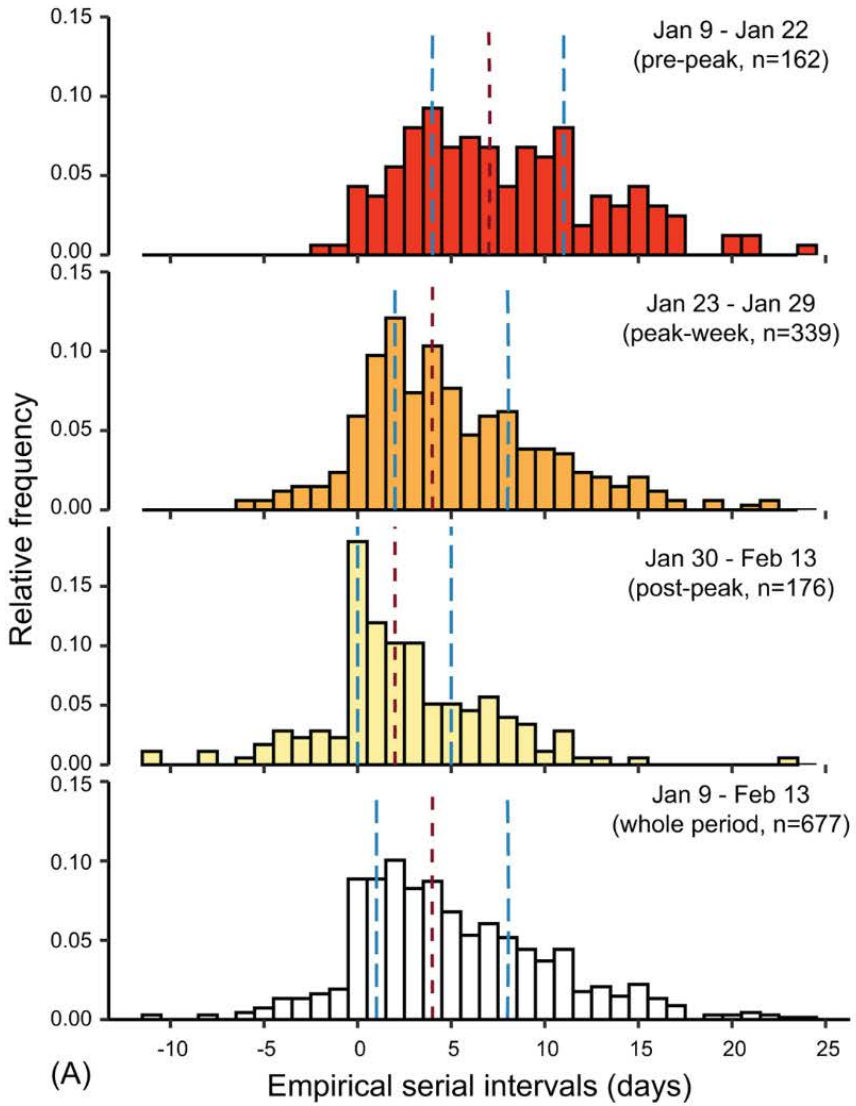


- Mean incubation period 5-6 days
- The serial interval is the interval between illness onset dates in transmission chains
- If transmission mostly occurring around illness onset in infector, the serial interval distribution will be similar to the incubation period distribution (scenario 1, left)



He et al. 2020 Nat Med

Serial interval distribution changed over time

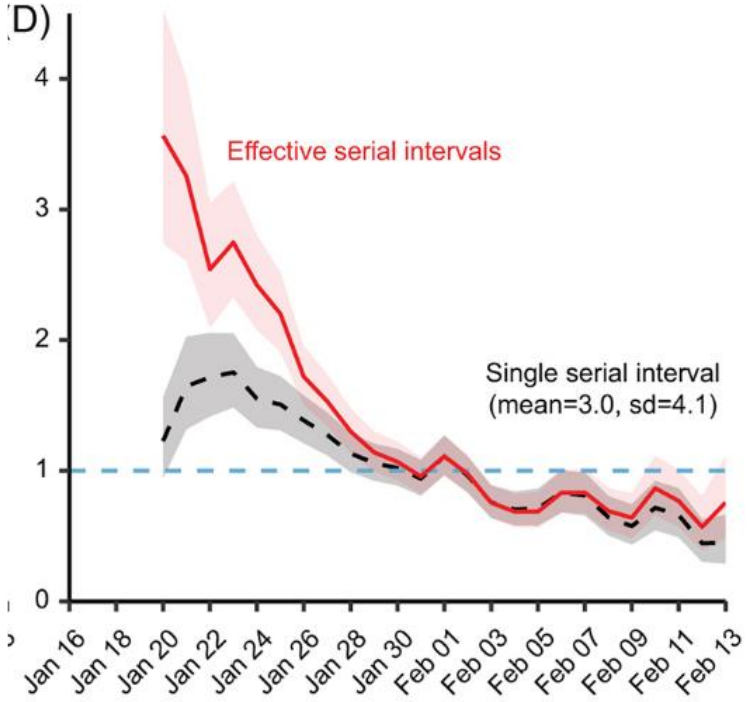


Mean 8 days before the epidemic peak

Mean 6 days around the epidemic peak

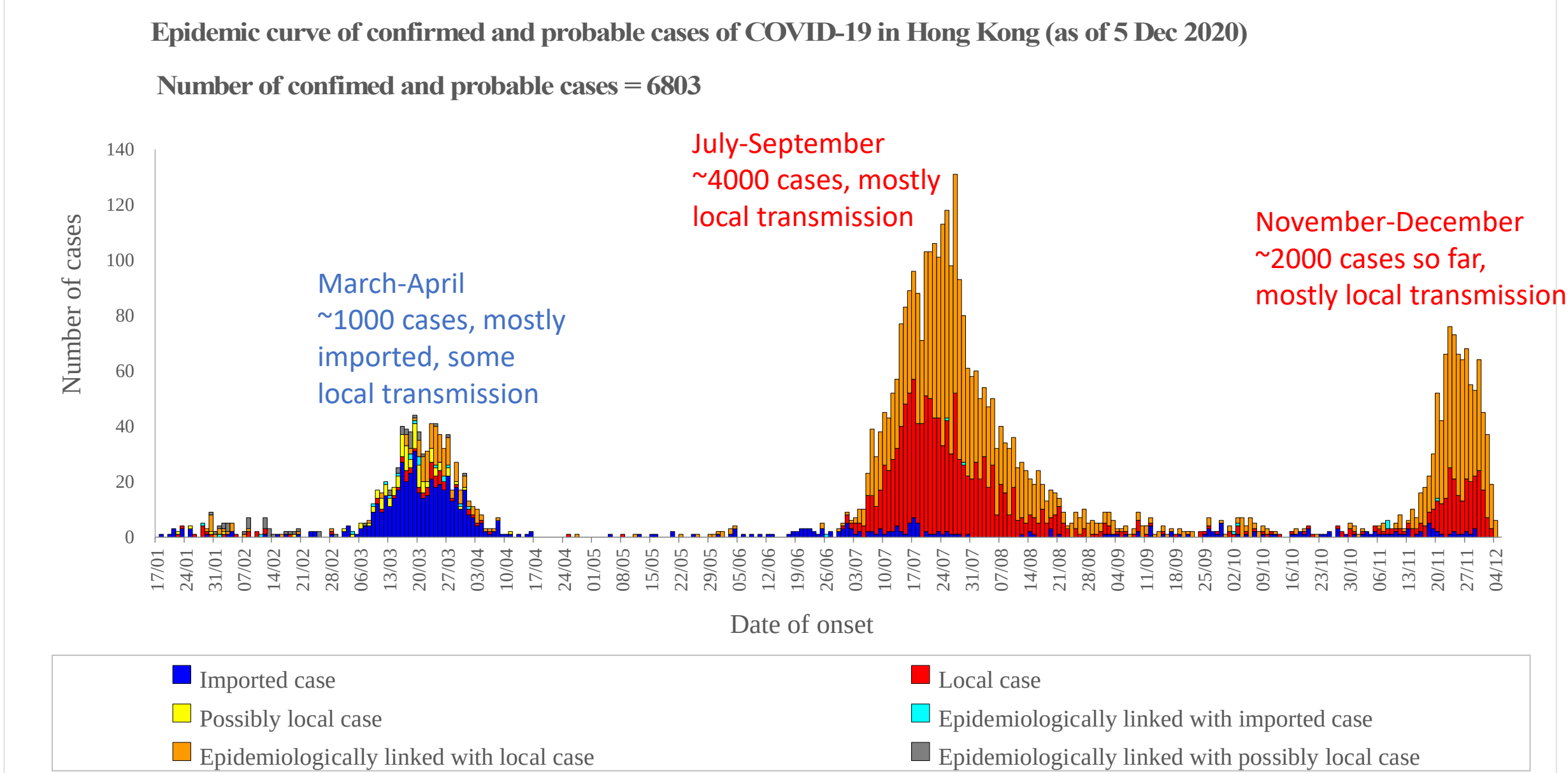
Mean 3 days after the epidemic peak

- Serial intervals shortened over time during the epidemic in mainland China because of effective detection and isolation of cases (reducing post-symptomatic transmission)
- Implications for Rt estimation:



Ali et al. 2020 Science

Downloaded from http://science.sciencemag.org/ on July 28

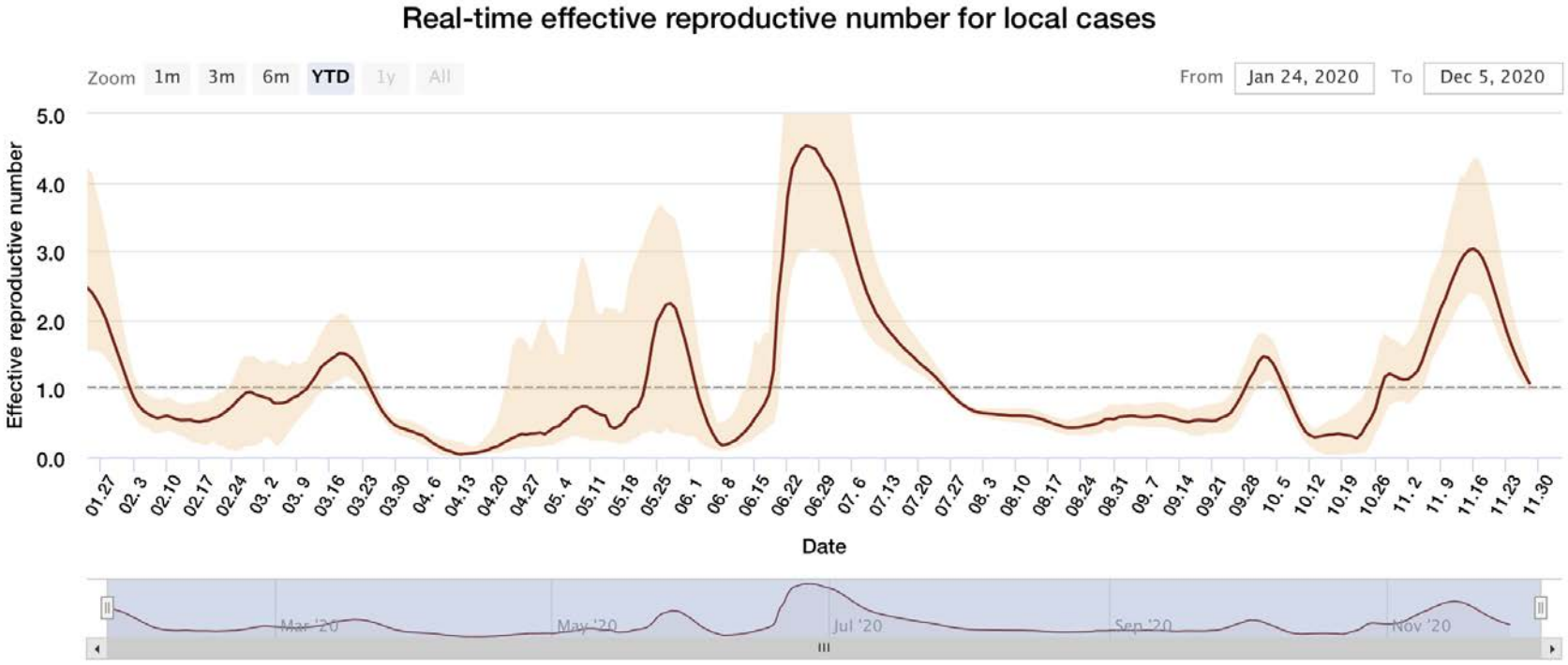


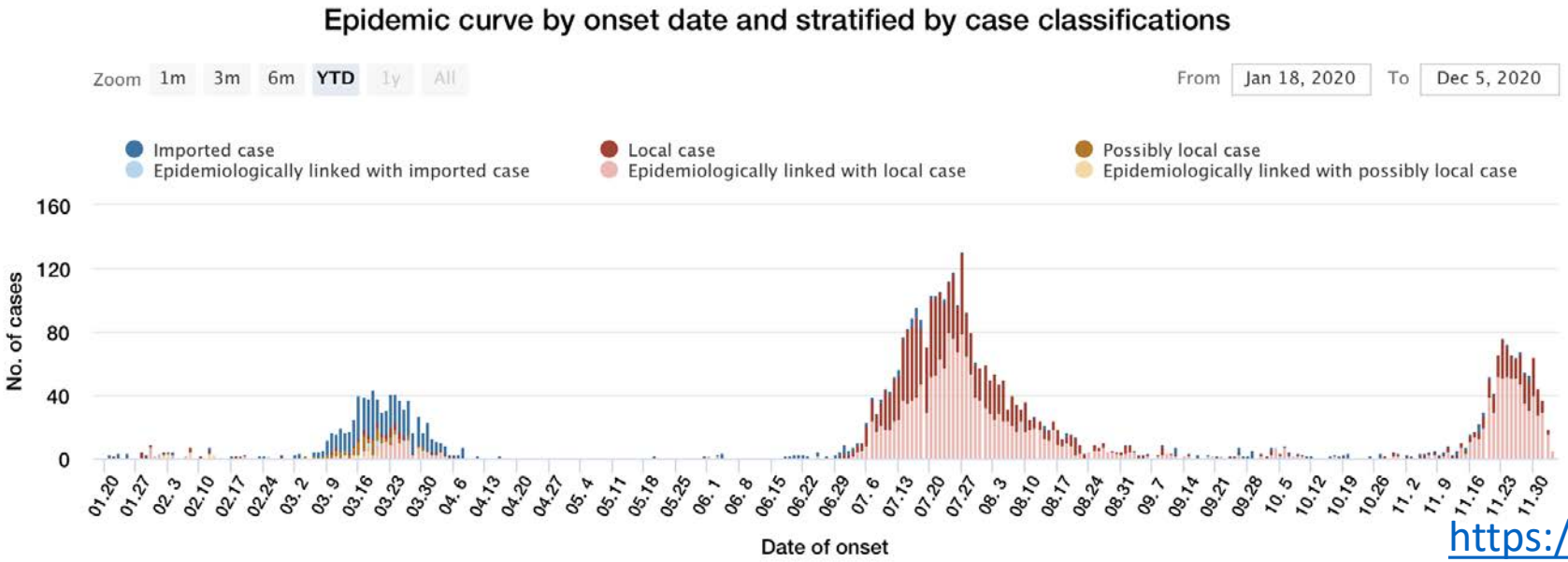
Note:

1. The case classification may be subject to changes when there is new information available.

https://www.chp.gov.hk/files/pdf/local_situation_covid19_en.pdf

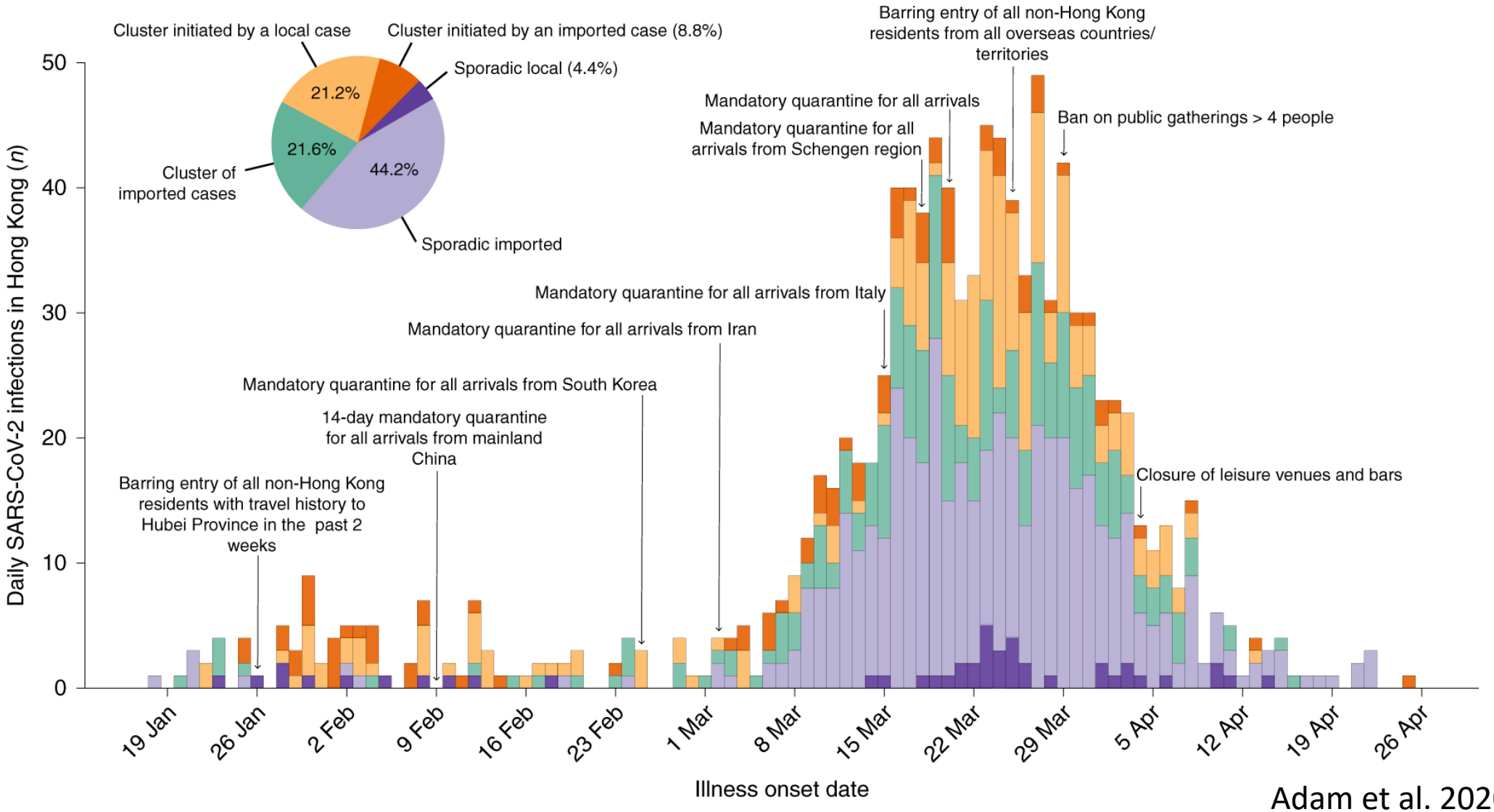
R_t





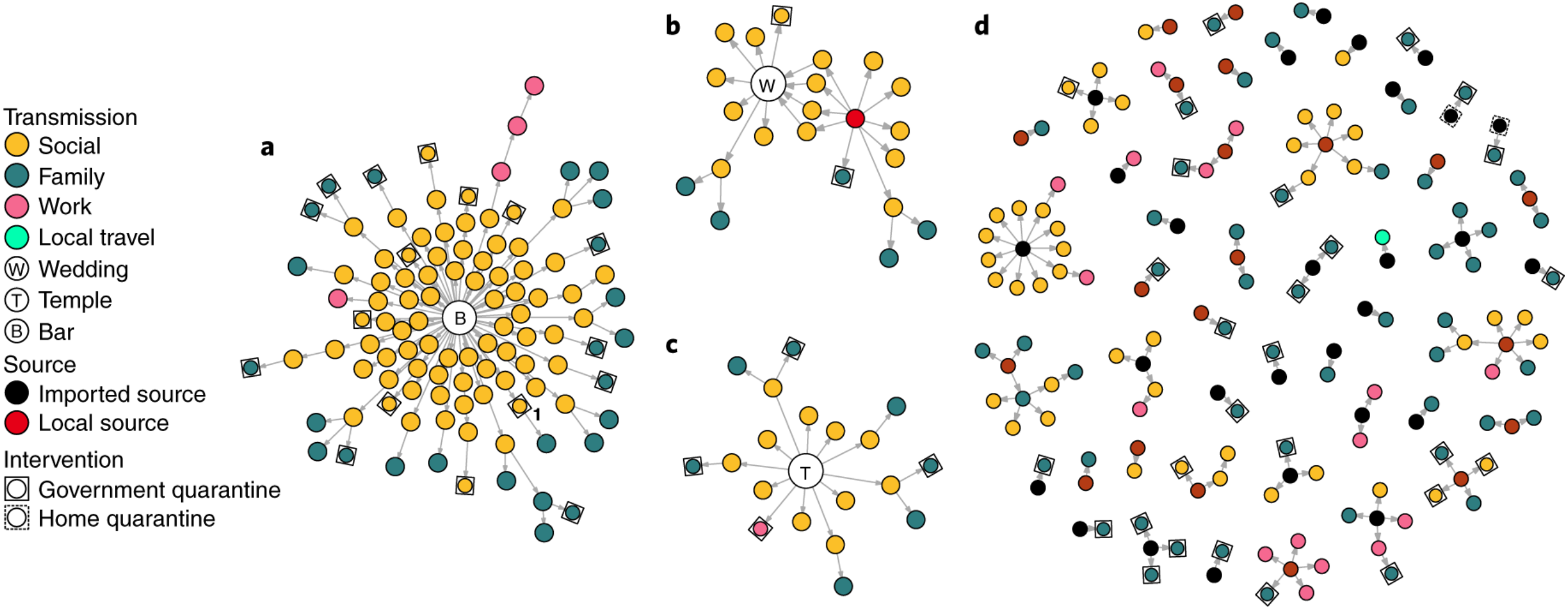
https://covid19.sph.hku.hk/

Clustering of local COVID-19 infections in March



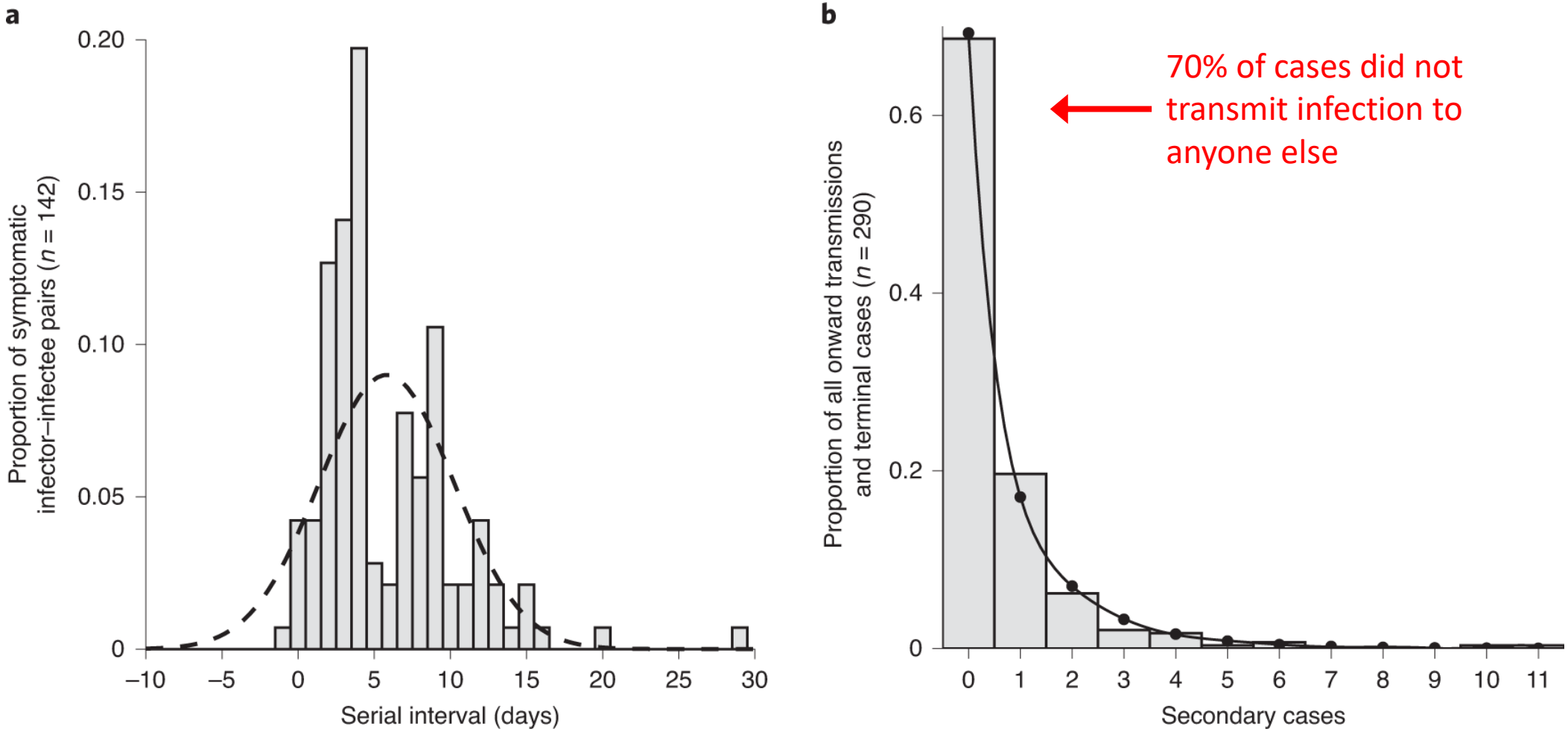
Adam et al. 2020 Nat Med

Clustering of COVID-19 infections



Adam et al. 2020 Nat Med

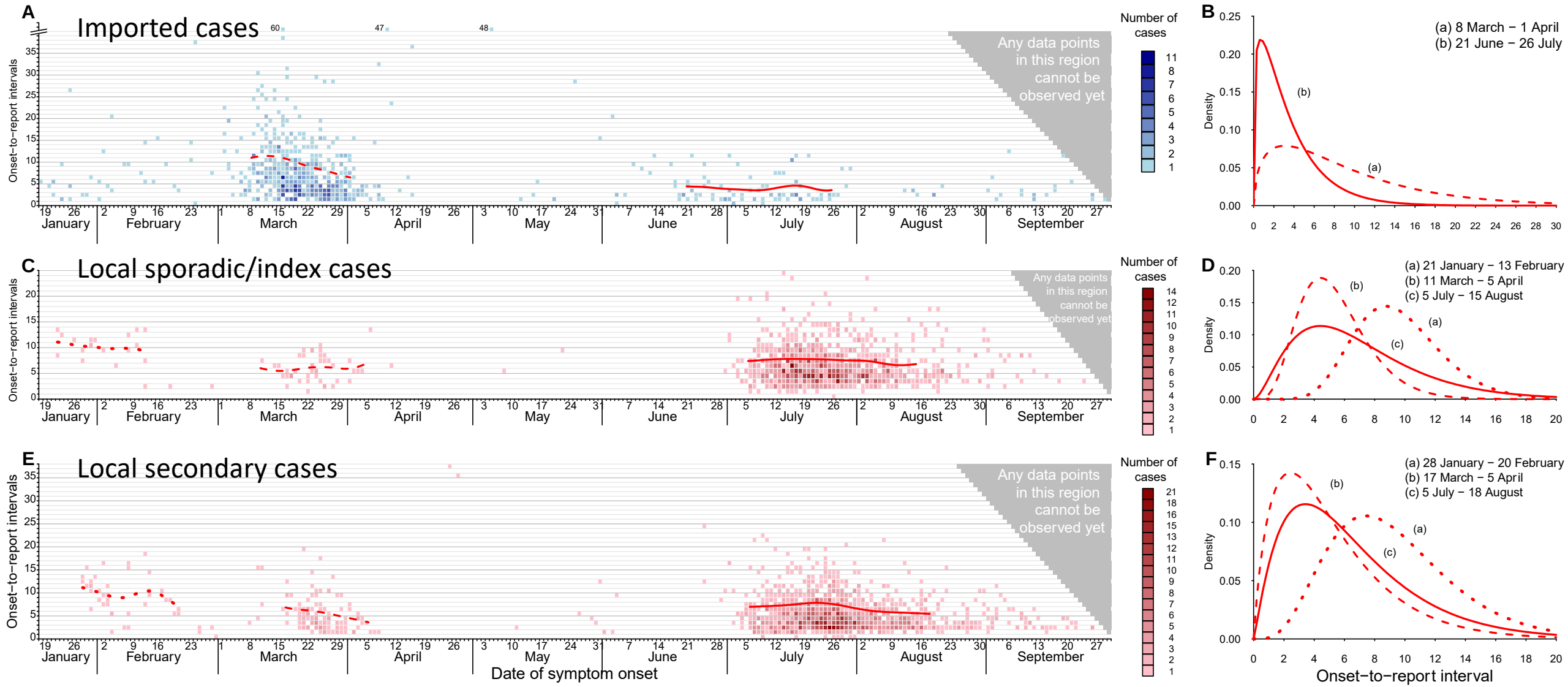
Serial interval and offspring distribution



19% of cases responsible for 80% of transmission events
(overdispersion parameter k=0.33)

Adam et al. 2020 Nat Med

Onset-to-confirmation delays

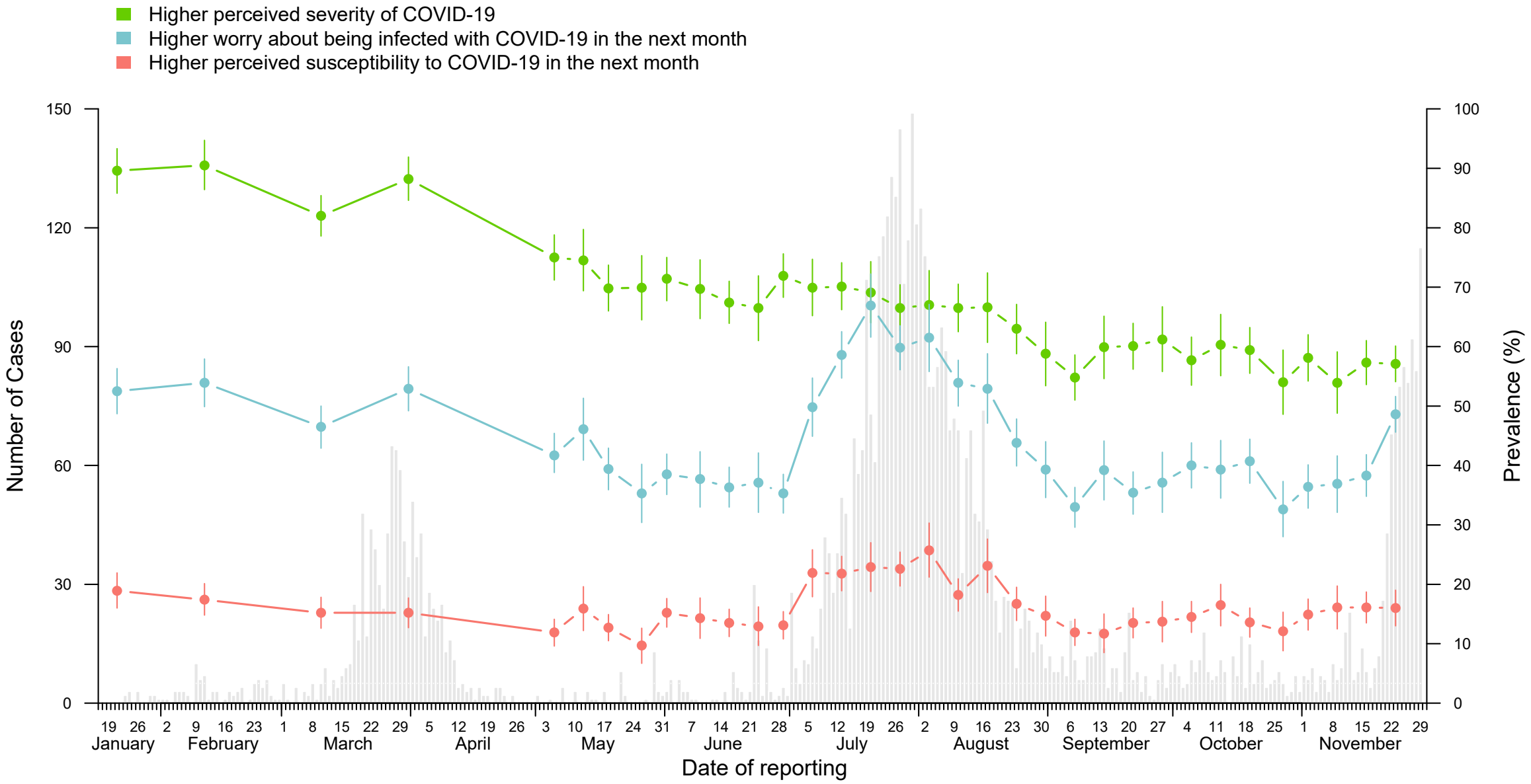


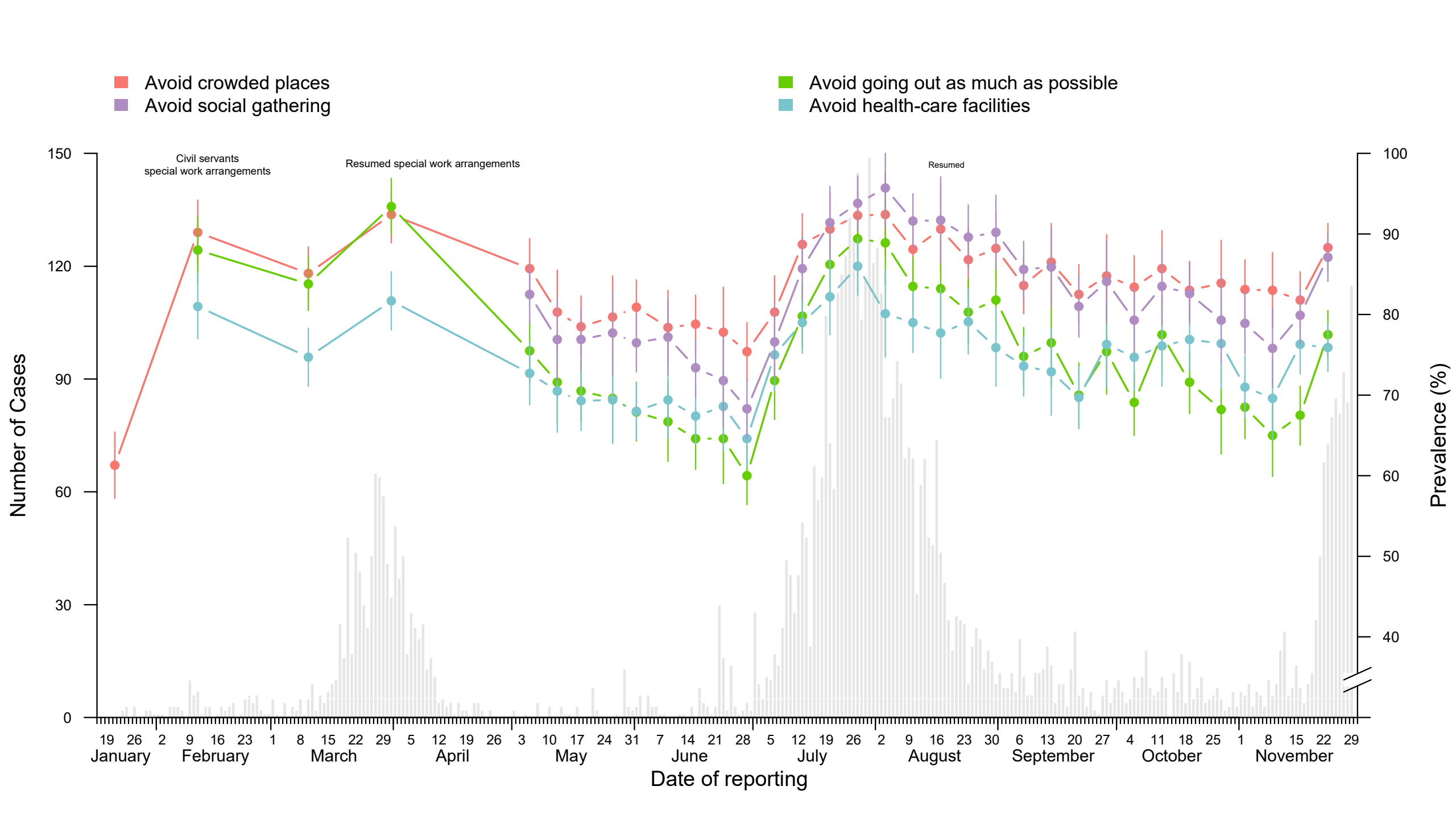
Implications of superspreading events

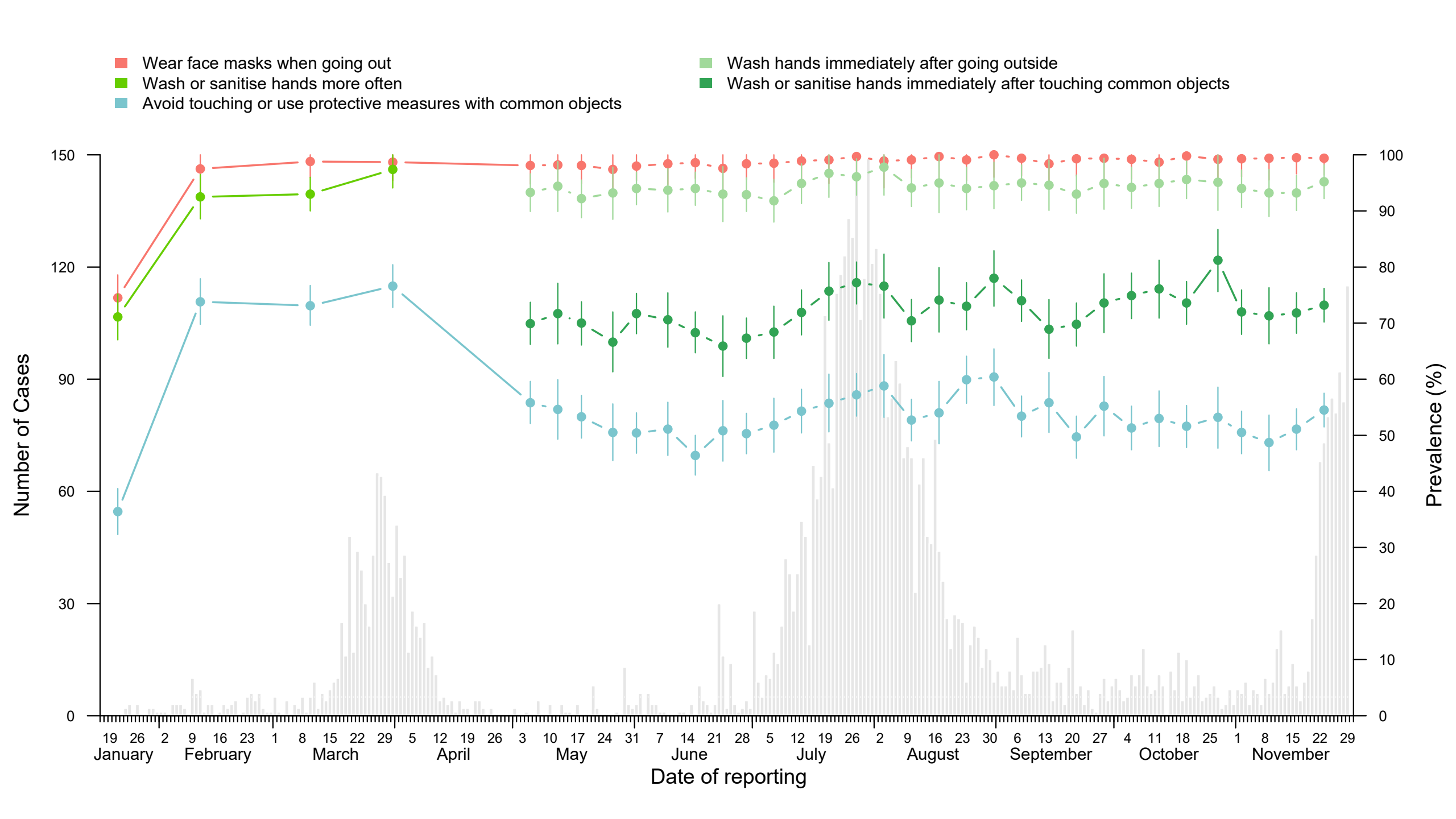
- Contact tracing and quarantine from SSEs will be particularly productive (distribution of illness onset dates can provide inferences on how many infections might not yet have been detected)

- If 80% of infections are acquired from 20% of cases, backwards contact tracing could identify SSEs, with forward contact tracing then identifying new cases and transmission chains

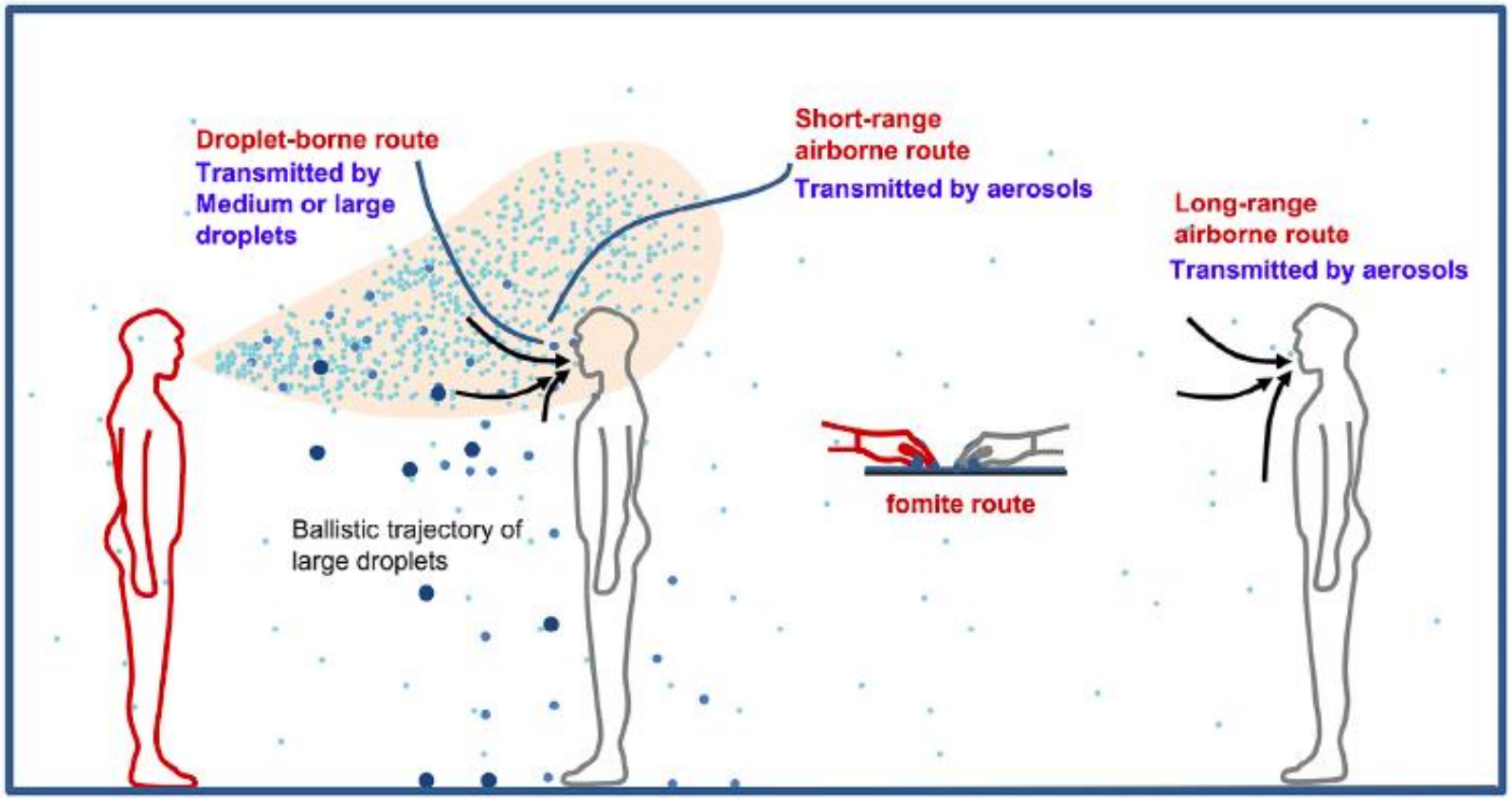
Population responses




Avoid crowded places
Avoid social gathering
Avoid going out as much as possible
Avoid health-care facilities
Civil servants special work arrangements
Resumed special work arrangements
Resumed
Number of Cases
Prevalence (%)
Date of reporting
January
February
March
April
May
June
July
August
September
October
November


Wear face masks when going out
Wash or sanitise hands more often
Avoid touching or use protective measures with common objects
Wash hands immediately after going outside
Wash or sanitise hands immediately after touching common objects
Number of Cases
Prevalence (%)
0
30
60
90
120
150
0
10
20
30
40
50
60
70
80
90
100
19 26 2 9 16 23 1 8 15 22 29 5 12 19 26 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 6 13 20 27 4 11 18 25 1 8 15 22 29
January
February
March
April
May
June
July
August
September
October
November
Date of reporting

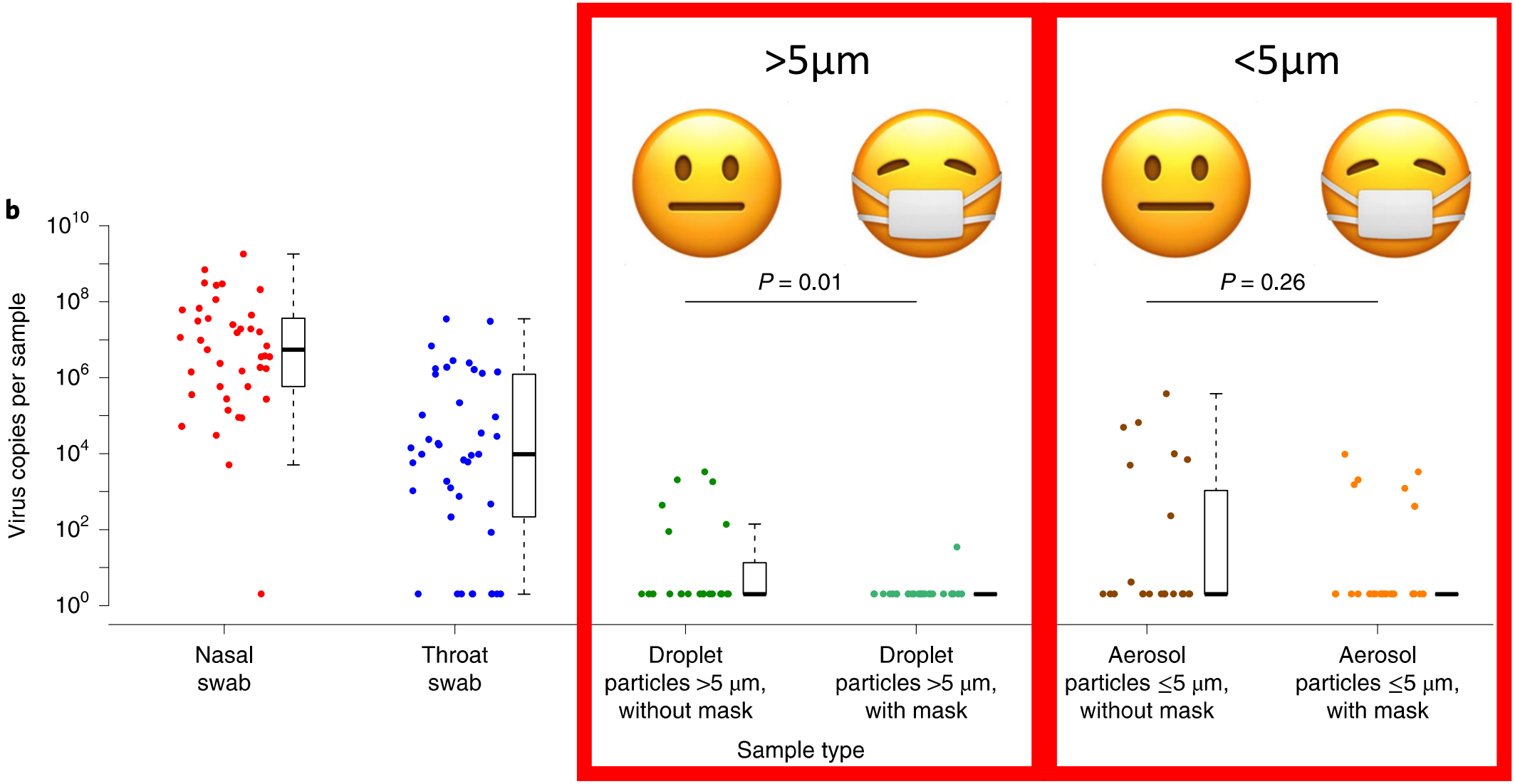
How do respiratory viruses spread?



- Large droplets (>100 μm) : Fast deposition due to the domination of gravitational force
- Medium droplets between 5 and 100 μm
- Small droplets or droplet nuclei, or aerosols (< 5 μm): Responsible for airborne transmission

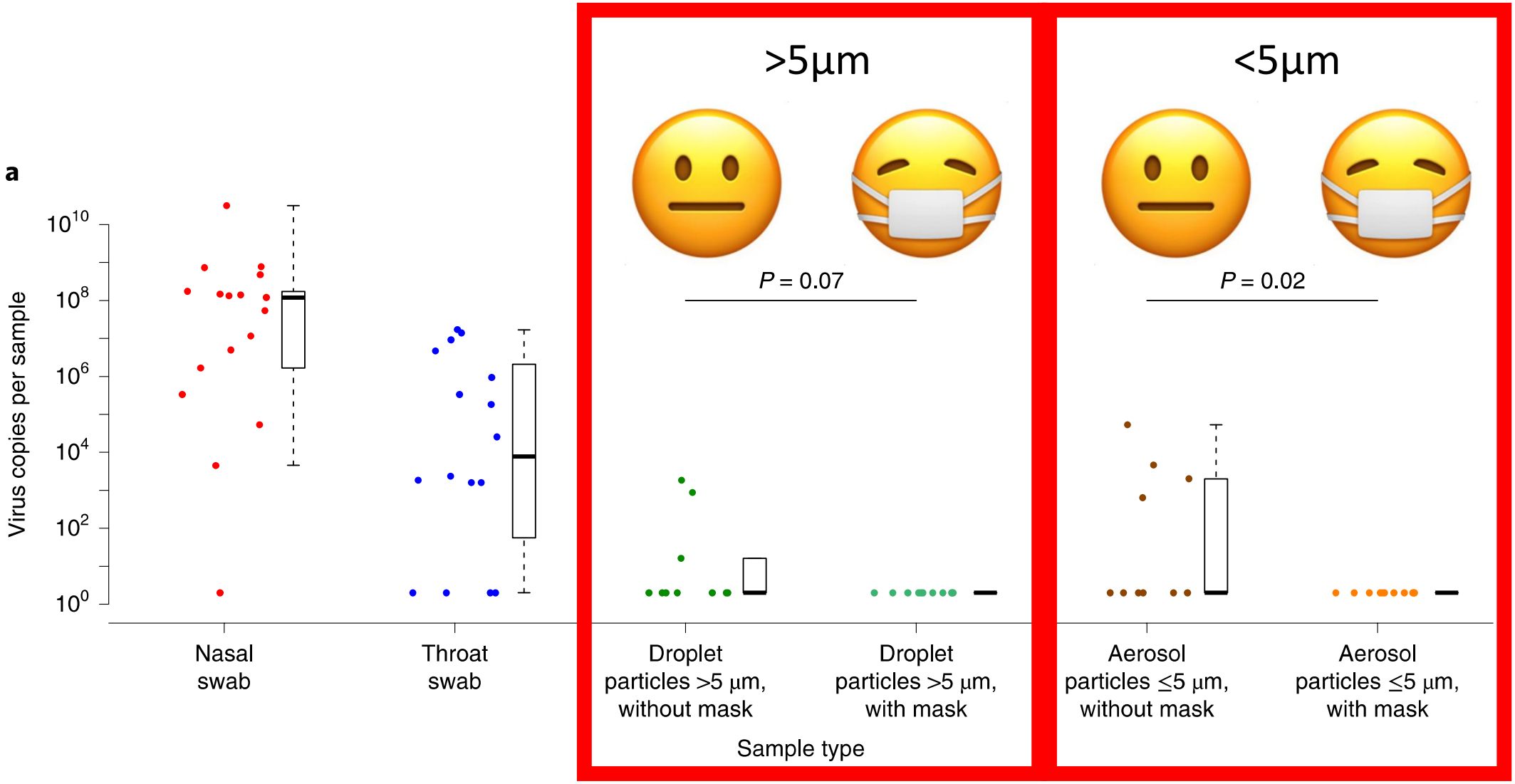
Wei et al. 2016 Am J Infect Control

Influenza virus



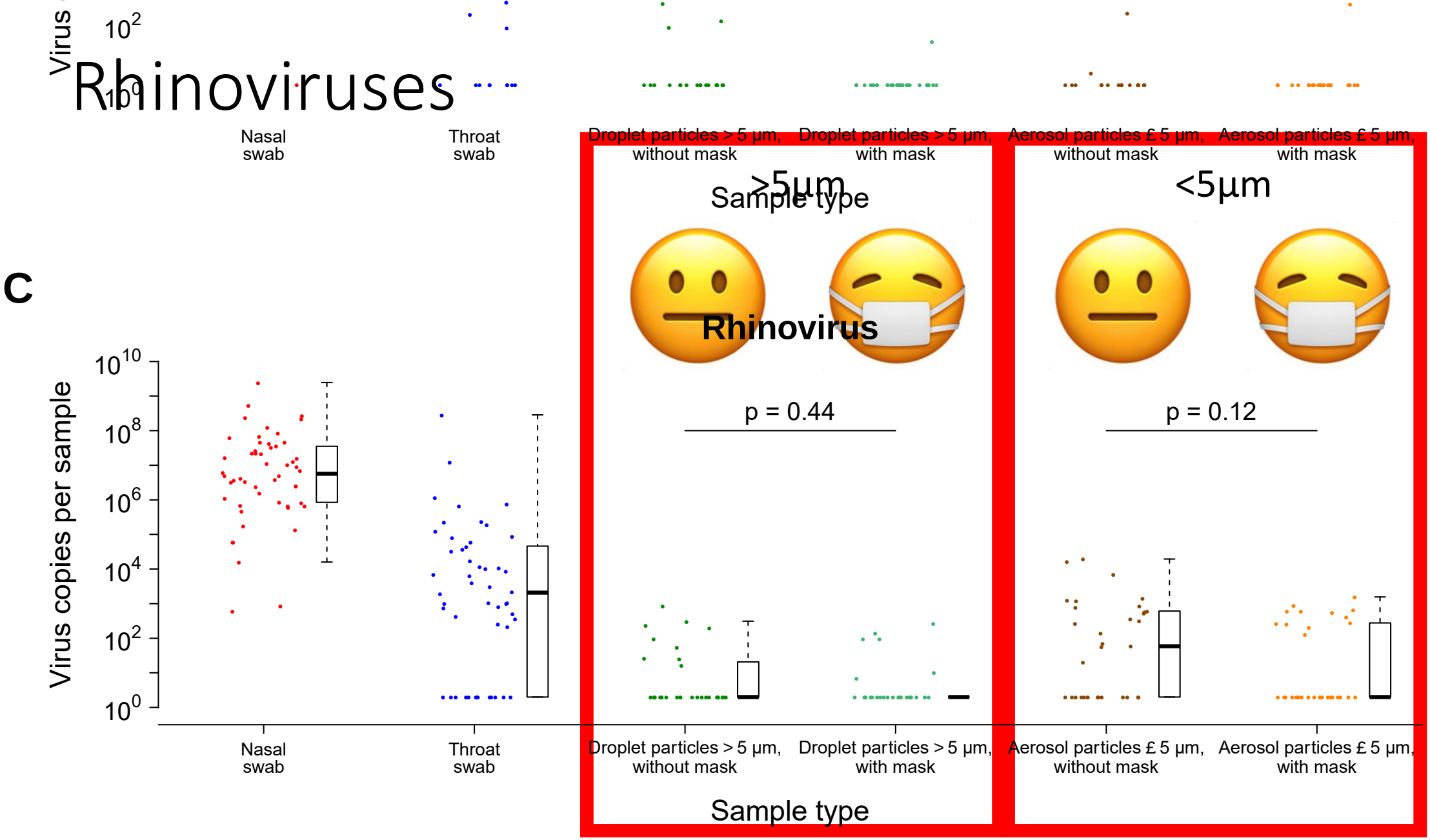
Leung NHL et al. 2020 Nat Med

Human coronaviruses (not COVID-19)



Leung NHL et al. 2020 Nat Med

Rhinoviruses



Leung NHL et al. 2020 Nat Med

Avoid the Three Cs

World Health Organization
Western Pacific Region

Be aware of different levels of risk in different settings.

There are certain places where COVID-19 spreads more easily:

Crowded places

with many people nearby

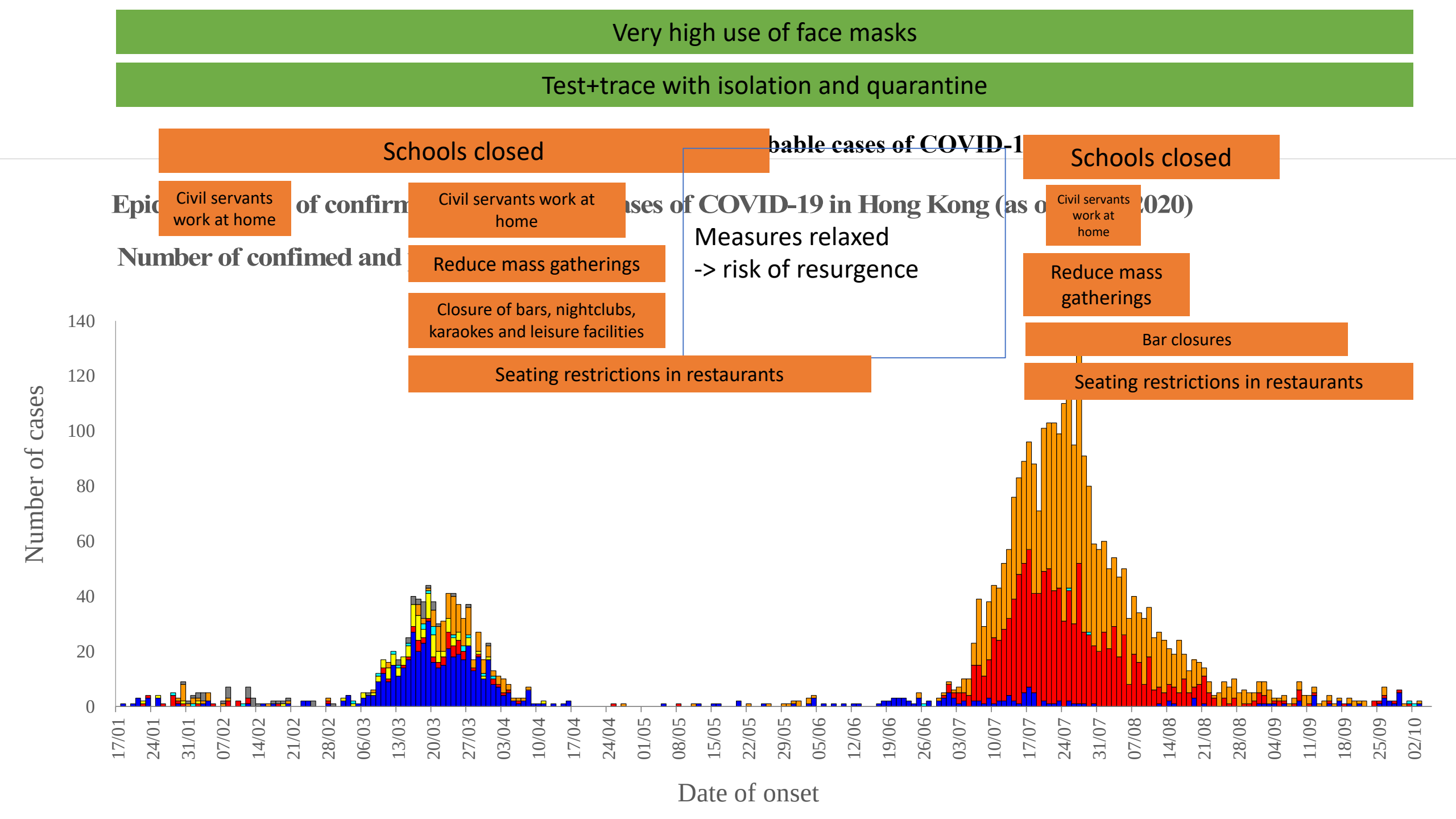
Close-contact settings

Especially where people have close-range conversations

Confined and enclosed spaces

with poor ventilation

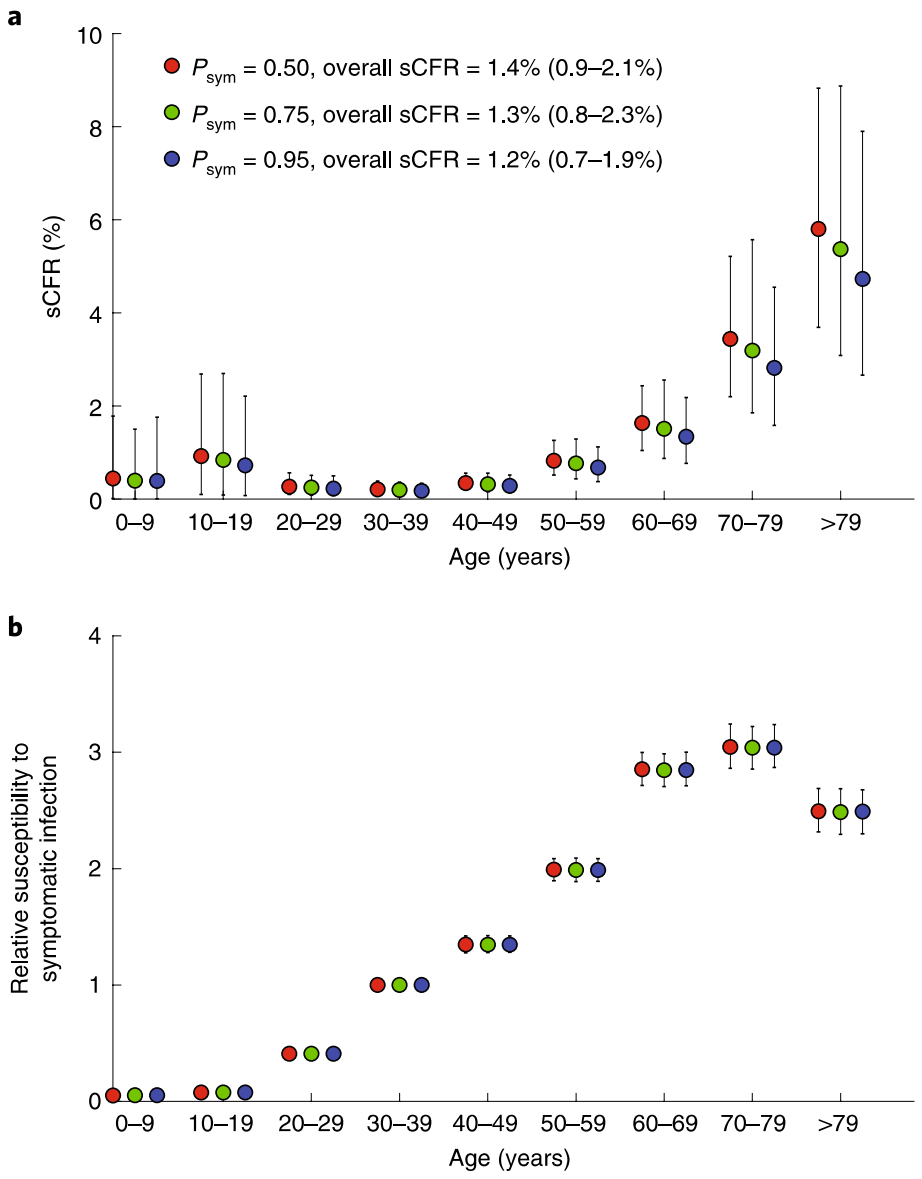
https://www.who.int/images/default-source/wpro/countries/malaysia/infographics/three-3cs/final-avoid-the-3-cs-poster.jpg


Very high use of face masks
Test+trace with isolation and quarantine
Schools closed
Civil servants work at home
Civil servants work at home
Reduce mass gatherings
Closure of bars, nightclubs, karaokes and leisure facilities
Seating restrictions in restaurants
Measures relaxed
-> risk of resurgence
Schools closed
Civil servants work at home
Reduce mass gatherings
Bar closures
Seating restrictions in restaurants
Number of cases
Date of onset
0
20
40
60
80
100
120
140
17/01
24/01
31/01
07/02
14/02
21/02
28/02
06/03
13/03
20/03
27/03
03/04
10/04
17/04
24/04
01/05
08/05
15/05
22/05
29/05
05/06
12/06
19/06
26/06
03/07
10/07
17/07
24/07
31/07
07/08
14/08
21/08
28/08
04/09
11/09
18/09
25/09
02/10

Impact of control measures

- Many cases identified in quarantined individuals -> potentially prevented onwards transmission
- Masks should be effective, but many local clusters have occurred in mask-off settings (e.g. bars, restaurants, dance-hall cluster, etc.)
- In addition to test+trace and universal masking, social distancing measures have been needed to bring second and third waves under control

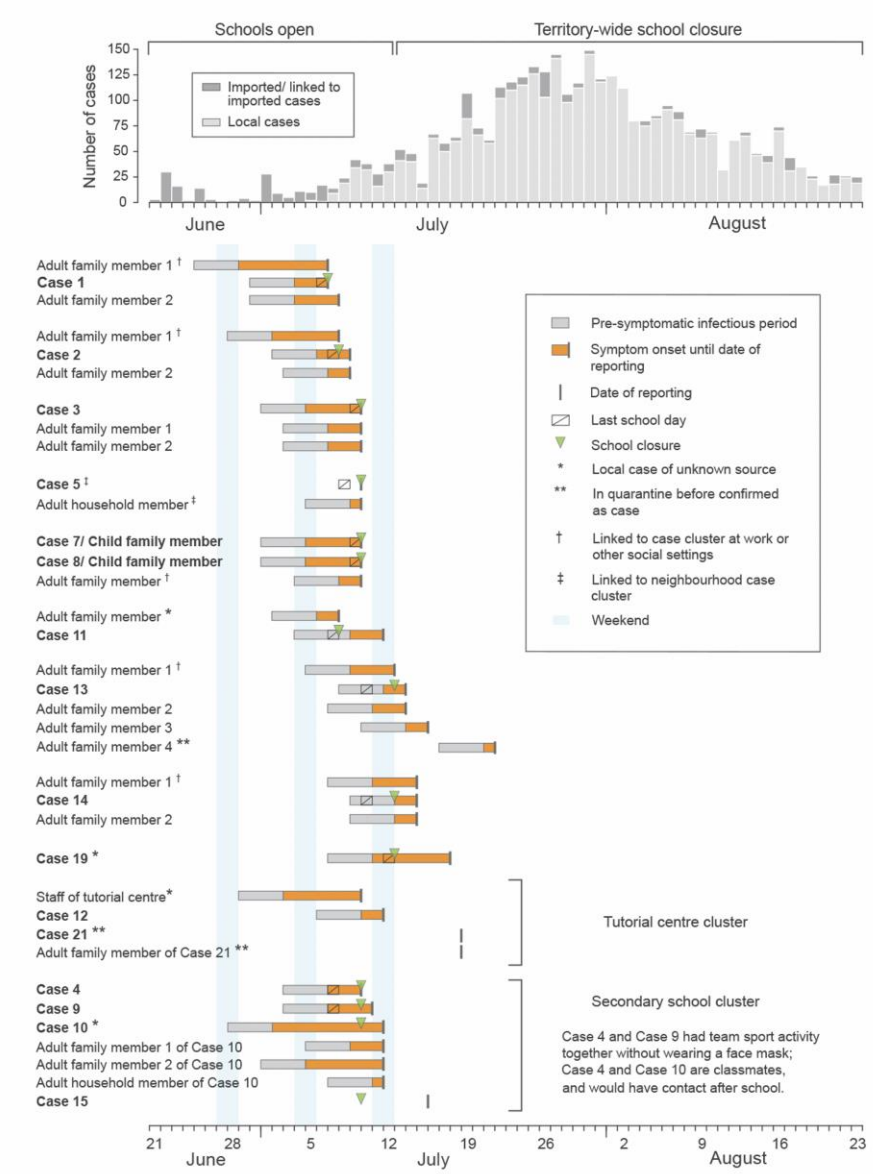
Susceptibility and severity in children



- Figure on left – early data from Wuhan on susceptibility and severity
- Throughout the pandemic we have consistently seen low rates of confirmed cases in children, and generally mild illnesses in this age group
- Still somewhat unclear whether children can have mild/asymptomatic infections and act as sources of transmission in the community

Wu et al. 2020 Nat Med

School measures in Hong Kong

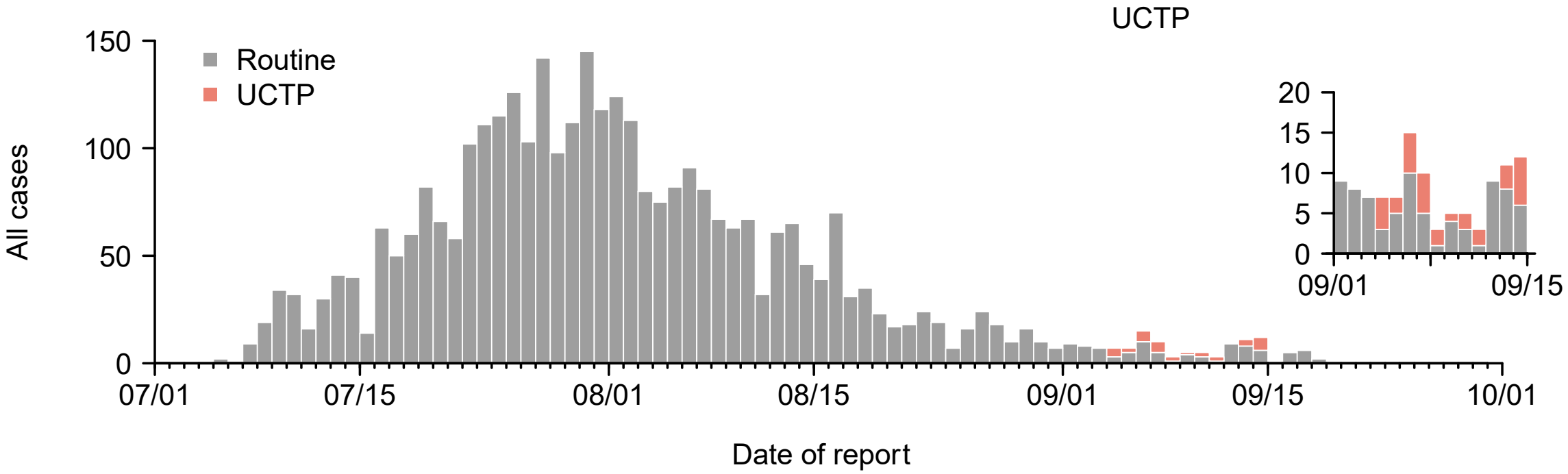


- Schools were closed between February and May but reopened for a period of around 4-6 weeks (depending on age group) in June and July while community incidence of COVID-19 was at a low level. Various measures were implemented to protect against transmission:
  - Daily temperature checks
  - Universal masking
  - All schools switched from full-day to half-day, omitting lunch hours
  - Arrival and dismissal times staggered or spread
  - Increased desk spacing and use of partitions. Group work and contact sports were limited as much as possible. Assemblies, extra-curricular and after-school activities were cancelled.
- We identified 15 cases in children where there could have been opportunities for transmission in schools, but transmission did not occur, perhaps because children could be less efficient spreaders of COVID-19, and perhaps because of the precautionary measures in place.

Fong et al. 2020 Eurosurveill

Mass testing scheme

- Universal testing conducted for first two weeks in September
- 1.7 million people tested (22% of population), identifying 32 cases that might otherwise not have been identified (see figure below), with positivity rate 1.9 per 100,000 tested.
- Results provide confirmation that there were some silent infections in the community, but not a lot



Conclusions

- Face masks and test+trace important but not sufficient to stop COVID-19 spread in the second, third and fourth waves.
- Infections in crowded mask-off settings have been particularly important – superspreading phenomenon
- Work-at-home, bar/karaoke/gym/leisure centre closures and restaurant measures were sufficient to control the second wave and the third wave
- Preventing imported infections will be important between waves
- Hoping for “back to normal” via mass vaccination by late 2021