

Estimating key parameters for novel infectious disease outbreaks and implications for control - SARS-CoV-2 as an example

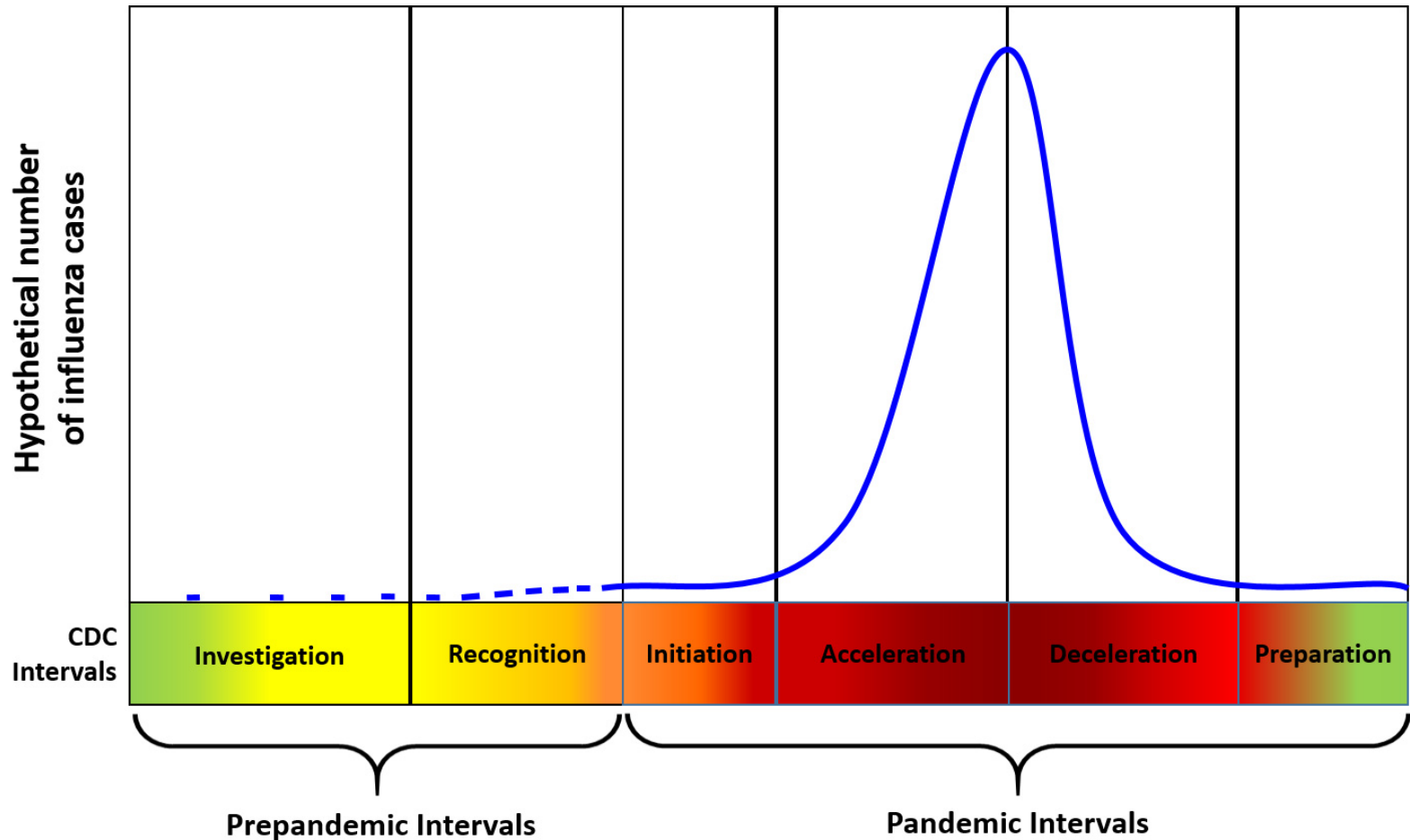
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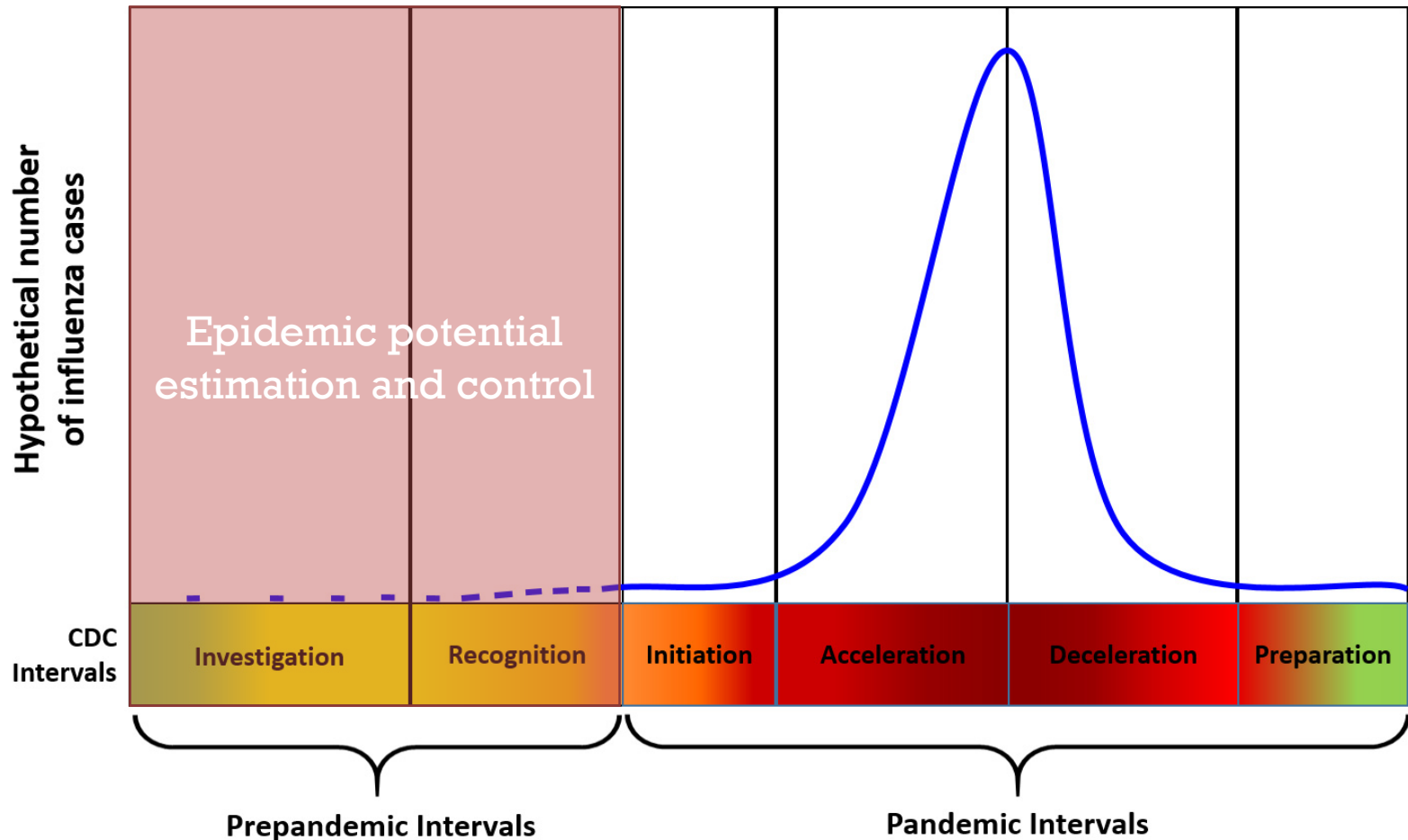
NSF-PREVENT symposium, February, 22, 2021



Preparedness and response framework: CDC intervals



Preparedness and response framework: CDC intervals



Two fundamental epidemiological parameters characterizing an outbreak in the absence of intervention efforts

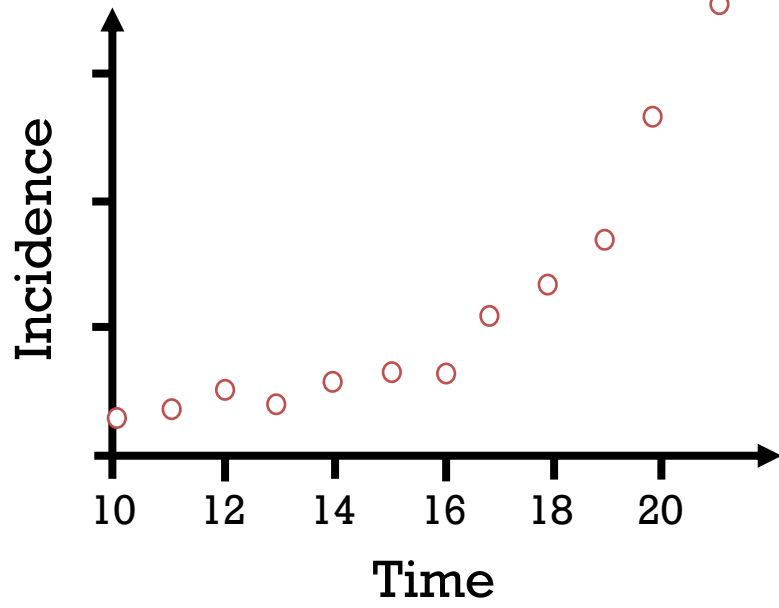
- 1. Early epidemic exponential growth rate, r**
- 2. The basic reproductive number, R_0**

Essential for

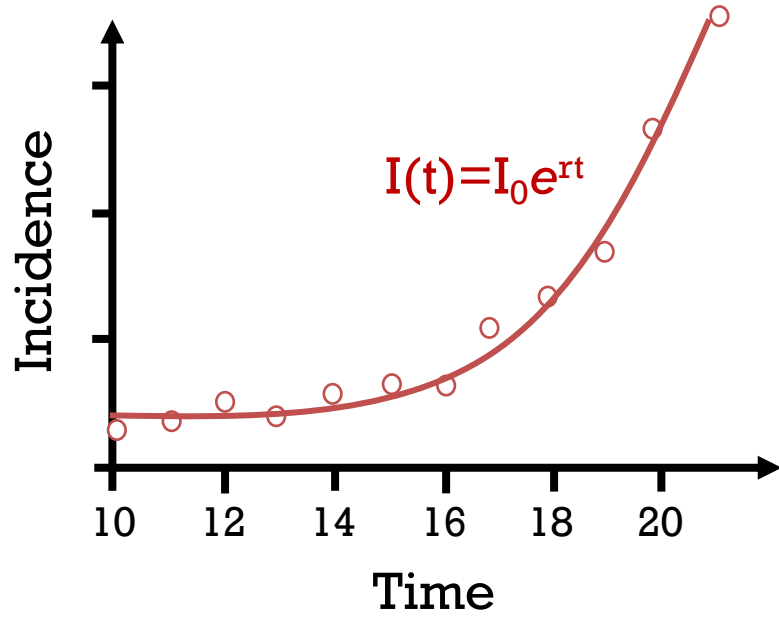
- forecasting epidemic trajectories
- evaluating effectiveness of intervention strategies
- predicting the herd immunity threshold
- etc.

1. Estimation of r

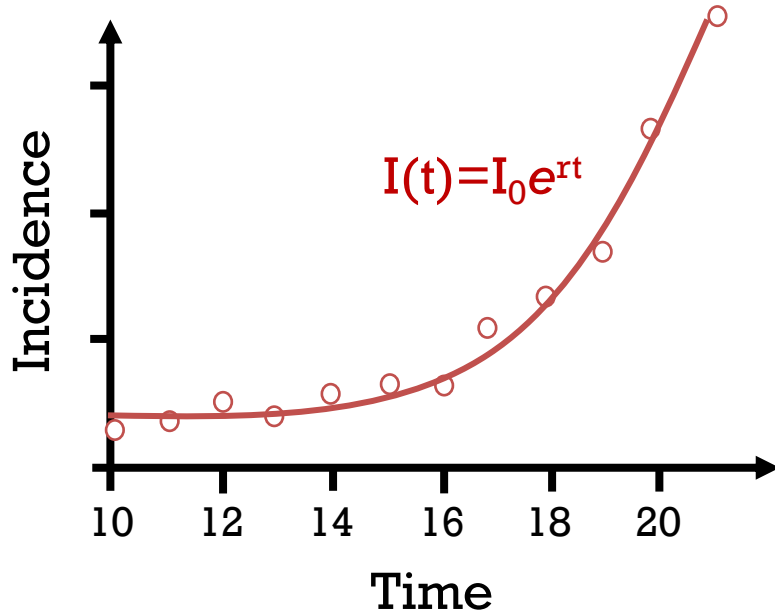
Estimation of r : Data collection



Estimation of r: Model fitting



Estimation of r : Difficulty in assessing bias and uncertainties in data



- Lack of diagnostic tools
- Low surveillance intensity
- Social, economical and political factors

How to evaluate uncertainties and reliability of estimation when data is likely to be noisy and biased?

Survey of estimates of r for early SARS-CoV-2 outbreaks

Growth rate, r	doubling time	Refs.
Low, 0.1-0.14/day	5-7 days	<ul style="list-style-type: none">• Li et al. (2020), NEJM• Wu et al. (2020) Lancet.• Kucharski et al. (2020) Lancet I.D.• Imperial College Report
High, 0.2-0.3/day	2-4 days	<ul style="list-style-type: none">• Sanche et al. (2020) Emerg. Inf. Diseases• Tang et al. (2020) J. Clin. Med.• Zhao et al. (2020), medRxiv.

Differences in the estimates of r lead to vast differences in epidemic projection

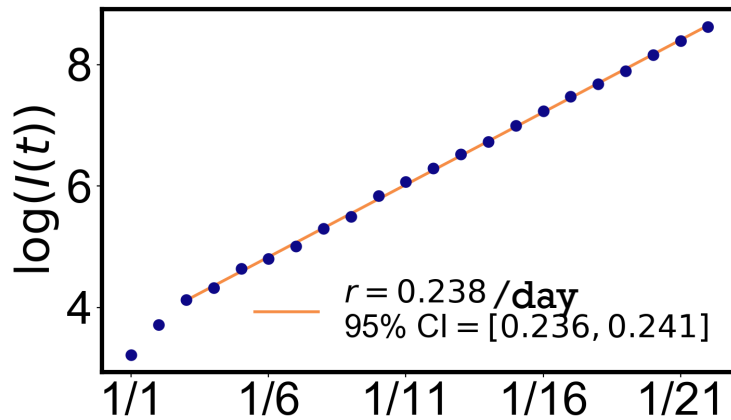
Doubling time	Epidemic size		
	At time 0	After 1 month	After 2 months
7 days ($r=0.1$ /day)	1	20	380
3 days ($r=0.23$ /day)	1	1,024	$\sim 10^6$

How can we be sure our estimates are reliable?

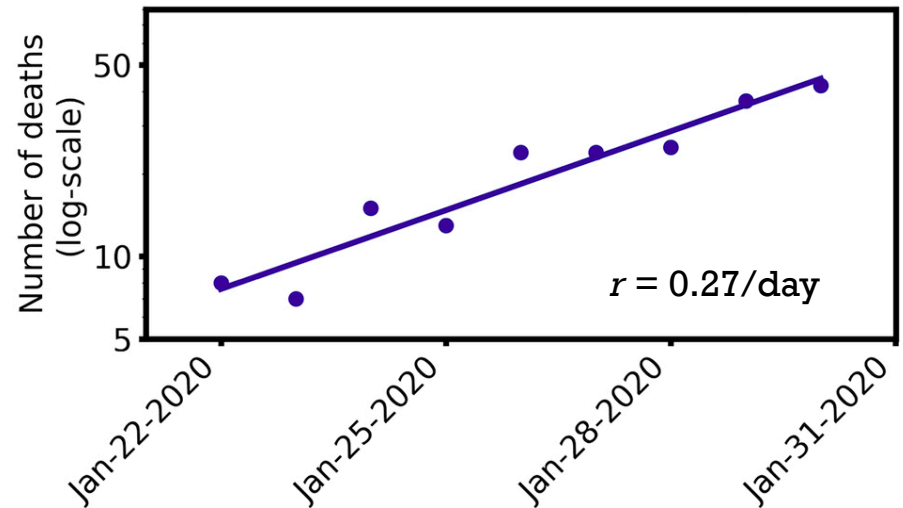
1. **Cross validation using multiple datasets**
2. **Predictability**

1. Cross validation – incidence curve by symptom onset

Growth of outbreak by date of symptom onset



Growth of outbreak by death counts



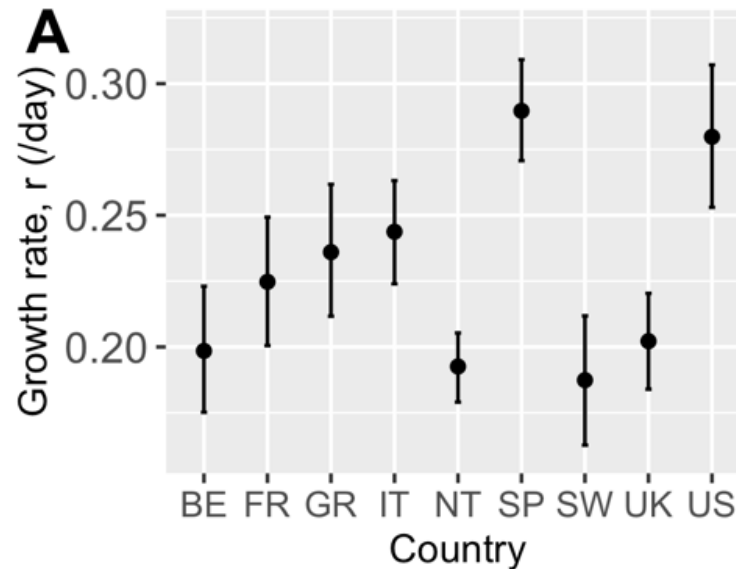
China

CDC: <http://weekly.chinacdc.cn/en/article/id/e53946e2-c6c4-41e9-9a9b-fea8db1a8f51>

[Sanche et al. (2020) Emerging Infectious Diseases]
Preprint online: Feb. 9, 2020
<https://www.medrxiv.org/content/10.1101/2020.02.07.20021154v1>

2. Predictability –

High epidemic growth rates across Europe and the US



The growth rates of outbreak are between **0.19-0.29/ day**
Epidemic doubling time: **2.4-3.7 days**

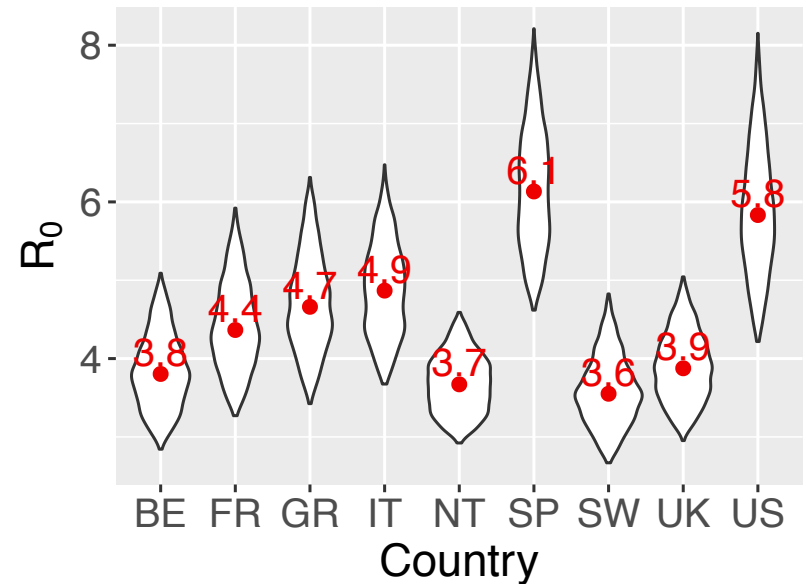
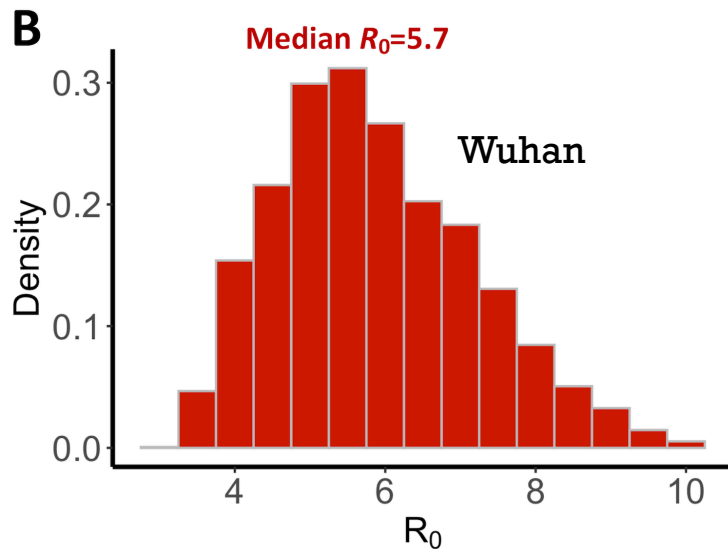
Preprint online: April 4, 2020: <https://www.medrxiv.org/content/10.1101/2020.04.04.20050427v2>]
Ke et al. (2021), Journal of Theoretical Biology (in press)

Also see:

- Flaxman et al. (2020), Nature
- Pellis et al. (preprint): <https://www.medrxiv.org/content/10.1101/2020.04.12.20059972v2.full.pdf>

2. Estimation of R_0

Estimating R_0 assuming a mean serial interval between 6-8 days

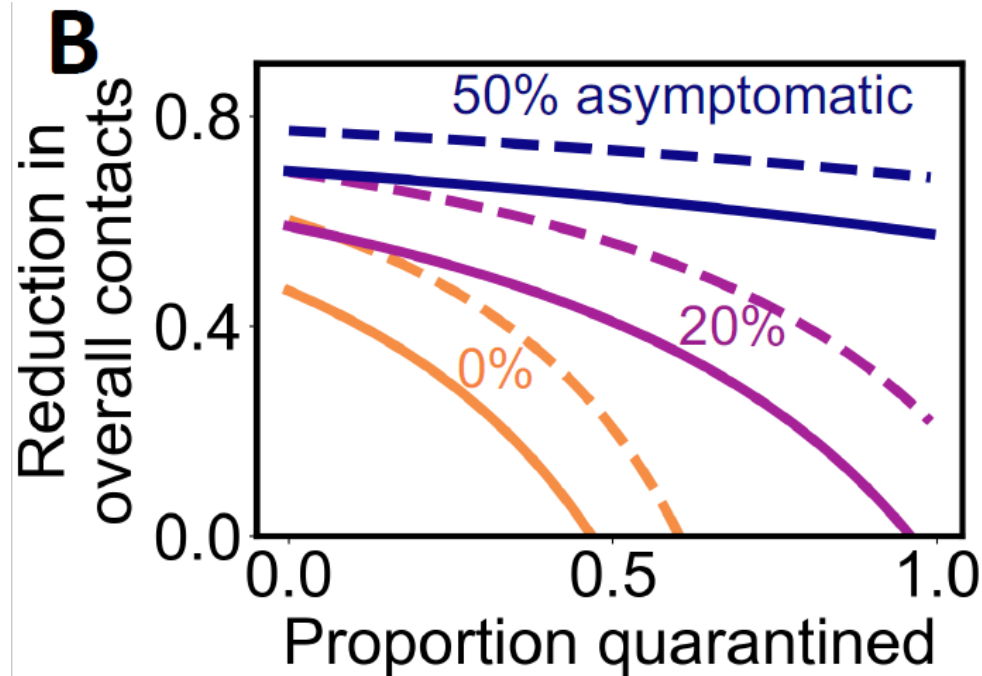


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Online: April 4, 2020

3. Implications for control

Early, strong social distancing efforts are needed to contain the spread.



Preprint online: Feb. 9, 2020

<https://www.medrxiv.org/content/10.1101/2020.02.07.20021154v1>

[Sanche et al. (2020) Emerging Infectious Diseases]

Lessons learned for assessing epidemic potential for a novel pathogen

1. **Noisy and biased data makes estimation uncertain.**
2. **Two ways to test the reliability of estimates:**
 - **Cross validation using multiple datasets**
 - **Predictability**
3. **Difficulty in challenging published results**

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Thank you!!!

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