Which COVID-19 Models Were Helpful?

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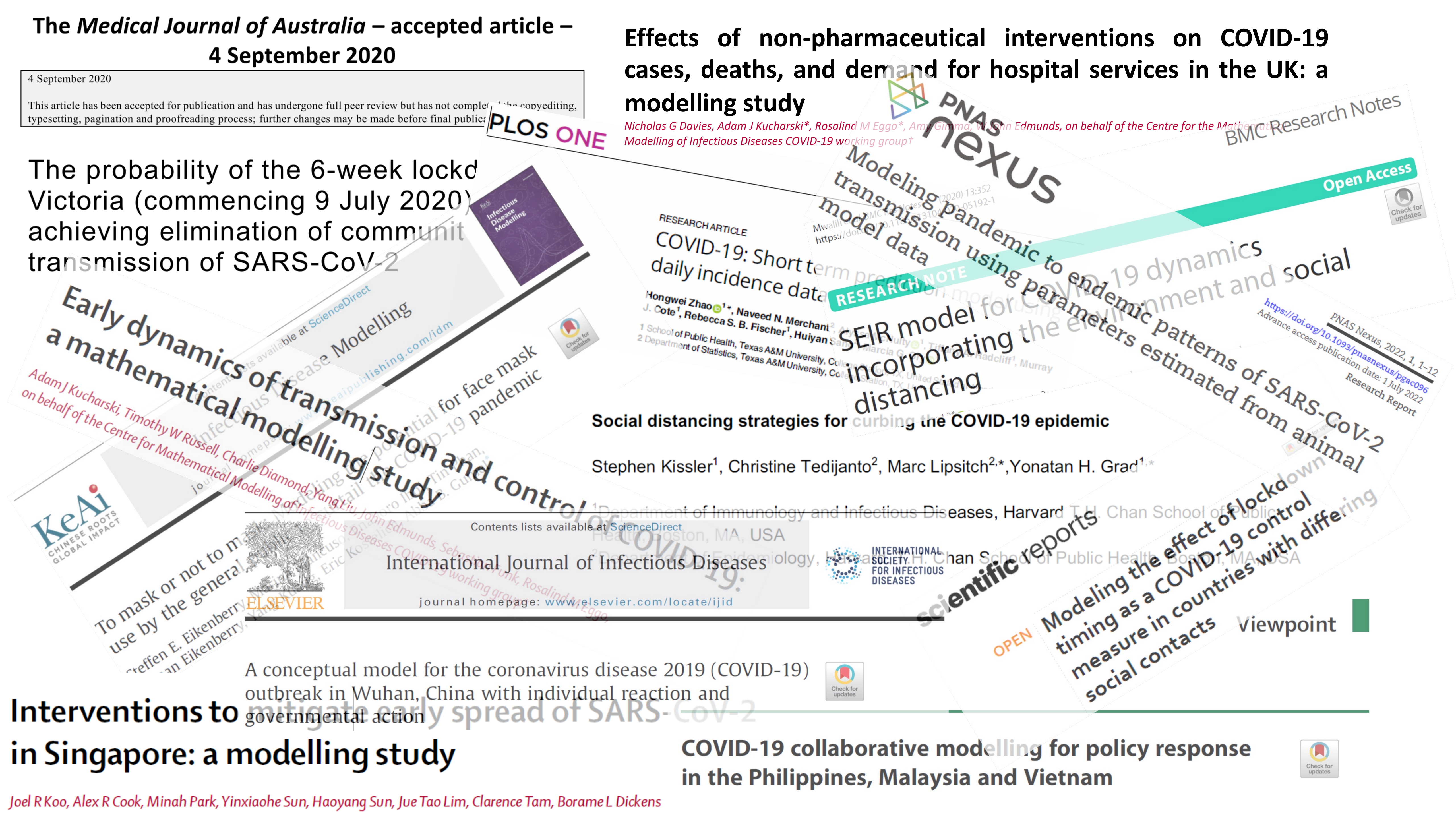

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typesetting, pagination and proofreading process; further changes may be made before final public
The probability of the 6-week lockd
Victoria (commencing 9 July 2020)
achieving elimination of communit
transmission of SARS-CoV-2
Effects of non-pharmaceutical interventions on COVID-19 cases, deaths, and demand for hospital services in the UK: a modelling study
Nicholas G Davies, Adam J Kucharski*, Rosalind M Eggo*, Amy Gimma, W John Edmunds, on behalf of the Centre for the Mathematical
Modelling of Infectious Diseases COVID-19 working group†
PLOS ONE
PNAS nexus
BMC Research Notes
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Modeling pandemic to endemic patterns of SARS-CoV-2 transmission using parameters estimated from animal model data
PNAS Nexus, 2022, 1, 1–12
https://doi.org/10.1093/pnasnexus/pgac096
Advance access publication date: 1 July 2022
Research Report
RESEARCH ARTICLE
COVID-19: Short term prediction model using daily incidence data
Hongwei Zhao, Naveed N. Merchant
RESEARCH NOTE
SEIR model for COVID-19 dynamics incorporating the environment and social distancing
Infectious Disease Modelling
Early dynamics of transmission and control of COVID-19: a mathematical modelling study
Adam J Kucharski, Timothy W Russell, Charlie Diamond, Yang Liu, John Edmunds, Sebastian Funk, Rosalind M Eggo, on behalf of the Centre for Mathematical Modelling of Infectious Diseases COVID-19 working group
KeAi
CHINESE ROOTS GLOBAL IMPACT
To mask or not to mask
use by the general
Steffen E. Eikenberry
Social distancing strategies for curbing the COVID-19 epidemic
Stephen Kissler[1], Christine Tedijanto[2], Marc Lipsitch[2,*], Yonatan H. Grad[1,*]
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[2]Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, MA, USA
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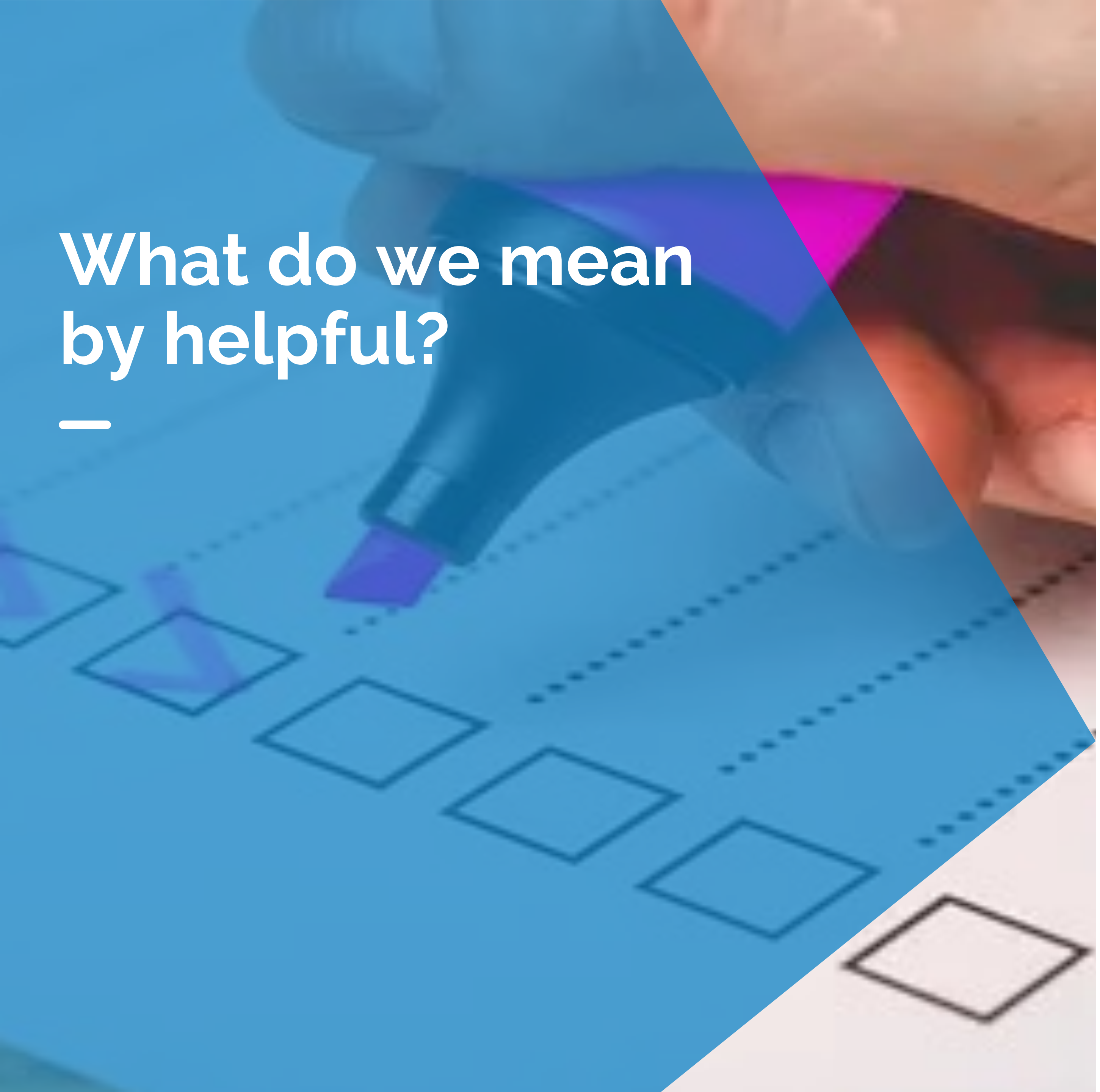
Modeling the effect of lockdown timing as a COVID-19 control measure in countries with differing social contacts
Viewpoint
A conceptual model for the coronavirus disease 2019 (COVID-19) outbreak in Wuhan, China with individual reaction and governmental action
Interventions to mitigate early spread of SARS-CoV-2 in Singapore: a modelling study
Joel R Koo, Alex R Cook, Minah Park, Yinxiaohe Sun, Haoyang Sun, Jue Tao Lim, Clarence Tam, Borame L Dickens
COVID-19 collaborative modelling for policy response in the Philippines, Malaysia and Vietnam

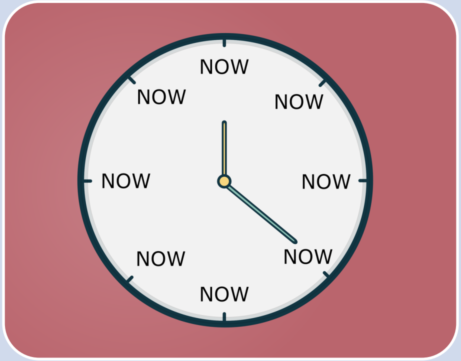


What do we mean by helpful?

Are models fit-for-purpose:

- Clear primary question
- Do the model features reflect what is known about the pathogen/disease?
- Population heterogeneity
- Use of data sources
- Uncertainty
- Was model the most appropriate to answer question

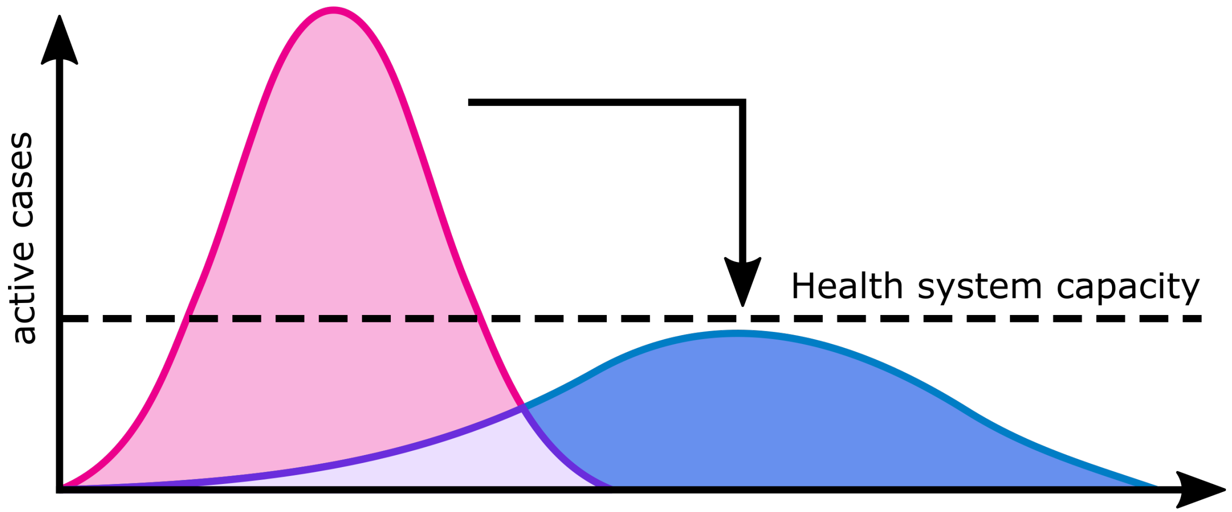
Models are designed for different purposes



Preparedness	Real time	Forecasting	Retrospection
Mitigate the impact of infectious diseases	Situational assessment and decision support	Predicting the likely course of disease epidemiology	Using models to understand the drivers of disease

Preparedness models

- Estimate health care needs following introduction of new pathogen – scenario based
- Compare unmitigated epidemic to one with a range of hypothetical interventions
- Inform what is required to remain within capacity
- Use information from other settings — transmissibility and severity

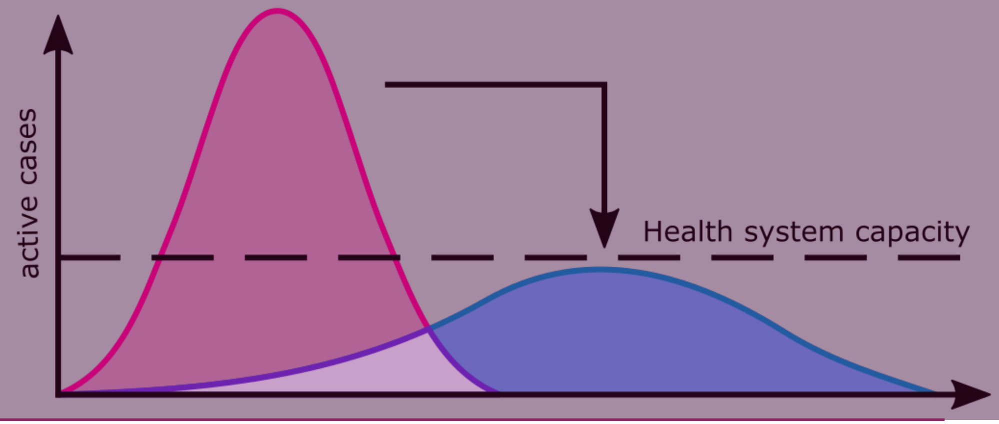


Preparedness models
Examples

- Australia[1]:
  - Coupled age- and risk-stratified transmission model with clinical pathways model
  - Interventions modelled were case isolation and contact quarantine
  - These measures alone could not constrain need within capacity
- UK[2]:
  - Used SEIR model, applying data from China to estimate deaths and hospitalisations
  - Interventions were school closures, distancing, shielding of >70 years, self isolation
  - Implemented alone, no interventions could constrain need within capacity
- India[3]:
  - Used SEIR model, measures were cumulative infection incidence and peak prevalence
  - Interventions modelled were symptomatic case isolation, port of entry screening
  - Screening would delay outbreak by days, case isolation may reduce burden (optimistic)

1. Moss et al. (2020) *Emerging infectious diseases* 26.12: 2844. 2. Davies et al. (2020) *Lancet Public Health* 5.7: e375-e385 3.Mandal et al. (2020) *Indian J Med Res* 151:190-199

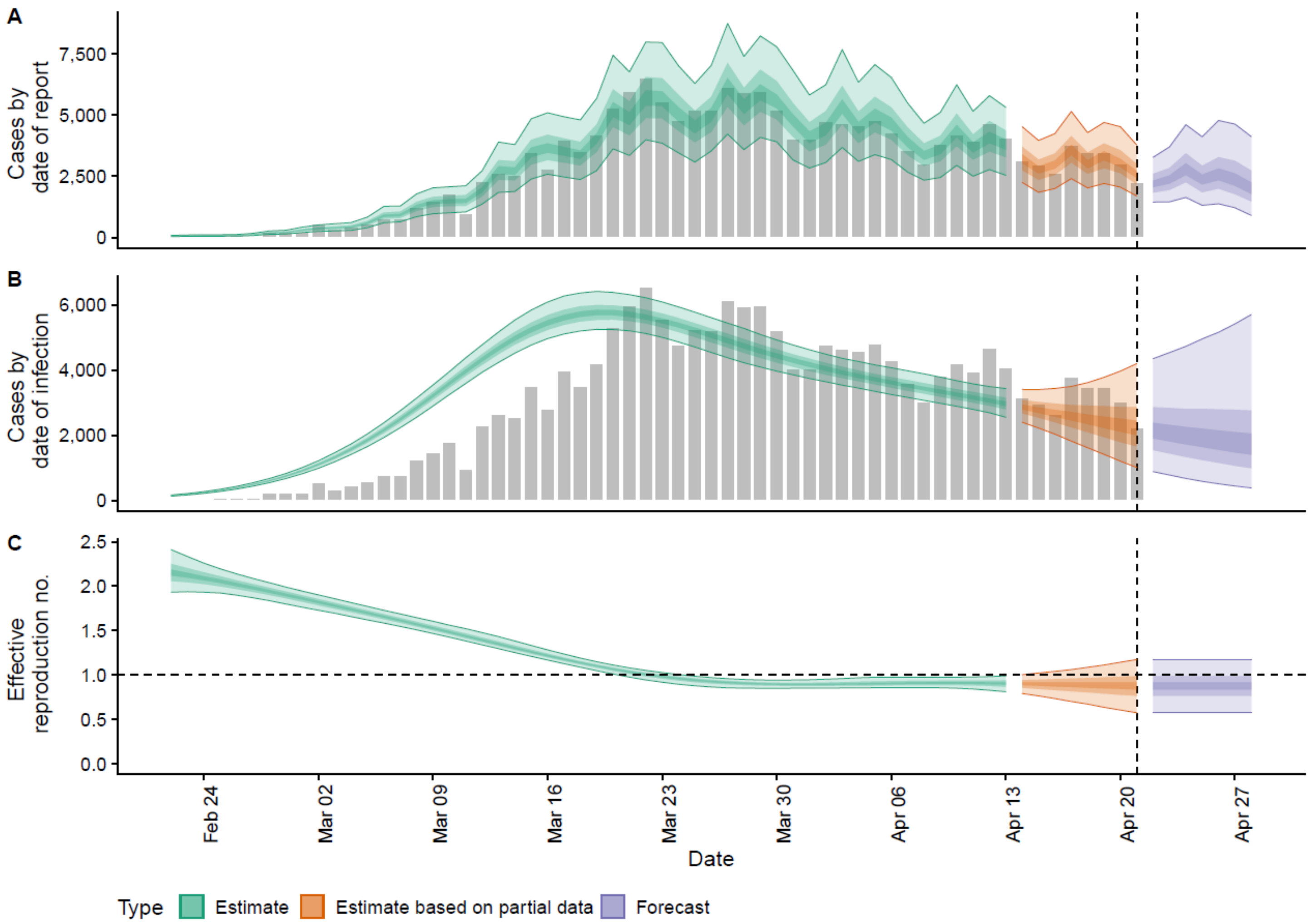
Were preparedness models fit-for-purpose?



	Moss et al. — Australia	Davies et al. — UK	Mandel et al. — India
Clear research question	✓	✓	✓
Reflect what is known	✓	✓	✓
Include heterogeneity	Age/Risk/Severity	Age/Location/Severity	Symptoms
Use of data sources	Literature	Literature	Literature
Uncertainty	✓	✓	✓
Most appropriate model	✓	✓	✓

Real-time (Nowcasting) models

Example only



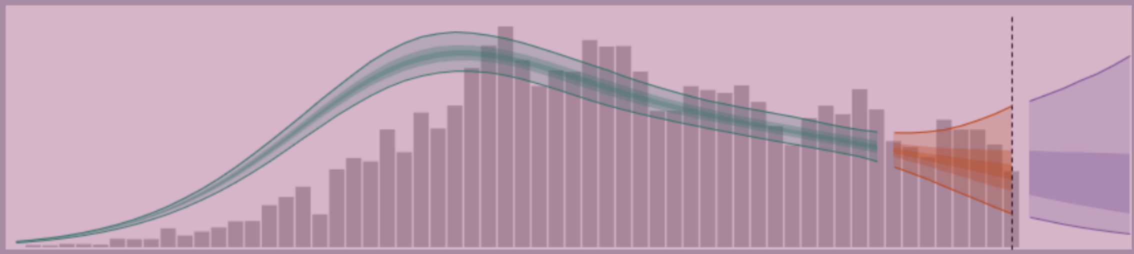
- Estimate current and future growth based on case counts
- May account for presentation and reporting delays
- Very short term predictions (~1–2 weeks)
- Measure effectiveness of interventions

Real-time (Nowcasting) models: Examples

- Australia[1]:
  - Semi-mechanistic framework incorporating behavioural and case data
  - Measures: effective reproduction number or transmission risk (when no/low cases)
  - Reported to peak national decision makers in Australia; common operating picture
- UK[2]:
  - Used age- and region- stratified SEIR model
  - Measures: effect of social restrictions on effective reproduction number, deaths
  - Reported to Public Health England and Joint Biosecurity Centre; regularly published
- Japan[3]:
  - Used regression modelling: cases ~ mobility + temperature + risk awareness
  - Measures: effective reproduction number
  - Model performance diminished with stringent interventions

1. Golding et al. (2023) *eLife* 12:e78089. 2. Birrell et al. (2021) *Phil. Trans. R. Soc.* 376: 20200279. 3. Jung et al. *Int J Inf Dis* (2021) 113:47-54

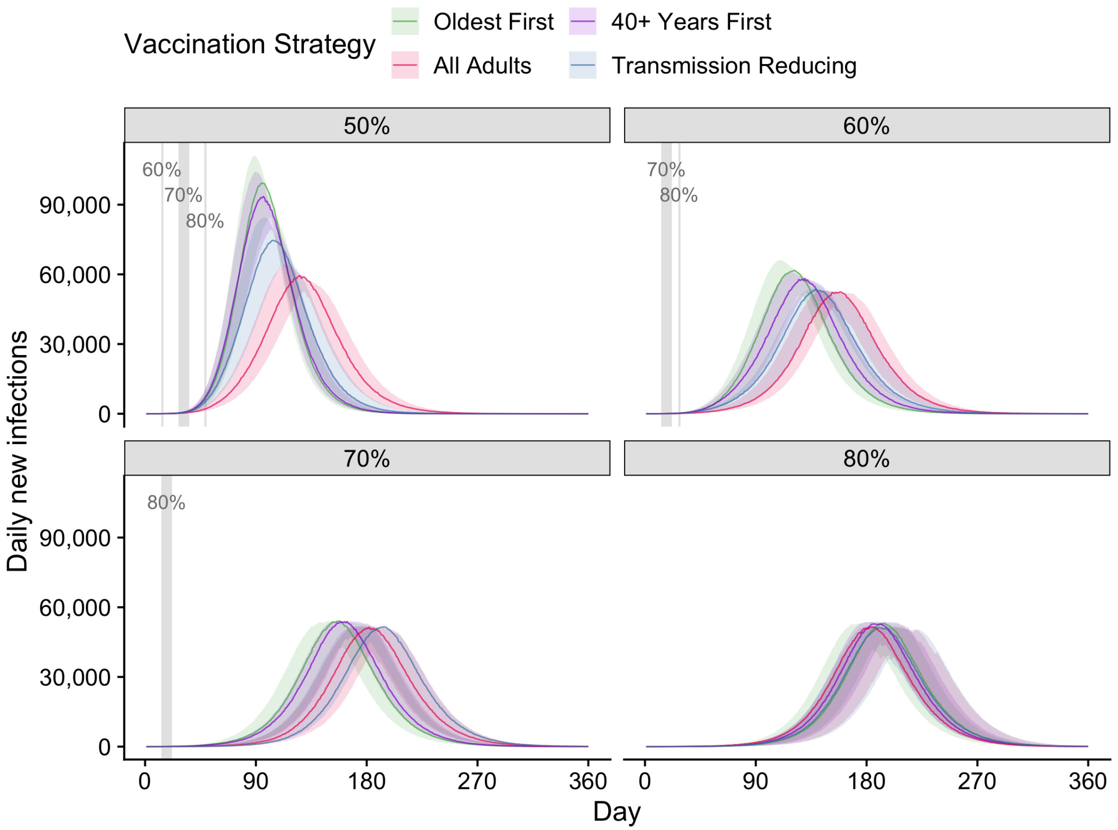
Were real-time (Nowcasting) models fit-for-purpose?



	Golding et al. — Australia	Birrell et al. — UK	Jung et al. — Japan
Research question	✓	✓	✓
Reflect what is known	✓	✓	~
Include heterogeneity	~	✓	~
Use of data sources	Surveys/Mobility/Cases	Deaths/Serology	Public data only
Uncertainty	✓	✓	Limitation
Most appropriate model	Novel method	✓	Regression

Forecasting models

- Typically, a longer time frame than real-time modelling
- Calibrate model to past experience
- Estimate what might happen in the future under different assumptions
- Still quite short timeframes for COVID-19 (~1 year)

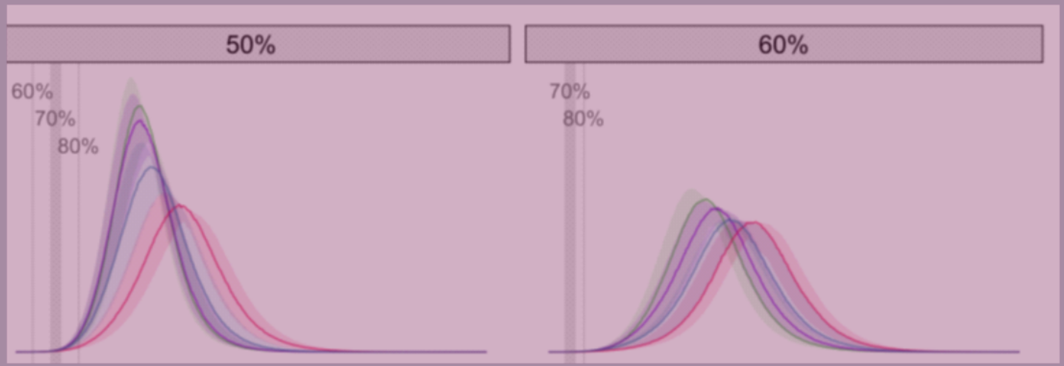


Forecasting models: Examples

- Australia[1]:
    - Vaccine allocation + Individual-based transmission model + Clinical Pathways
    - Incorporates transmission potential; public health and social measures
    - Modelled transitions in the National Plan; unlike other settings needed to seed infections
- US[2]:
    - Extended SEIR model to project mortality as restrictions were relaxed
    - Calibrated to US historical death data across pandemic
    - Projected deaths for a number of different dates of lifting non-pharmaceutical interventions
- UK[3]:
    - Extended SEIR model calibrated to UK outbreak data
    - Scenario modelling of three types of vaccines, based on anticipated effect
    - Projected deaths and QALY losses

1. Conway et al. (2023) *medRxiv https://doi.org/10.1101/2022.12.04.22282996*. 2. Linas et al. (2022) JAMA Health Forum 3. Moore et al. (2021) *PLOS Comp Biol* 17(5): e1008849

Were forecasting models fit-for-purpose?



	Conway et al. — Australia	Linas et al. — US	Moore et al. — UK
Research question	✓	✓	✓
Reflect what is known	✓	✓	✓
Include heterogeneity	Age/Immunity/Symptoms	Age/Vaccine doses/State	Age/Region
Use of data sources	✓	?	✓
Uncertainty	✓	Very limited	✓
Most appropriate model	IBM allows heterogeneity	?	✓

Summary

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- Main characteristic of these models is that they were the best that could be done *at the time*
- Methods often amalgamated mathematical, computational and statistical techniques
- Many of these models have been an integral part of the evidence base used to support COVID-19 policy
- Communication of uncertainty is particularly important — uncertain inputs mean uncertain outputs
- Focus here on separate models, but ensemble modelling may be able to do better