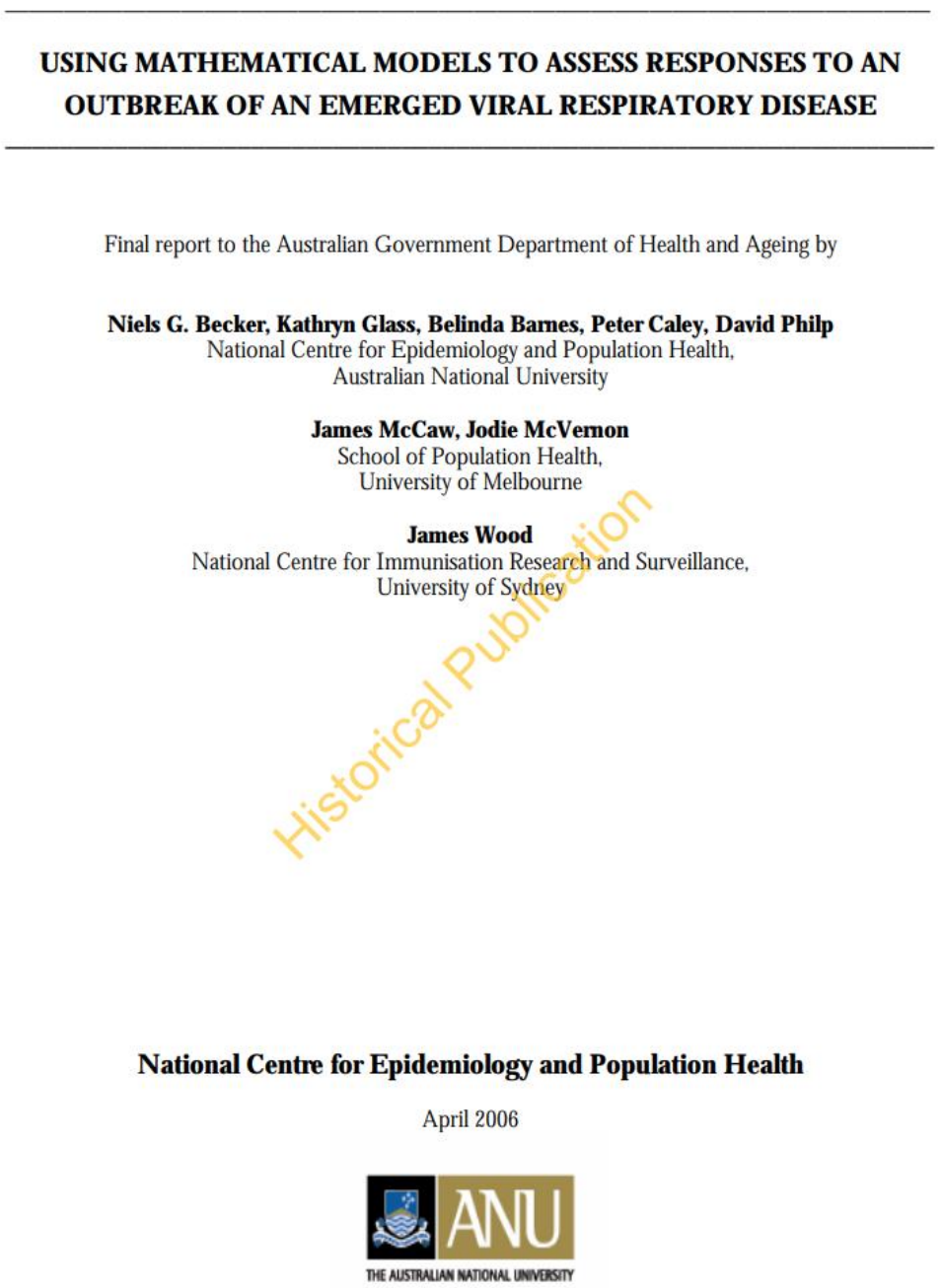
School of Public Health & Community Medicine

Assoc. Prof. James Wood

Australia's experience and the role of modelling in its responses to COVID-19

Personal trajectory

- PhD studies in applied maths/physics
- In 2005 started postdoc in modelling infectious diseases
  - Almost immediately involved in pandemic planning related to threat from H5N1
  - Began process of modelling being a key component of pandemic planning in Australia
  - Also co-wrote quantitative parts of scenarios for a simulation exercise held in 2006 (Exercise Cumpston)
- Since 2008 been at UNSW Sydney in the School of Public Health & Community Medicine (teaching+research) as mathematical scientist working in ID epi and control.



USING MATHEMATICAL MODELS TO ASSESS RESPONSES TO AN OUTBREAK OF AN EMERGED VIRAL RESPIRATORY DISEASE

Final report to the Australian Government Department of Health and Ageing by

Niels G. Becker, Kathryn Glass, Belinda Barnes, Peter Caley, David Philp
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April 2006

ANU
THE AUSTRALIAN NATIONAL UNIVERSITY

Source: https://www1.health.gov.au/internet/publications/publishing.nsf/Content/mathematical-models

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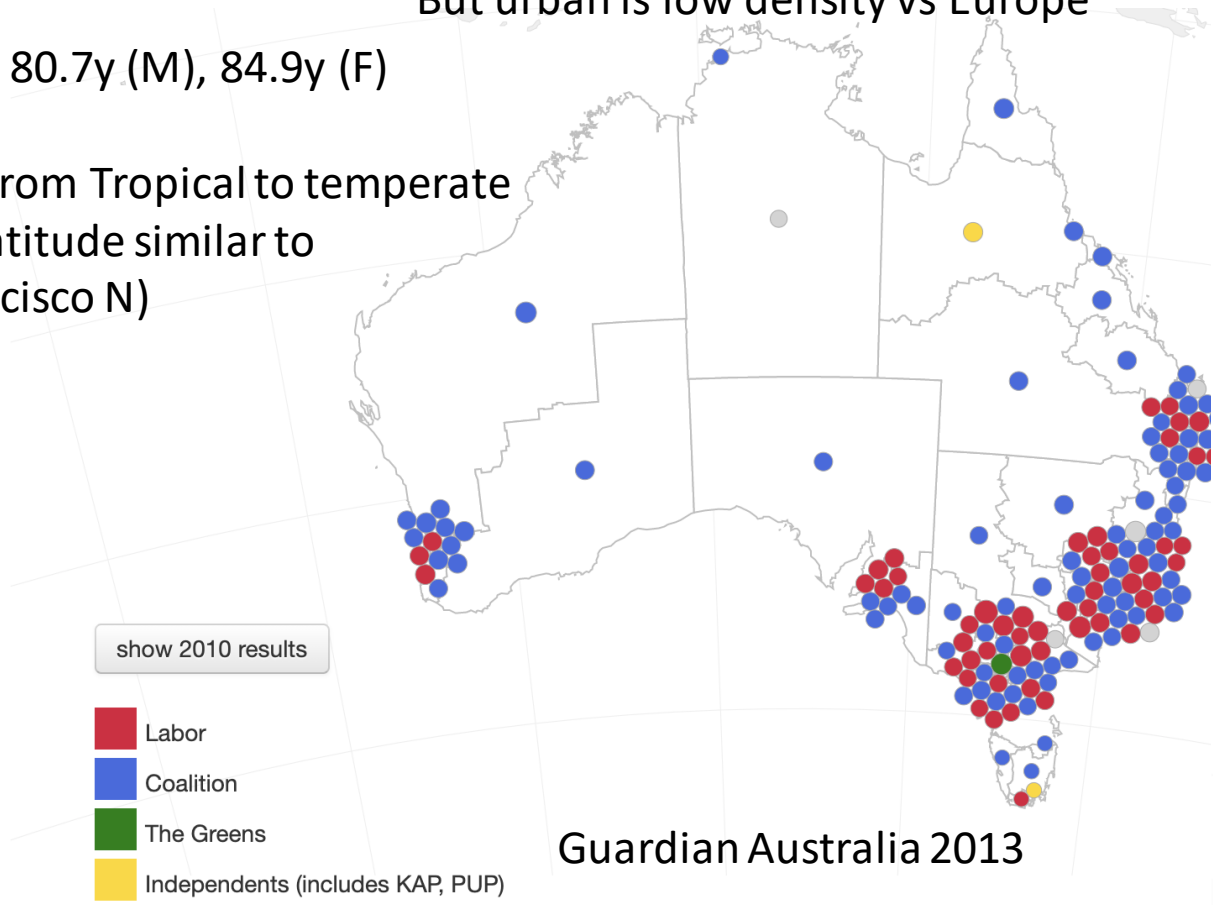
Orientation to Australia

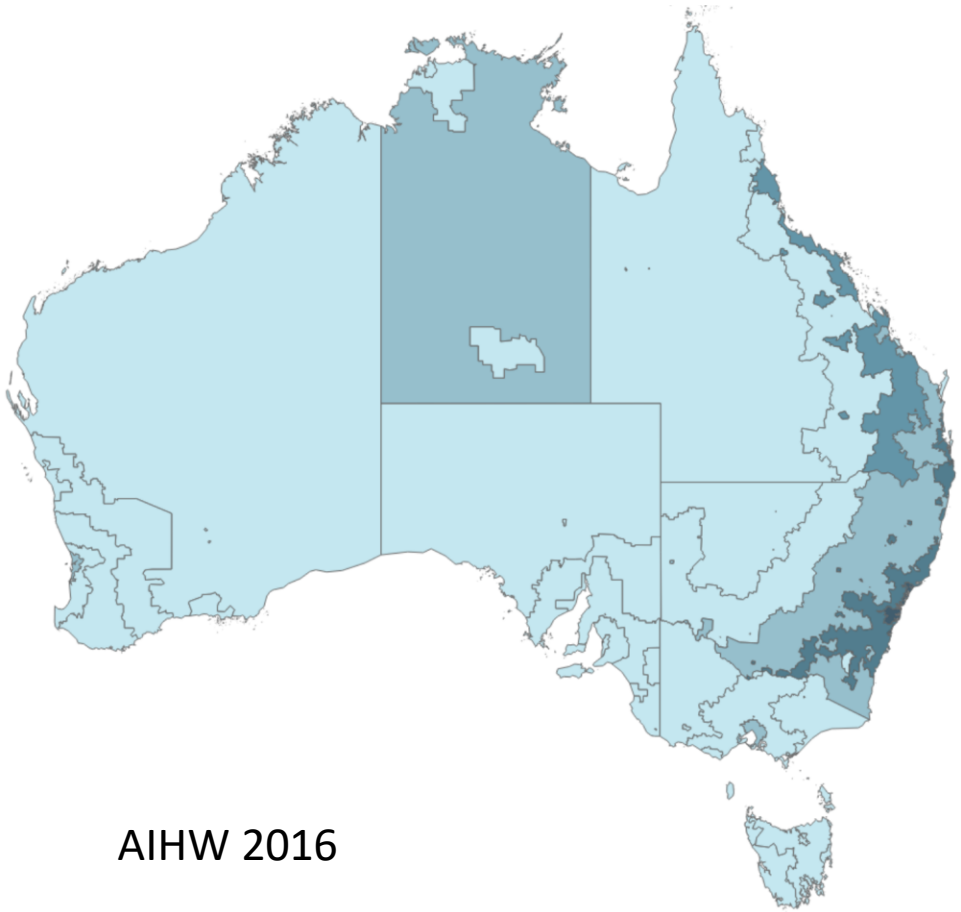
Median age: 37
Life expectancy: 80.7y (M), 84.9y (F)
>65y: 15.9%
Climate ranges from Tropical to temperate
(Melbourne S Latitude similar to
Lisbon/San Francisco N)

Mostly urban population (>85%)
But urban is low density vs Europe



Guardian Australia 2013

Indigenous population mostly along east coast



AIHW 2016

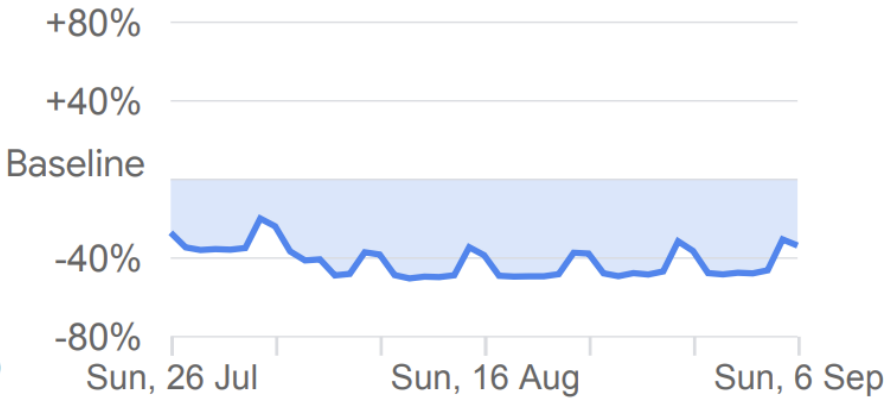
Our very different states (or territories)

Workplace mobility data from Google

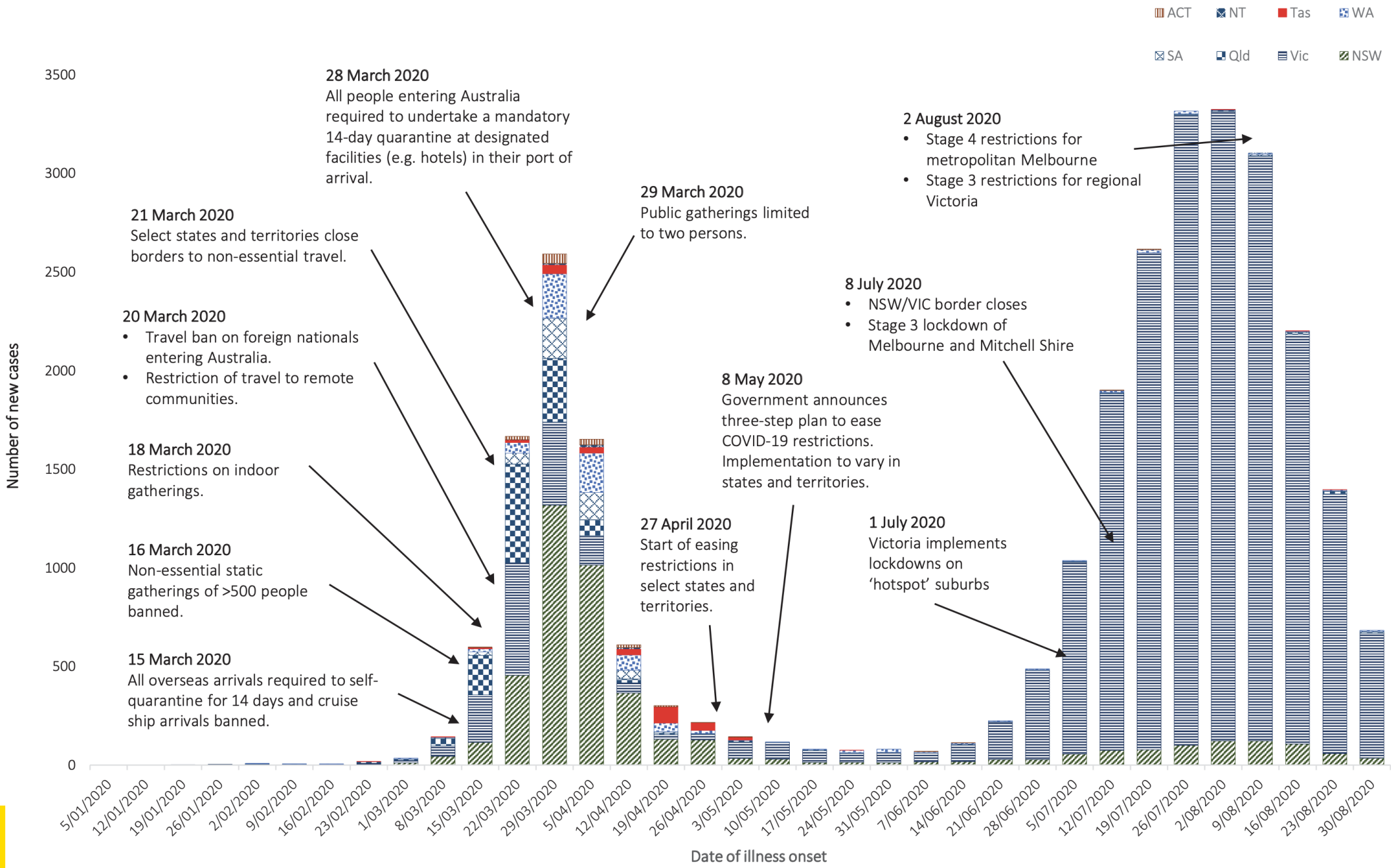
Northern Territory

NSW

Victoria

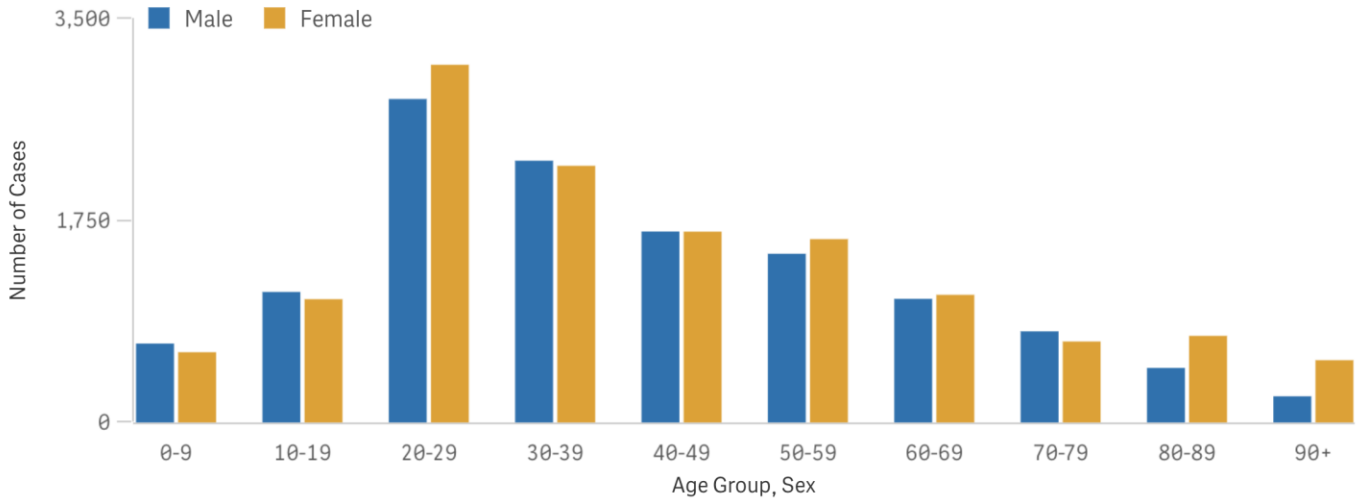


How did we get to here?

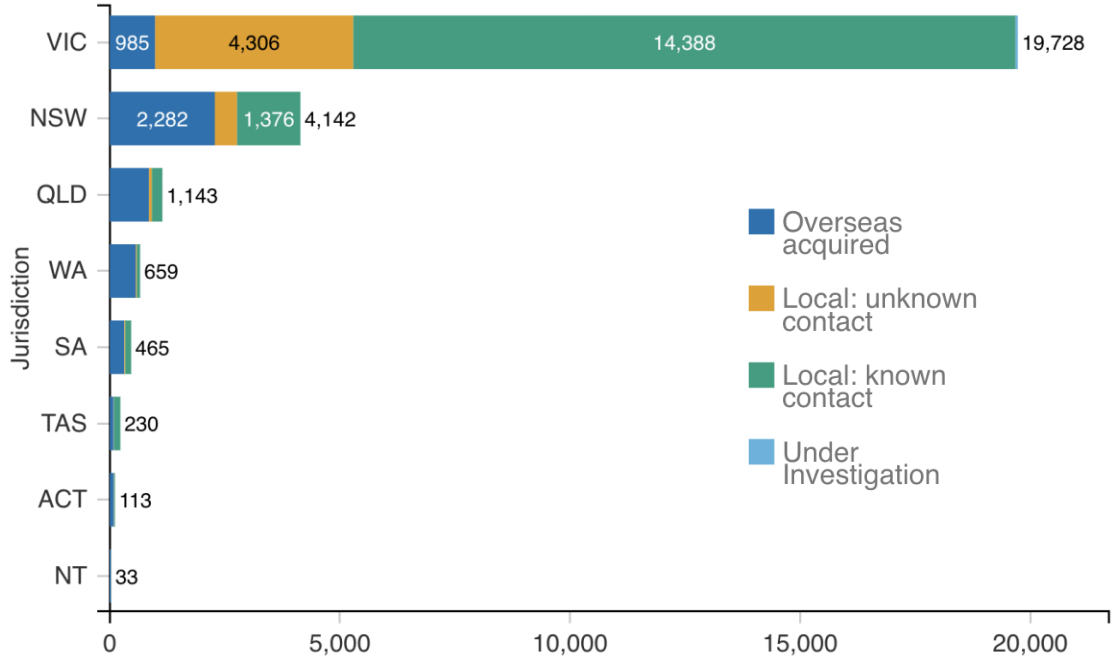

ACT
NT
Tas
WA
SA
Qld
Vic
NSW
Number of new cases
3500
3000
2500
2000
1500
1000
500
0
28 March 2020
All people entering Australia required to undertake a mandatory 14-day quarantine at designated facilities (e.g. hotels) in their port of arrival.
29 March 2020
Public gatherings limited to two persons.
2 August 2020
• Stage 4 restrictions for metropolitan Melbourne
• Stage 3 restrictions for regional Victoria
21 March 2020
Select states and territories close borders to non-essential travel.
20 March 2020
• Travel ban on foreign nationals entering Australia.
• Restriction of travel to remote communities.
8 July 2020
• NSW/VIC border closes
• Stage 3 lockdown of Melbourne and Mitchell Shire
8 May 2020
Government announces three-step plan to ease COVID-19 restrictions. Implementation to vary in states and territories.
18 March 2020
Restrictions on indoor gatherings.
27 April 2020
Start of easing restrictions in select states and territories.
1 July 2020
Victoria implements lockdowns on 'hotspot' suburbs
16 March 2020
Non-essential static gatherings of >500 people banned.
15 March 2020
All overseas arrivals required to self-quarantine for 14 days and cruise ship arrivals banned.
5/01/2020
12/01/2020
19/01/2020
26/01/2020
2/02/2020
9/02/2020
16/02/2020
23/02/2020
1/03/2020
8/03/2020
15/03/2020
22/03/2020
29/03/2020
5/04/2020
12/04/2020
19/04/2020
26/04/2020
3/05/2020
10/05/2020
17/05/2020
24/05/2020
31/05/2020
7/06/2020
14/06/2020
21/06/2020
28/06/2020
5/07/2020
12/07/2020
19/07/2020
26/07/2020
2/08/2020
9/08/2020
16/08/2020
23/08/2020
30/08/2020
Date of illness onset

Epidemiological snapshot

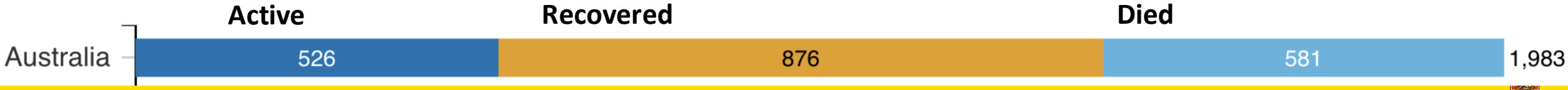
Age distribution (cases)



Age distribution (cases)



Residential aged care situation (as of yesterday **total** deaths in Australia were 788, total cases were 26,513)
Fatal fraction in residential aged care currently 30%. Fatal fraction outside of aged care currently 0.8%



https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert/coronavirus-covid-19-current-situation-and-case-numbers

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Regional comparison

Name	Cases - cumulative total	Deaths - cumulative total per 1 million population
Global	**27,738,179**	**115.281**
Philippines	245,143	36.37
China	90,595	3.22
Japan	73,221	11.12
Singapore	57,166	4.62
Australia	26,465	30.63
Republic of Korea	21,743	6.75
Malaysia	9,583	3.95
Guam	1,758	124.43
New Zealand	1,441	4.98
Viet Nam	1,059	0.36
French Polynesia	857	0
Papua New Guinea	504	0.56

Modelling and response

- **Originally**
  - Limited (soft) border measures
  - Case-based quarantine and isolation
  - Reactive school closures
  - Potential for wider school closures/work from home
- **Currently**
  - Hard border closure (external and internal)
  - 14-day hotel quarantine (external, internal)
  - High testing rate + outbreak capacity scale-up
  - Regional restrictions varying from very little to UK-like lockdown.

Early modelling inputs and responses

- Imperial College report 1 and Wu et. al. Lancet paper (2020) led to border closure with China Feb 1 (Sydney, Melbourne high importation risk)
- Followed immediately by two pieces of simple modelling
  - Risk assessment for entry of infection from the region
  - Models of the local epidemic and impact on ICU, hospital demand
- My involvement started in the 2nd week of February
- Specific modelling efforts since then (nationally)
  - Forecasting (techniques, data streams, forecasts, ensembles)
  - Capacity for testing, now shifting to detailed analysis of clusters, reporting indicators etc.
  - Specific populations (remote Indigenous communities)
  - Utility of spatial and mobility data (outbreaks, risk differentiation, local controls)
  - Analysis of household clusters

Pre-local spread

Risk monitoring

	Monthly air travel from China (in thousands) (Step 1)	Expected imported cases (Step 1)	Reported imported cases (Step 2)	Estimated undetected cases (Step 2)	Estimated probability of local transmission (Step 3)	Estimated local cases (Step 4)	Monthly air travel to Australia (in thousands) (Step 5)
Thailand	485.6	44 (27–68)	23	21 (4–45)	1	176 (59–397)	50.1
Japan	382.8	35 (20–54)	26	9 (0–28)	1	97 (28–269)	87.8
Hong Kong, China	244.4	22 (11–35)	62	0 (0–0)	1	13 (4–51)	46.4
Taiwan, China	237.7	22 (11–34)	28	0 (0–6)	1	21 (5–77)	21.4
South Korea	230.2	21 (10–34)	13	8 (0–21)	1	69 (17–202)	30.9
Malaysia	150.6	14 (6–24)	17	0 (0–7)	0.99	14 (2–51)	47.0
Singapore	138.6	13 (5–22)	23	0 (0–0)	0.98	7 (1–22)	73.2
Viet Nam	115.6	11 (4–18)	8	3 (0–10)	0.99	19 (2–69)	38.0
Indonesia	99.6	9 (3–17)	0	9 (3–17)	1	142 (24–444)	107.9
Cambodia	64.3	6 (1–11)	1	5 (0–10)	1	45 (3–187)	5.0
Macau, China	62.3	6 (1–11)	10	0 (0–1)	0.88	3 (1–12)	< 2.0
Philippines	61.6	6 (1–11)	3	3 (0–8)	0.99	36 (3–145)	33.2
New Zealand	29.5	3 (0–7)	0	3 (0–7)	0.94	37 (2–226)	244.7
India	26.0	3 (0–6)	3	0 (0–3)	0.77	5 (1–32)	71.9

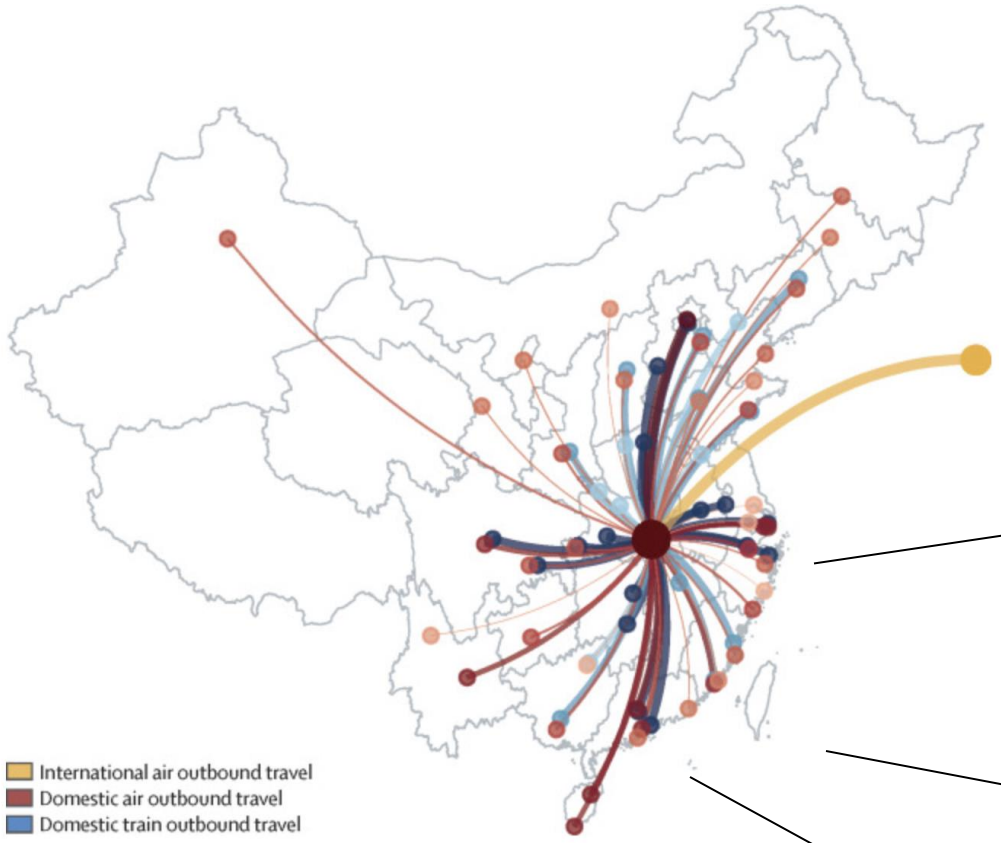
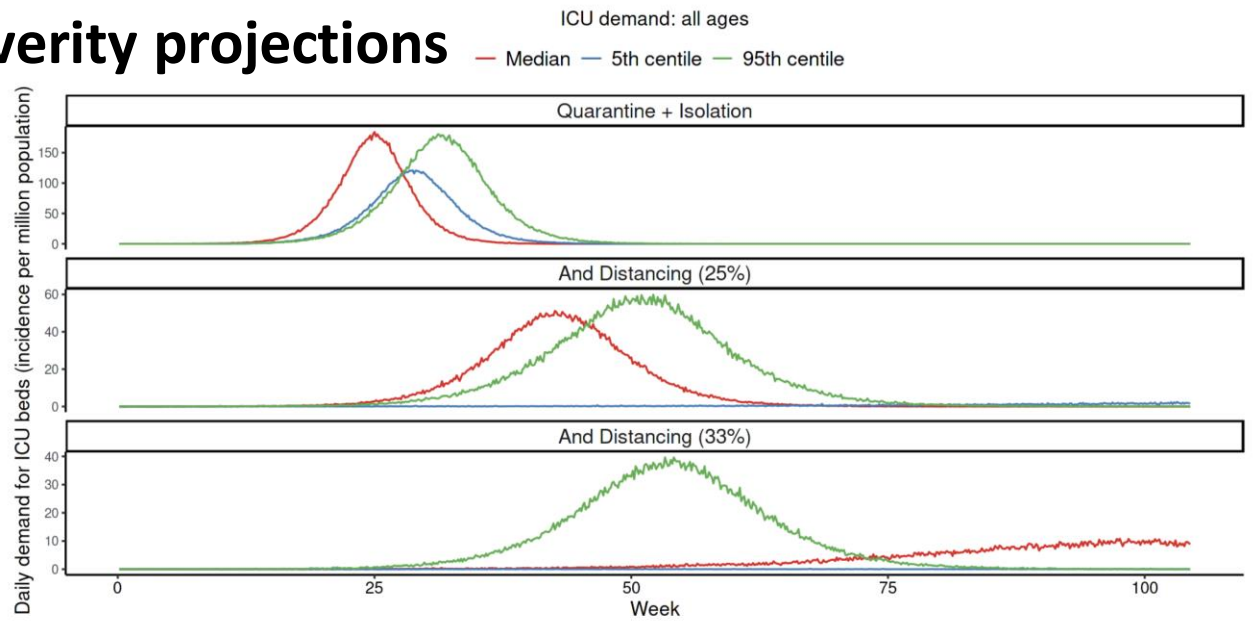


Figure 1 Risk of spread outside Wuhan

Severity projections

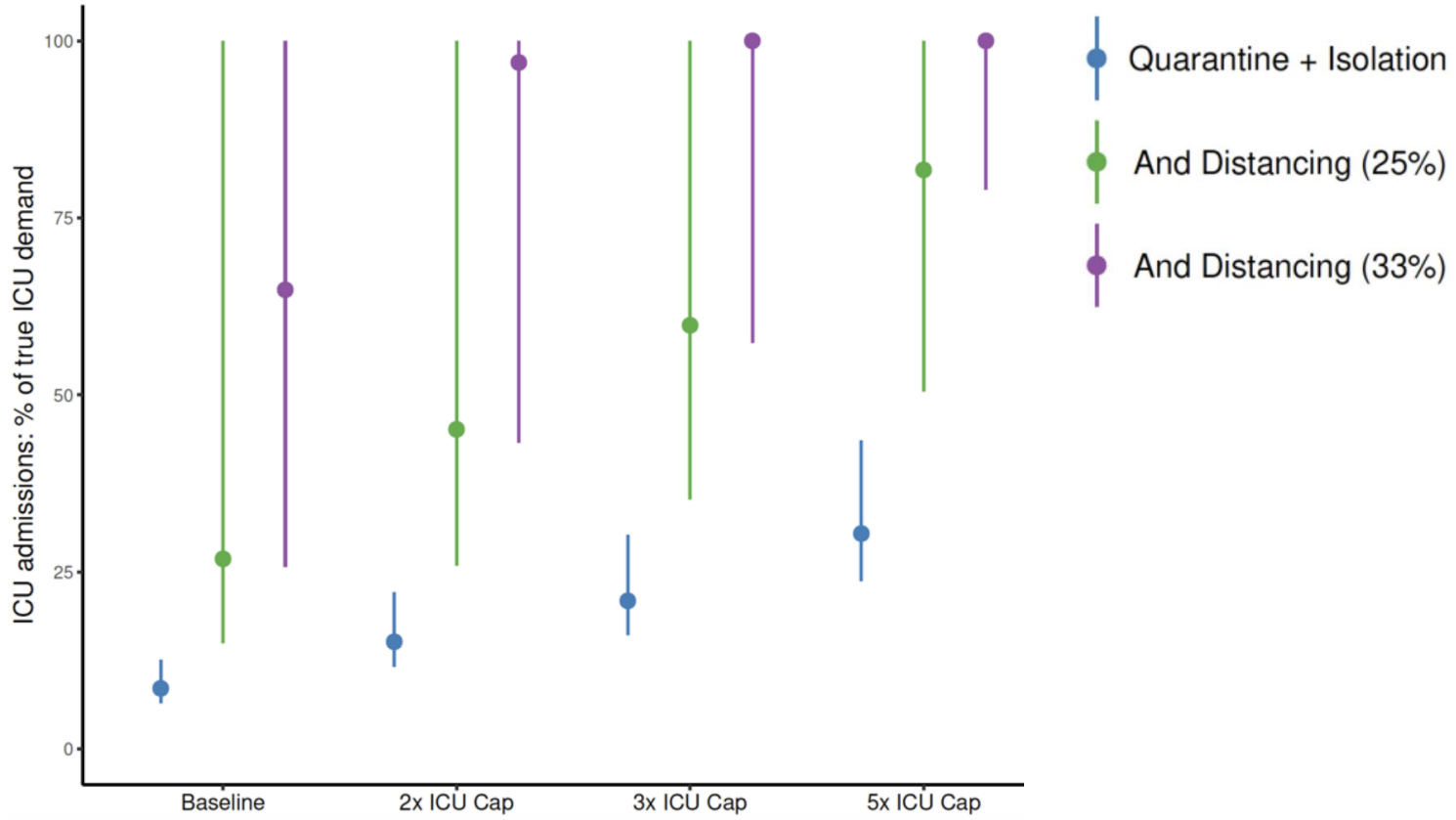


China border closure

https://doi.org/10.1016/S0140-6736(20)30260-9

https://www.doherty.edu.au/about/reports-publications

ICU capacity would not cope without distancing restrictions



https://www.doherty.edu.au/about/reports-publications

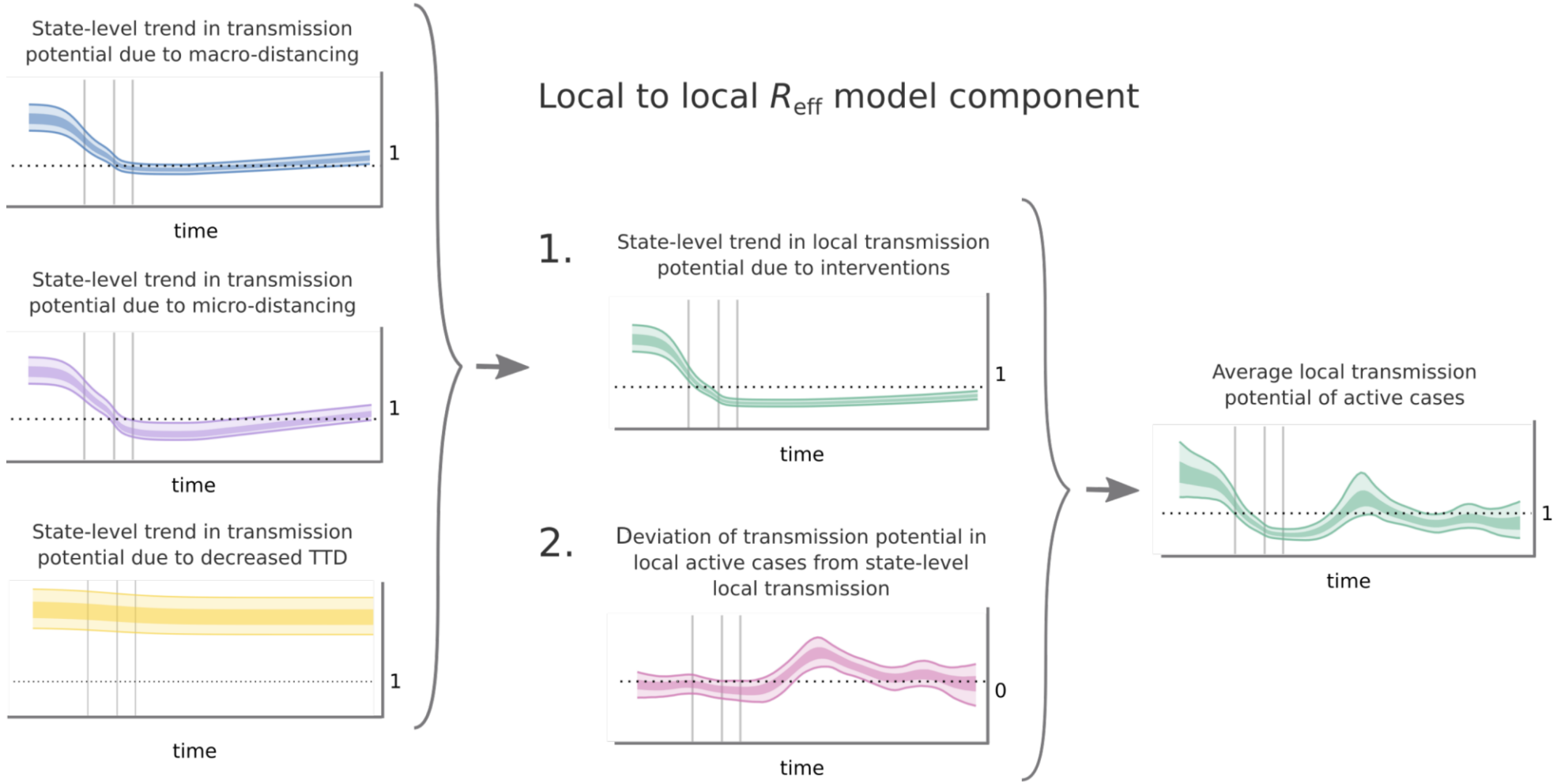
The 1st “wave” (March-April)

- Other national epidemics – expanded border restrictions
- Importations rise rapidly, largely from USA, UK where reported cases not yet large – Australia closes borders to non-residents and required 2-week self-quarantine.
- Growth in local cases in NSW and Victoria - tightening restrictions from mid-late March, applied nationally in “lockdowns” of slightly varying degree.
- Relatively high positivity rate in travellers led to 14-day hotel quarantine requirements from end of March.
- Lockdowns successfully restricted local transmission, travel bans + hotel quarantine shut-down international and to an extent domestic spread risk

Post wave-1 forecasting/monitoring challenges

- Forecasting with COVID is difficult because
  - Accurately measuring the underlying transmission (R0) is hard
  - We are all trying to keep the effective value Rt around or below 1
  - The difference between Rt=0.9 and 1.1 is often within measurement error but resulting trajectories diverge rapidly
  - It may vary by more than this between local communities and by season
- More difficult with few cases (no information) – need other data
  - Surveys of contact numbers and distancing behaviour
  - Macromobility via e.g. Google mobility data

Schematic approach to estimating Rt



https://www.doherty.edu.au/uploads/content_doc/Technical_report_4_update_29July2020.pdf

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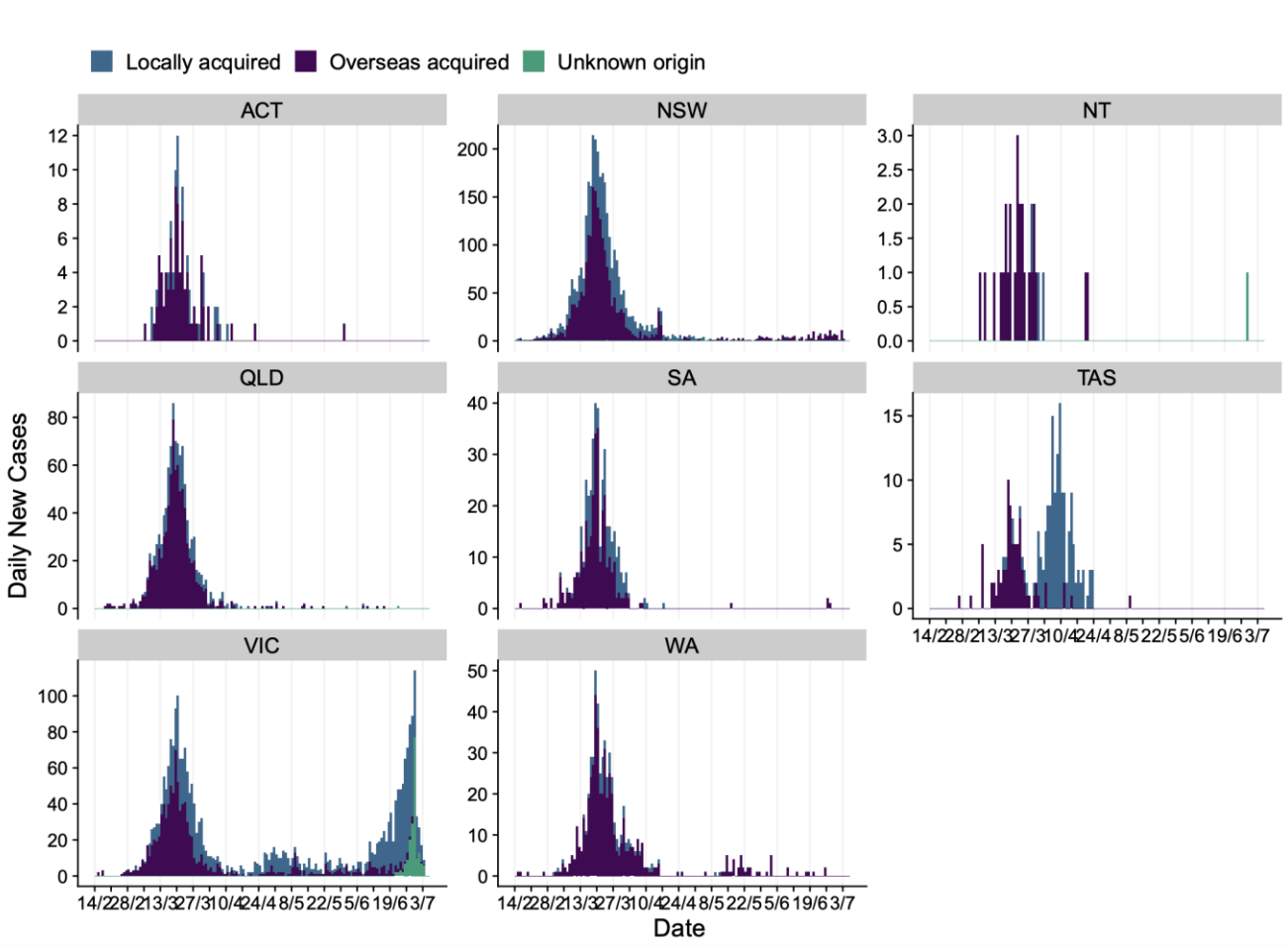
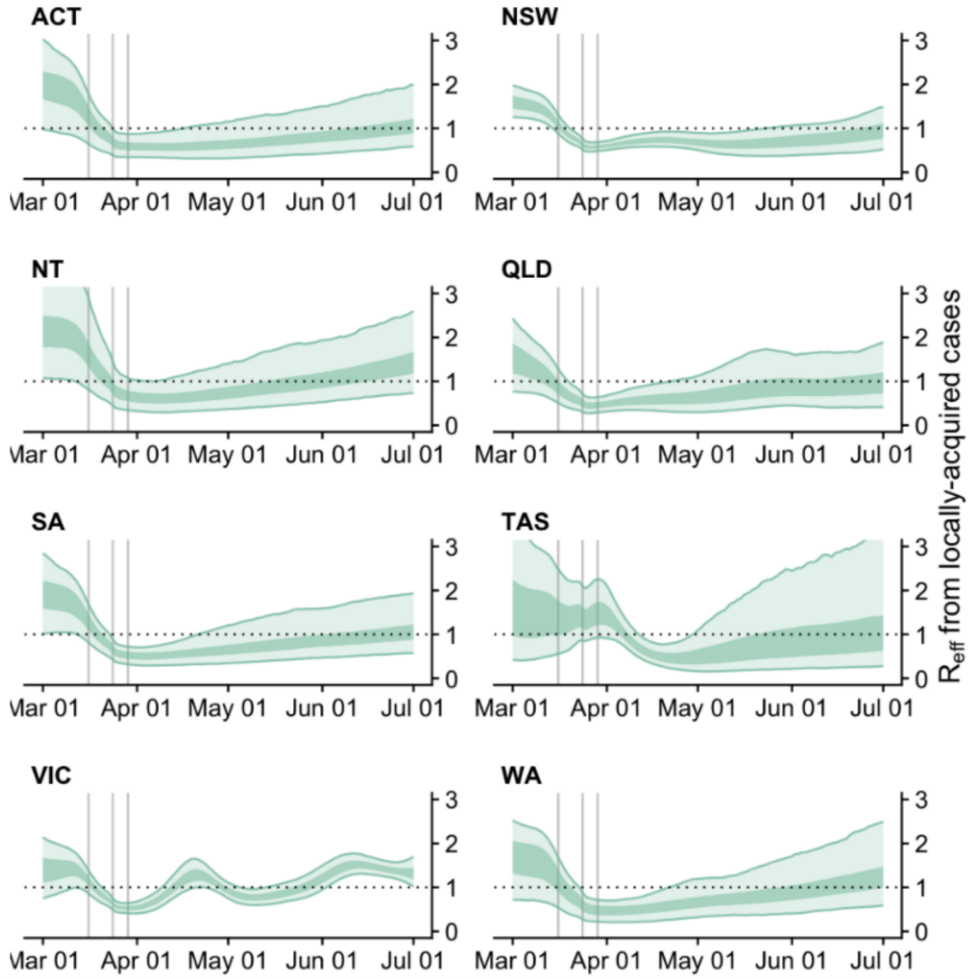
Approach useful but still high uncertainty with few cases





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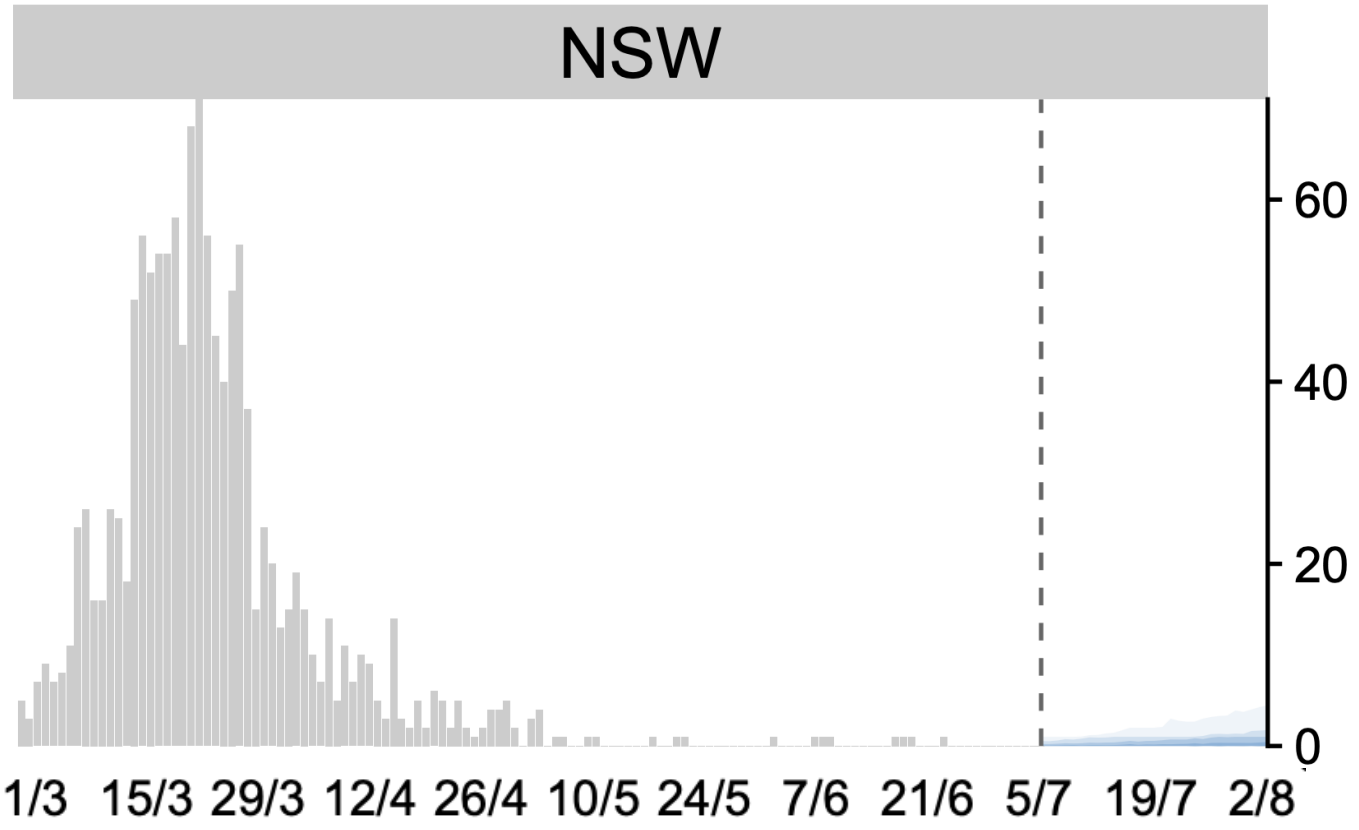
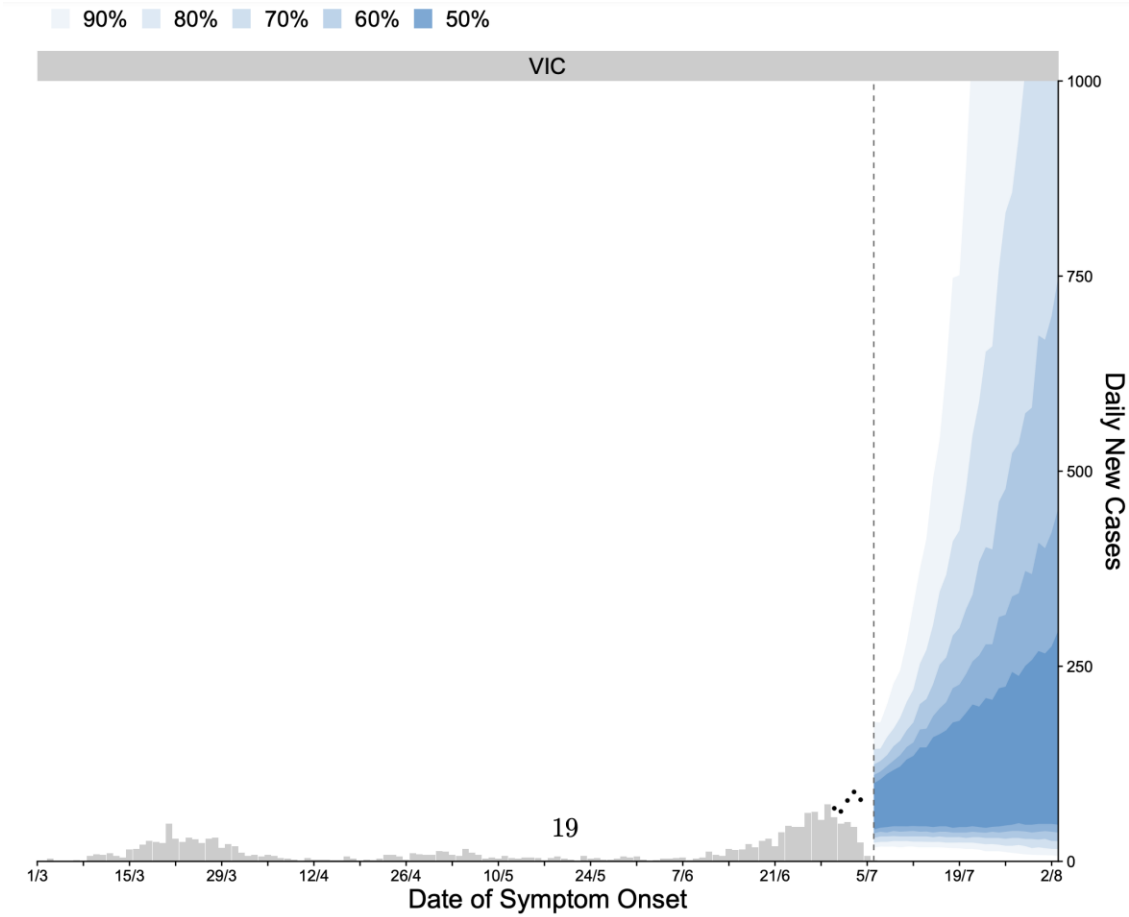
Examples of ensemble forecasts





https://www.doherty.edu.au/uploads/content_doc/Technical_report_4_update_29July2020.pdf

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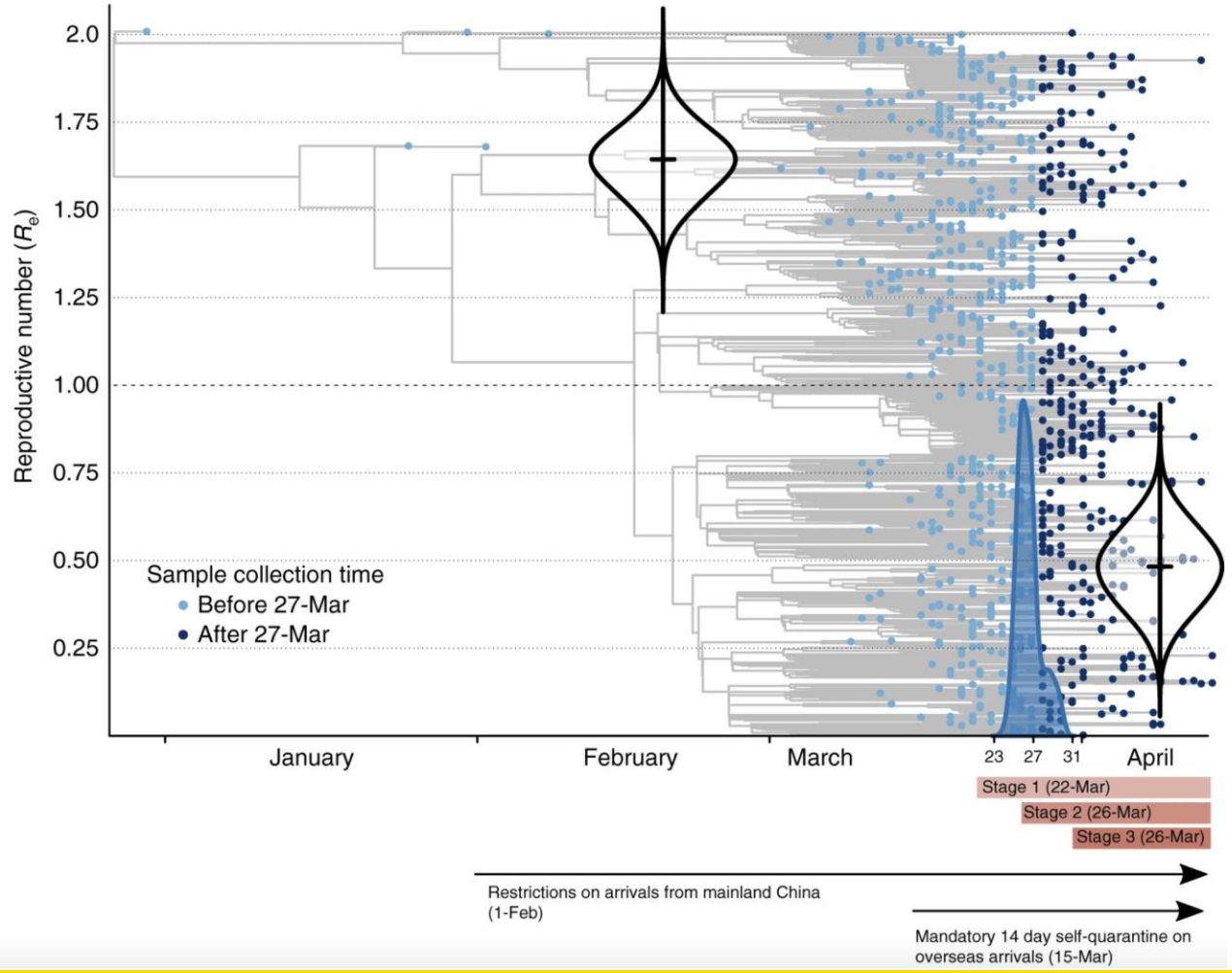
Initial transmission rates seemed lower than Europe

Phylodynamic estimates from Victoria suggest R0<2 pre lockdown and Rt~0.5 during lockdown.

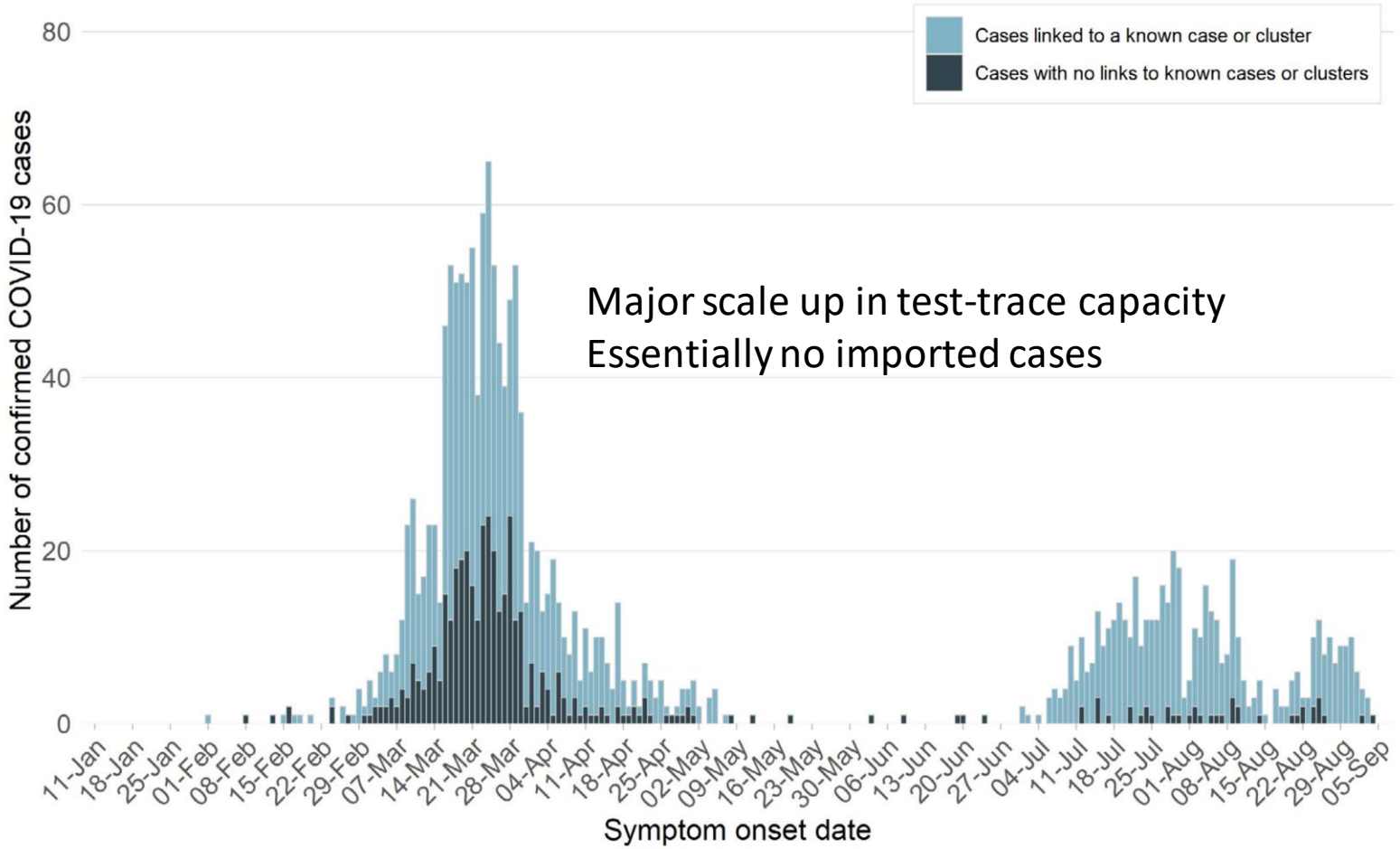
Does this reflect climate/density/subgroup where cases first arrived?



Seemann et. al. Nature Communications 2020.

Cluster control works better than models expect

Figure 2. Locally acquired COVID-19 cases by likely infection source and illness onset, NSW, 2020



The date of the first positive test is used for cases who did not report symptoms.

Divided responsibility leads to problems

Ruby princess: around 700 linked cases (>20 deaths)

AAP: Joel Carrett

First bad outbreak in aged care in Australia: 17 deaths

ABC News: Lily Mayers

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Differences in end-goals leads to lasting division

Two Options Proposed and a Third Rejected

For any jurisdiction facing an epidemic, there are three fundamental options:

1. Eliminate the illness;
2. Suppress the illness to a low level and manage it; or
3. Allow the epidemic to run through the population in a way that does not overwhelm the healthcare system. Some have called this approach "herd immunity."

QLD, WA, SA, ACT, Tasmania, NT

National, NSW, Victoria

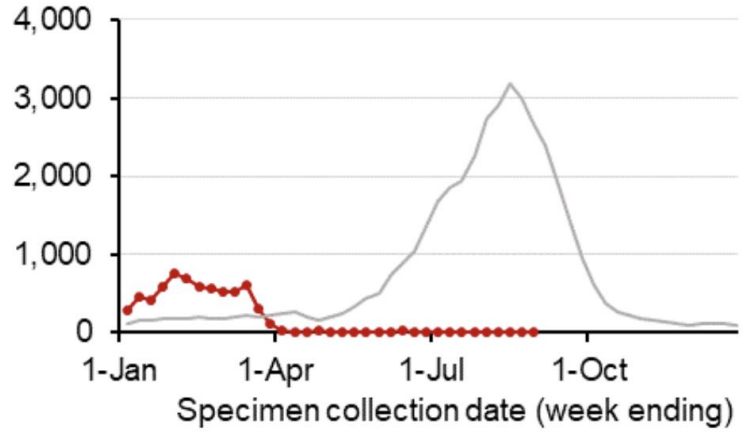
Two women, aged 19 and 22, charged after 'escaping hotel quarantine' in WA

Hotel quarantine will occasionally fail

- Breach in Victorian hotel quarantine is linked via genomics to almost all cases in 2nd wave.
- Large amounts of attention, criticism of approaches, an inquiry etc. has ensued
- However, since then
  - NSW has had 2 (unlinked) transmissions to security guards
  - NZ has had at least one case of transmission to a hotel staff member
- In NSW around 350 cases detected in hotel quarantine … risk of a breach at present seems of order 1/200.
- Suggests extensive community testing required even at elimination

NSW had a winter without flu or excess mortality

Influenza A



Influenza B

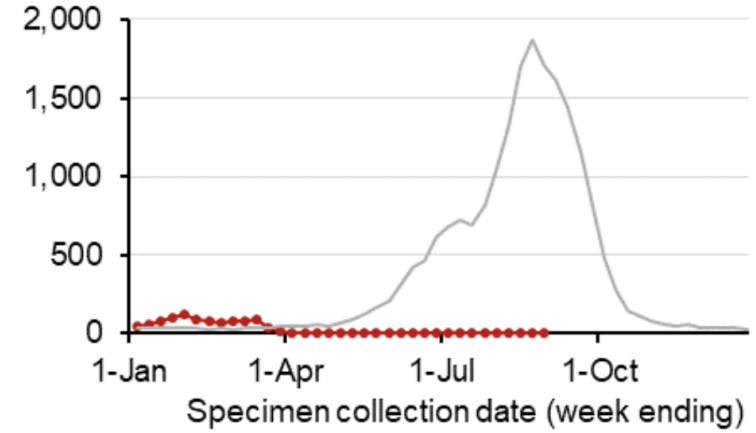
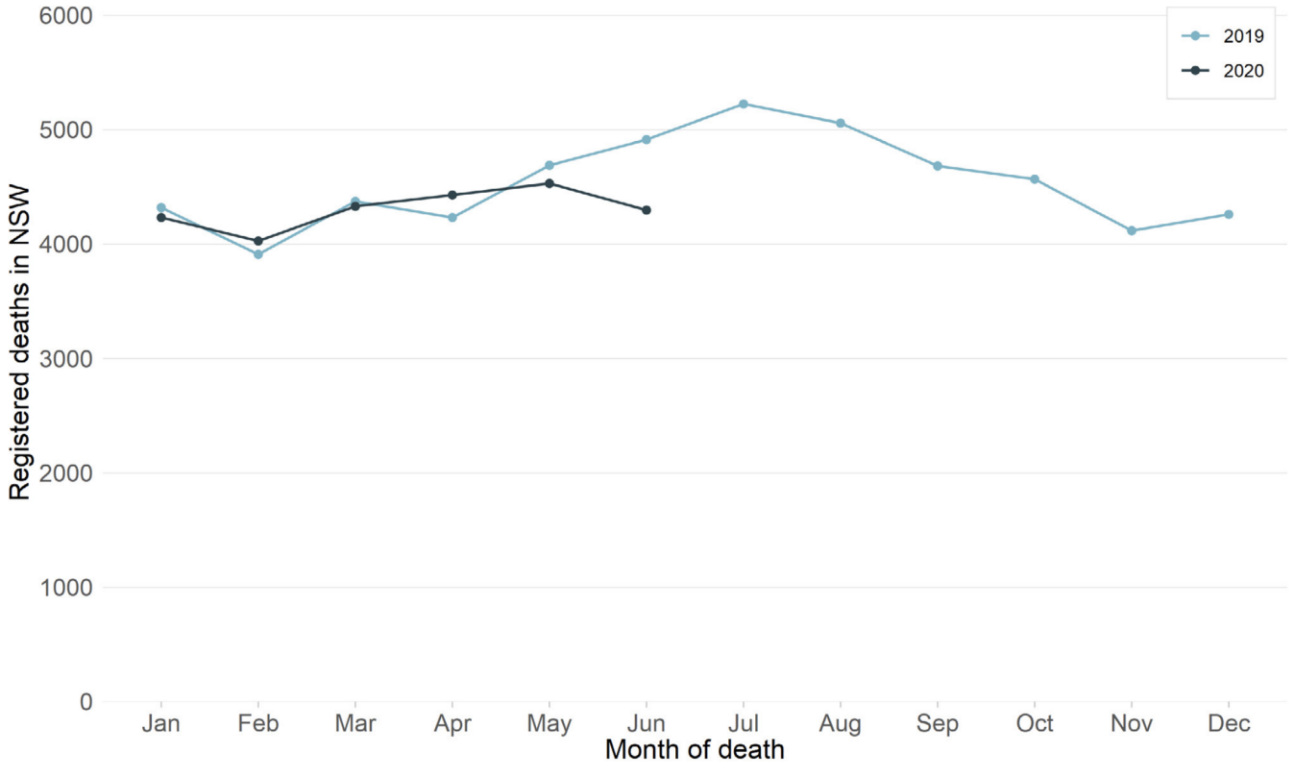


Figure 7. Deaths from any cause registered in NSW from January 2019 to June 2020



Based on deaths registered in NSW up to 03 September, 2020

https://www.health.nsw.gov.au/Infectious/covid-19/Documents/covid-19-surveillance-report-20200905.pdf

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Where are we turning towards?

- Understanding cluster data, dynamics and control better
  - Optimising outbreak control
  - Minimising requirements for other restrictions
- Understanding differential effects of restrictions
  - Looking at how mobility changes relate to socio-economic status
  - Potential extensions to regional vs urban
- Preparing for vaccines
  - Contracts have been signed for two candidate vaccines
  - Differential effects on transmission, disease could indicate quite different strategies