COVID-19 in India: Lessons Learnt

Ramanan Laxminarayan

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The New York Times

What India Needs to Fight the Virus

The country has three to four weeks to create an enormous, affordable and easily available testing infrastructure, contain local outbreaks and prepare for the avalanche of the coronavirus.

March 27, 2020

A crowded marketplace in New Delhi on Thursday, after a 21-day nationwide lockdown had been ordered. Yawar Nazir/Getty Images

By Ramanan Laxminarayan
Dr. Laxminarayan is an economist and an epidemiologist.

"This is an acid test of every single country's quality of healthcare, standard of governance and social capital. If any one of this tripod is weak, it will be exposed, and exposed quite unmercifully by this epidemic."

Vivian Balakrishnan, Foreign Minister of Singapore, March 16, 2020

Science

RESEARCH ARTICLES

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Epidemiology and transmission dynamics of COVID-19 in two Indian states

Ramanan Laxminarayan[1,2,3], Brian Wahl[3,4], Shankar Reddy Dudala[5], K. Gopal[6], Chandra Mohan[7], S. Neelima[8], K. S. Jawahar Reddy[9], J. Radhakrishnan[10], Joseph A. Lewnard[11,12]*

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WORLD & NATION

Largest study of COVID-19 transmission highlights essential role of super-spreaders

CORONAVIRUS AND PANDEMIC

California pioneered the COVID-19 stay-at-home lockdown. Now, it faces a backlash

San Marcos' 'Mr. Christmas' is taking a pandemic break

L.A. County tightens COVID-19 restrictions: What you need to know

L.A. mayor announces $800 stipends for food service workers

- **Over 3 million contacts traced**
- **Reliable data on 575,071 contacts traced from 84,965 primary cases**
- **5,703 deaths**

Huge Study of Coronavirus Cases in India Offers Some Surprises to Scientists

The rate of death went down in patients over 65. Researchers also found that children of all ages became infected and spread the virus to others.

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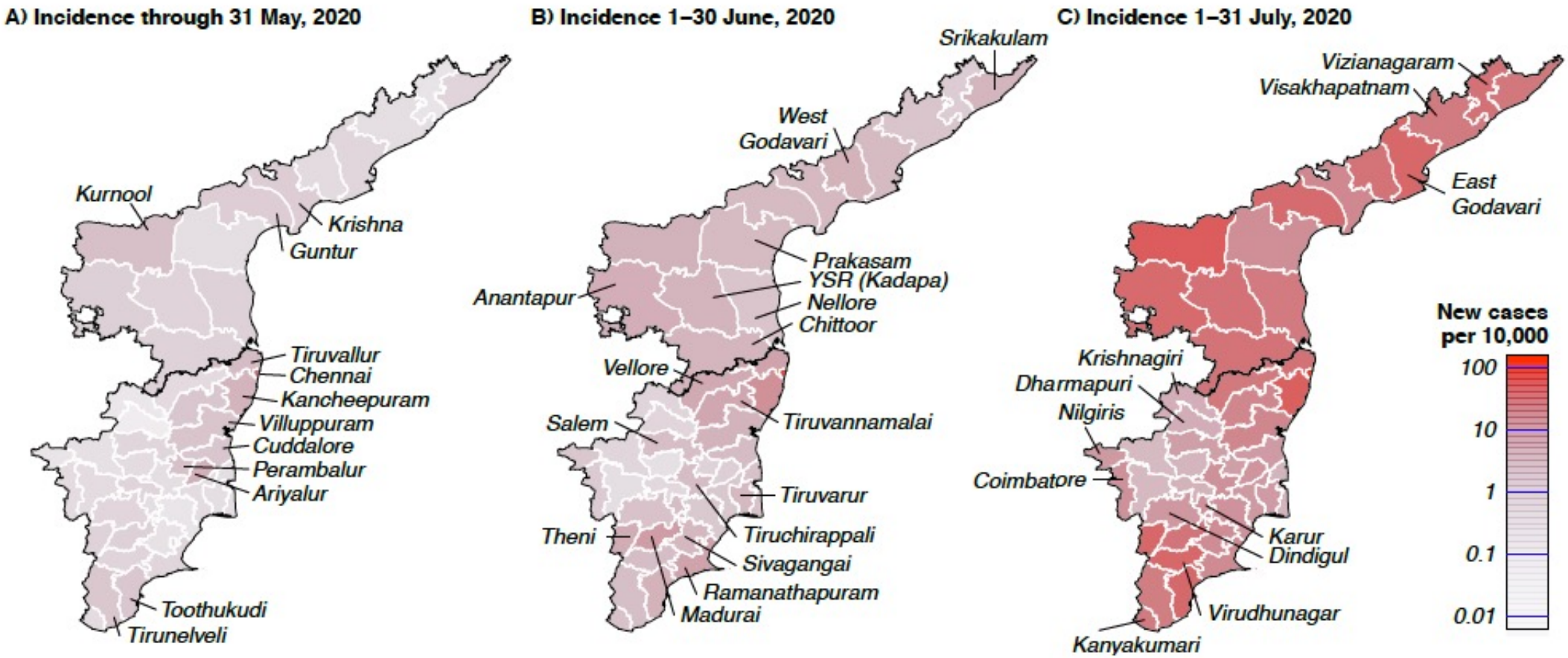

Laxminarayan et al, *Science*, August 2020.

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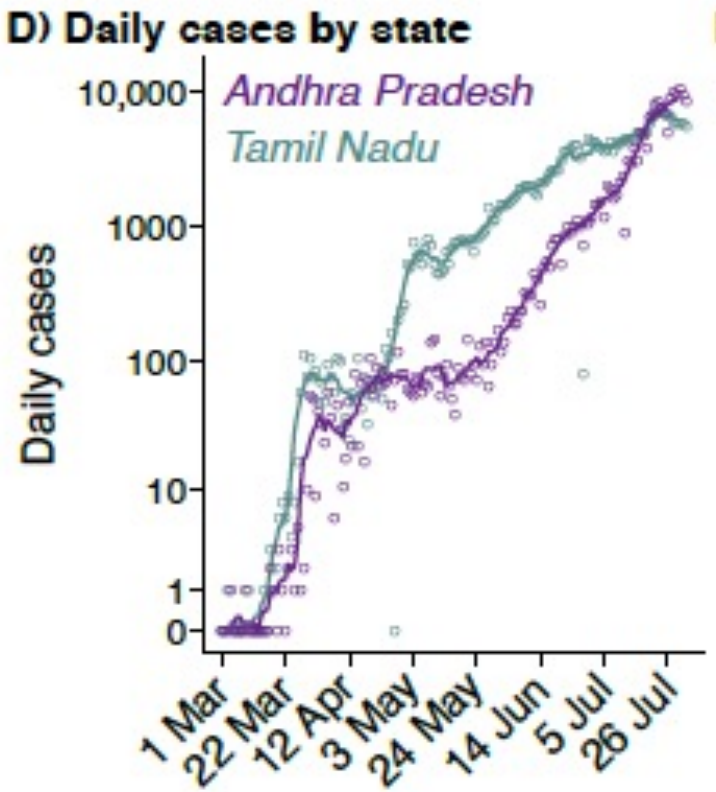

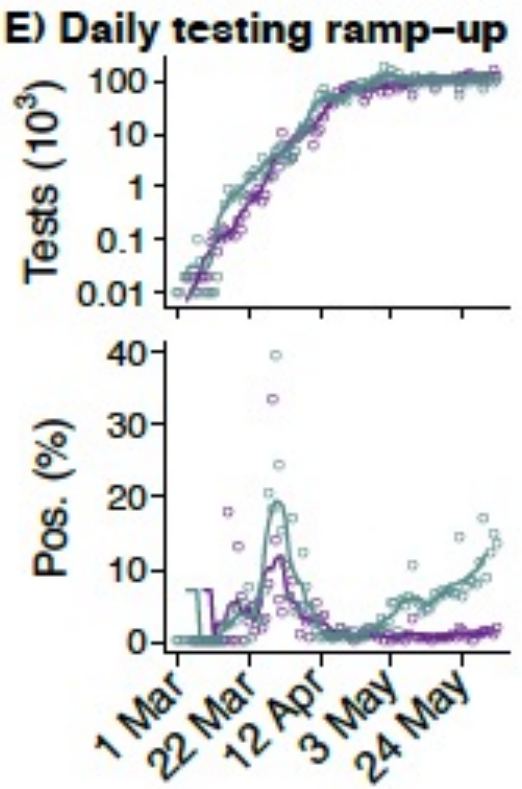

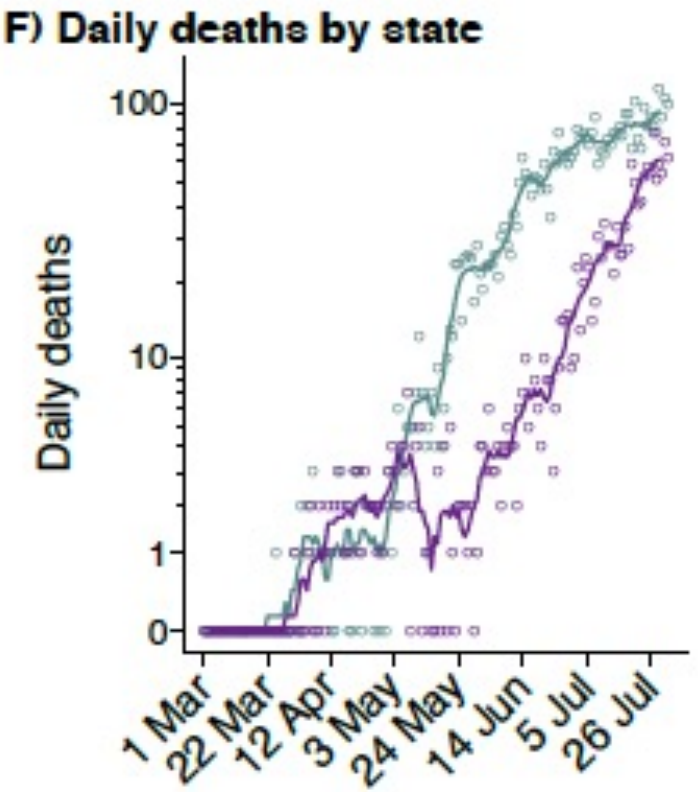

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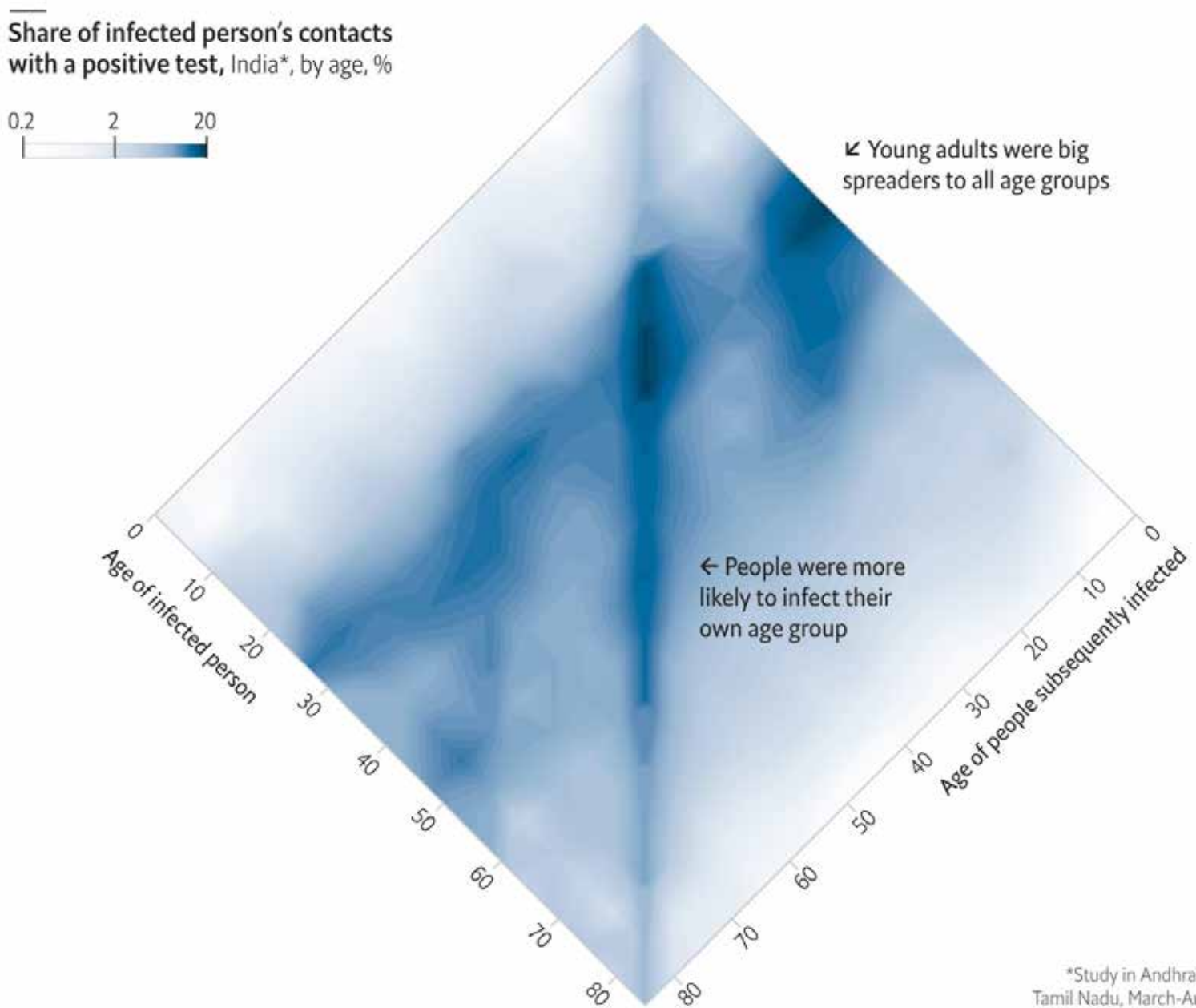
Table S7: Secondary attack rates by interaction type and setting.

Exposure setting	Any contact			High-risk contact[1]			Low-risk contact[1]		
	Index cases	Total contacts (infected)	SAR (95% CI)	Index cases	Total contacts (infected)	SAR (95% CI)	Index cases	Total contacts (infected)	SAR (95% CI)
Any setting (all cases and contacts)	84,964	574,745 (42,869)	7.5 (7.3, 7.6)	73,063	264,703 (28,384)	10.7 (10.5, 10.9)	62,572	309,801 (14,483)	4.7 (4.6, 4.8)
Any setting (exposure setting recorded)	1,342	18,158 (755)	4.2 (3.3, 5.2)	1,012	4,468 (592)	13.3 (10.3, 16.7)	792	13,651 (163)	1.2 (0.8, 1.6)
Community	596	9,540 (248)	2.6 (1.6, 3.9)	36	397 (107)	27.9 (8.4, 54.7)	567	9,142 (141)	1.6 (1.0, 2.20
Household	997	3,905 (350)	9.0 (7.5, 10.5)	978	3,782 (323)	8.8 (7.3, 10.4)	28	122 (18)	15.3 (5.8, 28.0)
Travel together	8	78 (63)	79.3 (52.9, 97.0)	8	78 (63)	79.3 (52.9, 97.0)	--	--	--
Healthcare	11	210 (2)	1.2 (0.0, 5.1)	5	98 (2)	4.7 (0.0, 40.0)	6	112 (0)	0
Other	151	4,425 (92)	2.1 (0.4, 4.4)	8	113 (88)	77.1 (35.3, 100.0)	144	4,275 (4)	0.1 (0.0, 0.2)

SAR (secondary attack rate) indicates the proportion of all tested contacts, who test positive. We obtain confidence intervals via cluster-bootstrap resampling of index cases.
[1]High-risk and low-risk contact criteria are defined in **Table S6.**

→ Transmission was more common among similarly aged people



*Study in Andhra Pradesh & Tamil Nadu, March-August 2020

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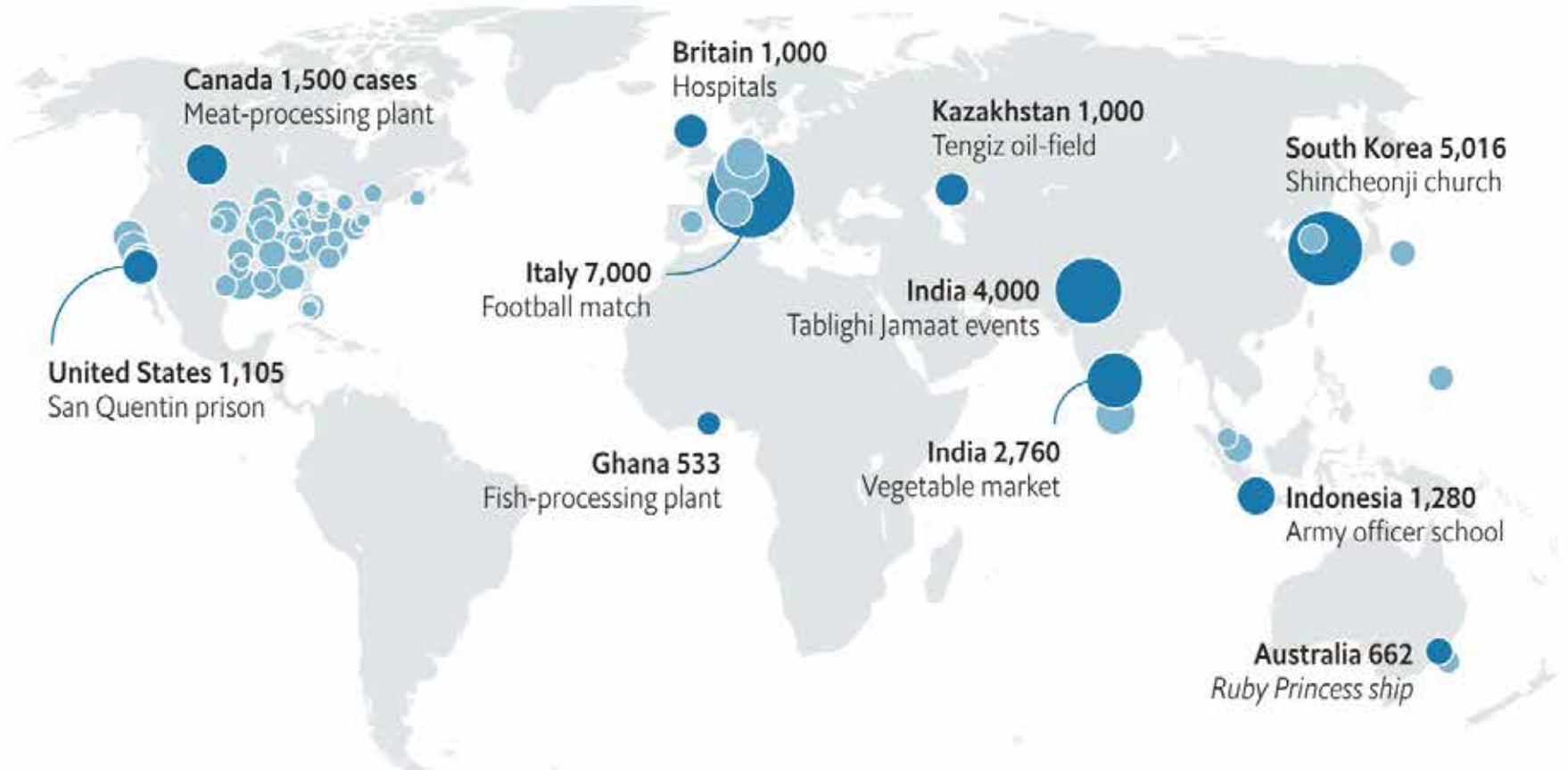
Superspreading

What does superspreading look like?

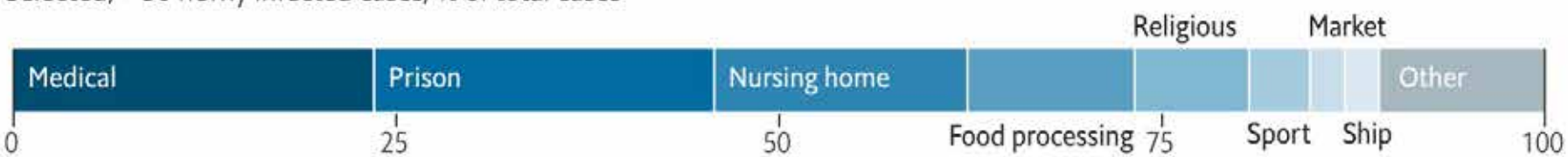
Super-spreading events

Selected, >300 newly infected cases



Setting of super-spreading events

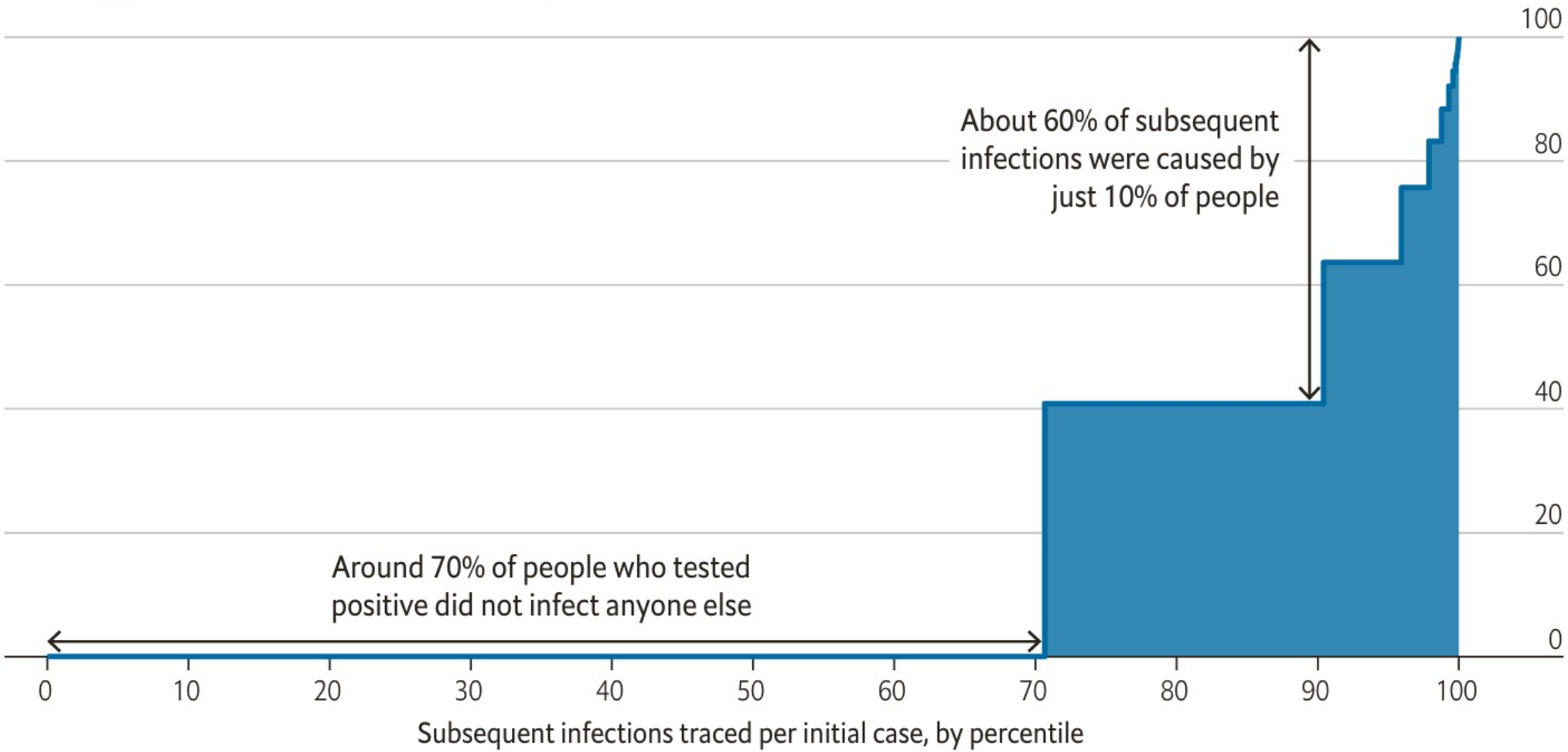
Selected, >30 newly infected cases, % of total cases



→ A small share of the population is responsible for a majority of infections

Cumulative share of subsequent covid-19 infections, %

India*, by percentile of subsequent infections per initial case



*Study in Andhra Pradesh & Tamil Nadu, March-August 2020

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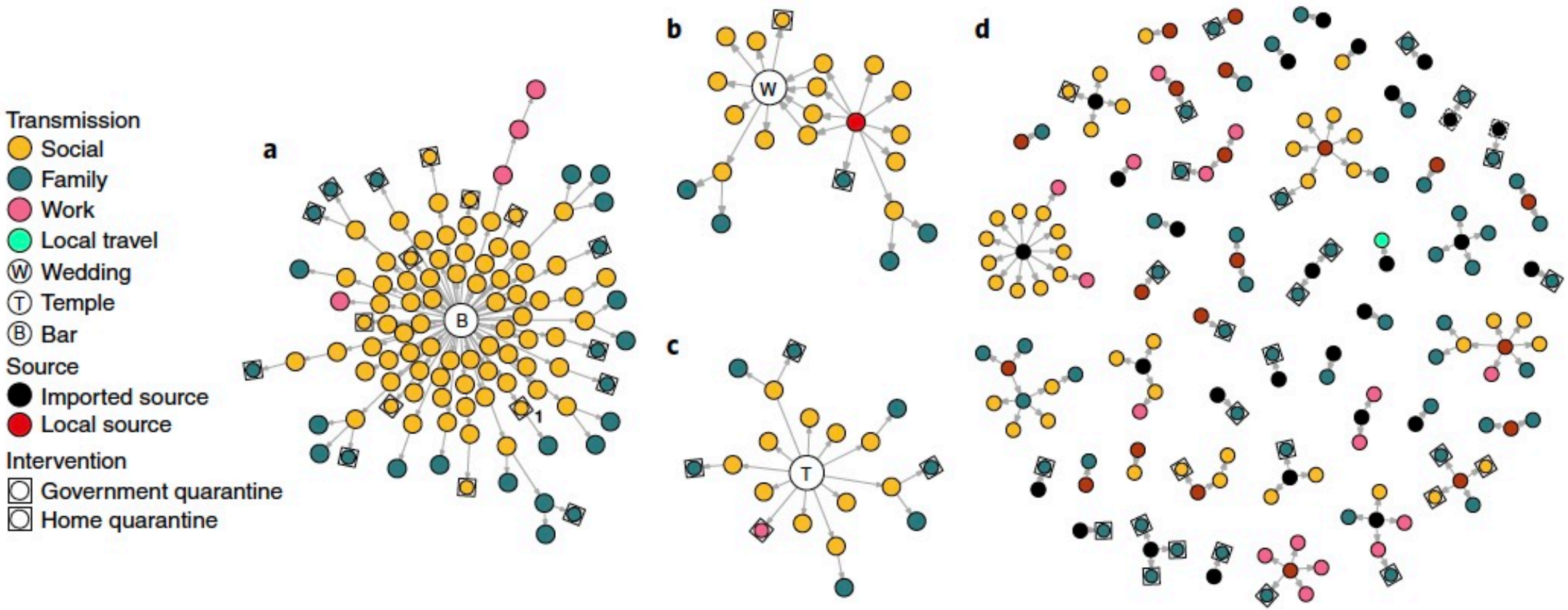
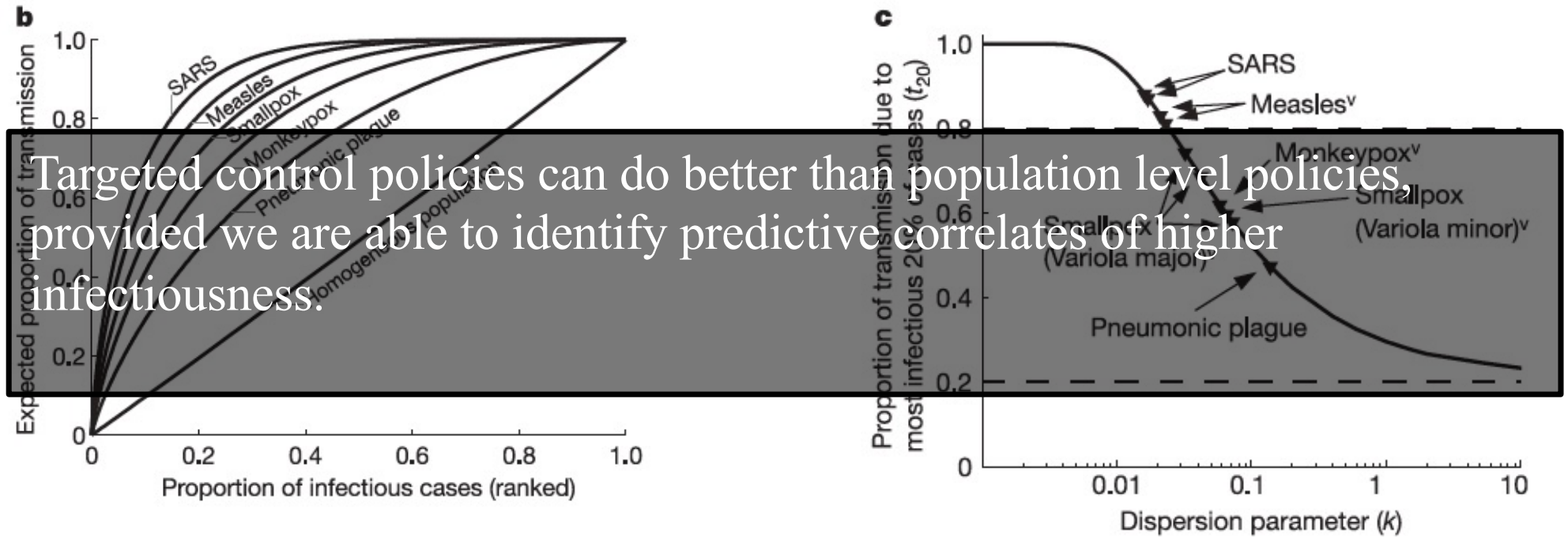


Adam et al, *Nature Medicine*, 2020


An outbreak in the Ischgl ski village in Austria was linked to cases in 45 different countries

What does superspreading look like?



Targeted control policies can do better than population level policies, provided we are able to identify predictive correlates of higher infectiousness.

Lloyd Smith et al, Nature 2005

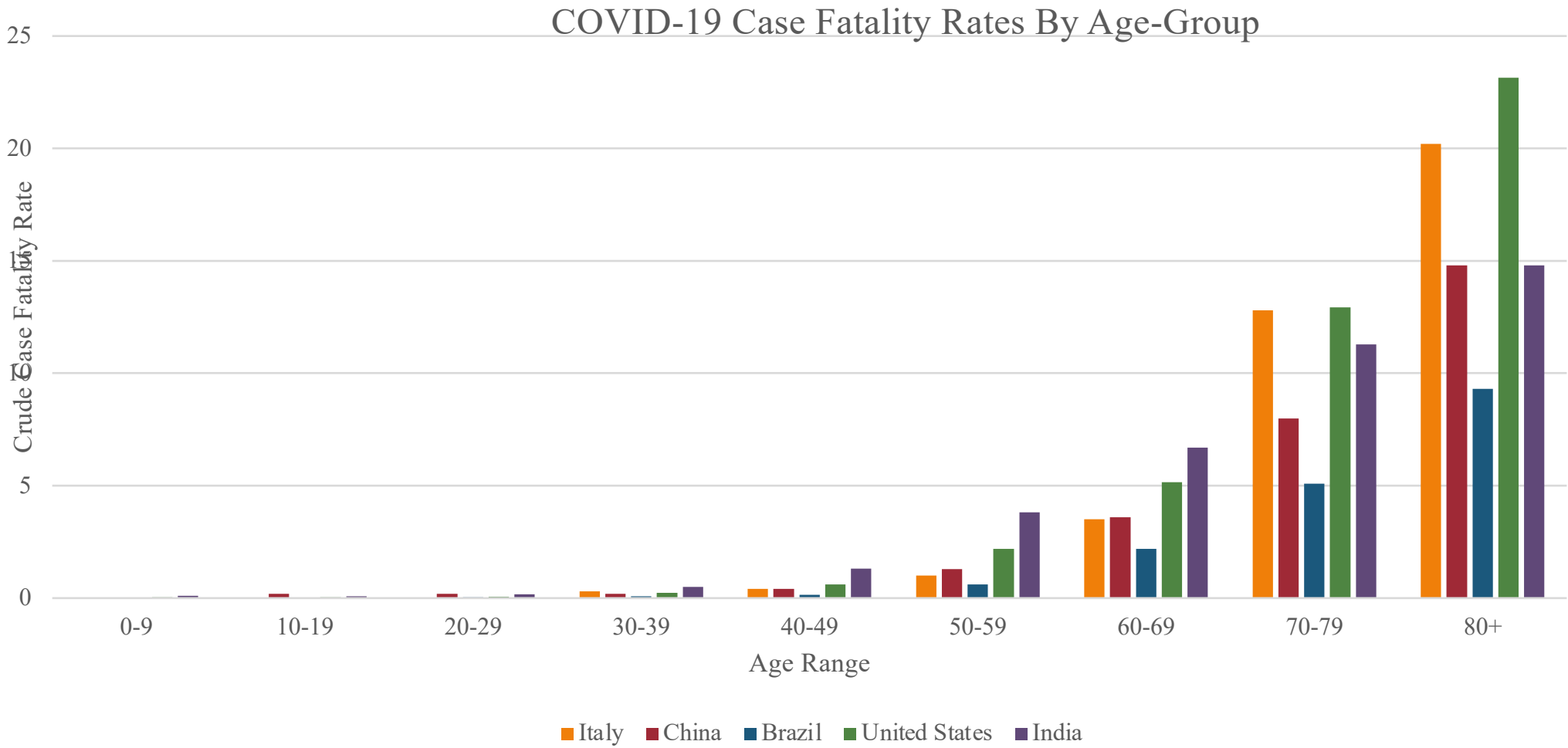
Mortality

A. Predictors of time to death

Exposure	Adjusted hazard ratio (95% Conf. int.)
Age group	
0–4 years	0.044 (0.016, 0.094)
5–17 years	0.021 (0.010, 0.034)
18–29 years	0.041 (0.033, 0.051)
30–39 years	0.12 (0.11, 0.14)
40–49 years	0.34 (0.31, 0.37)
50–64 years	Ref.
65–74 years	2.50 (2.34, 2.68)
75–84 years	3.60 (3.28, 3.95)
85+ years	4.64 (3.95, 5.44)
Sex	
Female	Ref.
Male	1.62 (1.52, 1.73)
Date of testing	
March 1 to April 30	Ref.
May 1 to June 30	0.87 (0.72, 1.07)
July 1 to August 1	0.74 (0.61, 0.91)
State	
Andhra Pradesh	Ref.
Tamil Nadu	1.08 (1.01, 1.16)

B. Case fatality ratios

Age group	Case fatality ratio (95% Conf. int.), %		
	All cases	Males	Females
0–4 years	0.16 (0, 0.36)	0.20 (0, 0.50)	0.11 (0, 0.35)
5–17 years	0.054 (0.012, 0.11)	0.022 (0, 0.07)	0.093 (0, 0.20)
18–29 years	0.16 (0.11, 0.20)	0.15 (0.097, 0.21)	0.16 (0.09, 0.24)
30–39 years	0.50 (0.42, 0.58)	0.54 (0.44, 0.66)	0.41 (0.29, 0.55)
40–49 years	1.31 (1.16, 1.45)	1.45 (1.26, 1.65)	1.05 (0.84, 1.28)
50–64 years	3.82 (3.58, 4.06)	4.34 (4.01, 4.67)	3 (2.66, 3.35)
65–74 years	9.58 (8.93, 10.3)	11.5 (10.6, 12.5)	6.67 (5.77, 7.60)
75–84 years	13.0 (11.7, 14.4)	16.0 (14.1, 17.9)	8.56 (6.8, 10.4)
85+ years	16.6 (13.4, 19.9)	20.5 (16.1, 25.1)	11.1 (7.14, 15.6)
All ages	**2.06 (1.98, 2.14)**	**2.38 (2.27, 2.49)**	**1.56 (1.45, 1.67)**



Note: United States and India data were available by the following age groupings: 0-4, 5-17, 18-29, 30-39, 40-49, 50-64, 65-74, 75-84, and over 85 years old. We assumed the CFR was uniformly distributed within age groups and used a simple average to convert the CFR values to the age groups presented here.

Sources: Italy and China - https://jamanetwork.com/journals/jama/fullarticle/2763667

Brazil - https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0236310

United States - https://covid.cdc.gov/covid-data-tracker/index.html#demographics

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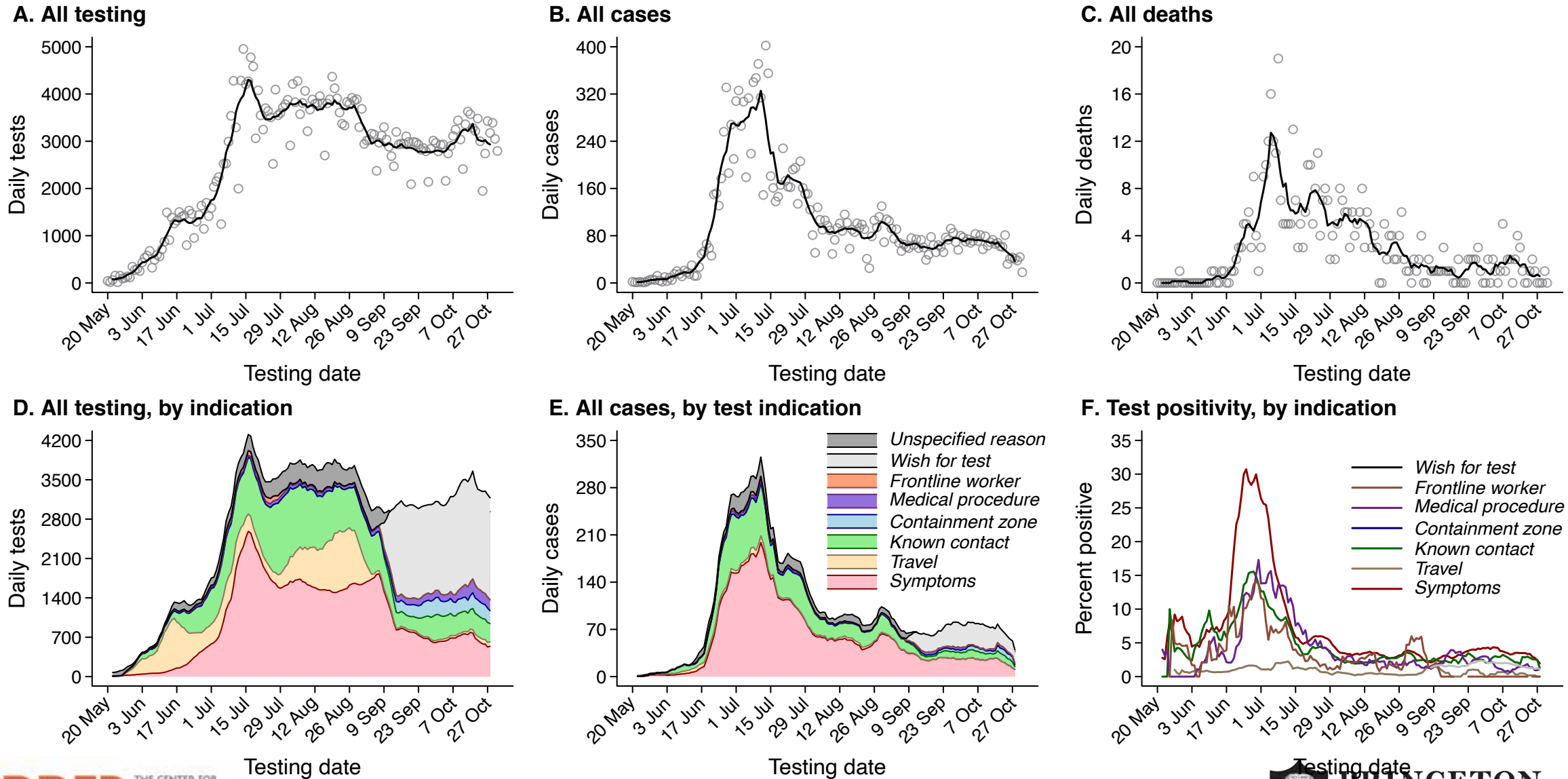
SARS-CoV-2 infection and mortality during the first epidemic wave in Madurai, south India: a prospective, active surveillance study

Ramanan Laxminarayan, Chandra Mohan B, Vinay T G, K V Arjun Kumar, Brian Wahl, Joseph A Lewnard

- Data collected under expanded programmatic surveillance testing for SARS-CoV-2 in the district of Madurai, Tamil Nadu, India (population of 3 266 226 individuals).
- Prospective testing via RT-PCR - 440,253 tests undertaken – of which 15,781 SARS-CoV-2 infections identified (3.6% test-positive fraction)
- Standardised data collection on symptoms and chronic comorbid conditions as part of routine intake.
- Seroprevalence of anti-SARS-CoV-2 immunoglobulin G assessed via a cross-sectional survey recruiting adults across 38 clusters within Madurai District from Oct 19, 2020, to Nov 5, 2020.



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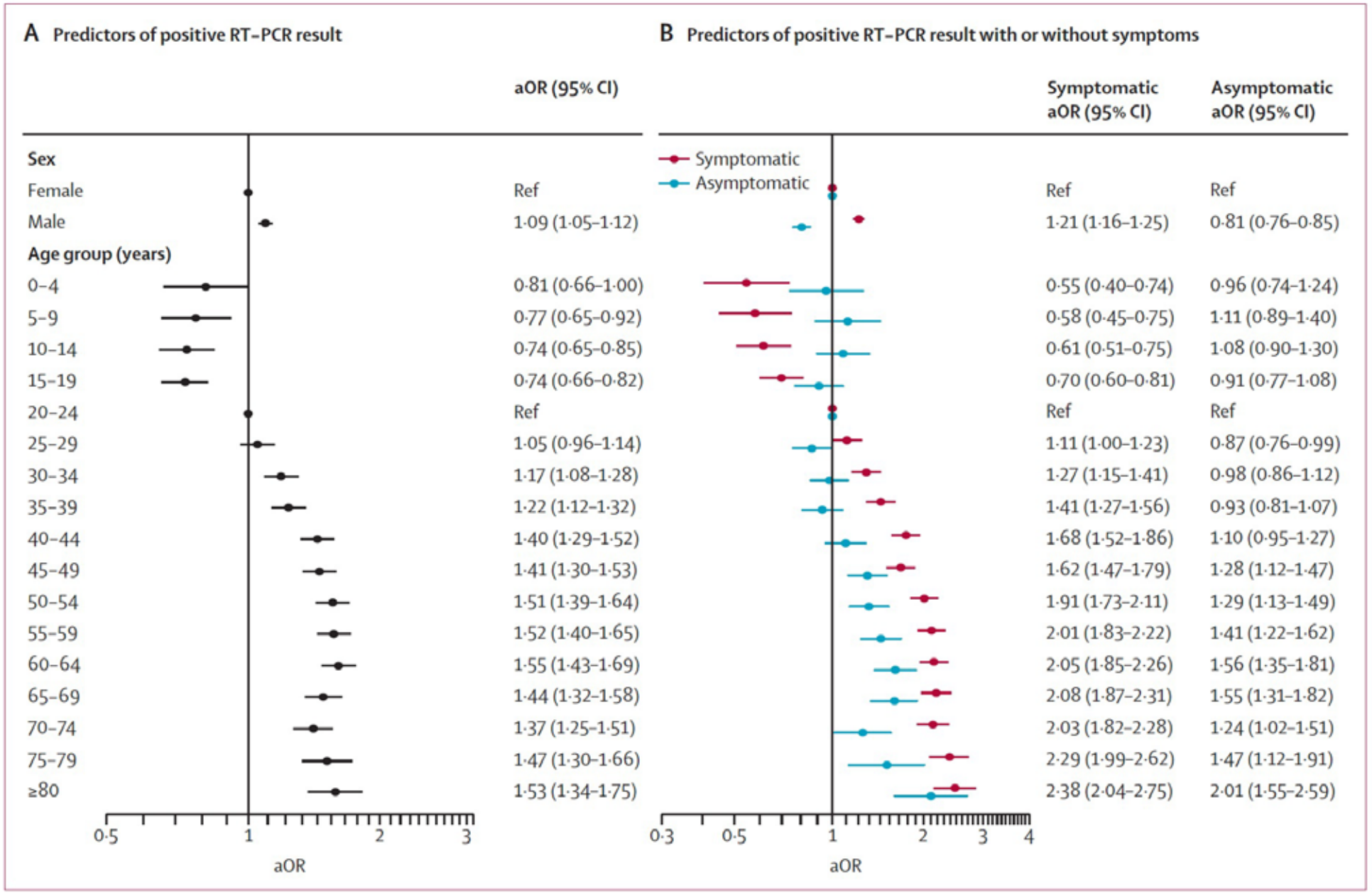
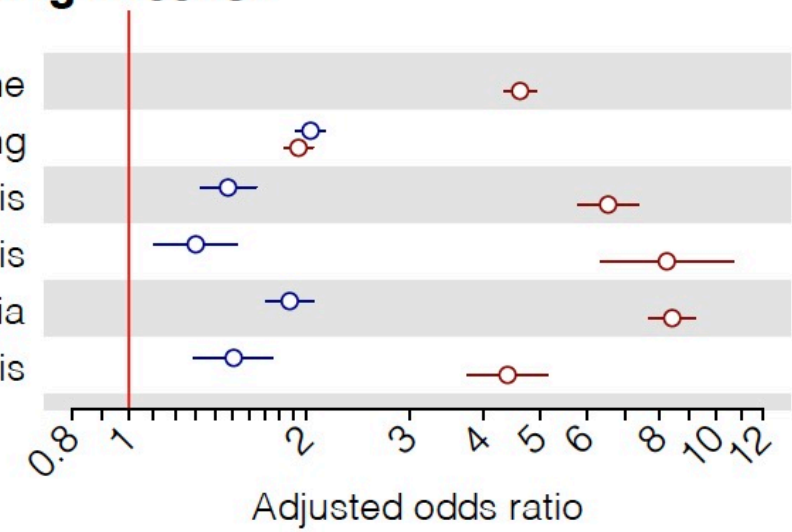


Figure 2: **Demographic predictors of infection**

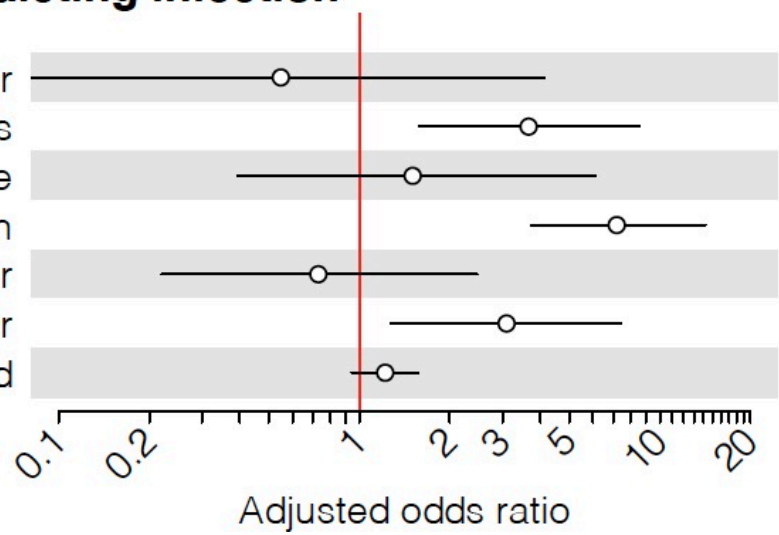
Estimates of the aOR for SARS-CoV-2 detection (A), and symptomatic or asymptomatic SARS-CoV-2 detection (B), on the basis of conditional logistic-regression models stratified for time and testing indication. Lines indicate 95% CIs around maximum-likelihood point estimates.

A. Symptoms predicting infection

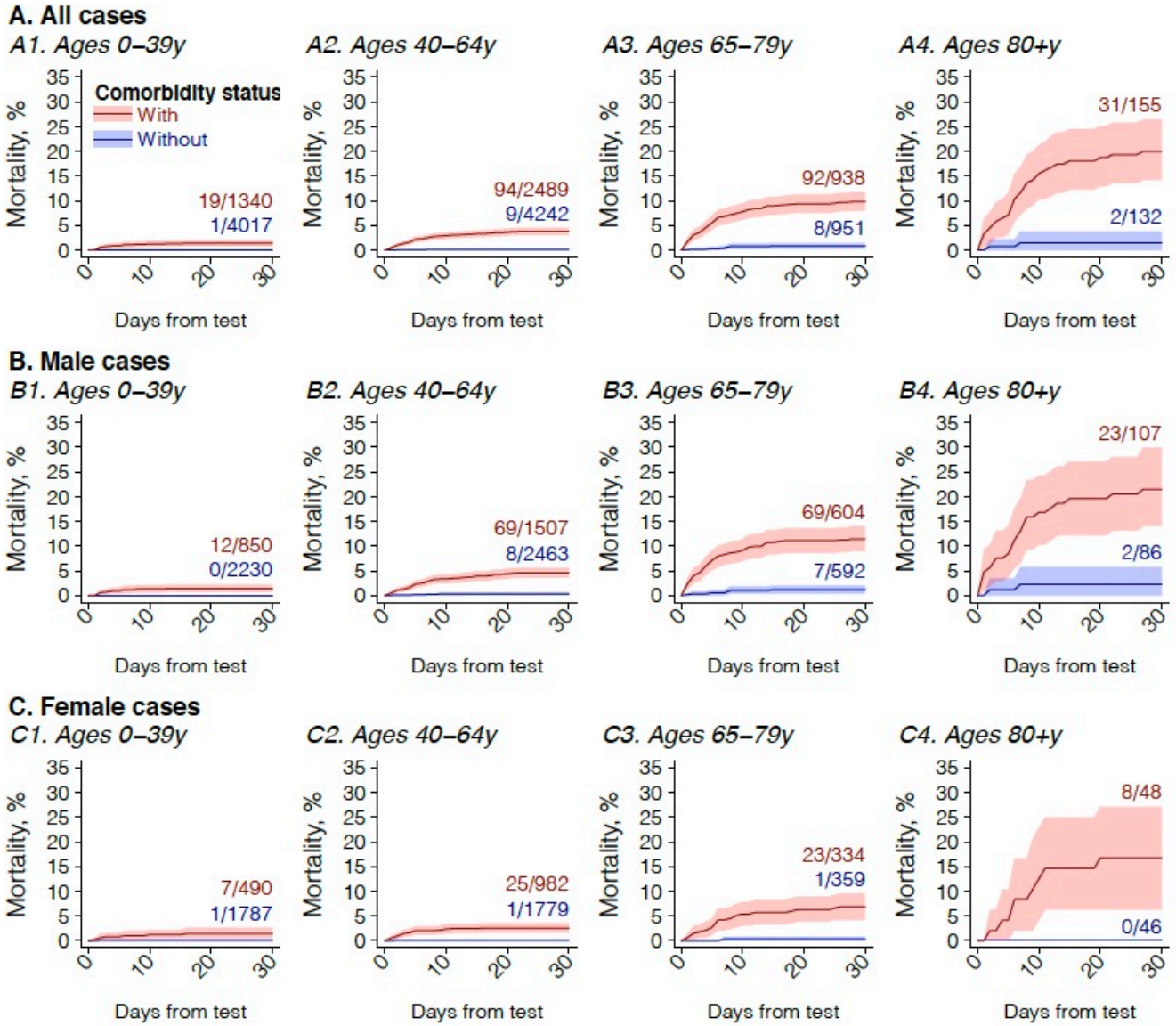


	Without fever aOR (95% CI)	*With fever* aOR (95% CI)
Fever alone	--	4.63 (4.35, 4.92)
Cough/difficulty breathing	2.04 (1.93, 2.15)	1.94 (1.84, 2.05)
Pharyngitis	1.47 (1.33, 1.64)	6.54 (5.81, 7.34)
Rhinitis	1.30 (1.11, 1.53)	8.23 (6.36, 10.69)
Myalgia	1.88 (1.71, 2.06)	8.40 (7.68, 9.20)
Gastroenteritis	1.51 (1.29, 1.75)	4.41 (3.77, 5.16)

B. Comorbidities predicting infection



	aOR (95% CI)
Cancer	0.55 (0.07, 4.12)
Diabetes	3.66 (1.58, 8.58)
Chronic kidney disease	1.51 (0.40, 6.12)
Hypertension	7.19 (3.74, 14.18)
Other circulatory disorder	0.73 (0.22, 2.46)
Respiratory disorder	3.09 (1.28, 7.43)
Immunocompromised	1.22 (0.94, 1.56)



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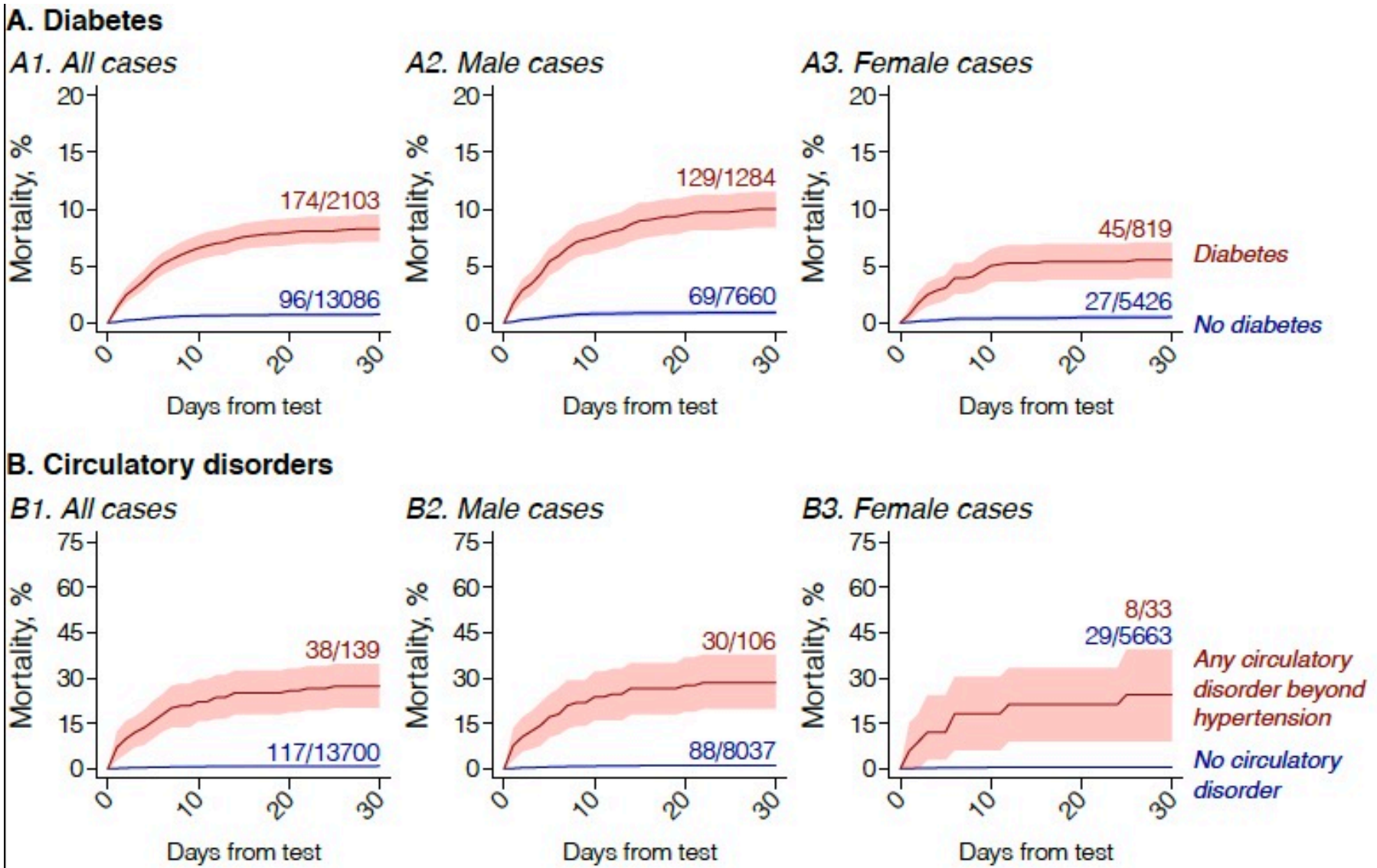

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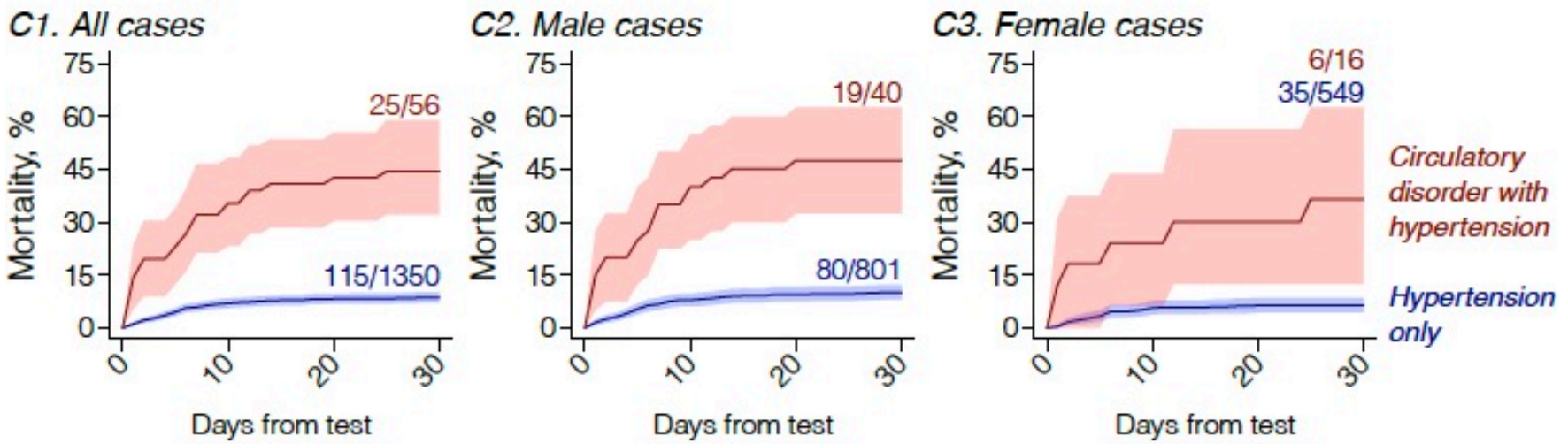
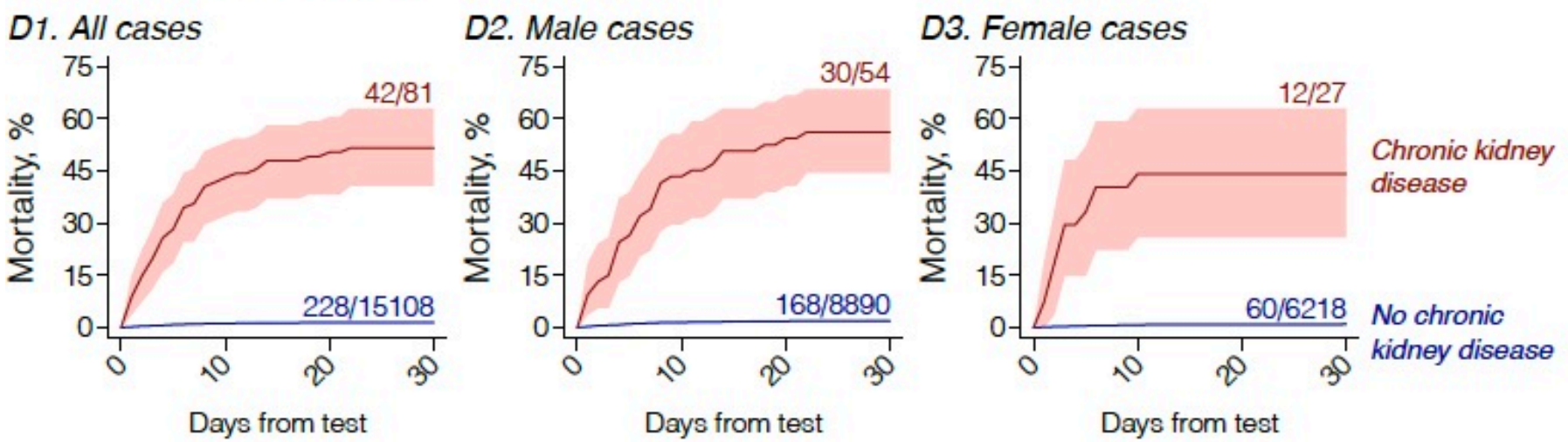
C. Circulatory disorders



D. Chronic kidney disease



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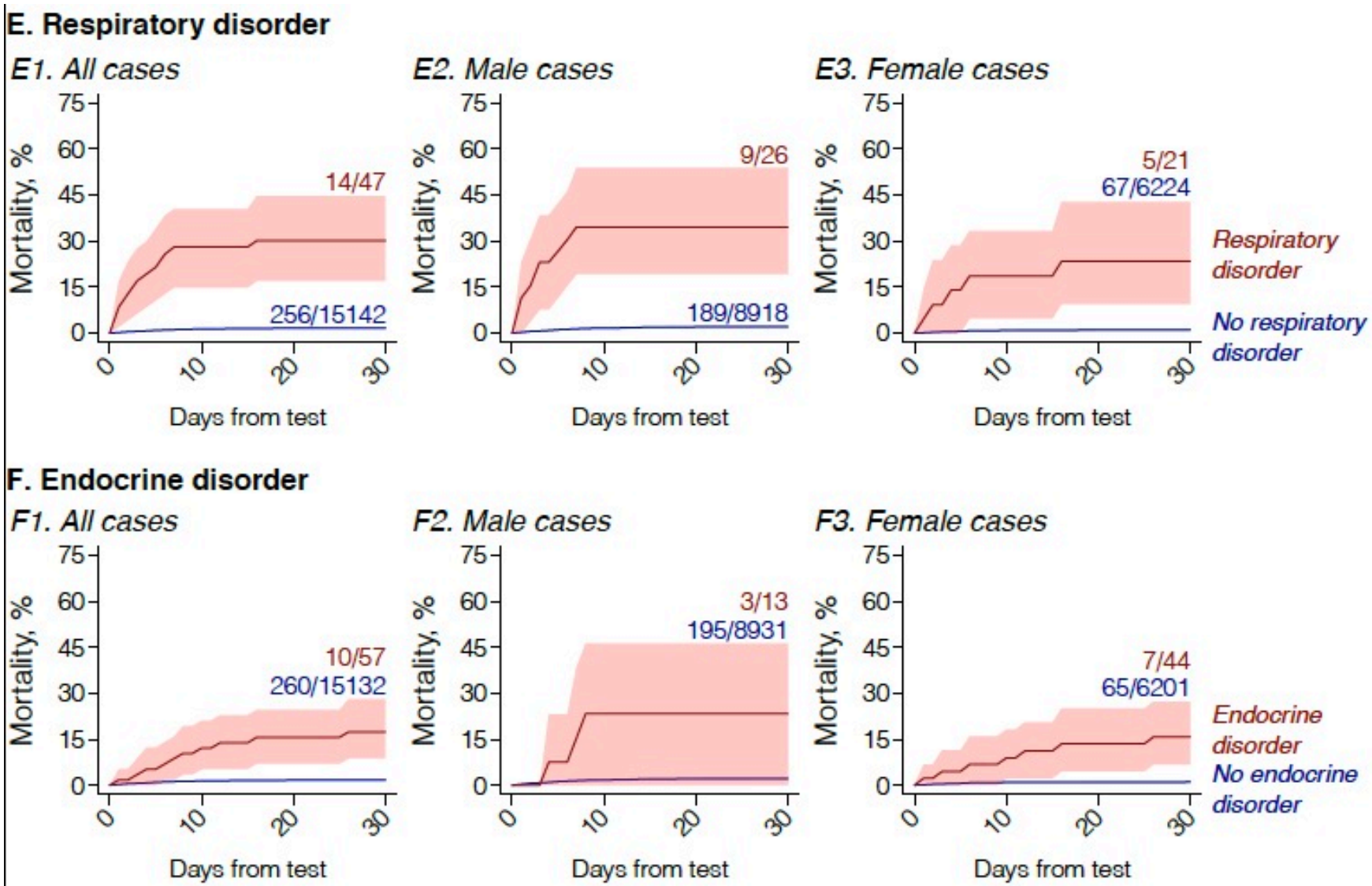

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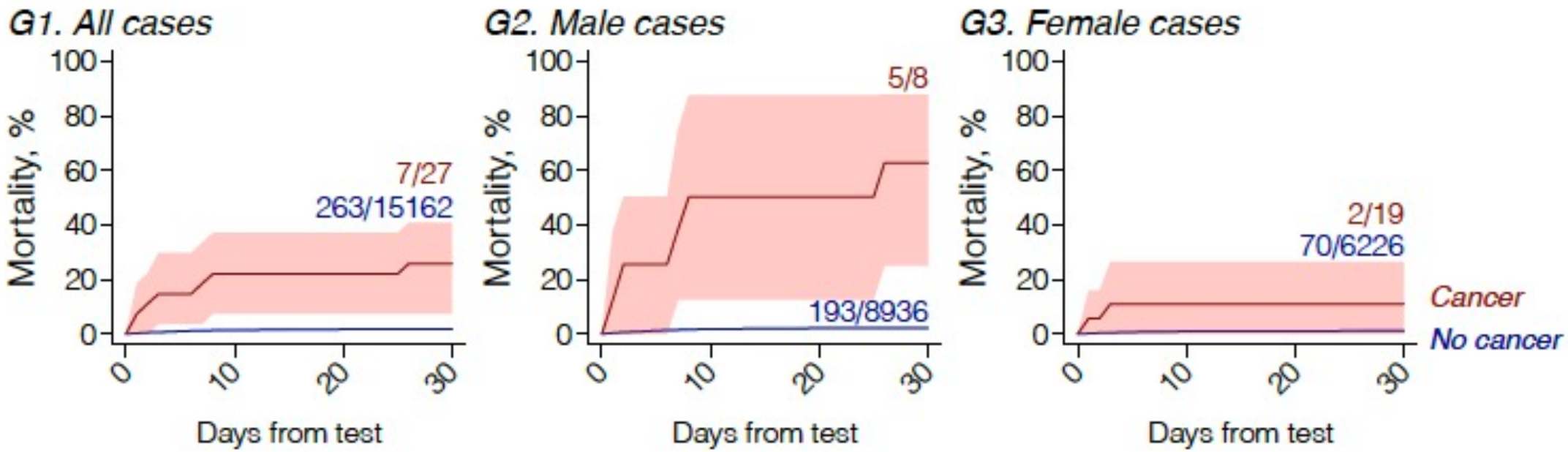
G. Cancer


G1. All cases
G2. Male cases
G3. Female cases
Mortality, %
100
80
60
40
20
0
0
10
20
30
Days from test
7/27
263/15162
5/8
193/8936
2/19
70/6226
Cancer
No cancer

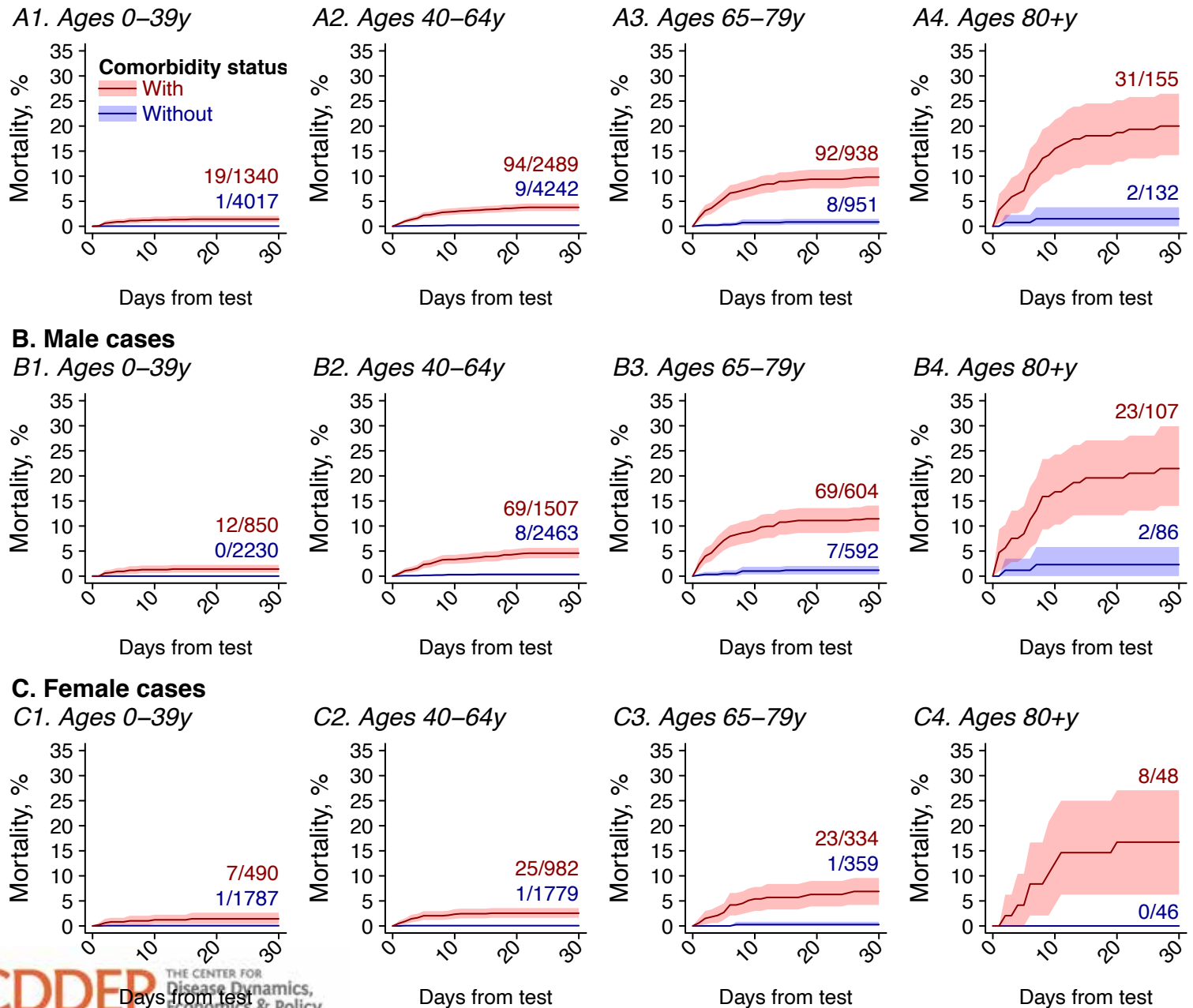


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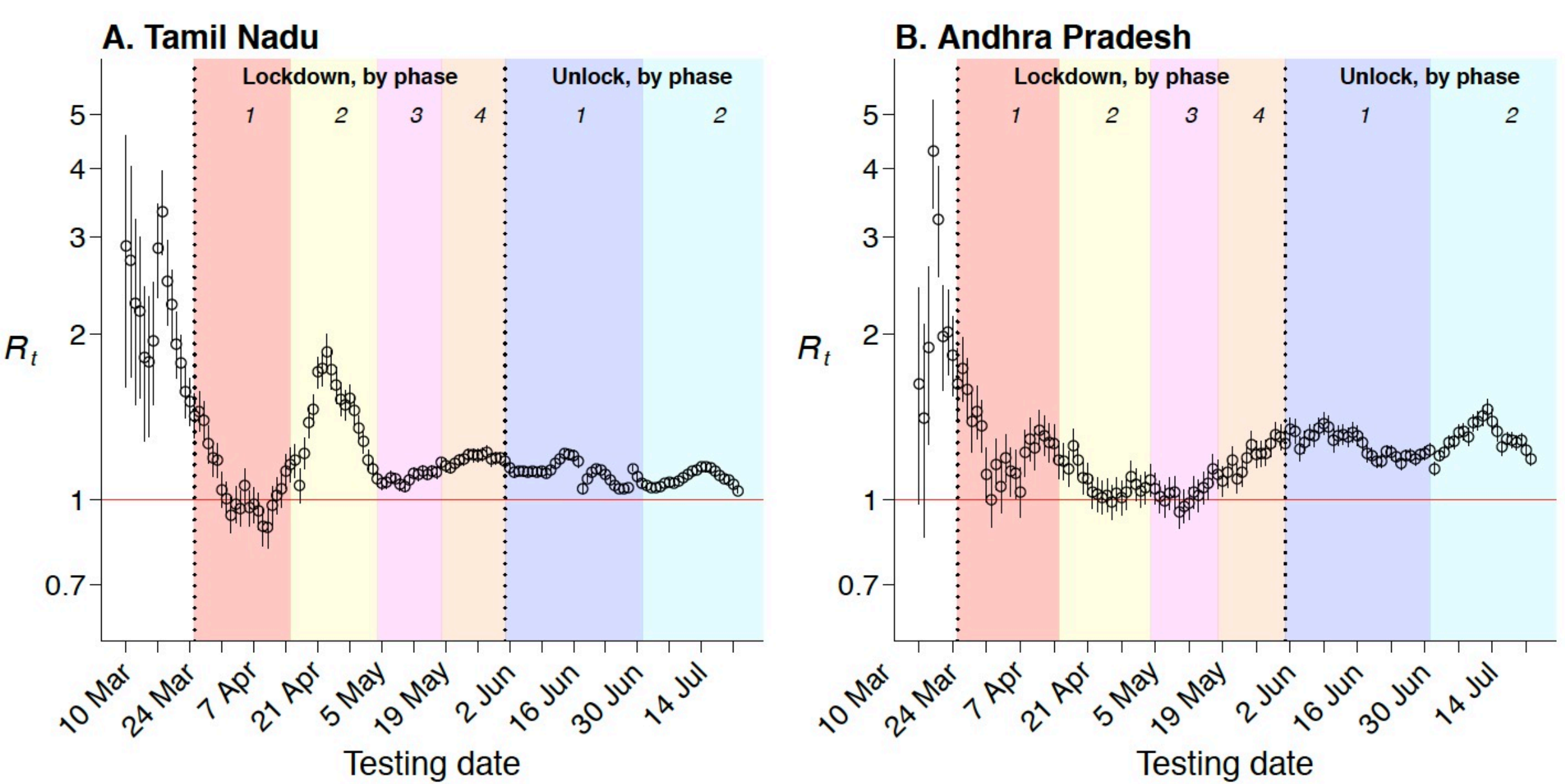
Table 3: Comparison of Madurai and US case fatality risk.

Measure	Comparison settings[1]				
	United States	England	Italy	China, Hong Kong, and Macau	South Korea
Overall mortality observed, %	5.4	3.0-3.2	3.3	1.4	1.7-2.0
Mortality among Madurai cases, reweighted by age distribution, % (95% CI)	7.2 (5.7-8.8)	4.6 (3.6-5.6)	6.3 (5.0-7.7)	5.3 (4.5-6.1)	4.8 (3.9-5.7)
Mortality among Madurai cases, reweighted by age and comorbidity distribution, % (95% CI)	11.1 (8.6, 13.8)	– –	8.9 (6.8, 11.1)	– –	– –

[1]Age distributions of cases in each setting and age-specific case-fatality ratios are presented in **Table S2**.

Effect of the Lockdown



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Covid Mortality

All-cause mortality during the COVID-19 pandemic in Chennai, India: an observational study

Joseph A Lewnard, Ayesha Mahmud, Tejas Narayan, Brian Wahl, T S Selvavinayagam, Chandra Mohan B, Ramanan Laxminarayan

Summary

Background India has been severely affected by the ongoing COVID-19 pandemic. However, due to shortcomings in disease surveillance, the burden of mortality associated with COVID-19 remains poorly understood. We aimed to assess changes in mortality during the pandemic in Chennai, Tamil Nadu, using data on all-cause mortality within the district.

Lancet Infect Dis 2021

Published Online December 22, 2021 https://doi.org/10.1016/S1473-3099(21)00746-5

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Key findings

- 5·2 excess deaths per 1000 individuals overall through the COVID-19 pandemic; excess mortality was substantially higher in older age groups.
- Greater increases in mortality in communities with lower socioeconomic status during the second wave of infections, but not during the first wave. Neighbourhoods with lower socioeconomic status had 0·7% to2·8% increases in pandemic-associated mortality per 1 SD increase in each measure of community disadvantage
- reductions in all-cause mortality concentrated among young adult men and within communities of low socioeconomic status immediately after the country-wide lockdown in March 24, 2020

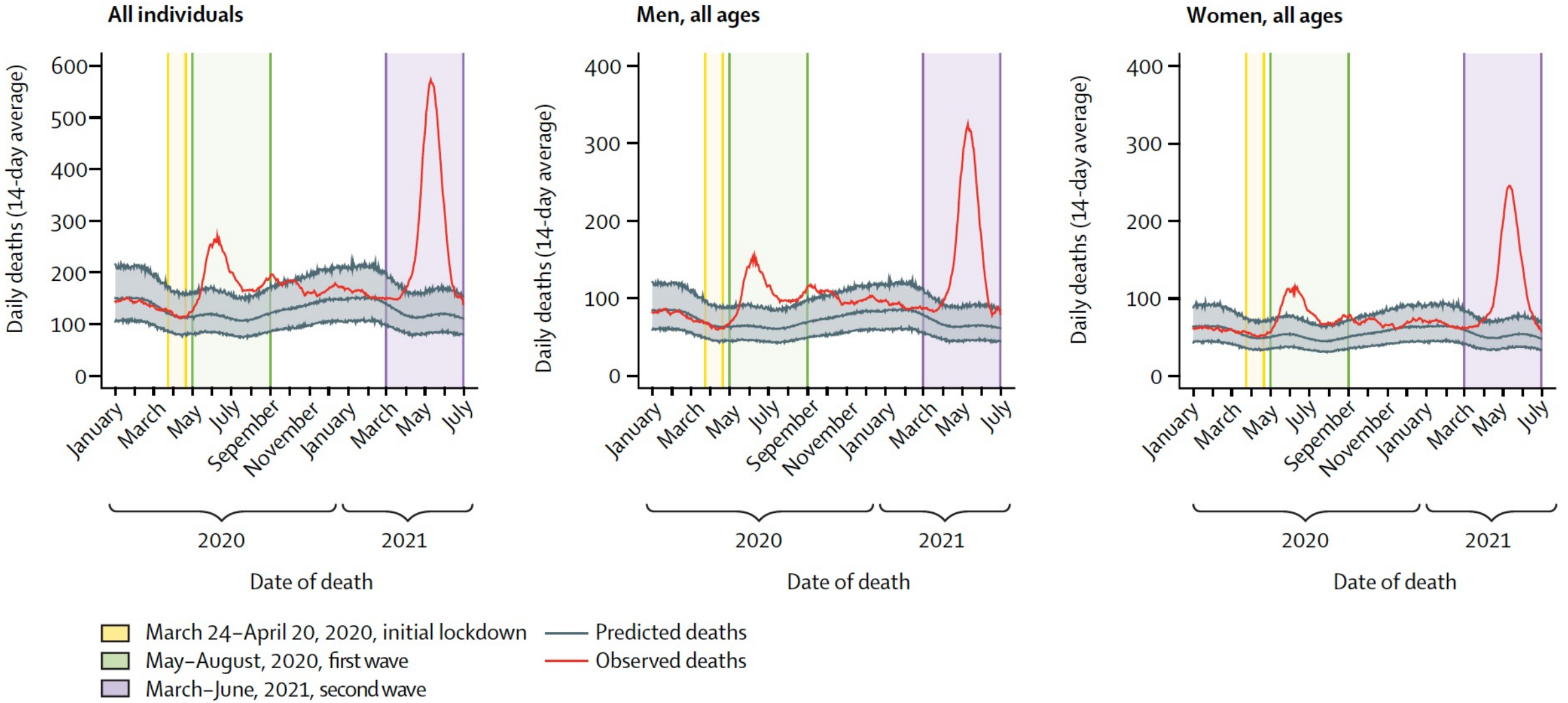
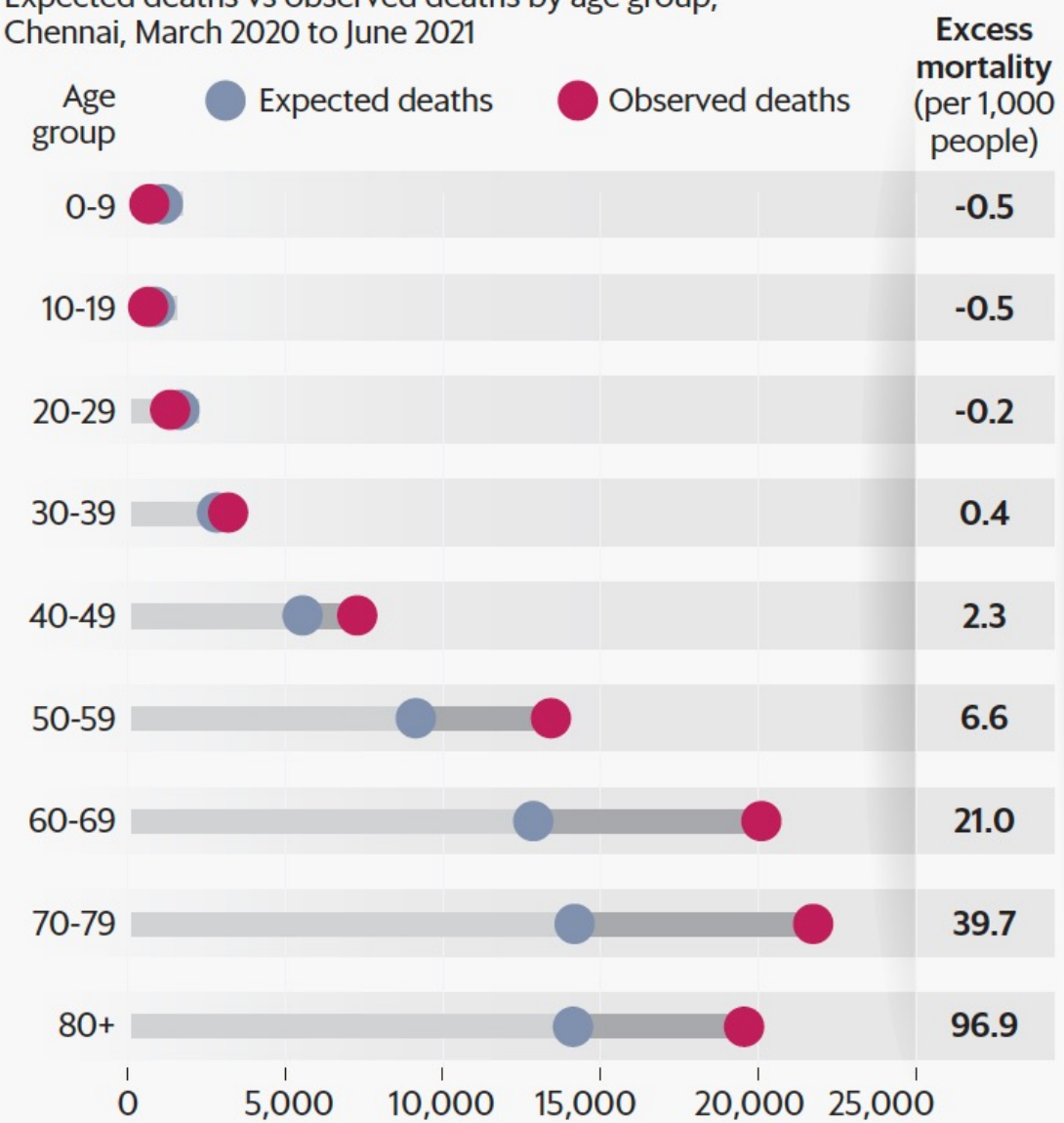


Figure 1: **Excess mortality during the COVID-19 pandemic in Chennai**

We plotted 14-day moving average estimates of daily mortality in 2020 and 2021 (observed deaths), corrected for lagged reporting based on 2019 observations (appendix 2 p 27). Grey lines and shaded areas illustrate model-based expectations of the 14-day moving average, according to pre-pandemic observations, together with 95% uncertainty intervals accounting for variation in the fitted model parameters and prediction of uncertainty. Estimates applying an alternative modelling framework to generate predictions, based on pre-pandemic observations, are presented in appendix 2 (p 28).

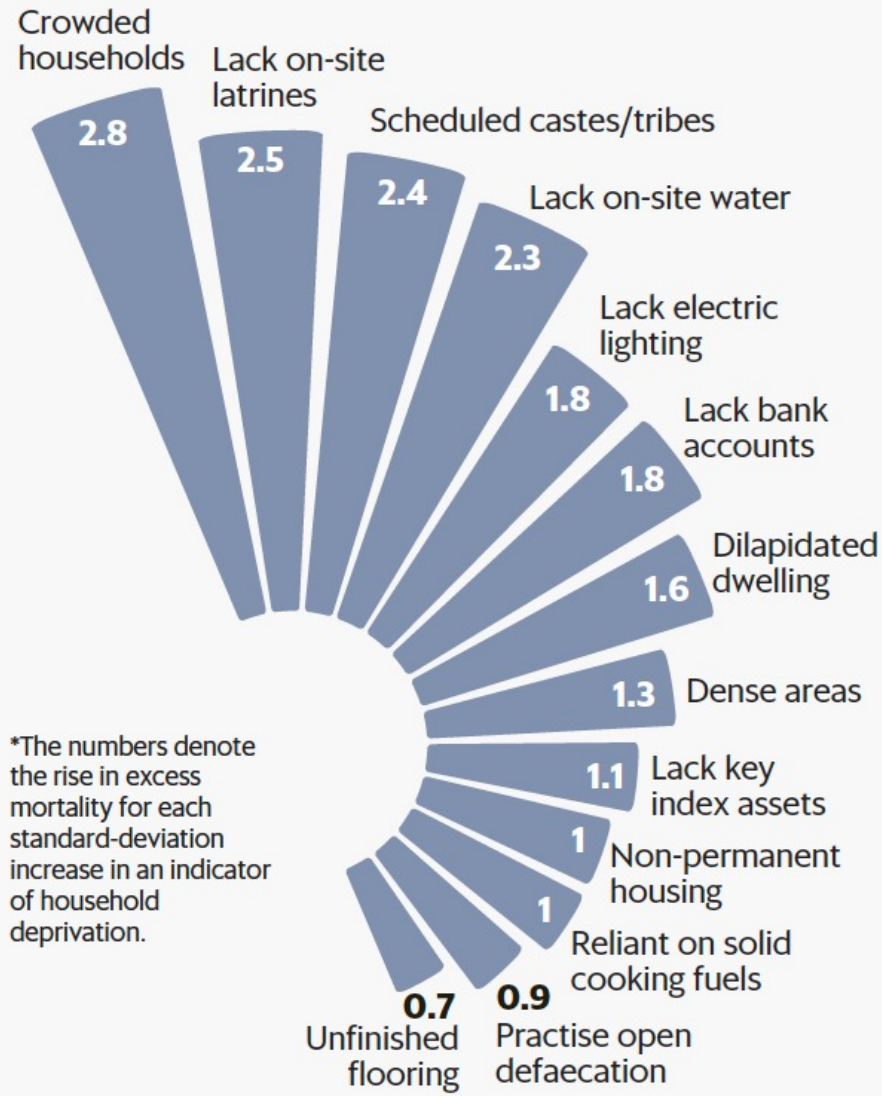
Mortality in Chennai rose significantly during the pandemic, especially among older age groups

Expected deaths vs observed deaths by age group, Chennai, March 2020 to June 2021



Covid-19 turned out to be more fatal in poor neighbourhoods

% increase in excess mortality (March 2020 to June 2021) for various household types*



*The numbers denote the rise in excess mortality for each standard-deviation increase in an indicator of household deprivation.

Source: "All-cause mortality during the covid-19 pandemic in Chennai, India: an observational study" by Laxminarayan et al, Lancet Journal of Infectious Diseases (December 2021)

Increase in mortality, and the undercount, was primarily driven by the second wave

Rise in mortality rate, in %, for various household types* (Chennai)

1 4 5

	First wave	Second wave
Crowded households	1	6.3
Dense areas	-0.8	3.7
Non-permanent housing	-1.5	4.5
Dilapidated dwelling	0.4	4.1
Unfinished flooring	-1.3	2.8
Lack on-site water	-1.5	7
Practise open defecation	-0.9	3.6
Lack on-site latrines	-0.1	6.4
Lack electric lighting	-1.5	5.3
Reliant on solid cooking fuels	-1.9	3.7
Scheduled castes/tribes	0.3	6.3
Lack bank accounts	-1.2	5.7
Lack key index assets	-0.2	3.1

*The numbers denote the rise in excess mortality for each standard-deviation increase in an indicator of household deprivation.
First wave: May to August 2020; second wave: March to June 2021.

Source: Laxminarayan et al (December 2021)

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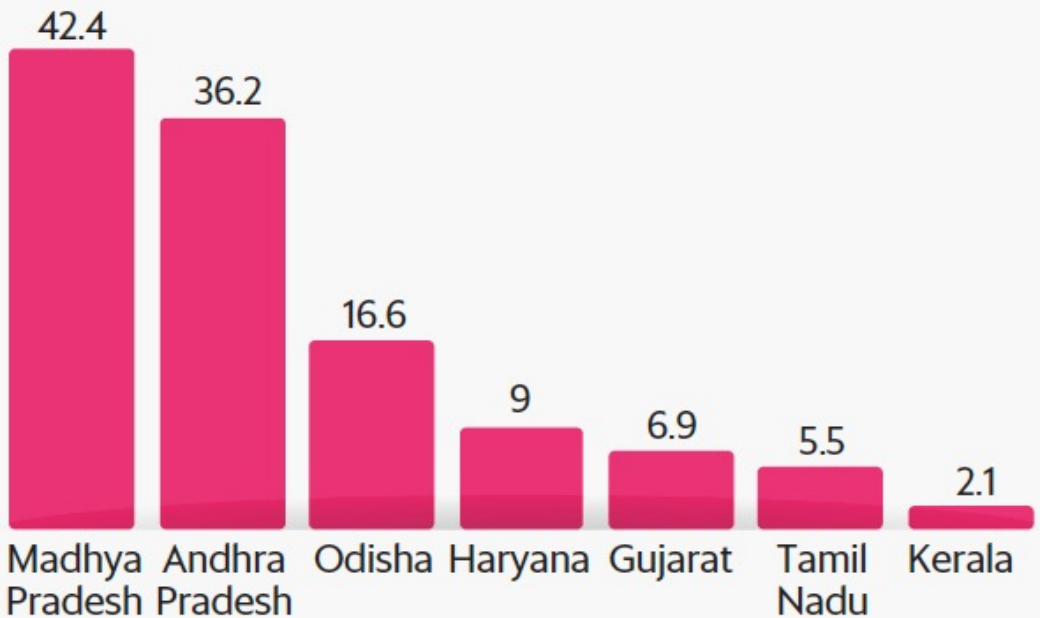
Tamil Nadu is likely among the states with the lowest death undercounts

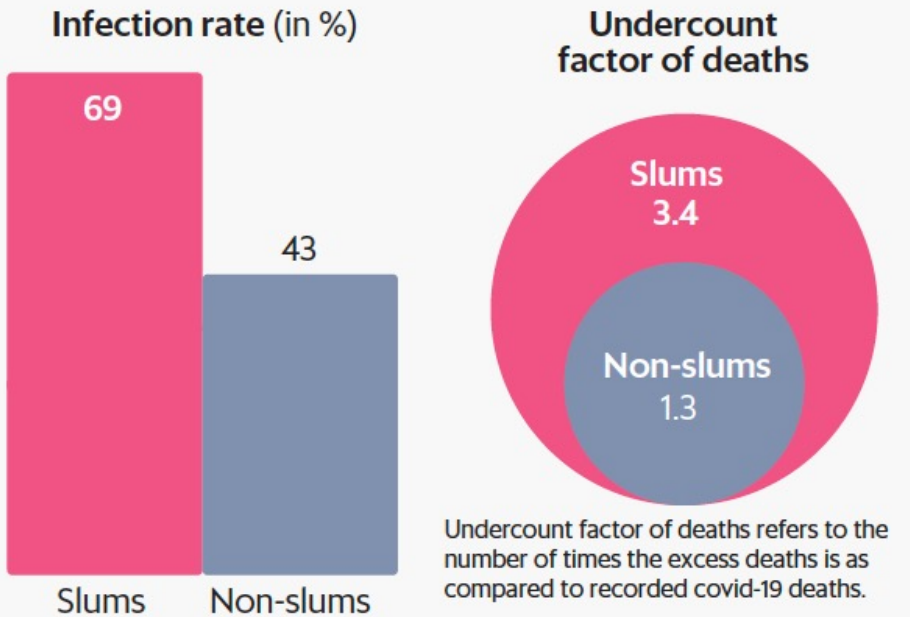
Ratio of excess registered deaths to confirmed covid deaths in the second wave



Source: Civil Registration System data compiled by Rukmini S, The Hindu and others, as reported in Jha et al

Studies from Mumbai suggest more missed deaths in poor areas

Covid-19 infection rates and deaths in Mumbai, 2020



Undercount factor of deaths refers to the number of times the excess deaths is as compared to recorded covid-19 deaths.

Source: "Estimating covid-19 infection fatality rate in Mumbai during 2020", Murad Banaji (September 2021)

AHMED RAZA KHAN/MINT

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Main messages

1. COVID-19 is high transmissible and containment has been challenging in most countries. Superspreading events are the rule rather than the exception
2. Children and young adults have an important role in transmission in this setting, where a third of cases are under 30 years old. But the under 30 population has been at very los risk.
3. Unlike observations in high-income settings, deaths are concentrated at ages 40-64 years and incidence of reported cases does not increase with older age.
4. Contrary to long hospital stays reported in high-income settings, the median time to death is 5 days following admission.
5. COVID is a disease of diabetes and hypertension. These comorbidities strongly predict infection and progress to mortality
6. The initial lockdown did help but on hindsight, the transition to a period of controlled transmission come have come sooner

Lessons Learnt

India's Cascading COVID-19 Failures

The Staggering Cost of an Unscientific Response to the Pandemic

By Ramanan Laxminarayan May 26, 2021

Most-Read Artic

What if Russi
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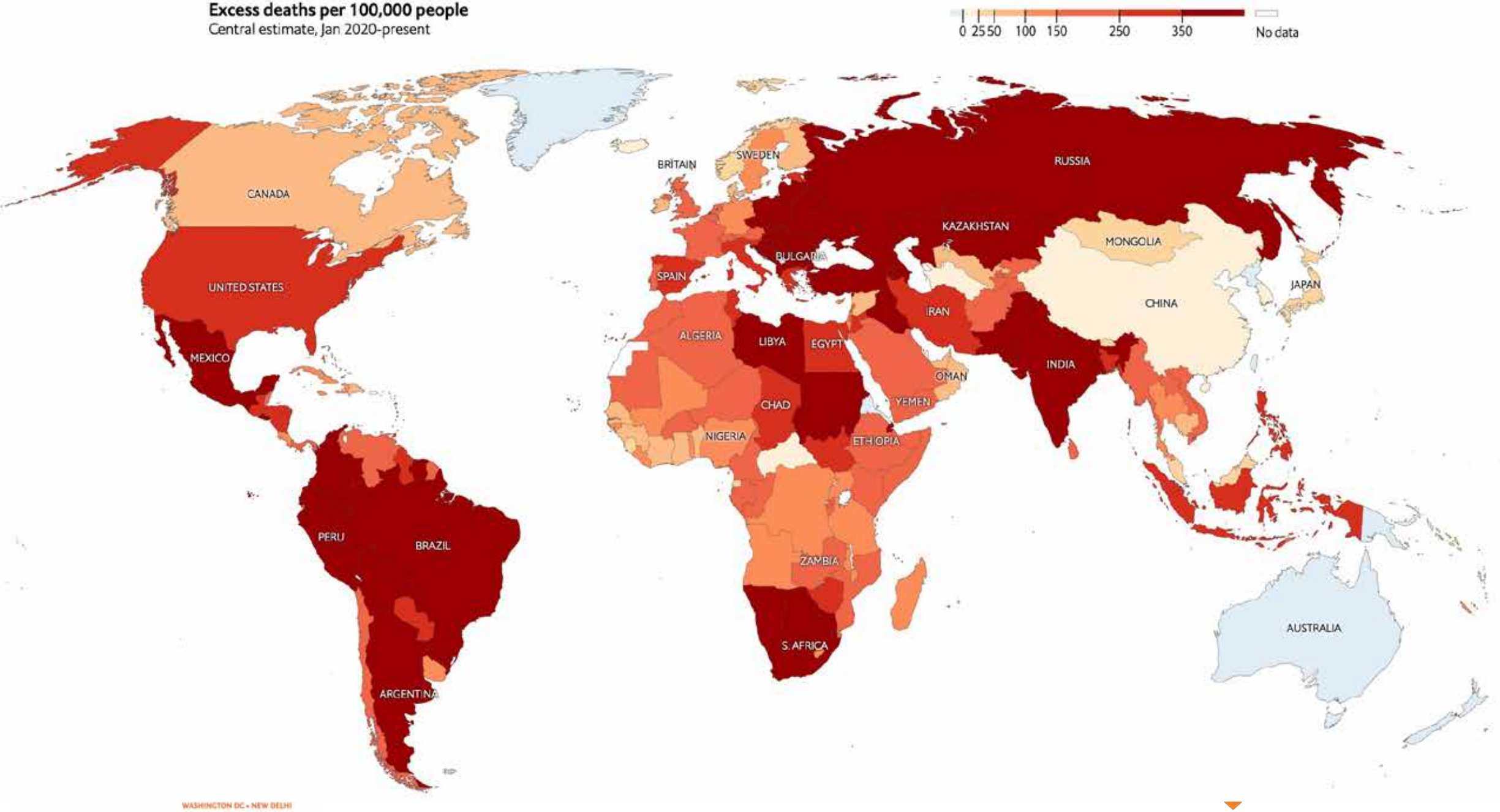
Excess deaths per 100,000 people
Central estimate, Jan 2020-present
0 25 50 100 150 250 350 No data
CANADA
UNITED STATES
MEXICO
PERU
BRAZIL
ARGENTINA
BRITAIN
SWEDEN
SPAIN
BULGARIA
RUSSIA
KAZAKHSTAN
MONGOLIA
CHINA
JAPAN
IRAN
ALGERIA
LIBYA
EGYPT
OMAN
INDIA
CHAD
YEMEN
NIGERIA
ETHIOPIA
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	OFFICIAL COVID-19 DEATHS	PER 100,000	▲ ESTIMATED EXCESS DEATHS	PER 100,000	ESTIMATE V OFFICIAL
India	514,023	36.9	2m to 9.1m	140 to 650	+1,000%
Russia	344,655	236.2	1.2m to 1.3m	800 to 860	+300%
United States	950,490	285.5	1.1m to 1.3m	340 to 380	+20%
Pakistan	30,196	13.4	370k to 1m	170 to 450	+2,700%
Indonesia	148,335	53.7	360k to 1m	130 to 370	+400%
Brazil	649,676	303.6	760k to 820k	350 to 380	+20%
Mexico	318,149	244.2	660k to 730k	500 to 560	+100%
Bangladesh	29,037	17.5	230k to 680k	140 to 410	+1,700%
Turkey	94,445	111.1	180k to 460k	220 to 540	+300%
Egypt	24,074	23.1	290k to 370k	270 to 350	+1,300%

AN OPEN LETTER TO DR RANDEEP GULERIA

What explains the misleading guidelines?

AIIMS prescribed plasma therapy, Remdesivir, Ivermectin and steroids without a timeline for Covid treatment before back tracking on each

Respected Dr Guleria,

I am a medical heretic who has inherited the trait of 'questioning' from the pioneers of modern medicine. You of course, have become a household name, a position well deserved for guiding the nation during the worst medical tragedy in our living memory.

People look up to doctors and doctors look up to institutions of excellence. The exalted status of the Director of All India Institute of Medical Sciences that you occupy has a halo that is richly deserved. Your words are treated as the Gospel by the entire medical fraternity in the country. Your responsibility therefore, is both onerous and unenviable.

But I draw your attention to the guidelines issued by AIIMS on April 07 of this year. It took up a solitary page in the manner of a flow chart that became the Bible of Covid treatment, from specialists down to the quacks.

For management of mild cases in home isolation, the AIIMS guideline advised prescribing Ivermectin. But as on 07th April there was overwhelming medical literature against the use of this drug. In March itself, WHO had noted that "current evidence on the use of Ivermectin to treat COVID-19 patients is inconclusive". In fact, there never was any evidence to start with. Could you have missed WHO's guideline or been unaware of the lack of medical evidence?

In a matter of weeks, the govt and ICMR publicly opposed the use of Ivermectin. By then of course there was a mad scramble for Ivermectin, which disappeared from pharmacies and was sold at a premium. But let it pass as no great harm was done to a patient by a couple of tablets that he gulped down in a state of panic.

Inexplicably Remdesivir was also recommended for cases admitted in hospitals. This recommendation was shocking because as you would have known, there is not an iota of evidence (except some low-quality manufactured evidence which has already been discredited) to support its use in Covid. In fact, WHO had dropped this medicine from the list of Covid drugs in November last year.

As the second wave of the pandemic spun out of control, Remdesivir earned for itself a place in the hall of shame of modern medicine. Black marketing, profiteering, counterfeiting, hoarding- the drug hogged the headlines for all the wrong reasons.

You took more than three weeks to tell us that there was no evidence to support the use of this drug. Weren't you aware of this fact earlier? As a Pulmonologist, I have reasons to believe that you would have been aware of the Tamiflu fiasco. Yet AIIMS prescribed Remdesivir under your watch.

Dr Randeep Guleria (left) and Dr VK Sinha

For a majority of Indians, procuring Remdesivir became an impossible task. Such was the desperation that relatives of patients were willing to pay any price for the drug to save their loved ones- a drug that unfortunately does not work by your own admission. Dare I say this has been a medical scam with few parallels?

Even more horrific has been the advisory on the use of steroids. Though for the last two weeks we find you are crying yourself hoarse against the indiscriminate use of steroids in Covid cases, every single hospital, dispensary and physician (unqualified quacks included) from the national capital to villages have been indiscriminately prescribing steroid tablets or injections to Covid patients. This has had disastrous consequences and led to hastening the progress of the disease besides causing bacterial and fungal infections.

That steroids should not be given during the first few days of a viral infection is plain common sense in the practice of medicine. Sadly, common sense is not very common. Most medical practitioners, unfortunately, continue to blindly follow the guidelines issued by AIIMS.

The practice of medicine requires sound judgement by discerning clinicians. This has not been possible in the present war like situation. The AIIMS guideline came to be followed blindly by physicians. An unintended error, lack of clarity or a genuine mistake might not have been fatal in normal times. But under these circumstances?

What proportion of Covid deaths could be attributed to the misuse of steroids will never be known; nor the number of families who pawned their meagre possessions or sold their tiny parcels of land for a prohibitively expensive but useless Remdesivir.

I have similar reasons to flag concerns on convalescent plasma and Tocilizumab in the guideline that does not pass muster of scientific scrutiny.

I conclude by referring to the doctrine of vicarious responsibility and with wishes for AIIMS to continue the good work for which it is rightly known.

With profound regards,

Major General (Dr) VK Sinha, VSM (Rtd)
(The writer is Quondam- Professor & Head of Orthopaedics, AFMC, Pune)

AIIMS,Delhi

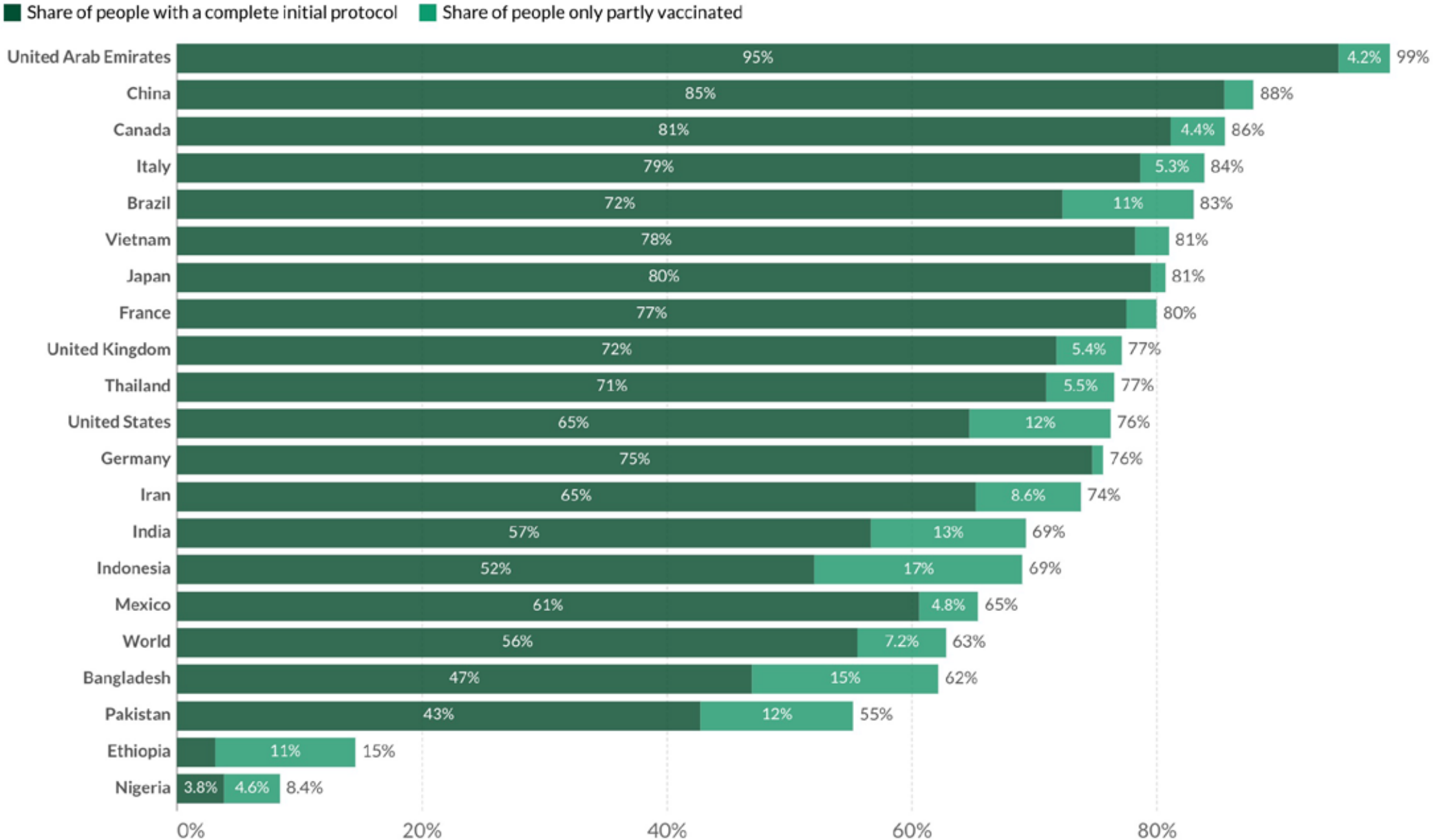
INTERIM CLINICAL GUIDANCE FOR MANAGEMENT OF COVID-19 (Version 1.6) ....7th April 2021

COVID-19 patient

MILD DISEASE	MODERATE DISEASE	SEVERE DISEASE
Upper respiratory tract symptoms (&/or fever) WITHOUT shortness of breath or hypoxia	Any one of: 1. Respiratory rate > 24/min 2. SpO2 < 94% on room air	Any one of: 1. Respiratory rate > 30/min 2. SpO2 < 90% on room air
HOME ISOLATION	ADMIT IN WARD	ADMIT IN ICU
• Contact & droplet precautions; strict hand hygiene • Symptomatic management • Stay in contact with treating physician Seek immediate medical attention if: • Difficulty in breathing • High-grade fever/ severe cough • A low threshold should be kept for patients with high-risk factor* Peripheral oxygen saturation (by applying a SpO2 probe to fingers) should be monitored at home Tab Ivermectin (200 mcg/kg once a day for 3 to 5 days) may be considered in patients with high-risk features* Steroids should NOT be used in patients with only mild disease	Oxygen Support: • Target SpO2: 92-96% (88-92% in patients with COPD) • Preferred devices for oxygenation: non-rebreathing face mask • Awake proning may be used in those with persistent hypoxia despite use of high flow oxygen Antiviral therapy: • Inj Remdesivir 200 mg IV on day 1 f/b 100 mg IV daily for 5 days • Convalescent plasma (CP) may be considered in carefully selected patients Anti-inflammatory or immunomodulatory therapy • Inj Methylprednisolone 0.5 to 1 mg/kg IV in two divided doses for 5 to 10 days Anticoagulation • Low dose prophylactic UFH or LMWH## Monitoring • Clinical Monitoring: Work of breathing, Hemodynamic instability, Change in oxygen requirement • Serial CXR, HRCT Chest (if worsening)	Respiratory support • Consider use of HFNC in patients with increasing oxygen requirement, if work of breathing is LOW • A cautious trial of NIV with helmet interface (if available otherwise face mask interface)/CPAP with oro-nasal mask may also be considered • Intubation should be prioritized in patients with high work of breathing /if NIV is not tolerated • Conventional ARDSnet protocol for ventilatory management Antiviral therapy • Antivirals may be considered if duration of illness < 10-14 days Anti-inflammatory or immunomodulatory therapy • Inj Methylprednisolone 1 to 2mg/kg in 2 divided doses for 5 to 10 days (or equivalent dose of dexamethasone) • Tocilizumab may be considered on a case-to-case basis preferably within 24 to 48 hours of progression to severe disease Monitoring • Serial CXR, HRCT Chest (if worsening) • Lab monitoring: CRP, D-dimer & Ferritin 24-48 hrly; CBC, LFT, KFT daily; IL-6 levels to be done if deteriorating (subject to availability)

Share of people vaccinated against COVID-19, Feb 27, 2022

Our World in Data



Source: Official data collated by Our World in Data
Note: Alternative definitions of a full vaccination, e.g. having been infected with SARS-CoV-2 and having 1 dose of a 2-dose protocol, are ignored to maximize comparability between countries.

Closing Thoughts

What worked?

- Early lockdown measures
- Scale up of manufacturing of essential supplies like PPEs, masks, sanitizers
- Vaccine development, manufacturing and rollout

What didn't work?

- Low levels of testing in early stages
- Lack of science-driven response and poor messaging
- Poor social cohesion in response to COVID, knee jerk policy-making, and consequently rising inequity

Acknowledgements

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J. Radhakrishnan
Thousands of public health workers in Tamil Nadu and Andhra Pradesh