Environmental Factors and COVID-19: Preliminary findings from China

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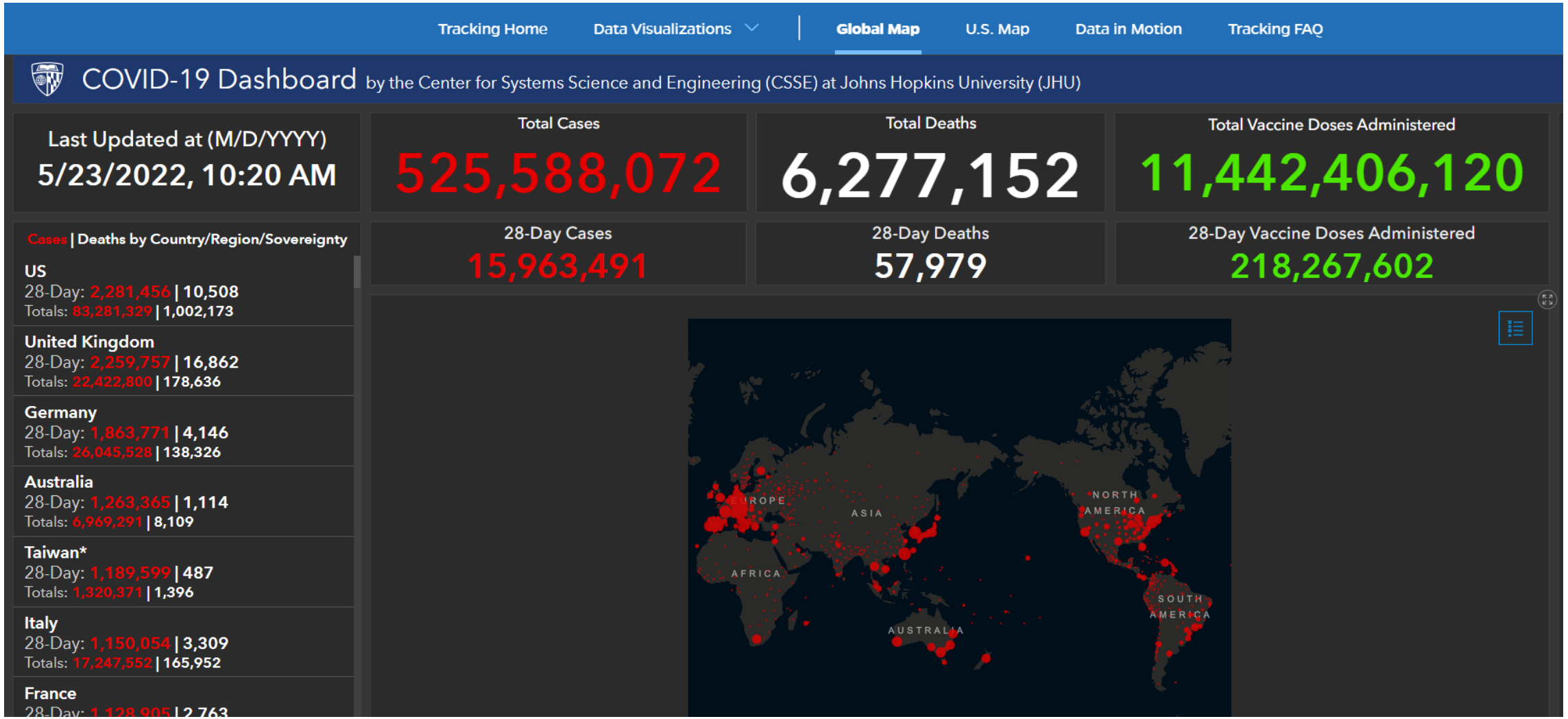
Outline

- Background
- Data & methods
- Results
  - Weather conditions and transmission of COVID-19
  - Air pollution and fatality rate of COVID-19
- Discussion & summary

Background

COVID-19 pandemic



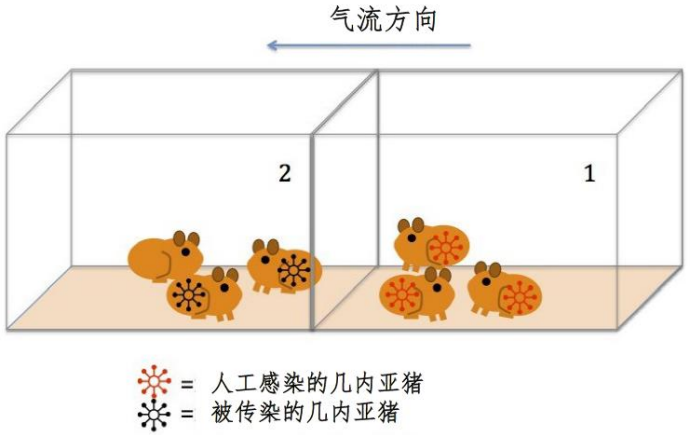
https://coronavirus.jhu.edu/map.html

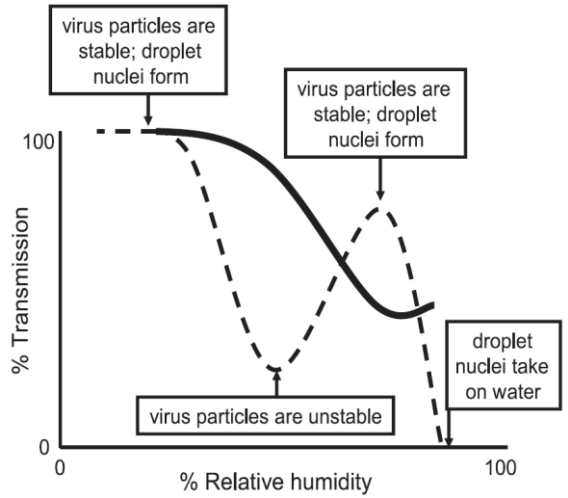
Key question

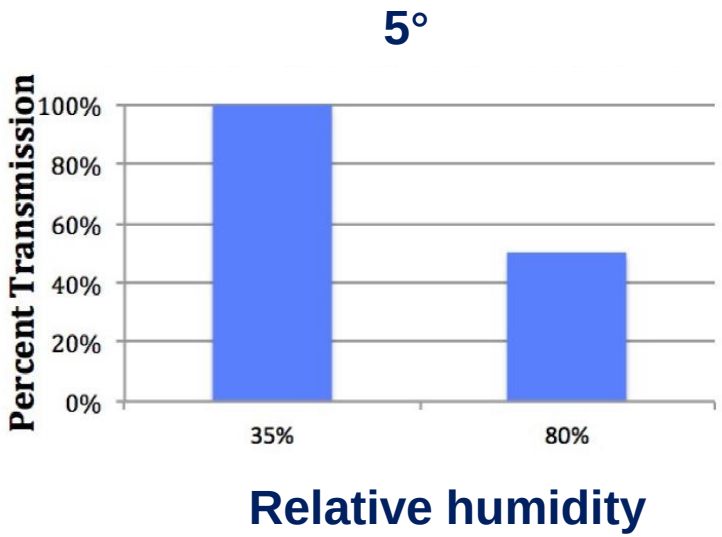
Is COVID-19 sensitive to temperature and other environment conditions?

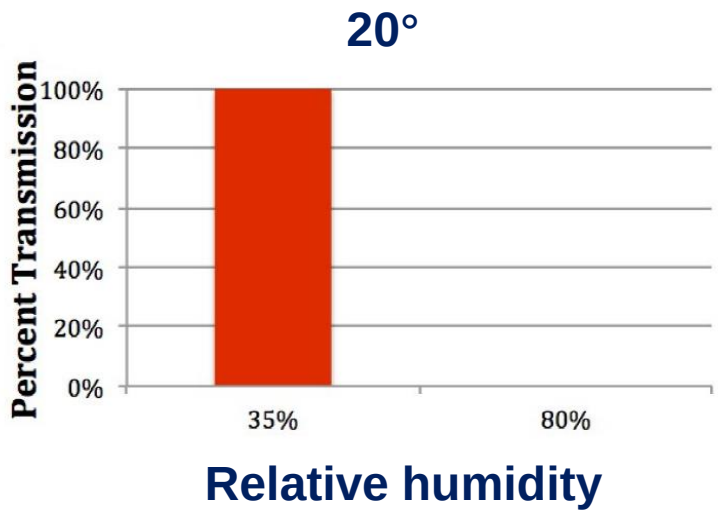
Background

Influenza Virus Transmission Is Dependent on Relative Humidity and Temperature in guinea pigs









Lowen et al, *PLOS Pathogens*, 2007

Background

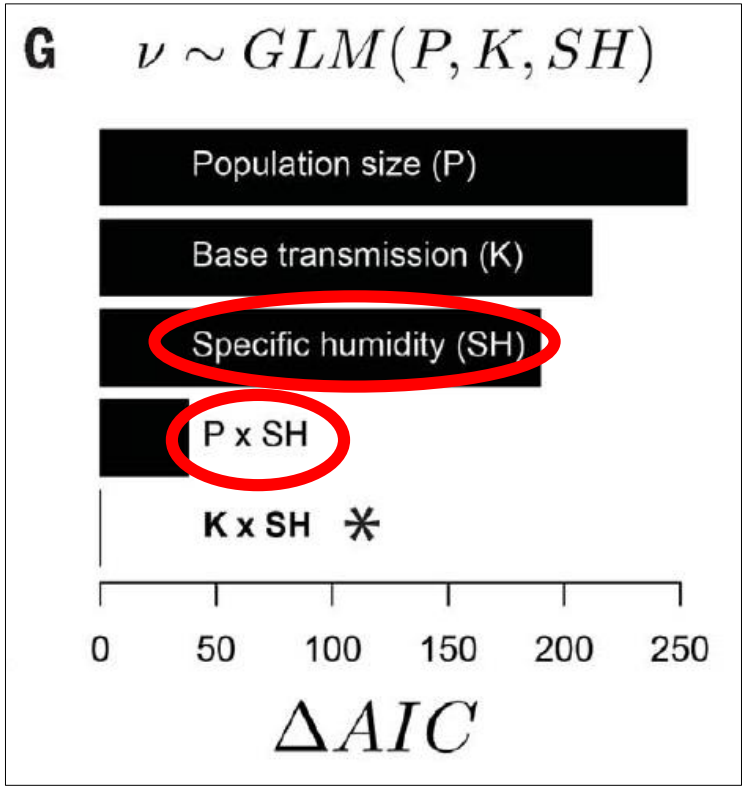
Humidity and influenza epidemics

INFLUENZA

Urbanization and humidity shape the intensity of influenza epidemics in U.S. cities

Benjamin D. Dalziel[1,2*], Stephen Kissler[3], Julia R. Gog[3], Cecile Viboud[4], Ottar N. Bjørnstad[5], C. Jessica E. Metcalf[6,7], Bryan T. Grenfell[4,6,7]

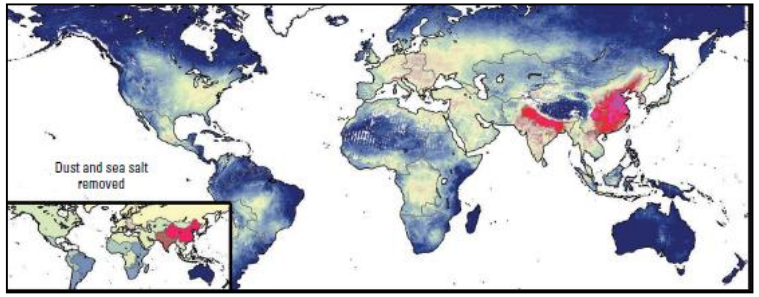
Influenza epidemics vary in intensity from year to year, driven by climatic conditions and by viral antigenic evolution. However, important spatial variation remains unexplained. Here we show predictable differences in influenza incidence among cities, driven by population size and structure. Weekly incidence data from 603 cities in the United States reveal that epidemics in smaller cities are focused on shorter periods of the influenza season, whereas in larger cities, incidence is more diffuse. Base transmission potential estimated from city-level incidence data is positively correlated with population size and with spatiotemporal organization in population density, indicating a milder response to climate forcing in metropolises. This suggests that urban centers incubate critical chains of transmission outside of peak climatic conditions, altering the spatiotemporal geometry of herd immunity.

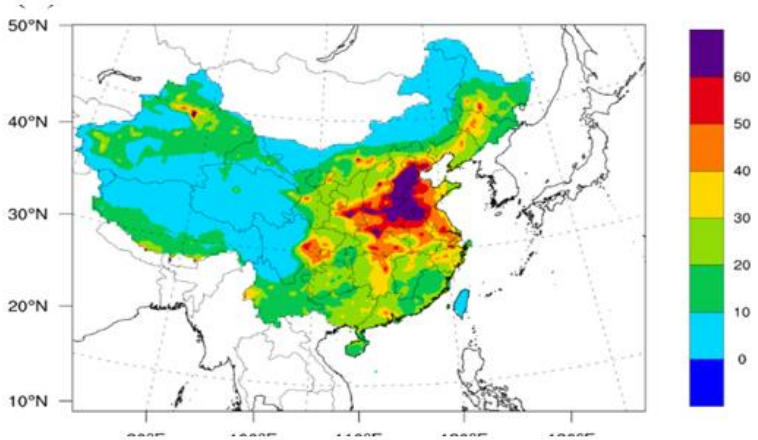


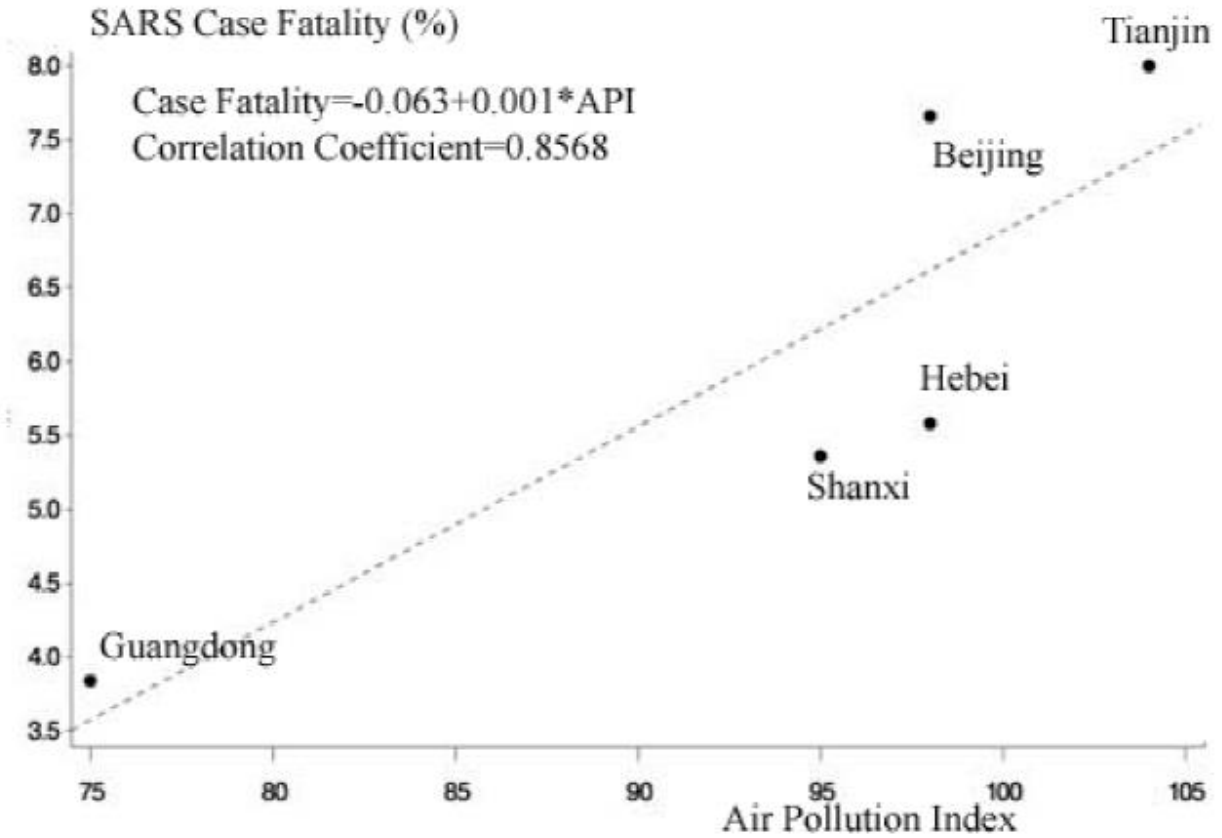
Dalziel et al, *Science*, 2018

Background

Ambient air pollution and SARS fatality rate
– cross-sectional analysis in China



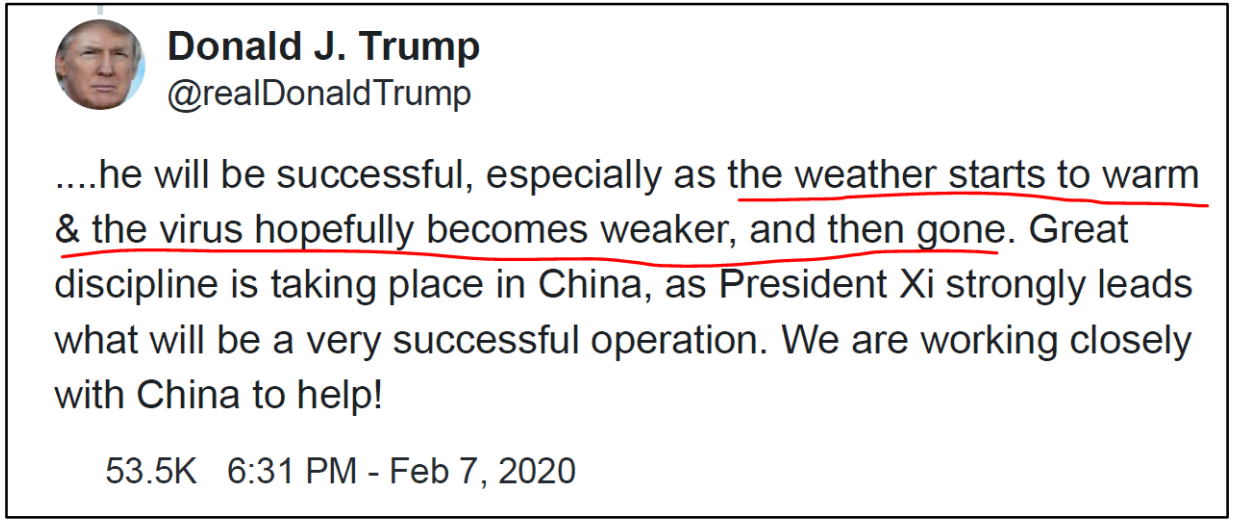


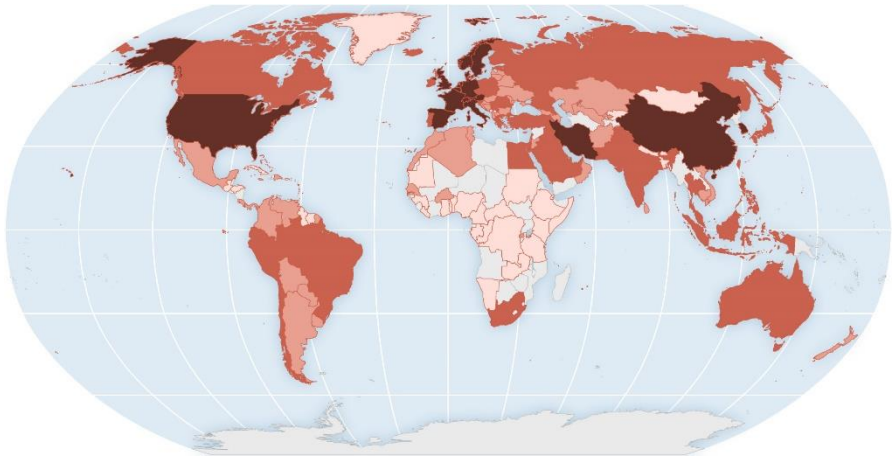


Cui et al, *Environ Health*, 2003

Background

Environment and COVID-19





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COVID-19 confirmed cases

- National Health Commission of China (www.nhc.gov.cn/xcs/xxgzbd/gzbd_index.shtml)

- Provincial Health Commissions of China (http://wjw.hubei.gov.cn/bmdt/ztzl/fkxxgzbdgrfyyq/)

- Johns Hopkins Coronavirus Resource Center (https://coronavirus.jhu.edu/map.html)

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Weather conditions

- Daily mean temperature and relative humidity collected from the China Meteorological Data Sharing Service System

- UV radiation: daily erythemally weighted daily dose (EDD) data extracted using the Dutch–Finnish ozone monitoring instrument (OMI) level 2 UV irradiance products, version 003 (OMUVB V003) at 13 km×24 km resolution

Data & methods

National air quality monitoring network since 2013

- 338 cities, 1,400+ stations
- 6 criteria pollutants ($PM_{2.5}$/PM_{10}/O_3/SO_2/NO_2/CO)
- Largest one in developing countries

Statistical methods

- Cumulative number of confirmed cases from 224 cities (207 outside Hubei, 17 inside Hubei) with more than 10 cases as of 9 March 2020
- **Basic reproduction number (R_0)**

✓for 62 cities (50 outside Hubei, 12 inside Hubei) with >50 cases as of 10 February 2020 (COVID-19 peak time in China).

✓202 locations of 8 countries, data as of April 2020.

  - R_0 means the expected number of secondary cases generated by an initial infectious individual, in a completely susceptible population.
  - If $R_0 < 1$, then the disease-free equilibrium is locally asymptotically stable; whereas, if $R_0 > 1$, then it is unstable.

Statistical methods

- **Case fatality rate (CFR) of COVID-19**

✓for 49 cities (33 outside Hubei, 16 inside Hubei) with >100 cases as of 22 March 2020.

✓Death risk among people got COVID-19

✓Indicator for severity and prognosis of COVID-19

Statistical methods

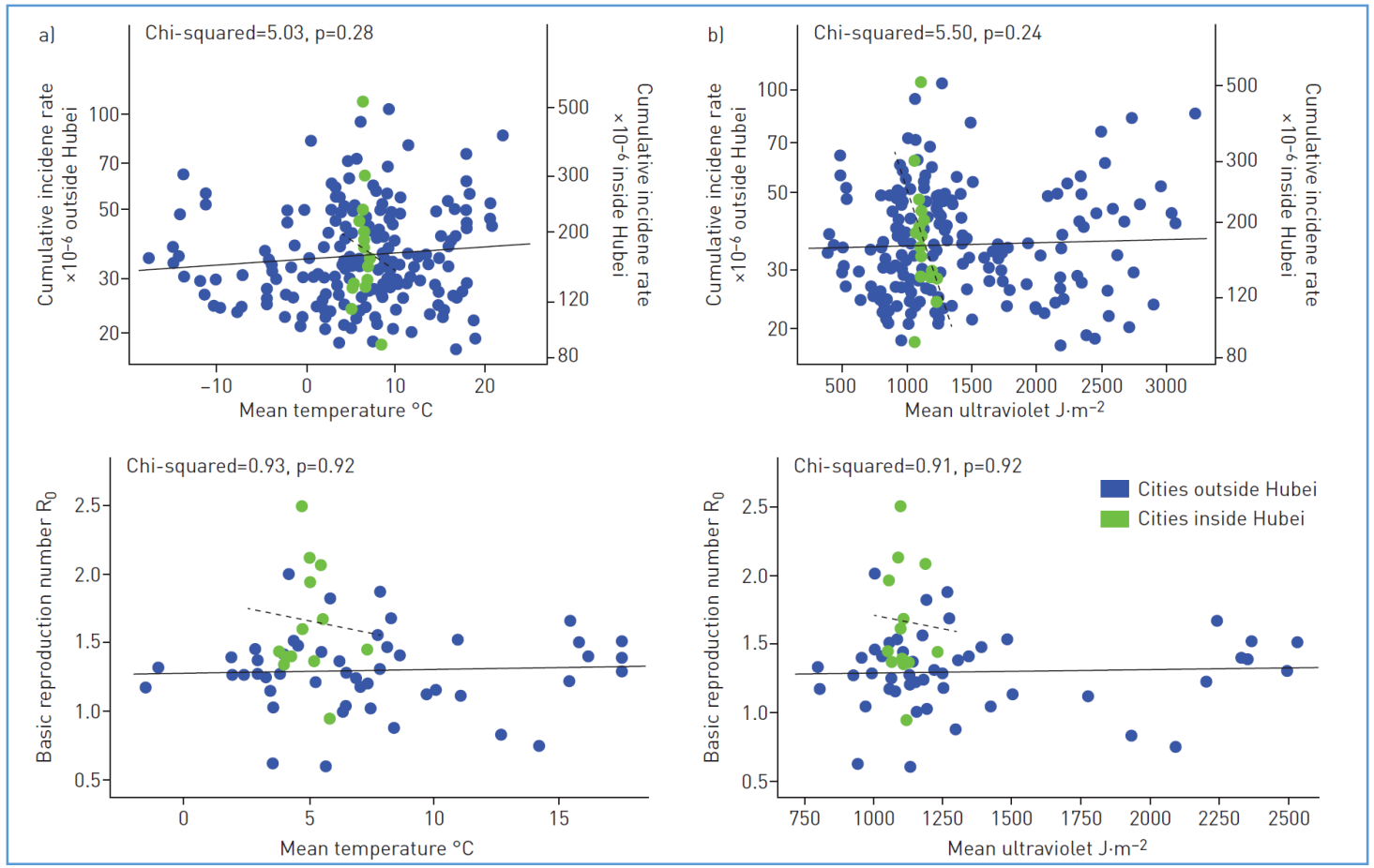
- **Cross sectional analysis**

➢Meteorological factors and COVID-19 transmission: in China and multi-locations worldwide

➢Particulate air pollution and COVID-19 CFR: in China

Results - 1

No association of COVID-19 transmission with temperature or UV radiation



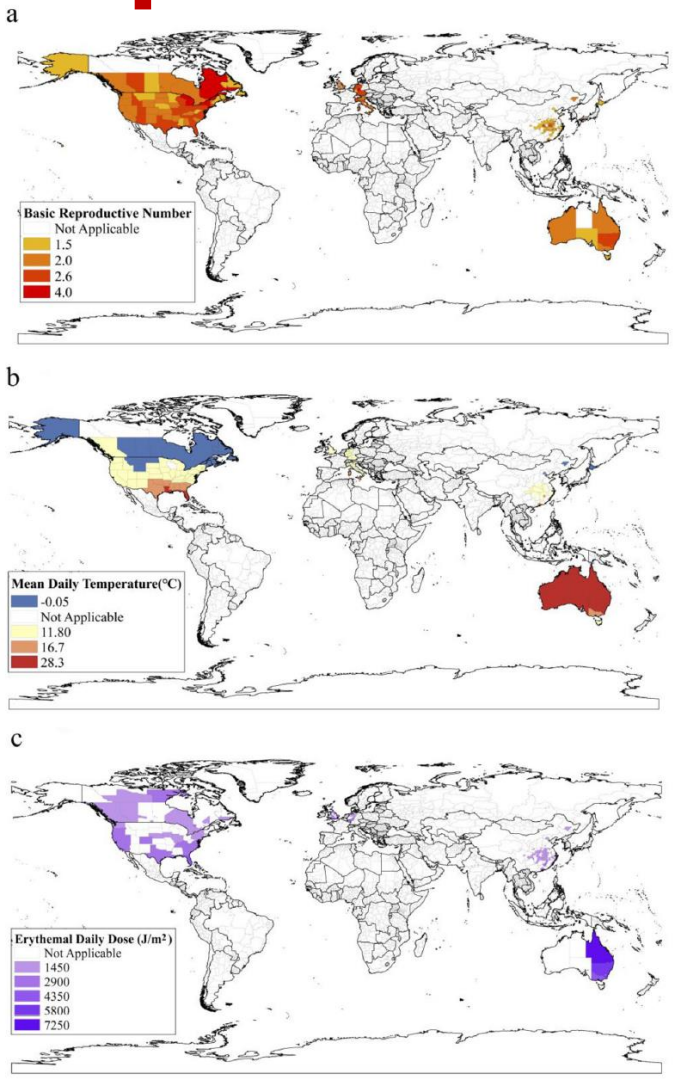
Yao et al, *European Respiratory Journal*, 2020

Results - 1

No association of COVID-19 transmission with temperature or UV radiation

Multiple locations of 8 countries

- 7 locations in Australia
- 9 locations in Canada
- 50 locations in the United States
- 63 locations in China
- 8 locations in Germany
- 19 locations in Italy
- 5 locations in Japan
- 41 locations in the United Kingdom (UK)

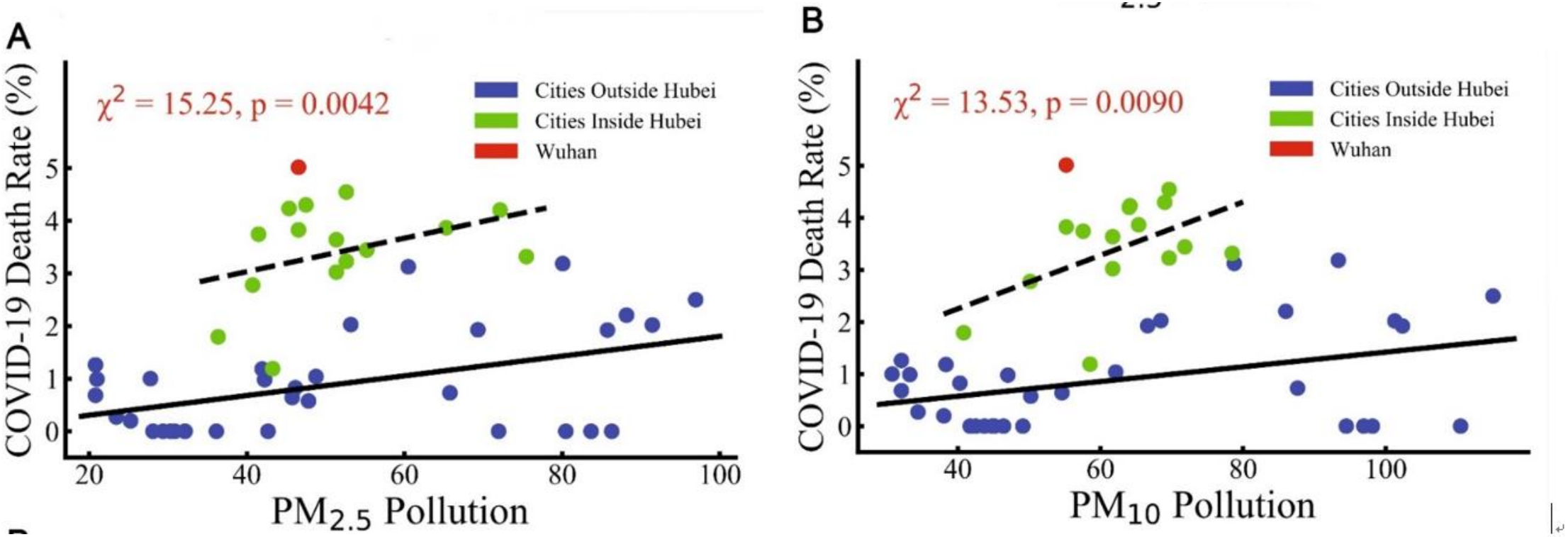


Variable	β(95%CI)	p value
UK		
Temperature	-0.050(-0.147,0.047)	0.305
Humidity	-0.007(-0.032,0.018)	0.565
Wind speed	-0.018(-0.090,0.055)	0.625
US		
Temperature	0.017(-0.004,0.039)	0.116
Humidity	-0.016(-0.029,-0.003)	0.019
Wind speed	0.049(-0.119,0.216)	0.562
Italy		
Temperature	0.021(-0.019,0.060)	0.278
Humidity	-0.014(-0.046,0.018)	0.367
Wind speed	0.015(-0.098,0.128)	0.785
Germany		
Temperature	-0.092(-1.415,1.230)	0.856
Humidity	-0.182(-0.589,0.224)	0.281
Wind speed	0.425(-1.798,2.649)	0.623
Australia		
Temperature	0.003(-0.197,0.203)	0.965
Humidity	-0.017(-0.111,0.077)	0.601
Wind speed	-0.134(-1.191,0.924)	0.714
Canada		
Temperature	0.023(-0.401,0.447)	0.895
Humidity	-0.023(-0.256,0.211)	0.813
Wind speed	-0.135(-1.222,0.951)	0.762
China		
Temperature	-0.008(-0.024,0.008)	0.310
Humidity	0.007(-0.005,0.020)	0.249
Wind speed	-0.011(-0.169,0.147)	0.890
Meta p		
Temperature		0.591
Humidity		0.215
Wind speed		0.986

Pan et al, *Science of the Total Environment*, 2020

Results - 2

PM and COVID-19 fatality rate



Results - 2

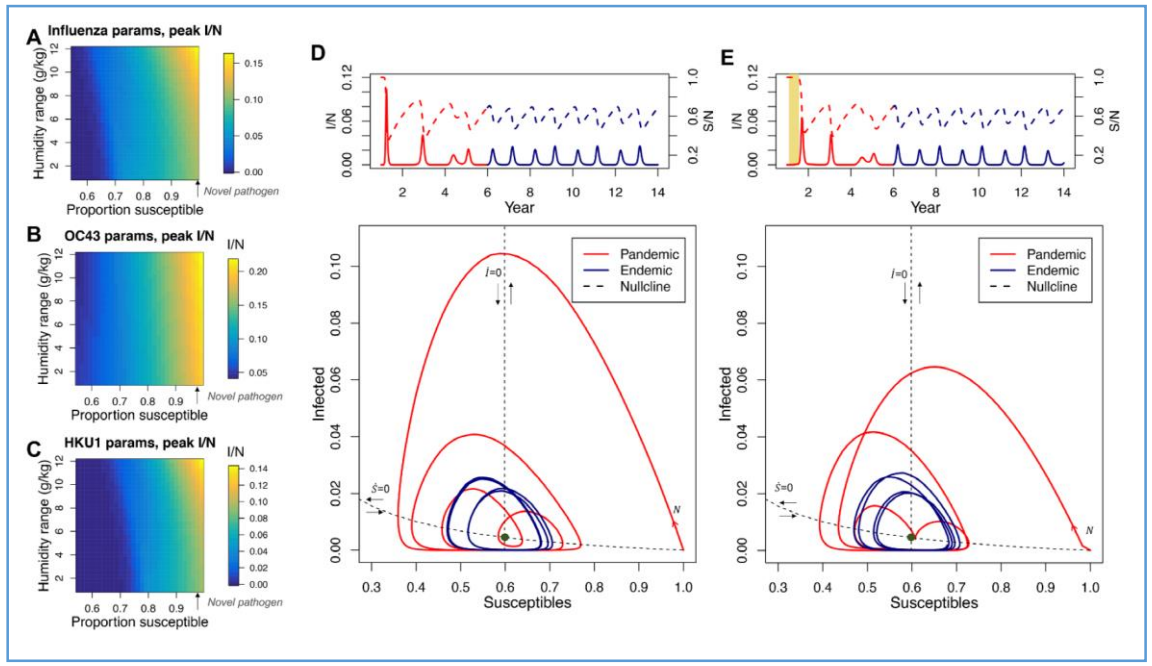
PM and COVID-19 fatality rate

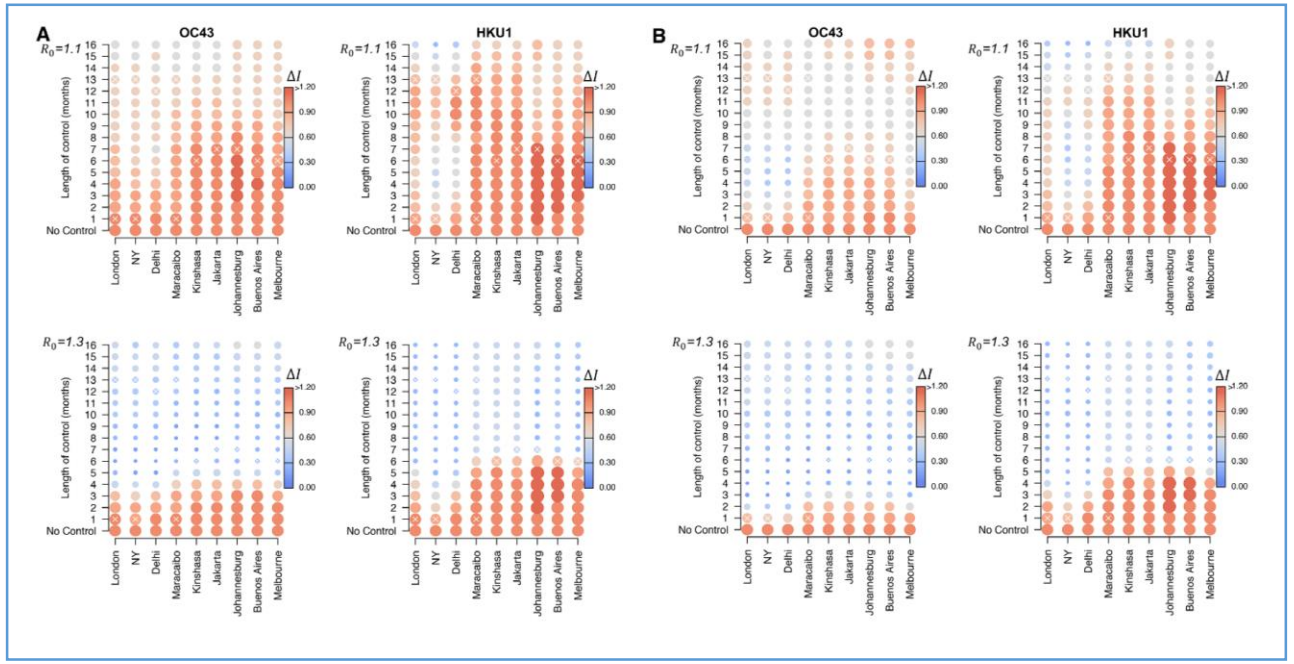
Exposure period	Domain	$PM_{2.5}$	PM_{10}
Epidemic period	Cities outside Hubei	0.25% (0.10% - 0.40%)	0.20% (0.05% - 0.35%)
	Cities inside Hubei#	0.23% (-0.20% - 0.67%)	0.38% (-0.10% - 0.86%)
	Pooled estimates	0.24% (0.01% - 0.48%)	0.26% (0.00% - 0.51%)
Long-term (2015-2019)	Cities outside Hubei	0.61% (0.28% - 0.94%)	0.30% (0.11% - 0.49%)
	Cities inside Hubei#	0.60% (-0.32% - 1.52%)	0.41% (-0.15% - 0.98%)
	Pooled estimates	0.61% (0.09% - 1.12%)	0.33% (0.03% - 0.64%)

Adjusted for: GDP per capita, and hospital beds per capita

Discussion -1

Weather and transmission of COVID-19





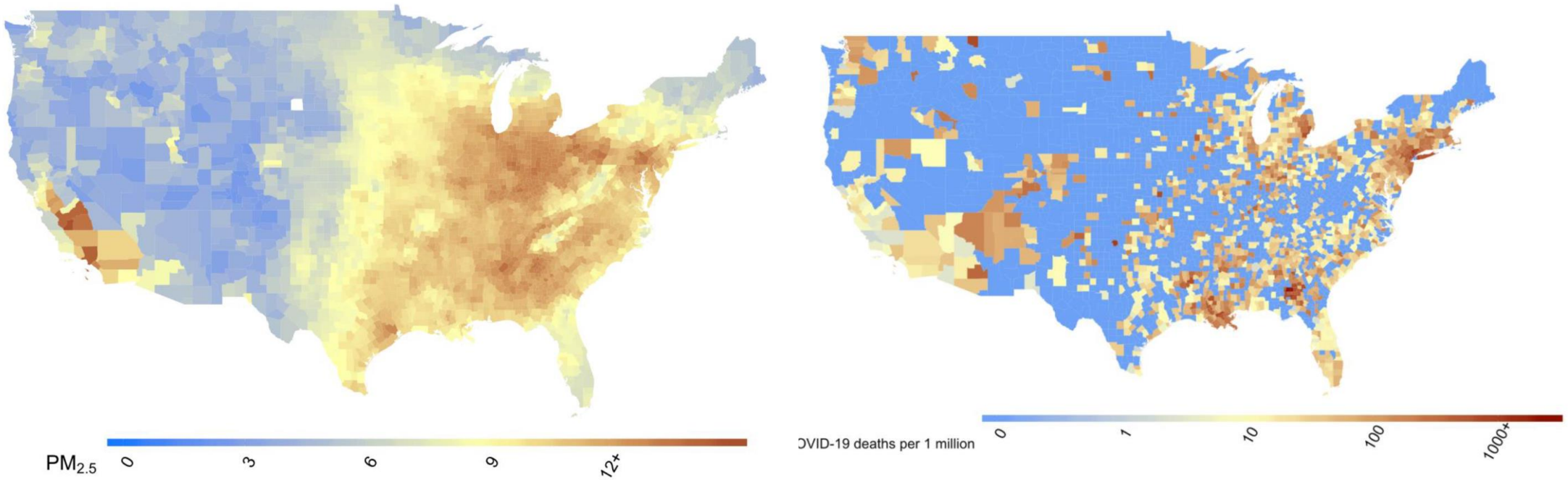
"During the pandemic stage of an emerging pathogen the climate drives only modest changes to pandemic size"

"Without effective control measures, strong outbreaks are likely in more humid climates and summer weather will not substantially limit pandemic growth"

Baker et al, *Science*, 2020

Discussion -2

Ambient PM and death risk of COVID-19 patients in the US



Wu et al, https://doi.org/10.1101/2020.04.05.20054502

Summary

Conclusion - 1

- Warmer weather might NOT reduce the transmission of COVID-19
- It might be premature to count on warmer weather to control COVID-19

Conclusion - 2

- **Adverse association between PM and COVID-19 death risk**
  - Robust relationship
  - Replicated in other parts of the world

Thanks !

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