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Centre for Environmental Health and Sustainability

Air quality and COVID-19
World Bank Webinar, 11 June 2020

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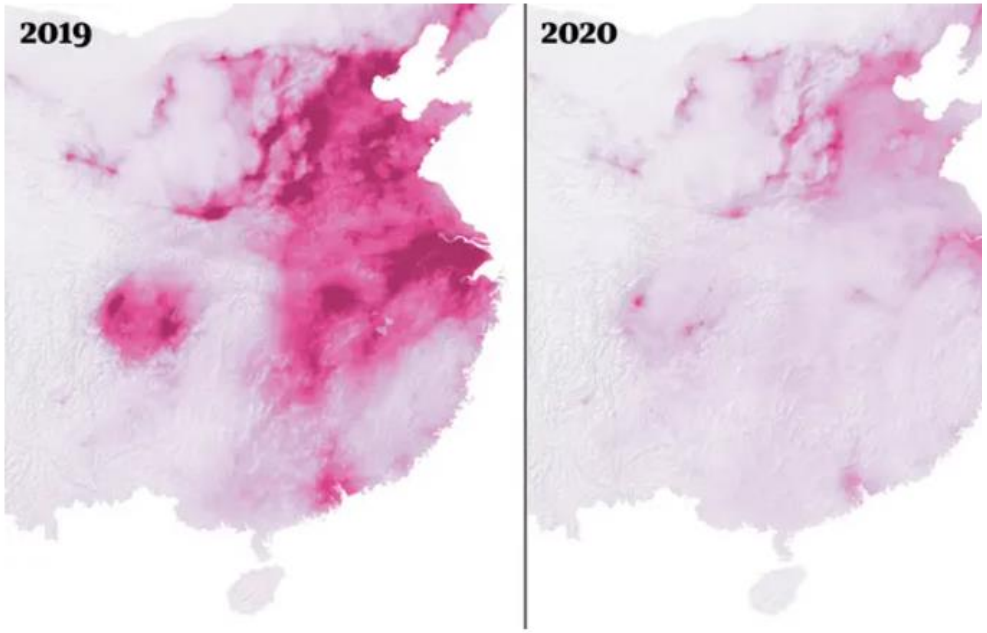
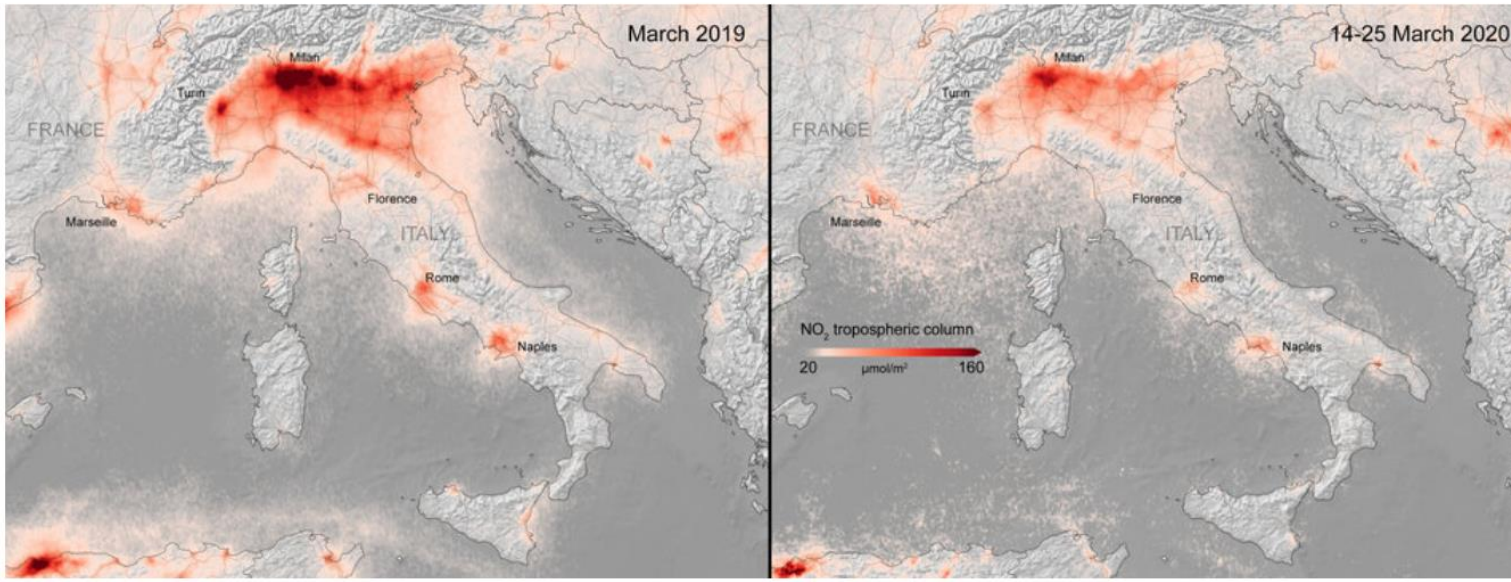
Air pollution in COVID-19 epicentres in China and Italy

- NO_2 level falls in China and Italy during lockdown



▲ Pollution levels in China in 2019, left, and 2020. Photograph: Guardian Visuals / ESA satellite data



— Nitrogen dioxide concentrations over Italy

Air pollution – Ogen, Sci Tot Env 2020 (reported 20 April)

ELSEVIER

Science of The Total Environment

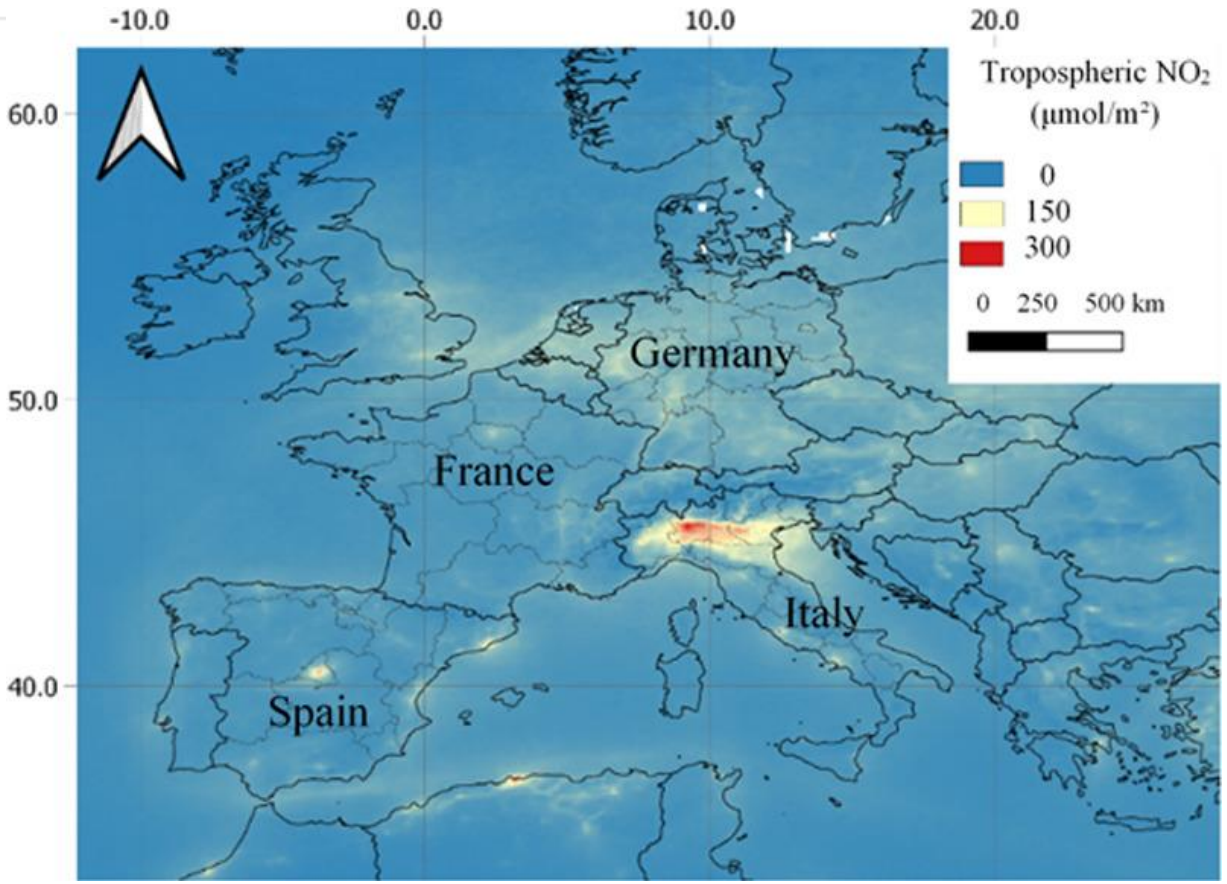
Volume 726, 15 July 2020, 138605

Short Communication

Assessing nitrogen dioxide (NO_2) levels as a contributing factor to coronavirus (COVID-19) fatality

Yaron Ogen

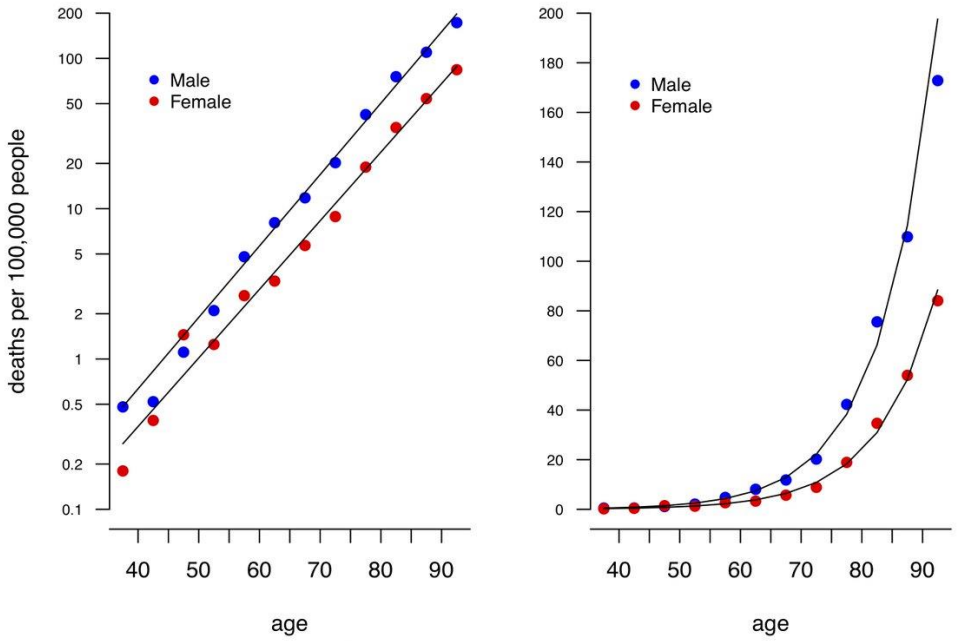
78% of COVID-19 deaths across four countries were in the most polluted regions



Epidemiology of COVID-19 mortality

COVID death rates around 11% higher for each year older, double every 7 years.
Men have double risk of women the same age.

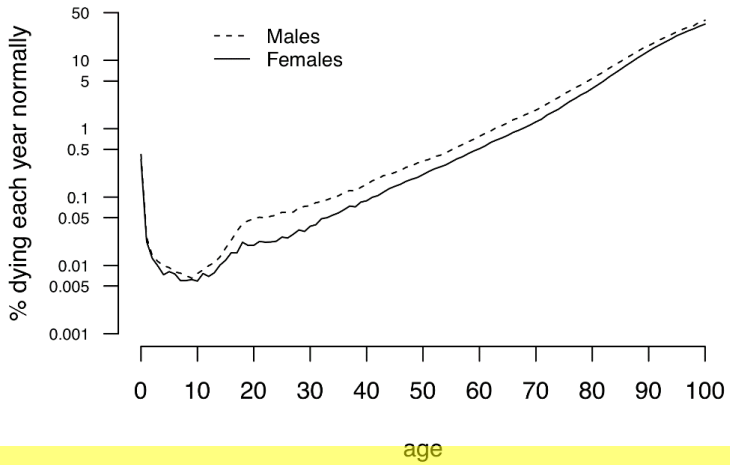
COVID population death rates – log and linear scales



Based on 3,354 COVID–19 deaths in March, registered by Apr 6 (E+W)
18 deaths under 35 not modelled
Poisson regression with over–dispersion

David Spiegelhalter, ONS England & Wales data
https://medium.com/wintoncentre/how-much-normal-risk-does-covid-represent-4539118e1196

Usual all-cause mortality rate curves



RISK FACTORS other than age and sex

- Comorbidity
  - Hypertension
  - Diabetes
  - Heart disease
  - Kidney disease
  - Chronic respiratory disease
  - Dementia
- Obesity
- Non-white ethnicity –confounded by comorbidities, deprivation, occupation, geographic location (e.g. cities)

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How might air quality impact on COVID-19?

INDIRECT

Increases risk of chronic disease. Chronic disease increases risk of severe COVID-19.

Expect risks to be similar to previous studies of air pollution & mortality

DIRECT

Increases infectivity

- Virus carriage
- General mechanisms e.g. lung inflammation
- Specific mechanisms e.g. virus receptors in the lungs, surfactant

Interaction: Expect higher **infection** risk in polluted areas

Increases risk of severe disease once infected

- General mechanisms - inflammation in lung and body systems
- Specific mechanisms e.g. via infectivity and higher infecting dose

Interaction: Expect higher case-fatality in polluted areas

Does air pollution enable carriage / persistence of SARS-CoV-2?

Air pollution

Coronavirus detected on particles of air pollution

Exclusive: Scientists examine whether this route enables infections at longer distances

- Coronavirus – latest updates
- See all our coronavirus coverage

Damian Carrington
Environment editor
@dpcarrington
Fri 24 Apr 2020
14.29 BST

18k

▲ Large virus-laden droplets from infected people's coughs and sneezes fall to the ground within 1-2 metres. Photograph: Nick Gregory/Alamy

Coronavirus has been detected on particles of air pollution by scientists investigating whether this could enable it to be carried over longer distances

Setti et al. Preprint, reported UK Guardian 24 April 2020
https://www.medrxiv.org/content/10.1101/2020.04.15.20065995v2
Presence of SARS-CoV-2 viral RNA on 8 of 34 filters for PM10 in Bergamo

Role of aerosol transmission not established in community settings

- In rooms/inside spaces
- Outside
- From toilet flushing!

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Could air pollution increase infectivity of SARS-CoV-2?

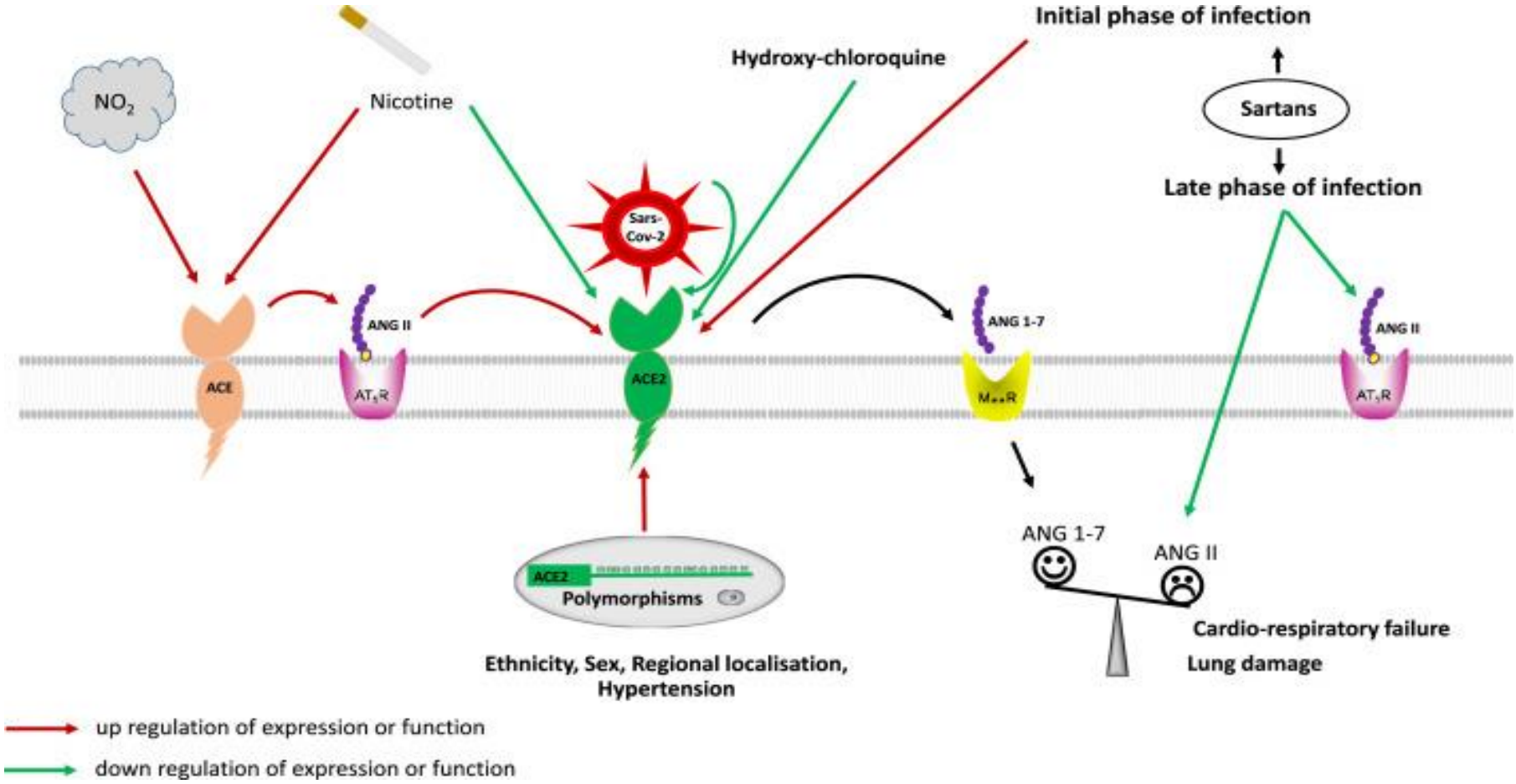

Figure from Alifano et al. Renin-angiotensin system at the heart of COVID-19 pandemic Biochimie. 2020

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Are there epidemiological studies on air quality and COVID-19?

- Where do I look?
  - PubMed
  - WHO database https://www.who.int/emergencies/diseases/novel-coronavirus-2019/global-research-on-novel-coronavirus-2019-ncov
  - ?Medrxiv
- Outcome measures are not well understood and may be subject to bias www.medrxiv.org/content/10.1101/2020.05.04.20090506v3
- Methodological challenges relating to disease propagation especially for short-term (time-series) studies, where lockdown impacts on air pollution as well as transmission

thebmj

BMJ 2020;369:m2045 doi: 10.1136/bmj.m2045 (Published 28 May 2020) Page 1 of 2

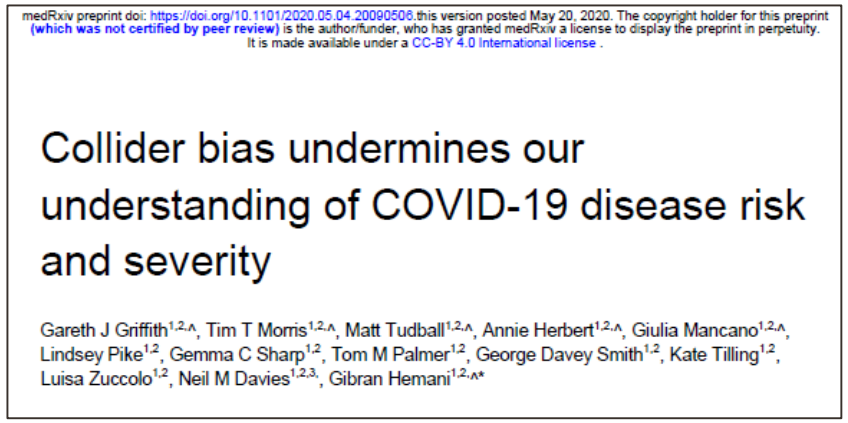
FEATURE

Research on covid-19 is suffering "imperfect incentives at every stage"

The rush to publish and report during the pandemic is compromising quality, worried experts tell **Stephen Armstrong**

Stephen Armstrong *freelance journalist*

London



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Collider bias undermines our understanding of COVID-19 disease risk and severity

Gareth J Griffith[1,2,^], Tim T Morris[1,2,^], Matt Tudball[1,2,^], Annie Herbert[1,2,^], Giulia Mancano[1,2,^], Lindsey Pike[1,2], Gemma C Sharp[1,2], Tom M Palmer[1,2], George Davey Smith[1,2], Kate Tilling[1,2], Luisa Zuccolo[1,2], Neil M Davies[1,2,3], Gibran Hemani[1,2,^*]

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Wu/Dominici 7 April 2020

Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study

Xiao Wu, Rachel C. Nethery, Benjamin M. Sabath, Danielle Braun, Francesca Dominici

doi: https://doi.org/10.1101/2020.04.05.20054502

This article is a preprint and has not been peer-reviewed [what does this mean?]. It reports new medical research that has yet to be evaluated and so should *not* be used to guide clinical practice.

Abstract | Info/History | Metrics | Preview PDF

Abstract

Objectives: United States government scientists estimate that COVID-19 may kill tens of thousands of Americans. Many of the pre-existing conditions that increase the risk of death in those with COVID-19 are the same diseases that are affected by long-term exposure to air pollution. We investigated whether long-term average exposure to fine particulate matter ($PM_{2.5}$) is associated with an increased risk of COVID-19 death in the United States. Design: A nationwide, cross-sectional study using county-level data. Data sources: COVID-19 death counts were collected for more

Liang/Chang 7 May 2020

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Comment on this paper

Urban Air Pollution May Enhance COVID-19 Case-Fatality and Mortality Rates in the United States

Donghai Liang, Liuhua Shi, Jingxuan Zhao, Pengfei Liu, Joel Schwartz, Song Gao, Jeremy A Sarnat, Yang Liu, Stefanie T Ebelt, Noah C Scovronick, Howard Chang

doi: https://doi.org/10.1101/2020.05.04.20090746

This article is a preprint and has not been peer-reviewed [what does this mean?]. It reports new medical research that has yet to be evaluated and so should *not* be used to guide clinical practice.

Abstract | Info/History | Metrics | Preview PDF

Abstract

Background: The novel human coronavirus disease 2019 (COVID-19) pandemic has claimed more than 240,000 lives worldwide, causing tremendous public health, social, and economic damages. While the risk factors of COVID-19 are still under investigation, environmental factors, such as urban air pollution, may play an important role in increasing population susceptibility to COVID-19 pathogenesis.

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Wu	Liang
Death counts from Johns Hopkins database	Deaths and cases from New York Times, USAFACTS, and 1Point3Acres.com databases
All up to April 22	Jan 22-April 29
3,087 counties (98% population)	3122 US counties
45,817 deaths	58,489 deaths and 1,027,799 cases
$PM_{2.5}$ 2000-2016	NO_2, $PM_{2.5}$, Ozone 2010-2016
Negative binomial mixed model, random intercept by state	Zero-inflated negative binomial mixed model, random intercept by state
	Adjusts for 'spatial autocorrelation'
Comprehensive confounder adjustment + quantified unmeasured confounder bias	Comprehensive confounder adjustment including 'spatial autocorrelation
6 secondary analyses, 68 sensitivity analyses	4 sets of sensitivity analyses
$PM_{2.5}$ associated with +8% (95% CI: 2% to 15%) mortality rate per 1 μg/m³ increase	$PM_{2.5}$ associated with +10.8% (95% CI: -1.1% to 24.1%) mortality rate per IQR increase (3.4 ug/m³)
-	NO_2 associated with +11.2% (95% CI 3.4% to 19.5%) mortality rate per IQR increase (4.6 ppb)
-	Ozone – no association
Coefficient is 11x higher than for all-cause mortality in a previous analysis	One IQR reduction in NO_2 would have avoided 4,181 deaths

Average PM2.5 levels were 8.4 mcg/m3 (SD 2.5)

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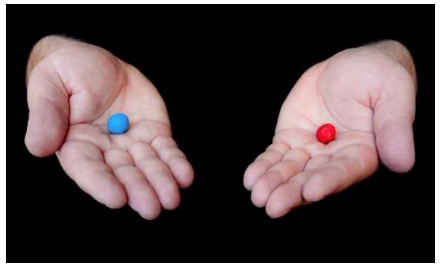
Inference from epidemiological studies

- Epidemiological studies are observational not experimental

Experimental studies can stand alone if needed e.g. RCT of a specific drug



vs.

Results from observational studies usually viewed in the light of (all) other knowledge

- Natural experiments can be very useful
- Ecological (area-level) studies (e.g. Wu, Liang) are often used in initial assessments
- Individual follow-up studies (cohort studies) provide the highest quality observational evidence but are time-consuming and can be expensive

It would be surprising NOT to see a link between air pollution and COVID-19

- Air pollution kills 4.2 million people per year (WHO)
- $PM_{2.5}$ caused an estimated 7·6% of total global mortality in 2015 (Global Burden of Disease, Cohen et al, Lancet 2017)
- 91% of the world's population live in places where air quality exceeds WHO guideline limits

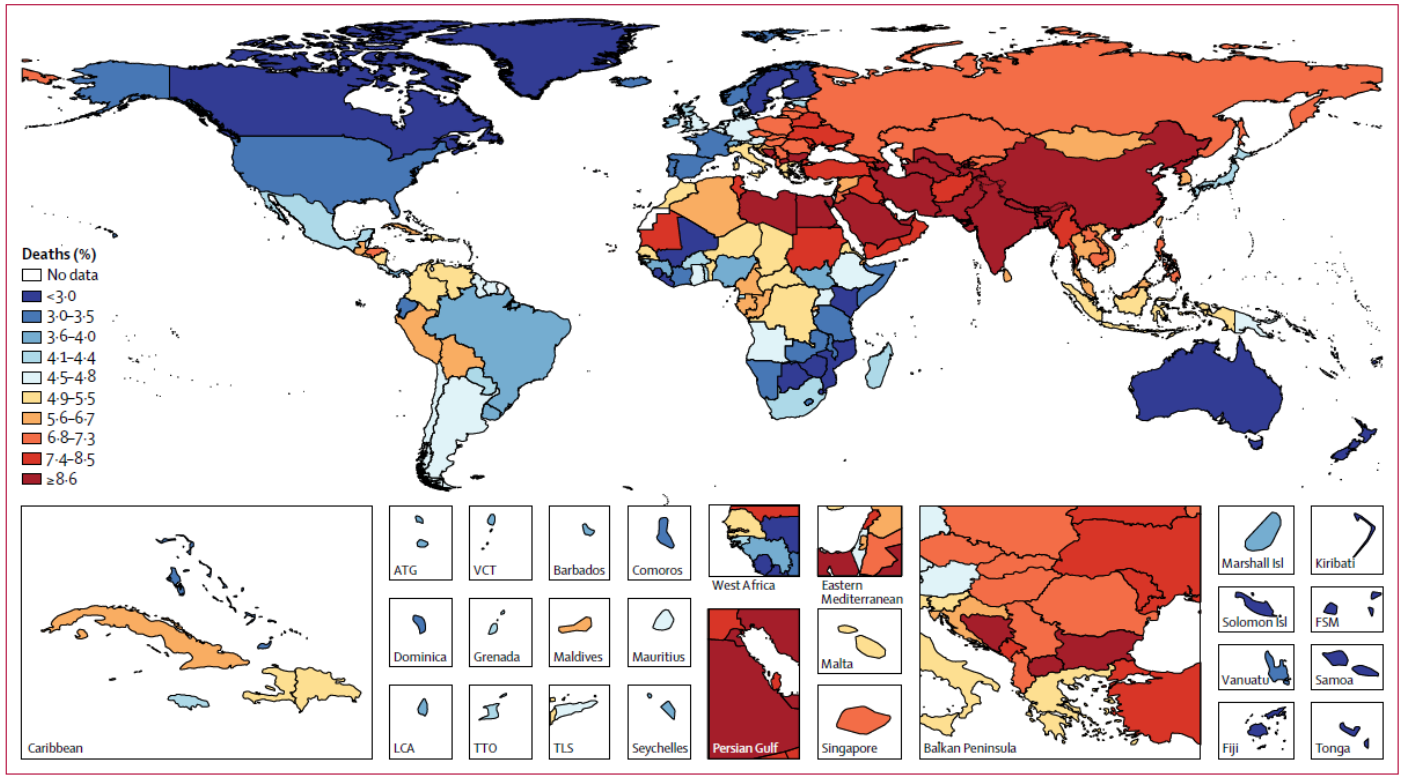
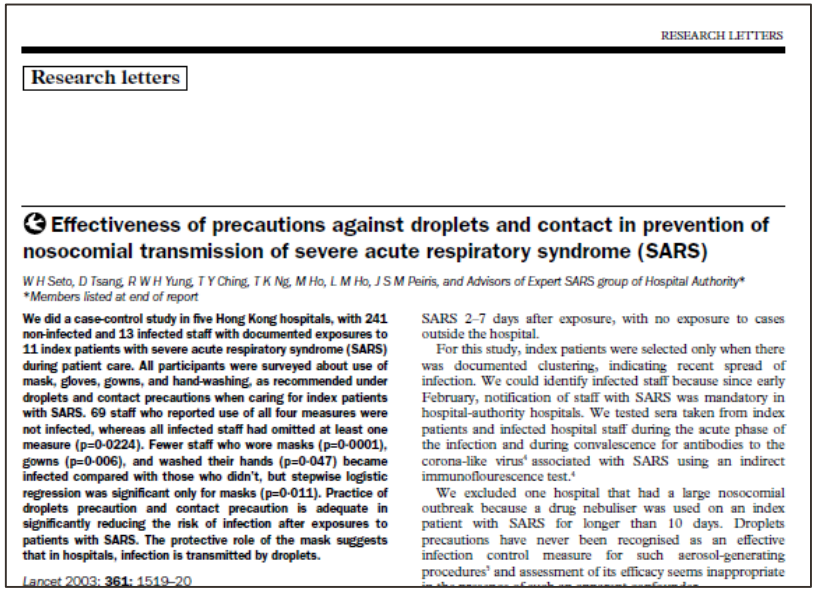


Figure 5: Deaths attributable to ambient particulate matter pollution in 2015
ATG=Antigua and Barbuda. FSM=Federated States of Micronesia. Isl=Island. LCA=Saint Lucia. TLS=Timor-Leste. TTO=Trinidad and Tobago. VCT=Saint Vincent and the Grenadines.

What can we learn from SARS?

- Standard public health infection control measures controlled the disease (before genotyping/vaccine)
- A high profile case-control Lancet study early on (Seto et al, 2003) established importance of PPE to prevent healthcare worker infection – but masks most important!
- Clusters but also some super-spreaders
- A vaccine for SARS was not developed
  - Some reports suggest vaccine candidates made the disease worse
- One study on SARS case-fatality and air pollution:
  - Cui et al, Env Health 2003.
  - Hospital in-patient data: 349 deaths, 5327 cases
  - No control for confounders so not very informative
  - SARS patients from regions with high APIs were twice as likely to die from SARS compared to those from regions with low APIs. (RR = 2.18, 95% CI: 1.31–3.65)



RESEARCH LETTERS

Research letters

Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS)

*W H Seto, D Tsang, R W H Yung, T Y Ching, T K Ng, M Ho, L M Ho, J S M Peiris, and Advisors of Expert SARS group of Hospital Authority**
**Members listed at end of report*

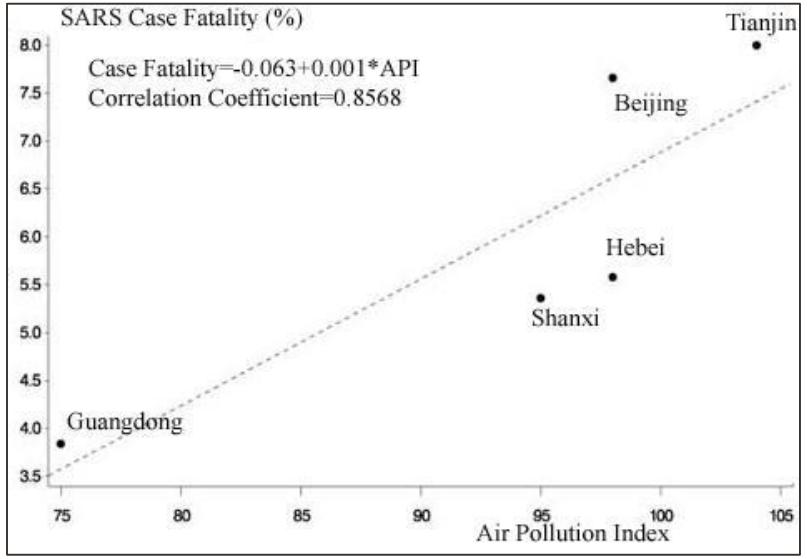
We did a case-control study in five Hong Kong hospitals, with 241 non-infected and 13 infected staff with documented exposures to 11 index patients with severe acute respiratory syndrome (SARS) during patient care. All participants were surveyed about use of mask, gloves, gowns, and hand-washing, as recommended under droplets and contact precautions when caring for index patients with SARS. 69 staff who reported use of all four measures were not infected, whereas all infected staff had omitted at least one measure (p=0·0224). Fewer staff who wore masks (p=0·0001), gowns (p=0·006), and washed their hands (p=0·047) became infected compared with those who didn't, but stepwise logistic regression was significant only for masks (p=0·011). Practice of droplets precaution and contact precaution is adequate in significantly reducing the risk of infection after exposures to patients with SARS. The protective role of the mask suggests that in hospitals, infection is transmitted by droplets.

Lancet 2003; **361:** 1519–20

SARS 2–7 days after exposure, with no exposure to cases outside the hospital.

For this study, index patients were selected only when there was documented clustering, indicating recent spread of infection. We could identify infected staff because since early February, notification of staff with SARS was mandatory in hospital-authority hospitals. We tested sera taken from index patients and infected hospital staff during the acute phase of the infection and during convalescence for antibodies to the corona-like virus[4] associated with SARS using an indirect immunofluorescence test.[4]

We excluded one hospital that had a large nosocomial outbreak because a drug nebuliser was used on an index patient with SARS for longer than 10 days. Droplets precautions have never been recognised as an effective infection control measure for such aerosol-generating procedures[5] and assessment of its efficacy seems inappropriate



[For Influenza pandemics see CDC website https://www.cdc.gov/flu/pandemic-resources/2009-h1n1-pandemic.html]

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COVID-19 in LMICs – some good news, some bad news

Countries with an established strong public health workforce have been able to control outbreaks (e.g. Thailand with local community health workers in every village)

Public health measures are low tech: Restriction of contacts, limit/organise movements outside the house and WASH (water sanitation hygiene) or using alternative to water to clean hands

Sharing guidance & hotlines e.g. WHO guidance on keeping mildly ill patients out of hospital

Limited testing, PPE etc. – logistics (lockdown), test charges

Migrant workers - contact tracing, disease spread

Stigma for diagnosed cases - education

Fake news - risk communication & education

Conclusions

1. Air pollution is associated with all-cause mortality and many specific causes of death including pneumonia and cardiovascular disease – it is unlikely there is no association with COVID-19
2. Two good quality area-level studies in the US suggest associations of COVID-19 with traffic related air pollution, but further studies are needed including mechanistic studies
3. Evidence to date does not warrant specific public health measures against COVID-19 in high air pollution areas that are different from low pollution areas
4. Epidemiological data to date have many gaps – understanding asymptomatic disease, risk factors for disease progression, data from developing countries, key components of PPE, aerosol disease transmission etc..
5. Well-functioning public health systems can achieve low disease transmission including in LMICs
6. *Lockdowns break transmission but may increase mortality from impacts on healthcare & economy and/or decrease it through improvements in air quality, road traffic accidents etc.*

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Thank you!