Ambient air pollution and the COVID-19 pandemic – any link?

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Dean Swiss School of Public Health (SSPH+)

Chair Swiss Federal Commission on Air Hyigene (FCAH)

Thu 16.9.2021 – 17:00-18:00 CEST

Webinar jointly organised by ERS and the International Society for Aerosols in Medicine (ISAM)

Annual mean particulate matter concentration (PM10 in µg/m^3)

- Wuhan: ~ 100+
- Lombardia: ~ 40-50

- WHO Air Quality Guideline Value: 20

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössische Kommission für Lufthygiene EKL
Commission fédérale de l'hygiène de l'air CFHA
Commissione federale per l'igiene dell'aria CFIA
Cumissiun federala per l'igiena da l'aria CFIA

Air pollution and the COVID-19 epidemic

Six aspects discussed by the Federal Commission for Air Hygiene

Luftverschmutzung und COVID-19 Epidemie

Sechs Aspekte erläutert von der
Eidgenössischen Kommission für Lufthygiene

Pollution de l'air et épidémie de COVID-19

Six éléments expliqués par la Commission fédérale de l'hygiène de l'air

Inquinamento atmosferico ed epidemia di COVID-19

Sei aspetti spiegati dalla Commissione federale d'igiene dell'aria

www.ekl.admin.ch

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European Parliament

Air pollution and COVID-19

Including elements of air pollution in rural areas, indoor air pollution, vulnerability and resilience aspects of our society against respiratory disease, social inequality stemming from air pollution

EN

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Possible roles of ambient air pollution - 6 aspects

1. Transmission

2. Defence of the exposed

3. Resilience of population

4. COVID patient care

5. Recovery after COVID
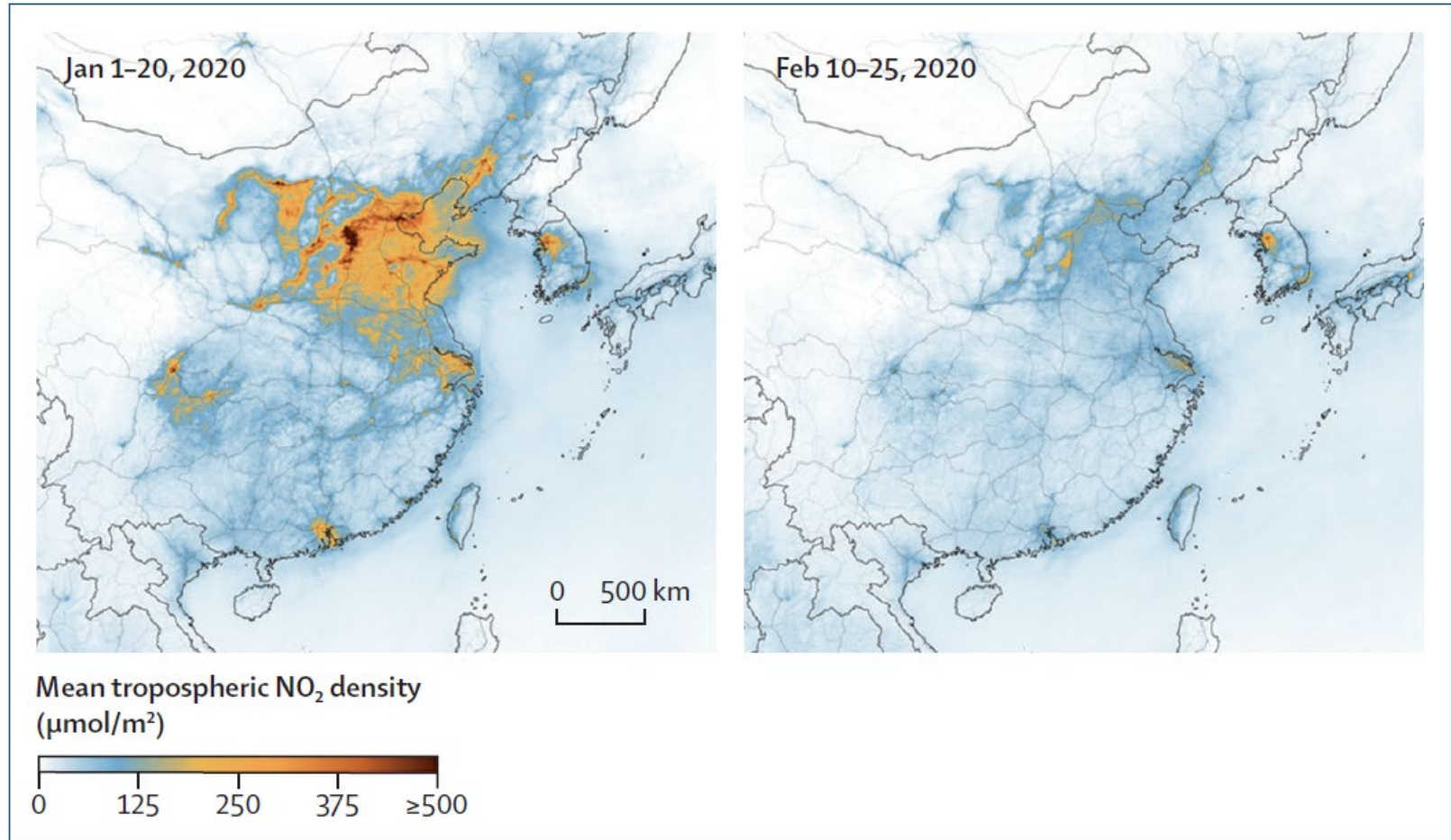
STAY HOME SAVE LIVES

6. Lockdown

Figure: Airborne nitrogen dioxide pollution, China, Jan 1 to Feb 28, 2020
Images are from NASA Earth Observatory images by Joshua Stevens, using modified Copernicus Sentinel 5P data processed by the European Space Agency. NO2=nitrogen dioxide.

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Reduction of primary traffic-related pollutants (nitrogenoxides – NOx) due to the lockdown (at a traffic-related monitoring station in Bern, Switzerland
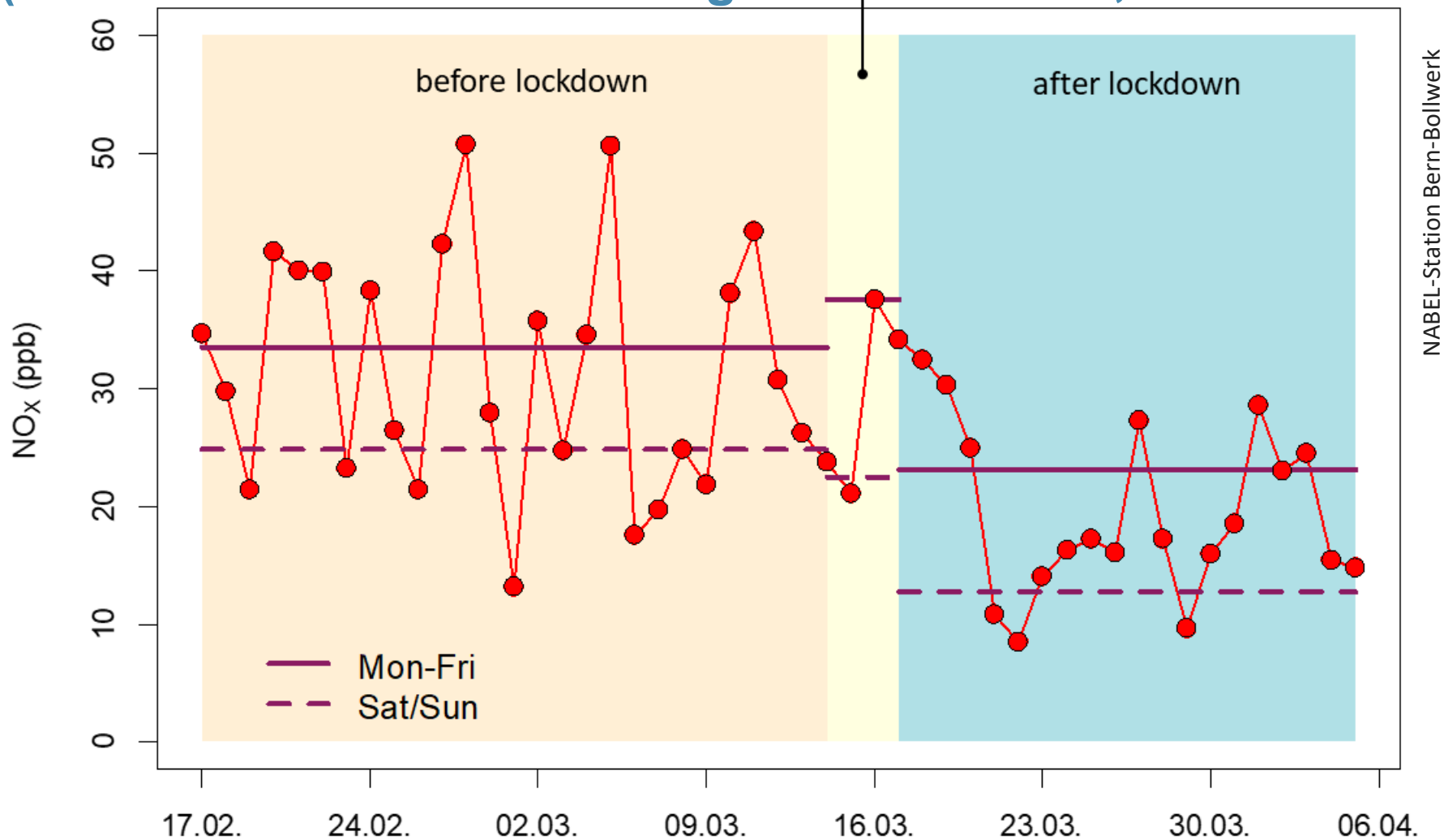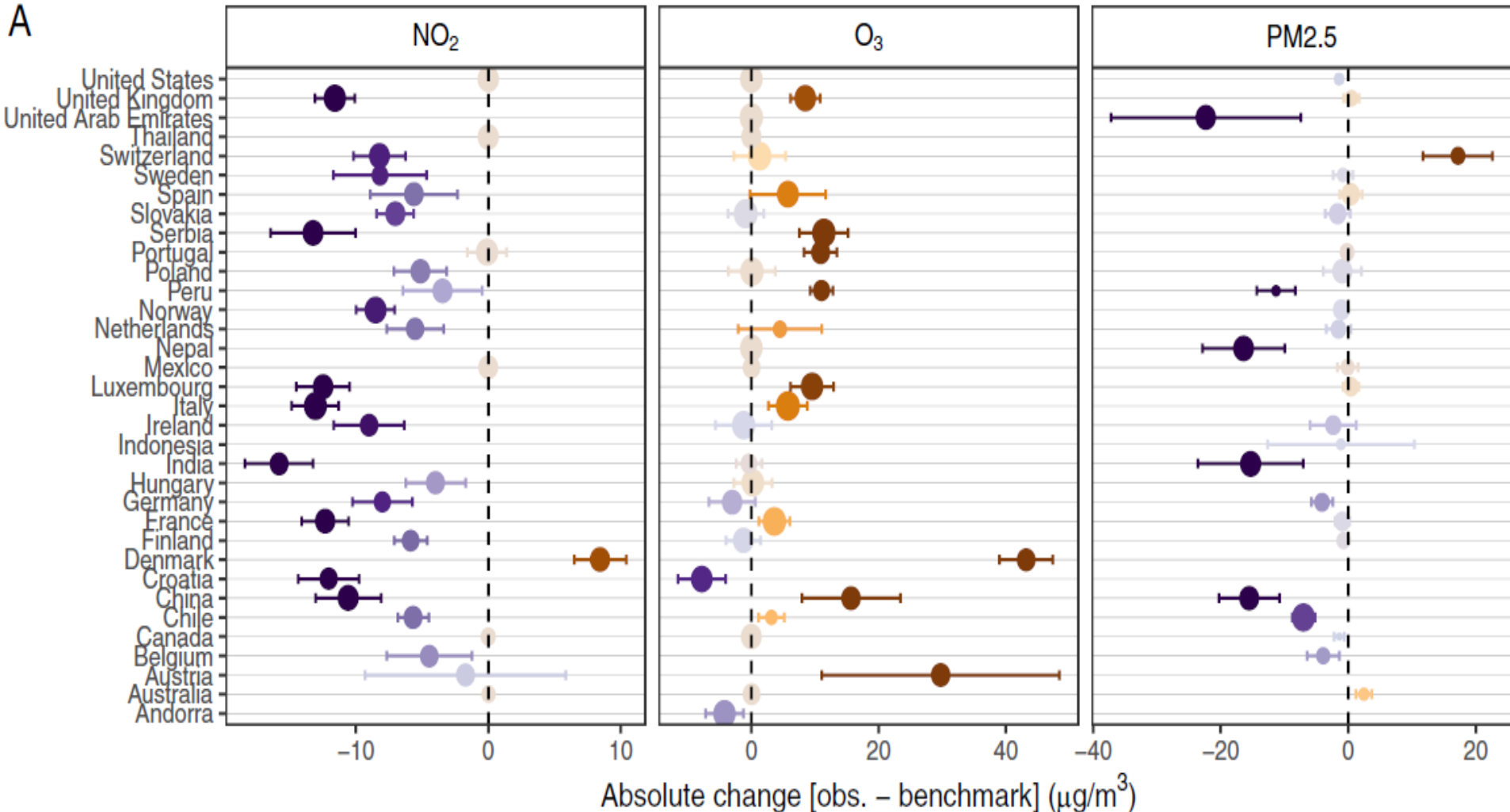
Lockdown cause air pollution declines
(adjusted for weather conditions)   (Venter at al, PNAS 2020; 34 countries)

- 60% reduction of population-weighted average of NO2 (heavy-duty vehicles!)
- 31% reduction of fine particuate matter (PM2.5) - but more heterogeneous

Air Quality Changed Disproportionally Across World Urban Agglomerations, Countries, and Regions due to COVID-19 Containment Response Policies
(under review – do not cite nor quote)
(Zhang *et al* & Heresh Amini)

DATA

- Jan 2019- July 2020
- 1'267 ground monitoring stations at 496 urban agglomerations
- Eight daily national COVID-19 containment response policies → mild, moderate or stringent "lockdowns"
- Adjusted for meteo and time trends

RESULTS for NO2 changes:

- Strongest air quality improvements in more polluted and populated areas
- Mild CRP: no change
- Moderate CRP: -26% (19-34%)
- Stringent CRP: -32% (25-39%)

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Possible roles of ambient air pollution - 6 aspects
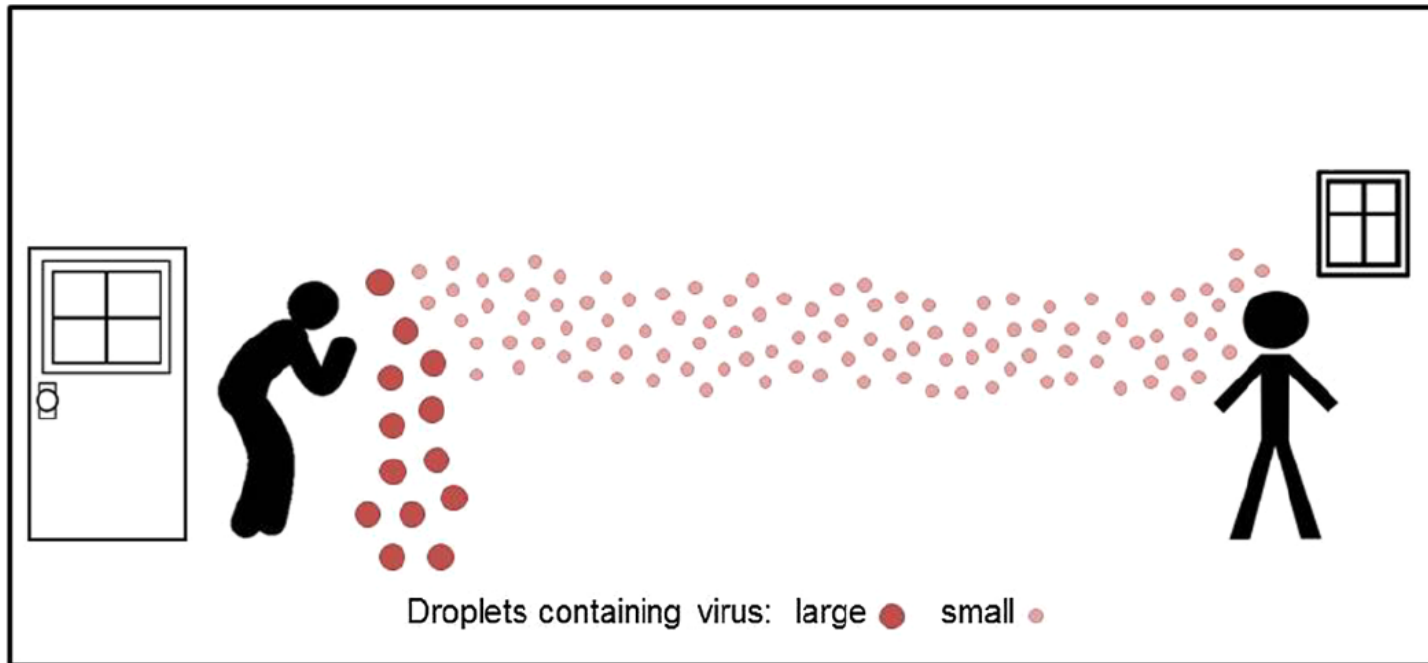
1. Transmission

Airborne transmission of SARS-CoV-2: The world should face the reality

Lidia Morawska[a,*], Junji Cao[b]

[a] International Laboratory for Air Quality and Health (ILAQH), School of Earth of Atmospheric Sciences, Queensland University of Technology, Brisbane, Queensland 4001, Australia
[b] Key Lab of Aero

Droplets containing virus: large ● small ·

https://worldhealthorg-my.sharepoint.com/personal/forastieref_who_int/Documents/Attachments/Lidia%20Morawska.mp4

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"Particulate Matter" (PM) defined by size (diameter, in micrometers) Nel et al, Science, 2005; 307:1858
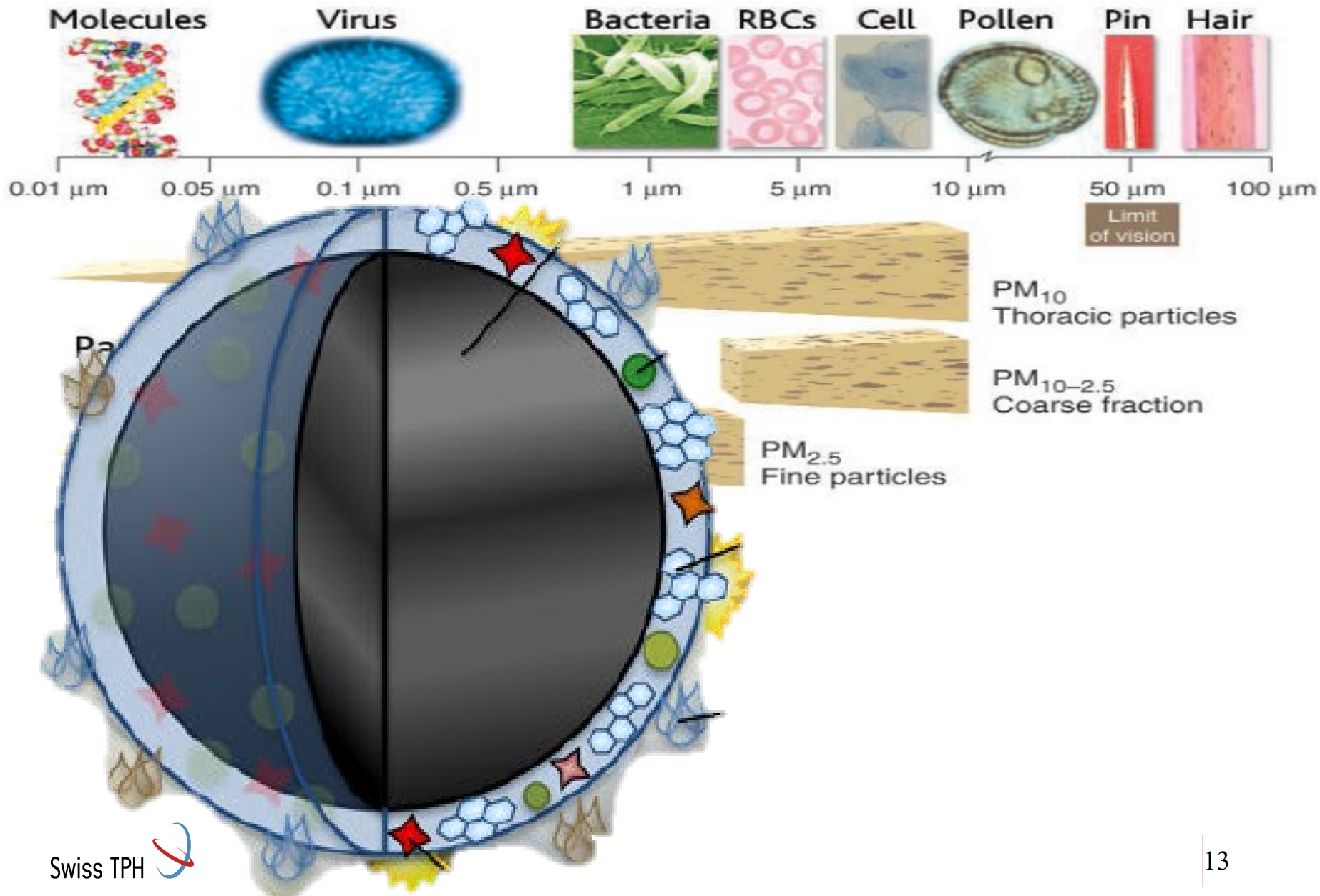
SARS-Cov-2 RNA identified on ambient particulate matter

Setti et al, Int J Environ Res Pub Health 2020 & Setti et al, Env Res 2020

International Journal of
**Environmental Research
and Public Health**

Editorial

Searching for SARS-COV-2 on Pa
A Possible Early Indicator of CO
Epidemic Recurrence

Epidemic relevance of the findings is unknown

- **for transmission?**
- **for infections?**
- **as a marker of recurrence of epidemic?**

Leonardo Setti [1], Fabrizio Passarini [2], Gianluigi De Gennaro [3], Pierluigi Barbieri [4],
Alberto Pallavicini [5], Maurizio Ruscio [6], Prisco Piscitelli [7,8], Annamaria Colao [8]
and Alessandro Miani [7,8]

Environmental Research 188 (2020) 109754

Contents lists available at ScienceDirect

Environmental Research

ELSEVIER

journal homepage: www.elsevier.com/locate/envres

SARS-Cov-2 RNA found on particulate matter of Bergamo in Northern Italy: First evidence

Check for updates

Leonardo Setti [a,*], Fabrizio Passarini [b], Gianluigi De Gennaro [c], Pierluigi Barbieri [d],
Maria Grazia Perrone [e], Massimo Borelli [f], Jolanda Palmisani [c], Alessia Di Gilio [c], Valentina Torboli [f],
Francesco Fontana [g], Liber..... Alberto Pallavicini [f], Maurizio Ruscio [g], Prisco Piscitelli [h]
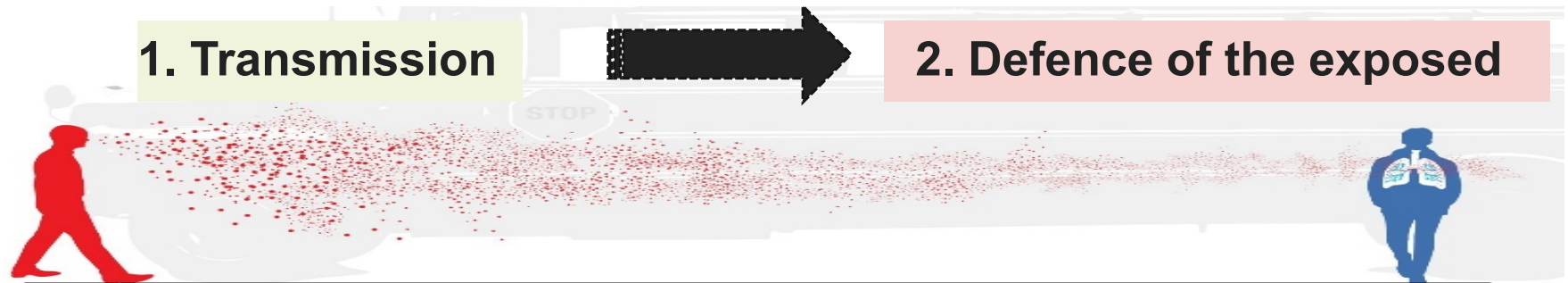Alessandro Miani [h,i]

Journal Pre-proof

Potential link between compromised air quality and transmission of the novel corona virus (SARS-CoV-2) in affected areas

M.G. Manoj, M.K. Satheesh Kumar, K.T. Valsaraj, C. Sivan, Soumya K. Vijayan
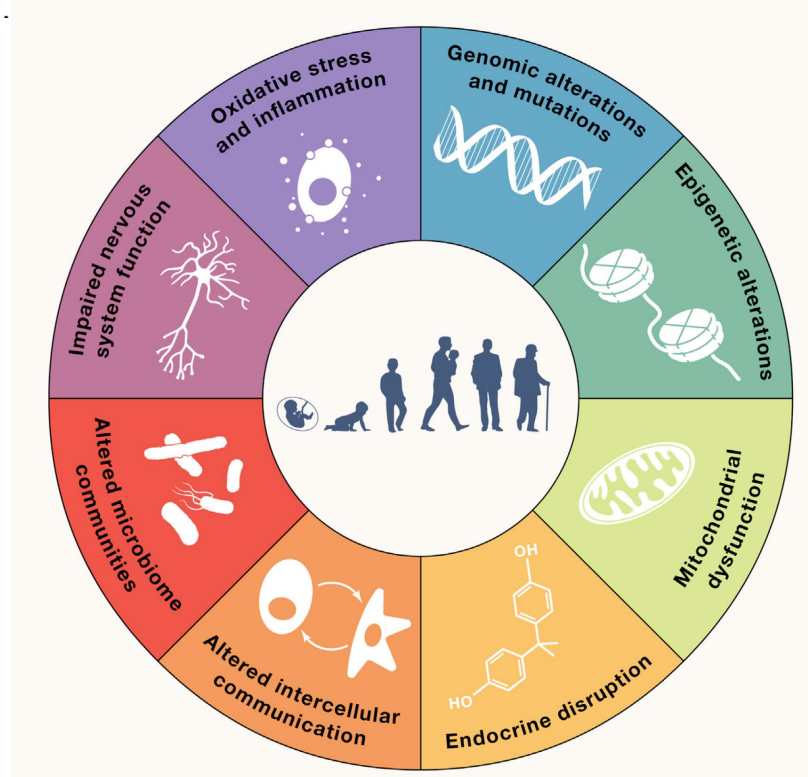
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Possible roles of ambient air pollution - 6 aspects

1. Transmission

2. Defence of the exposed

Review
Hallmarks of environmental insults

Annette Peters,[1,2,3,*] Tim S. Nawrot,[4,5] and Andrea A. Baccarelli[6]

Summary of air pollution health effects

Acute

- ❑ **Respiratory problems, cough, dyspnoea**
- ❑ **Asthma attacks**
- ❑ **Myocardial infarction,**
- ❑ **Stroke**
- ❑ **Hospital admissions**
- ❑ **Doctoral visits**
- ❑ **Death**
- ❑ **…**

A lot of poor science got high media attention..

«Ecologic correlation» does not imply «causation»

Nobel Laureates per 10 Million population vs. Chocolate consumption (kg/yr/capita)

r=0.791
P<0.0001

Messerli NEJM 2012
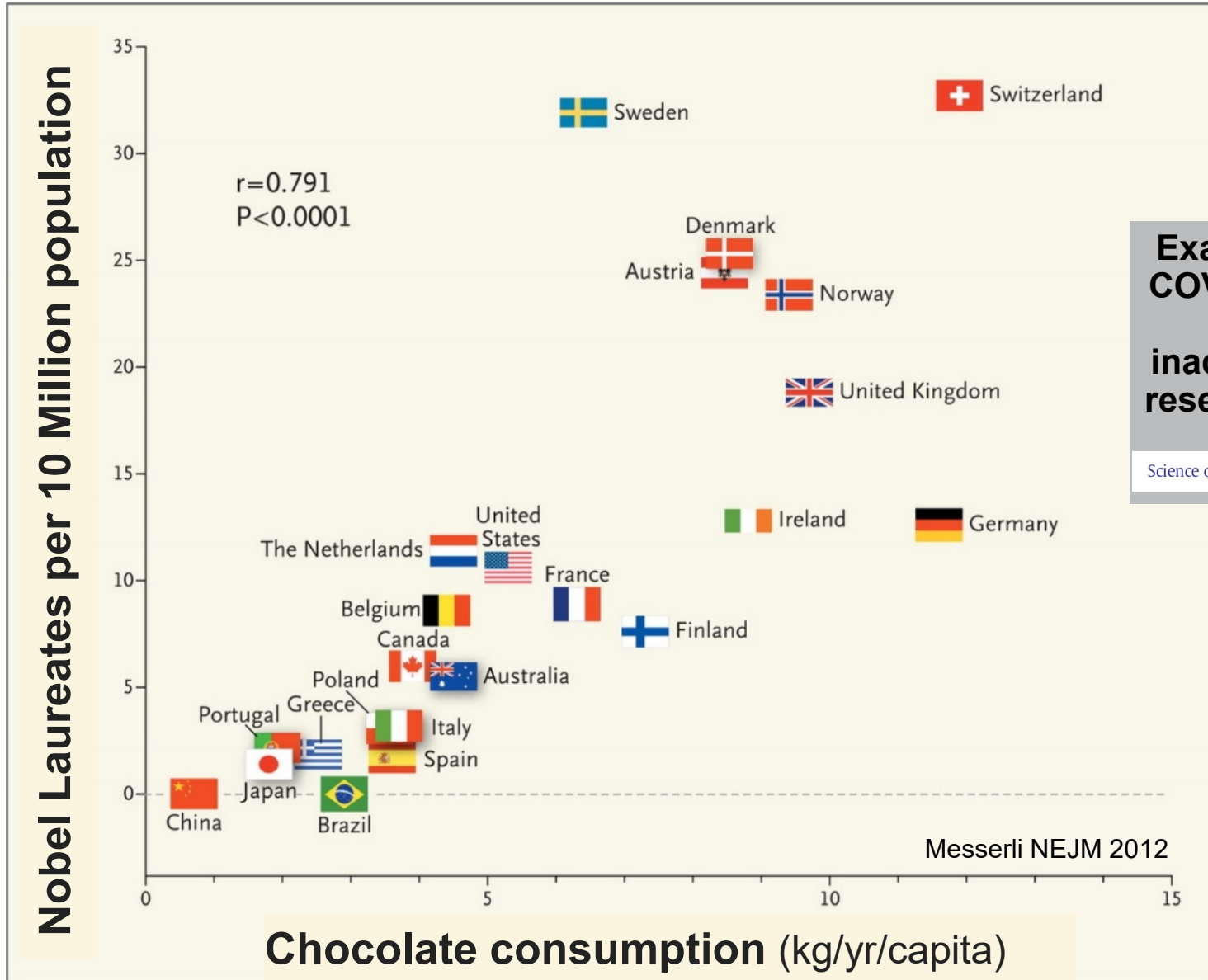
Examples of flawed COVID / air pollution studies with inadequate ecologic research design: see letter by Ricco
Science of the Total Environment 734 (2020) 139489

Air pollution interacts with tuberculosis infection

AJRCCM online Sept 21

Indoor Air Pollution and Susceptibility to Tuberculosis Infection in Urban Vietnamese Children

Robert J. Blount MD, MAS[1], Ha Phan PhD[2,3], Trang Trinh BS[2,3], Hai Dang BS[2,3], Cindy Merrifield RN, BSN[2,4,5], Michael Zavala BS[1], Joseph Zabner MD, PhD[1], Alejandro P. Comellas MD[1], Emma M. Stapleton PhD[1], Mark R. Segal PhD[6], John Balmes MD[4,7], Nguyen Viet Nhung MD, PhD[2,8], Payam Nahid MD, MPH[2,4,5]

- 109 household contacts of 72 cohort patients with active tuberculosis
- OUTCOME: Cross-sectional correlates of asymptomatic (latent) Tbc of those contacts
- Potential determinants studied: range of personal factors, personally monitored PM2.5 and personal sources of environmental exposure (passice smoking, indoor cooking etc.)

RESULTS:

- 53% with latent Tbc
- Significant correlates:
  - Number of smokers in households,
  - living on 1st floor,
  - 3-7 motorcycles parked inside house;
- Personal PM2.5: no clear association

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Hospitalization due to culture-negative pneumonia increases by 1-3% (lag days 0-6) per 7 ug/m³ increase in the daily mean PM₂.₅ concentration
(500'000 adults, New York; Croft et al, 2019)

- Lag day

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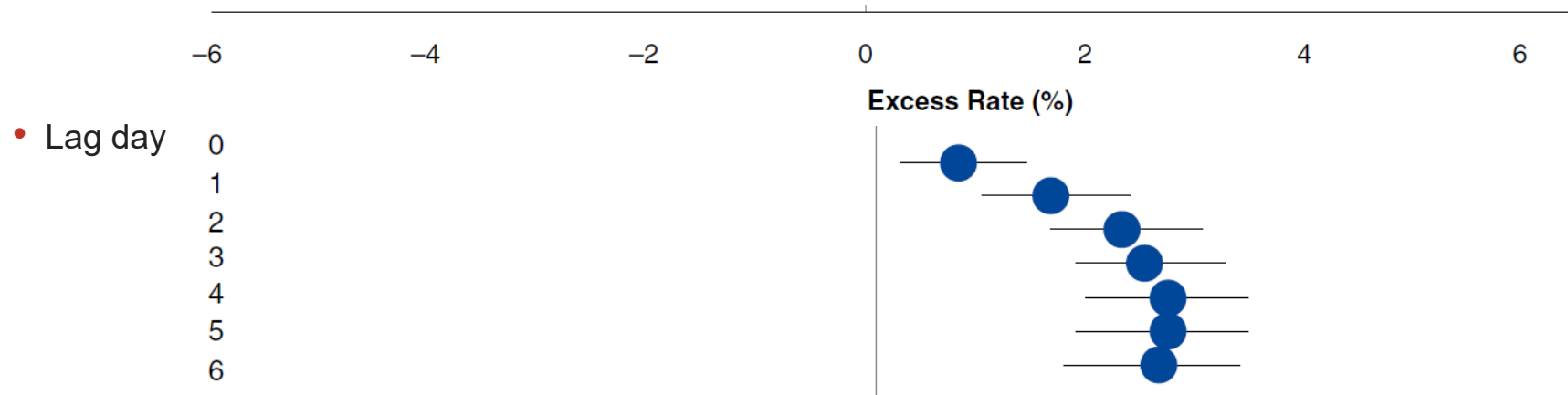
Established acute health effects of ambient air pollution:
number of cases are higher if air pollution increases, thus pressure on health care system further increased…

Severity

RESPIRATORY
Asthma attacks
COPD exacerbations
Pneumonia
Bronchitis
Cough

CARDIOVASCULAR
Myocardial infarction
Coronary syndrom
Stroke
Arrythmia
Blood clotting

Death

Hospitalization

Emergency room

Doctor's visit

Reduced activity

Medication

Symptoms

Changes in physiologic measures

Numbers affected

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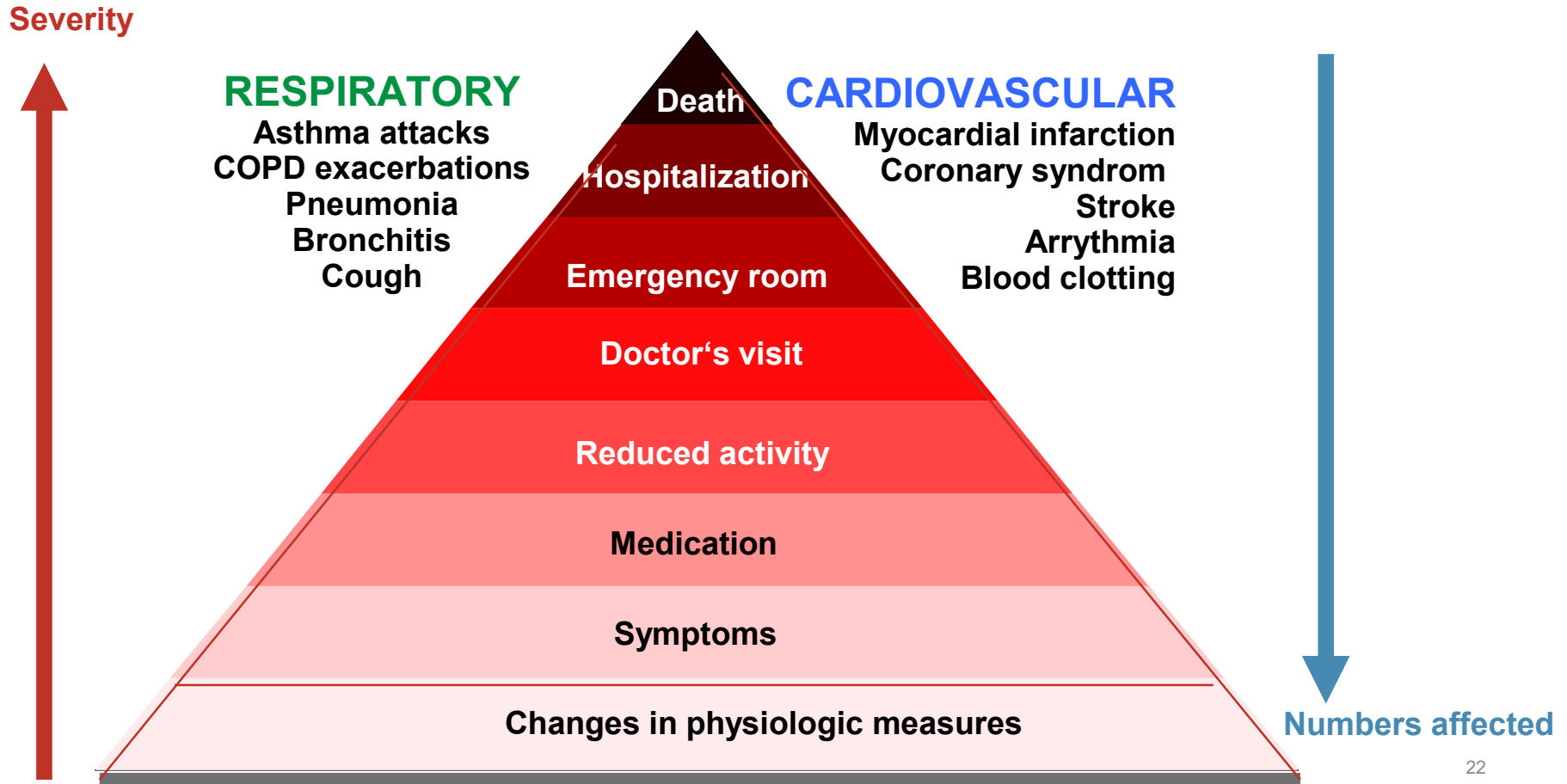
Pre-lockdown exponential growth of COVID-19: number of days to double # of cases (until March 15th, 2020)

Italy — 4 days

Iran — doubled in 7 days

South Korea — doubled in 14 days

Spain — doubled in 3 days

France — doubled in 4 days

Germany — doubled in 3 days

United States — doubled in 4 days

Switzerland — doubled in 3 days

Total Coronavirus Cases in the United States

Total Cases
(Linear Scale)

linear   logarithmic
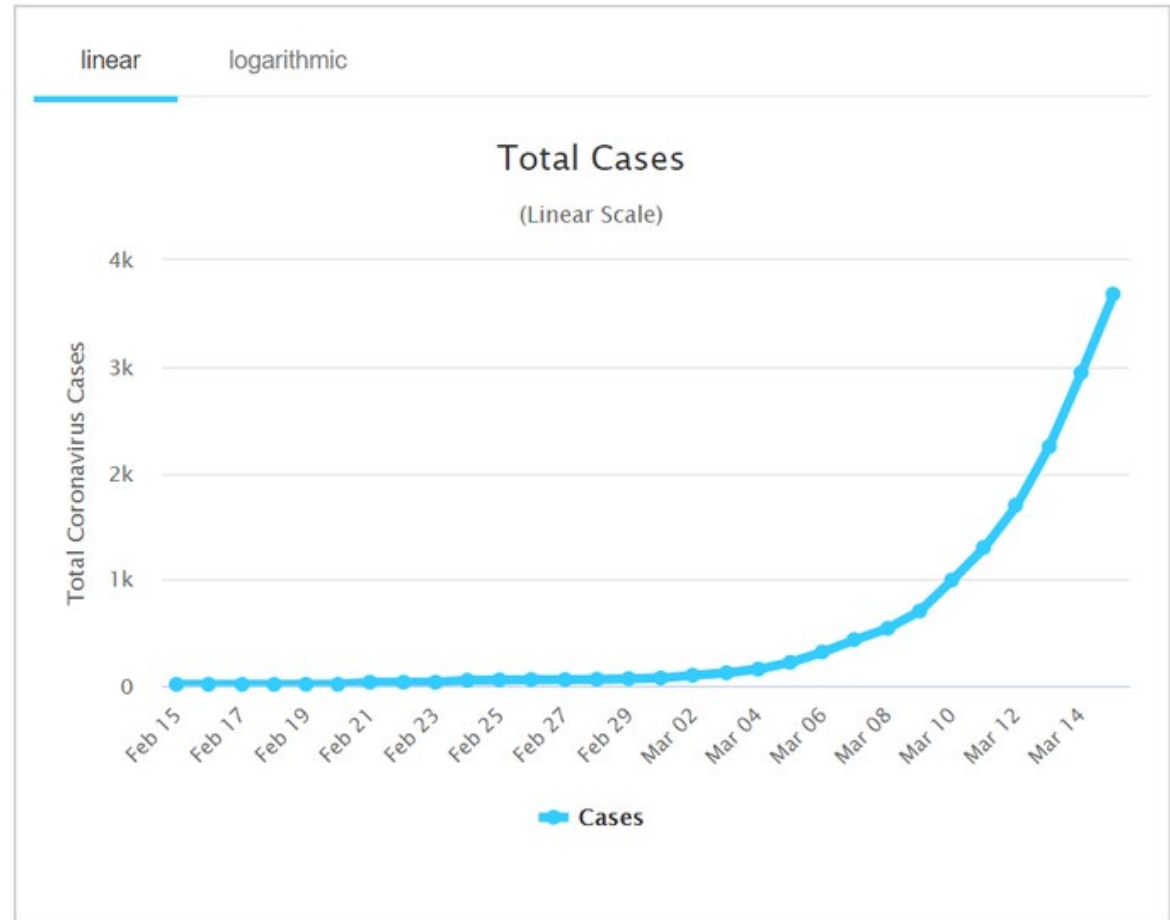
25-50% increase PER DAY

Possible roles of ambient air pollution - 6 aspects

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- ☐ **Death**
- ☐ **…**

Long-term effects

- ☐ **Chronic lung diseases**
- ☐ **Poor lung function**
- ☐ **Atherosclerosis**
- ☐ **Lung cancer**
- ☐ **Shorter life expectancy**
- ☐ **Diabetes**
- ☐ **Likely:**
  - ☐ **reduced cognitive function;**
  - ☐ **Low birth weight**
  - ☐ **Etc....**

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Percentage of four causes of death attributable to ambient air pollution

Global Burden of Disease– accessed 14.9.2021 - http://ihmeuw.org/5kf9

- COPD (Chronic Obstructive Lung Diseases) — 40%
- Heart Diseases — 20%
- Lung Cancer — 19%
- Diabetes — 19%

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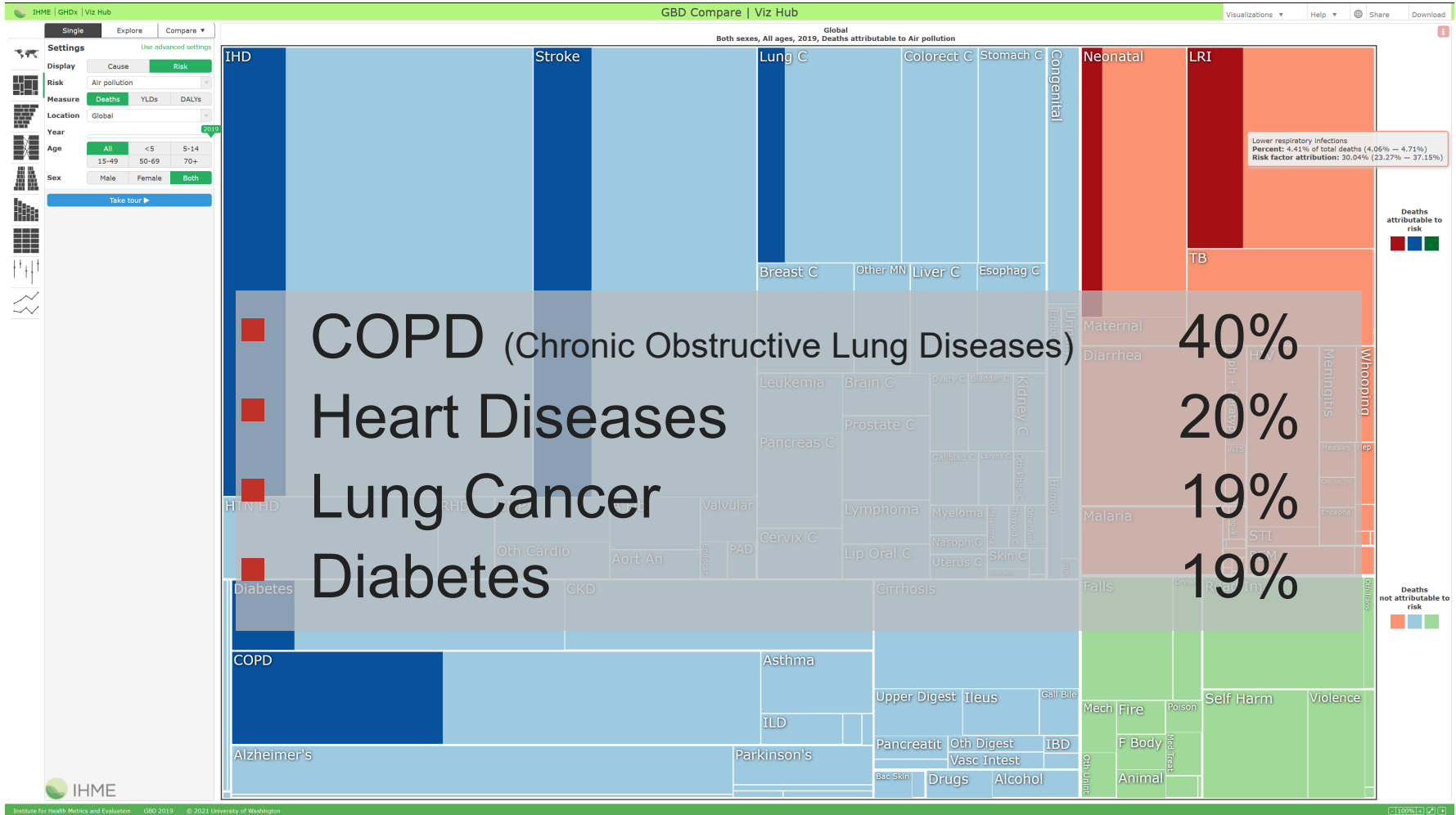
Very high uncertainty about the quantitative contribution of air pollution to severe COVID-19 cases (death)

Estimated % change in COVID-19-Case Fatality Rate
per 10µg/m3 PM10 (China; Yao et al 2020)

~0.2 %

Estimated % change in COVID-19-death
per 10µg/m3 PM10 (Wu, USA))

Updated April 5, 2020

~150%

Exposure to air pollution and COVID-19 mortality in the United States

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

All authors are part of the Department of Biostatistics, Harvard T.H. Chan School of Public Heath, Boston, MA, 02115, USA

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Scoping review posted on 20.8.2020 on pre-print server Bashkar et al confirms large inconsistencies across studies – inadequate study designs.
Bhaskar et al medRxlv

- 28 publications identified
- 16 «short-term» effect studies
- 12 «long-term» studies
- 27 with «ecologic study design»
- Large quantitative discrepancies in the observed associations

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Pai Zheng [a, 1], Zhangjian Chen [a, 1], Yonghong Liu [b, 1], Hongbin Song [c, 1], Chieh-Hsi Wu [d, 1], Bingying Li [b], Moritz U.G. Kraemer [e, f, g], Huaiyu Tian [b], Xing Yan [b], Yuxin Zheng [h], Nils Chr. Stenseth [i], Guang Jia [a, *]
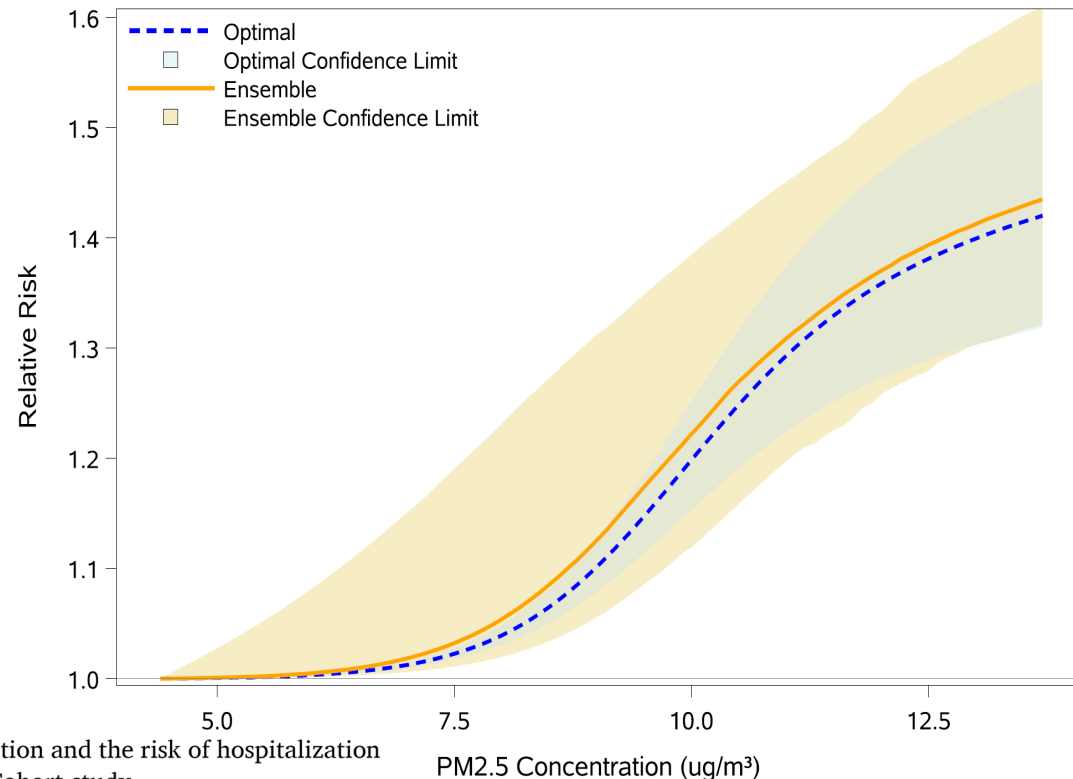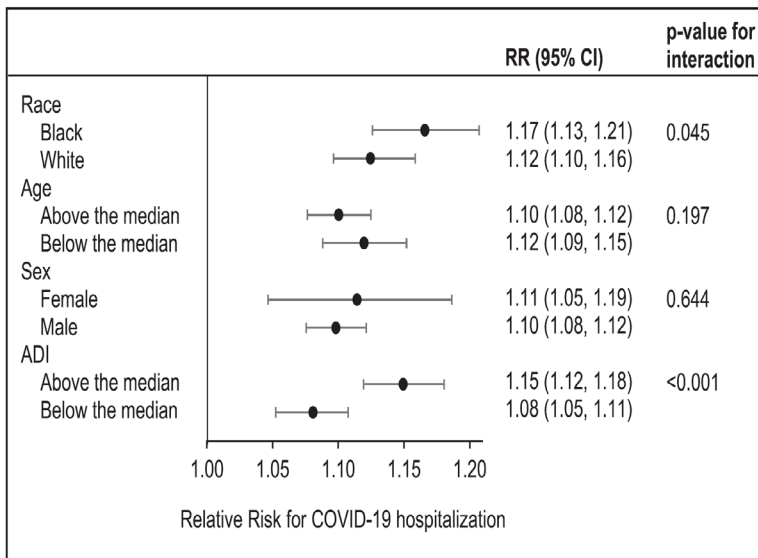
Env Internat, 2021

- 324 cities in China
- First wave only
- Long-term home outdoor NO2, PM2.5, PM10 models
- Adjustment for ecologic co-variates including lockdown measures (mobility data)

- Severe diseases increased 38%, 32% and 14% per 10ug/m3 NO2, PM2.5 and PM10

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Association between 2018 home outdoor mean PM2.5 and COVID-19 hospitalization rates among 169'102 veterans with a positive SARS-COV2-test
Bowe et al, Env Internat 2021

Hospitalizations (N=25'000) defined as those within 3 weeks around the positive test

- Hospitalization risk increased by ~10% per 1.9ug/m3 long-term mean PM2.5
- Strongest in black and areas with high deprivation (ADI)

	RR (95% CI)	p-value for interaction
Race		
Black	1.17 (1.13, 1.21)	0.045
White	1.12 (1.10, 1.16)	
Age		
Above the median	1.10 (1.08, 1.12)	0.197
Below the median	1.12 (1.09, 1.15)	
Sex		
Female	1.11 (1.05, 1.19)	0.644
Male	1.10 (1.08, 1.12)	
ADI		
Above the median	1.15 (1.12, 1.18)	<0.001
Below the median	1.08 (1.05, 1.11)	

Relative Risk for COVID-19 hospitalization

Ambient fine particulate matter air pollution and the risk of hospitalization among COVID-19 positive individuals: Cohort study

Benjamin Bowe [a,b,c], Yan Xie [a,b,c], Andrew K. Gibson [a,c], Miao Cai [a,c], Aaron van Donkelaar [d,e], Randall V. Martin [d,e], Richard Burnett [f], Ziyad Al-Aly [a,c,g,h,i,*]

COVID-19

Check for updates

COVID-19 mortality in the UK Biobank cohort: revisiting and evaluating risk factors

Joshua Elliott[1,2,3] · Barbara Bodinier[1,2] · Matthew Whitaker[1,2] · Cyrille Delpierre[4] · Roel Vermeulen[6] ·
Ioanna Tzoulaki[1,2,5] · Paul Elliott[1,2] · Marc Chadeau-Hyam[1,2]

In 473'000 U.K. Biobank cohort participants, 2010 mean concentrations of pollutants (home outdoor models) were not associated with COVID-19 mortality in 2020

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Association between ambient air pollution and tuberculosis risk: A systematic review and meta-analysis

Kun Xiang [a, b, 1], Zhiwei Xu [c, 1], Yu-Qian Hu [a, b], Yi-Sheng He [a, b], Yi-Lin Dan [a, b], Qian Wu [a, b], Xue-Hui Fang [d], Hai-Feng Pan [a, b, *]

Long-term exposure (but not short-term) to PM10, NO2 and SO2 are associated with increased tuberculosis incidence

Possible roles of ambient air pollution - 6 aspects

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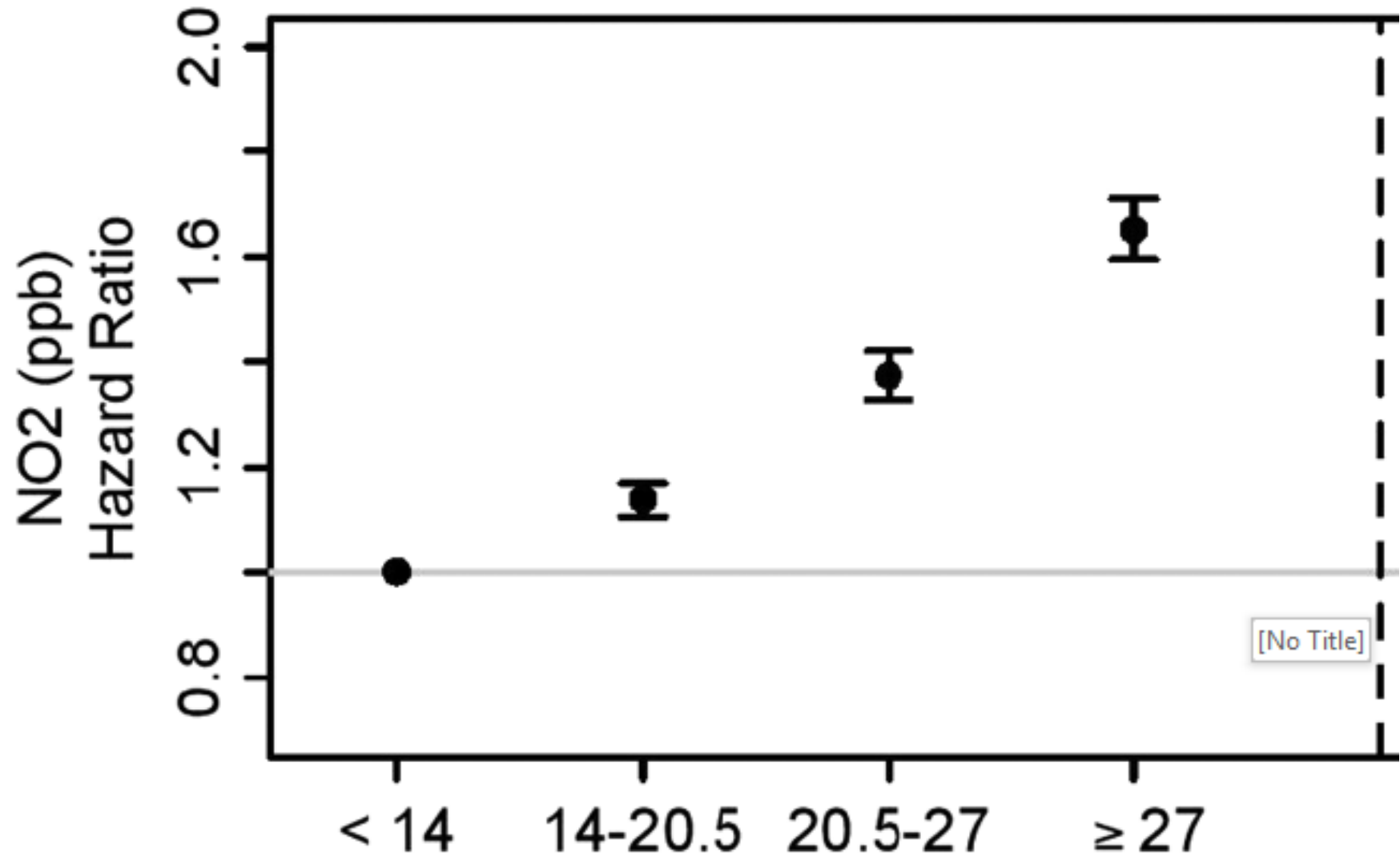
4. COVID patient care

5. Recovery after COVID

Mortality among lung cancer patients in California increased with the outdoor concentration of nitrogen dioxide
(per 20 μg/m3 NO2)
(Eckel et al. 2016)

The «magic mountain» approach: clean air for tuberculosis patients

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SUGGESTED EFFECTS AND EVIDENCE

SUGGESTED EFFECT	HYPOTHESIS	SCIENTIFIC EVIDENCE
1. Transmission per se: no evidene for a role of air pollution	QUESTIONABLE	NONE
2. Acute immune defence of exposed might be jeopardized if air pollution is high	PLAUSIBLE	SOME INDIRECT
3. Resilience against severe COVID might be compromised in those with a history of long-term exposure to ambient air pollution	STRINGENT	SOME
4. Acute course of Covid-19 disease might be compromised during periods of higher air pollution	PLAUSIBLE	NONE
5. Longer-term recovery from COVID-19 might profit from cleaner air	PLAUSIBLE	NONE for Covid
6. Lockdowns of sources of air pollution result in lower concentrations of primary pollutants	STRINGENT	STRONG

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Clean air policies work! A major sucess story (in some countries)
Fine particulate annual means (PM₂.₅) 1990 – 2015
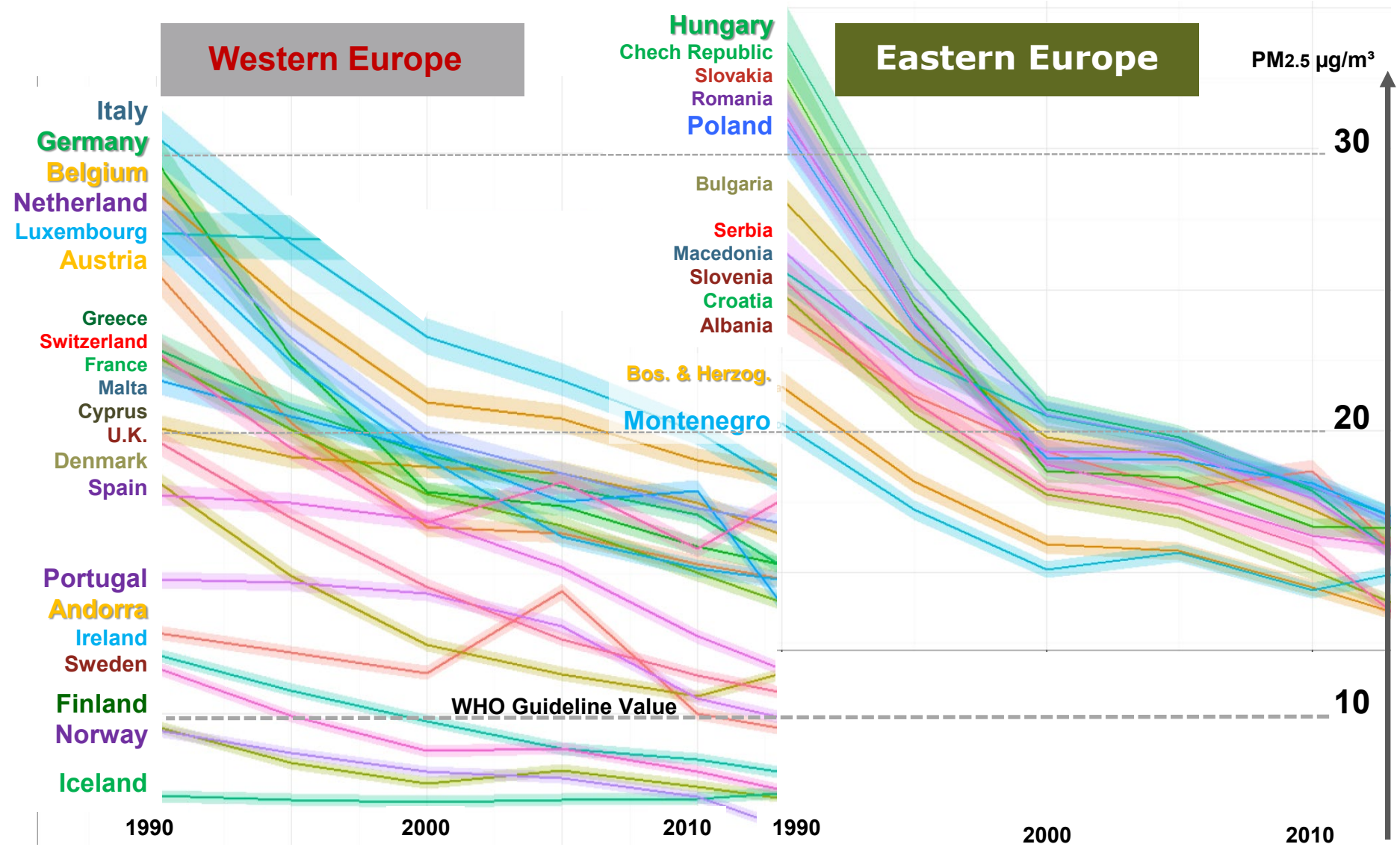
Figures: from Brauer et al. ES&T 2016

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NEEDED

- Better individual-level study designs
- Stronger case definition (e.g. confirmed COVID-19 cases are only a proxy for the true SARS-CoV-2 infection incidence rate; notification day may fall well outside real and more appropriate infection time lapse (onset of symptoms)
- Better control of pandemy control measures, compliance and behaviour (e.g. highly polluted areas are often characterized by higher rates of human interaction and international travelers AND control measures are potentially stronger in high density areas)
- Control of lockdown measures (e.g. affecting air pollutant concentrations but also health determinants etc.)
- Better control for important individual-level confounders (e.g. population density, temperatur, humidity, autocorrelation, mobility, policy measures, socioeconomic and lifestyle factors)

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In sum, use the «right arguments» and research methods for the «right case»

- Emergency clean air policies to not «flatten the curve» during the pandemic crisis
- Research will estimate the overall contribution of air pollution to the pandemic (and the air pollution related benefits of the lockdown

BUT

- Air pollution causes morbidities and diseases at risk for severe COVID-19 illnesses
- Populations with less exposure to ambient air pollution are healthier
- Healthier populations are more resilient
- Sustained globalized clean air policies and ambient air quality standards are needed to protect peoples health

Thank you

Nino.Kuenzli@swisstph.ch

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WORLD HEALTH ORGANIZATION

EUROPE

Air Quality Guidelines

Global Update 2005

Particulate matter, ozone, nitrogen dioxide and sulfur dioxide