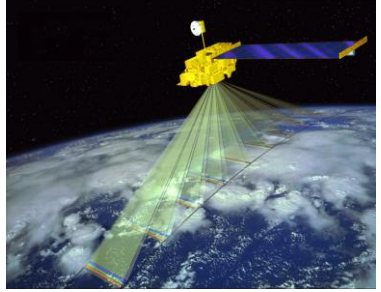
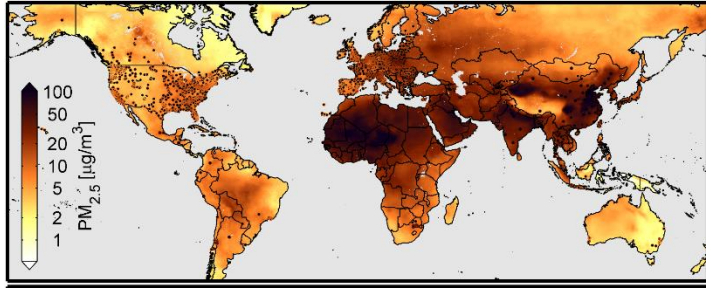
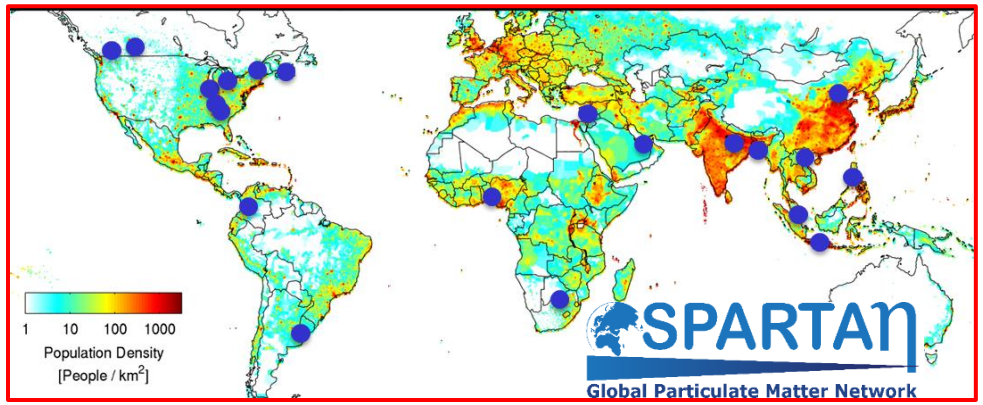
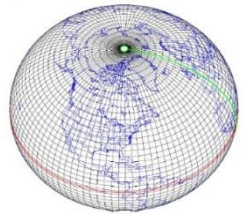


Global satellite-based pollution estimates

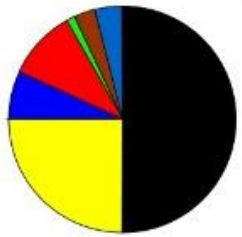


Global health/environment assessments (GBD, WHO, OECD, World Bank…)



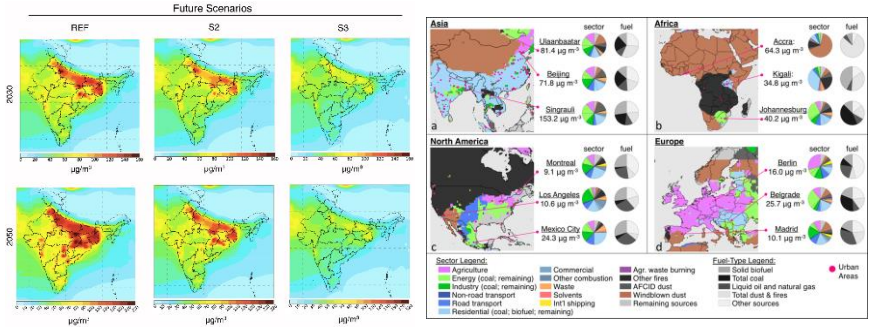


Simulation models for national/regional policy evaluation (GBD-MAPS)



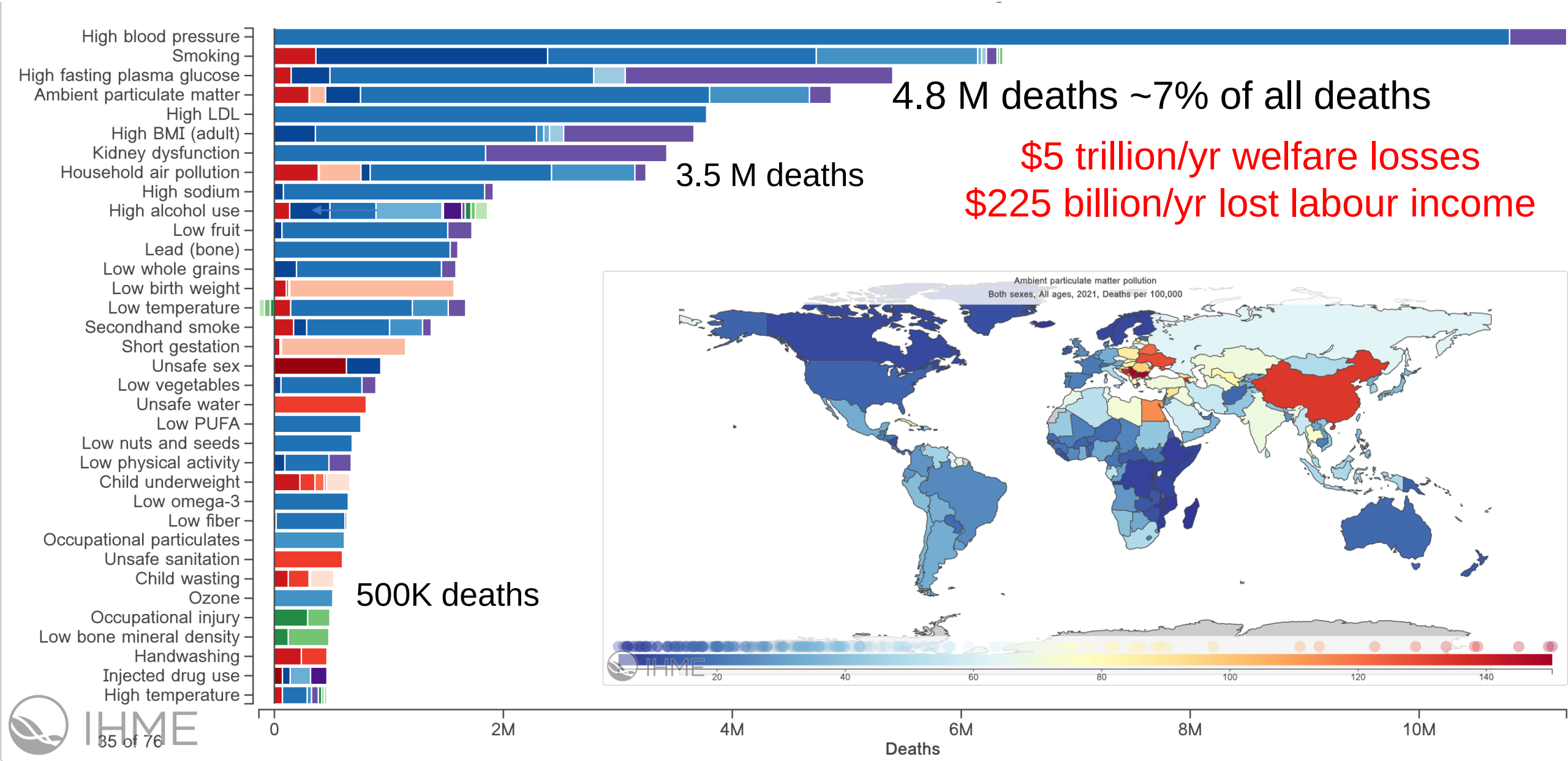
Local pollution source information

Local sensor networks



Air pollution is a major risk factor for global health

2021



World Bank. 2016. *The cost of air pollution : strengthening the economic case for action*

WORLD HEART FEDERATION

EXECUTIVE SUMMARY

CLEAN AIR, SMART CITIES, HEALTHY HEARTS: ACTION ON AIR POLLUTION FOR CARDIOVASCULAR HEALTH

Air pollution is one of the most important risk factors for heart attack, stroke, diabetes and respiratory diseases, and exposure to air pollution has also been linked with increased vulnerability to the more severe consequences of COVID-19. In 2019, an estimated 6.7 million deaths, or 12 percent of all deaths worldwide, were attributable to outdoor or household air pollution. As many as half of these deaths were due to heart disease and stroke.

Air pollution is a complex and dynamic mixture of numerous compounds in gaseous and particle form originating from diverse sources. Three common air pollutants, particulate matter (PM), ozone, and nitrogen dioxide (NO_2), are the focus of most monitoring programs, communication efforts, health impact assessments, and regulatory efforts. Air pollution can also be classified into pollution of outdoor/ambient or indoor origin, both of which have serious health effects.

The tiny particles that make up air pollution can enter the blood stream and damage the inside walls of the blood vessels, causing them to become narrower and harder. This restricts the movement in the blood vessels, which can increase blood pressure, form blood clots, affect the normal electrical functioning of the heart, and eventually lead to cardiac events.

The complexity and scale of this issue creates an unfortunate lack of understanding among those with the power to make change for good, including doctors and policymakers, which in turn results in a subsequent lack of concerted action.

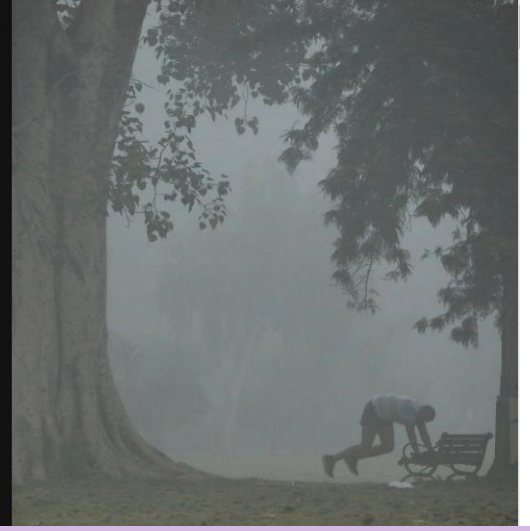
Political commitments and policy measures to mitigate pollution emissions will ultimately be necessary to reduce harmful exposures. Nevertheless, healthcare providers can play several important roles before, and while, such mitigation is achieved.

Think Global Health

ENVIRONMENT

Every Breath We Take

Air pollution is a perniciou
millions of deaths each yea

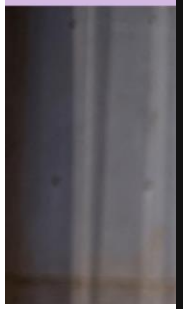


Think Global Health

POVERTY

Tackling Air Pollution Starts at Home

Rapidly developing countries critically need clean household energy



Think Global Health

ENVIRONMENT

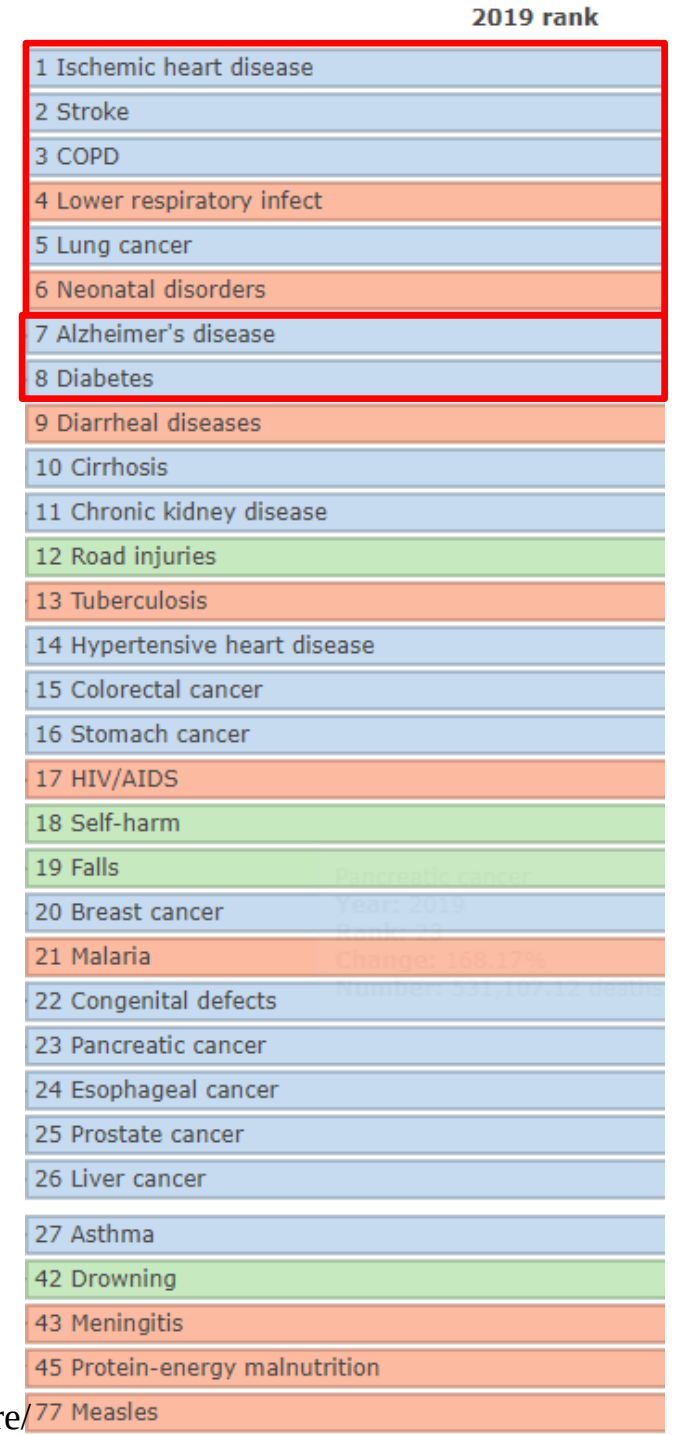
India's Pollution Problem

India's former secretary for the Ministry of Health and Family Welfare talks smog and health

https://world-heart-federation.org/global-advocacy/air-pollution/

Air pollution affects the top 8 global causes of death

- Ischemic Heart Disease mortality/incidence: PM
- Stroke mortality/incidence: PM
- COPD mortality: PM, ozone
- ALRI mortality/incidence: PM
- Lung Cancer mortality: PM
- Low birthweight/short gestation -> neonatal
- Type 2 Diabetes mortality / incidence: PM
- **Childhood asthma: NO2; Dementia: PM**

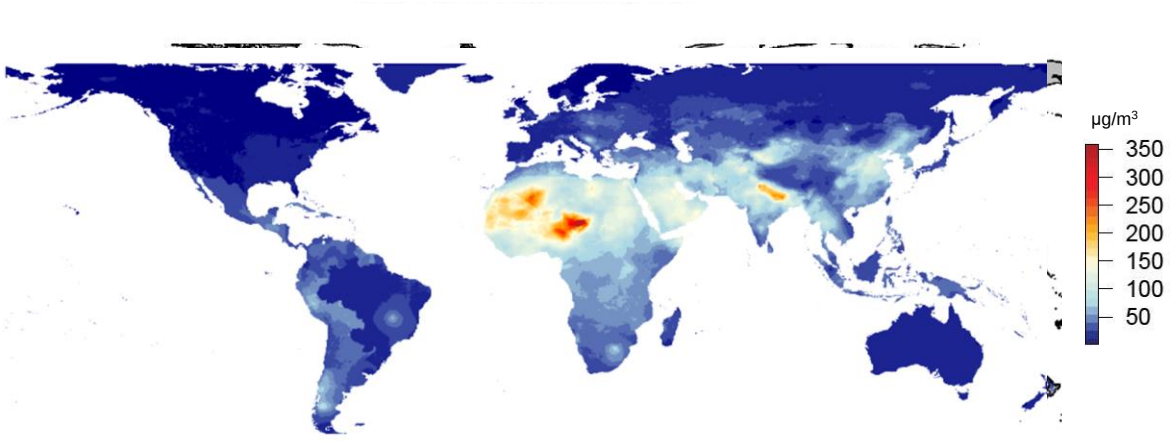


https://vizhub.healthdata.org/gbd-compare/

Combining satellite and ground monitoring to estimate exposure

$$\log(PM_{2.5st}) = \beta_{0st} + \beta_{1st}\log(SAT_s) + \beta_{3..P}X_{st} + \varepsilon_{st}$$

Bayesian Hierarchical Model (DIMAQ2)



Spatially varying determinants of AOD-$PM_{2.5}$ relationship (from chemical transport model, other) + hierarchical random effects

Ground measurements, GBD 2021
N = 18,406 unique locations, from 120 countries

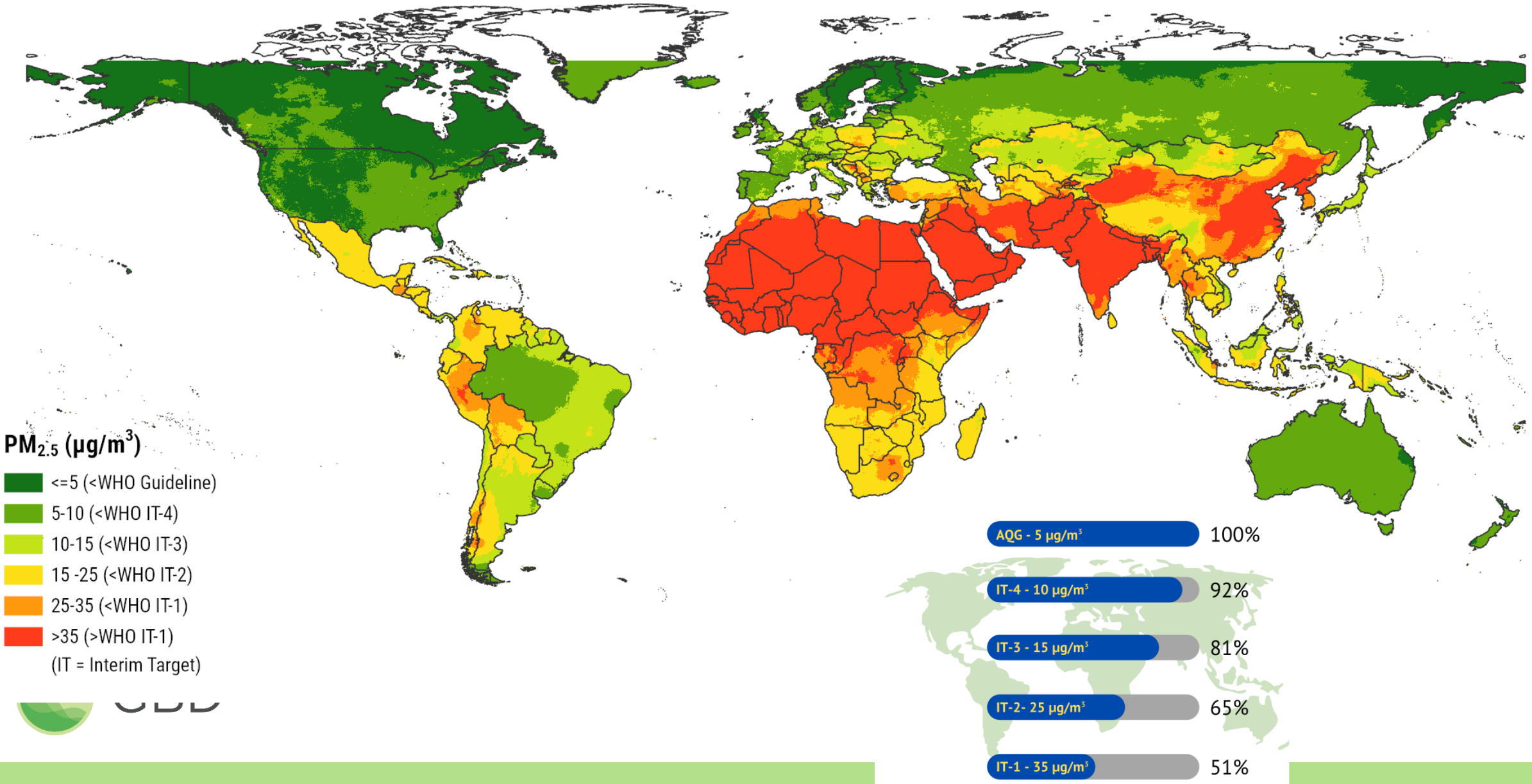
GBD 2021 evaluation:
Mean R^2 = 0.91 (95% UI 0.87 – 0.93)
Mean Pop-weighted RMSE = 8.5 (6.2 – 12.8) µg/m3

~11 x 11 km resolution (also 1 x 1 km) , annual average

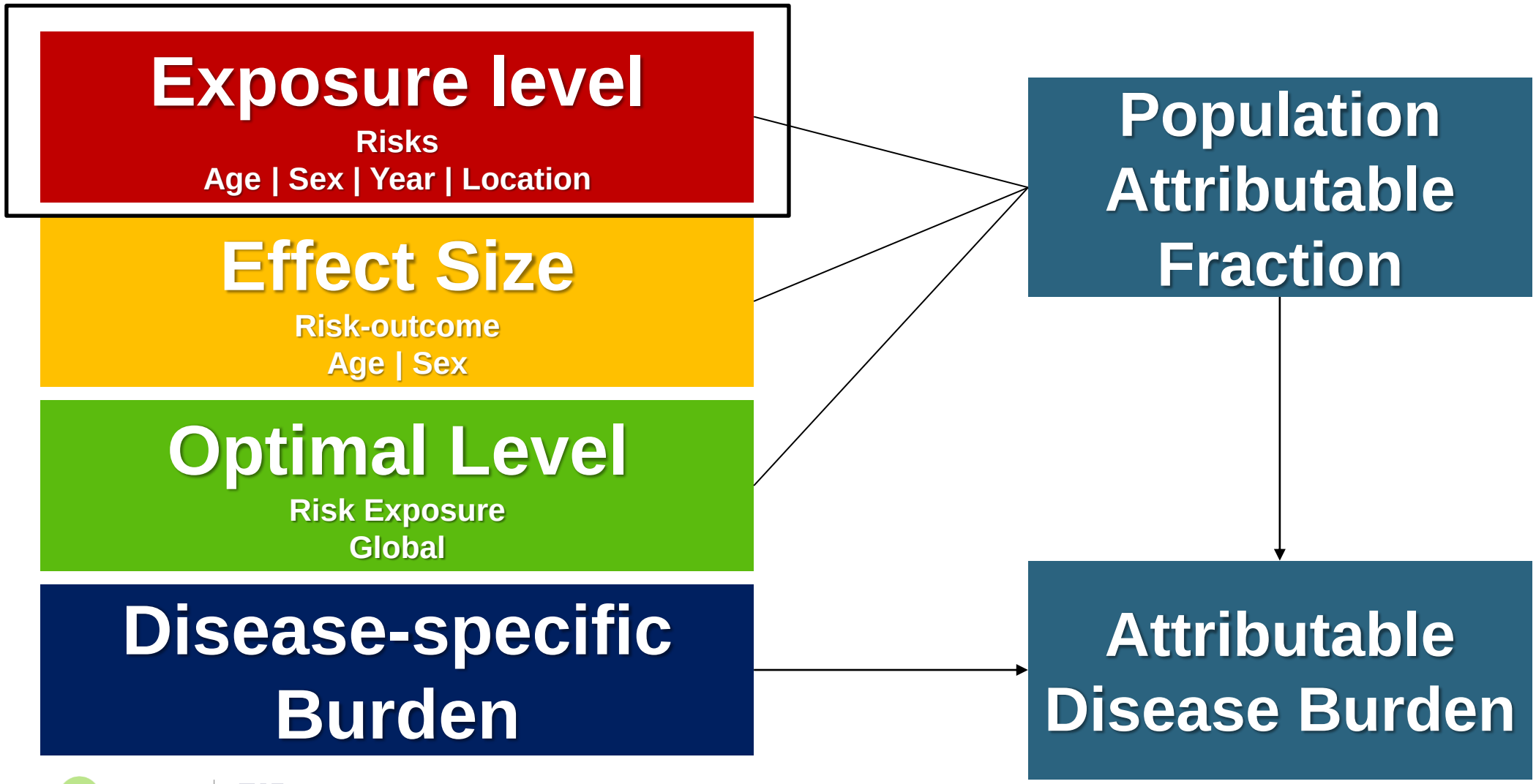
IHME GBD

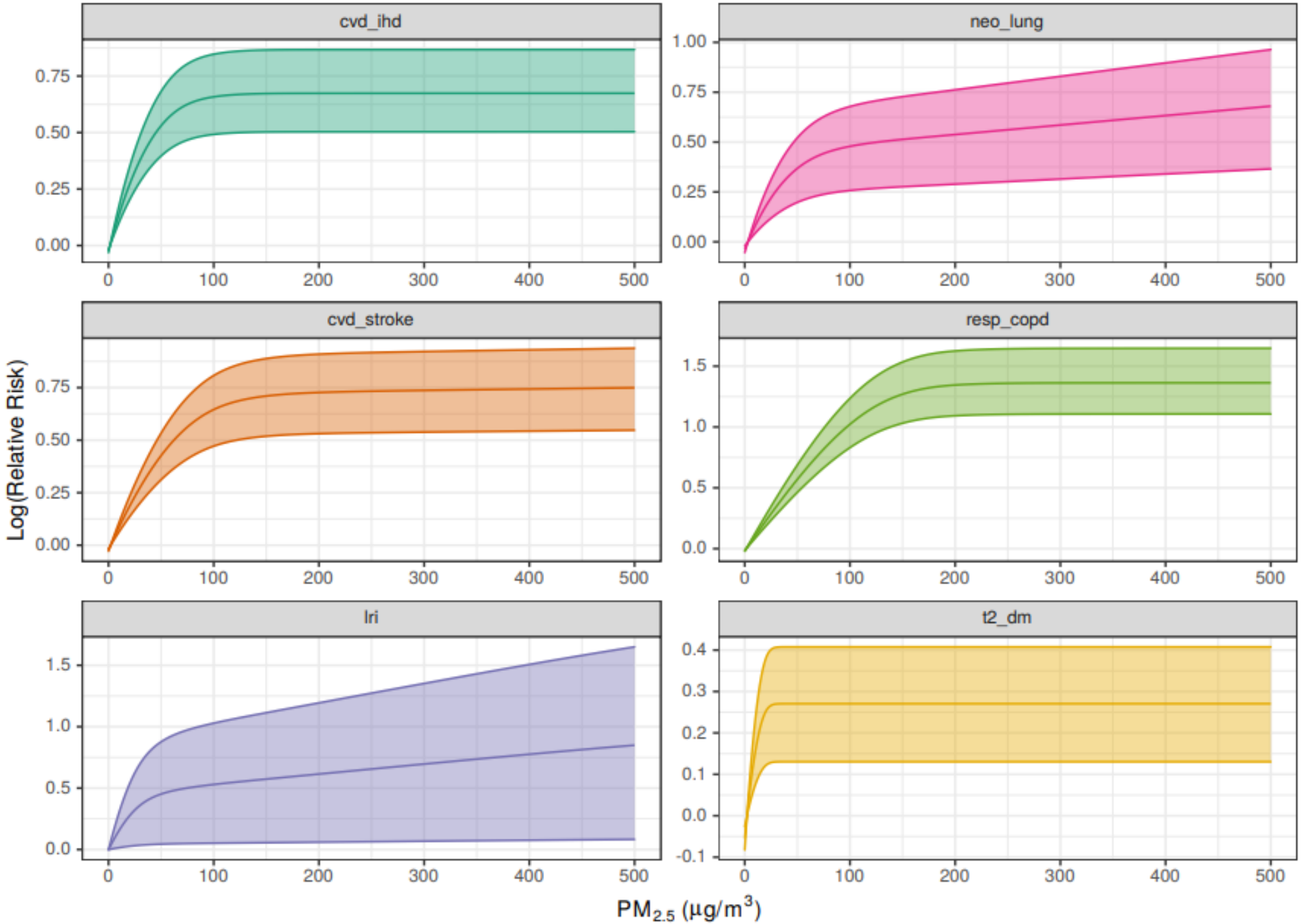
Shaddick et al. 2018. Data integration model for air quality: a hierarchical approach to the global estimation of exposures to ambient air pollution. J. R. Stat. Soc. C, 67: 231–253.
Shaddick et al. 2018. Data Integration for the Assessment of Population Exposure to Ambient Air Pollution for Global Burden of Disease Assessment. Environ Sci Technol. 2018 Aug 21;52(16):9069-9078.

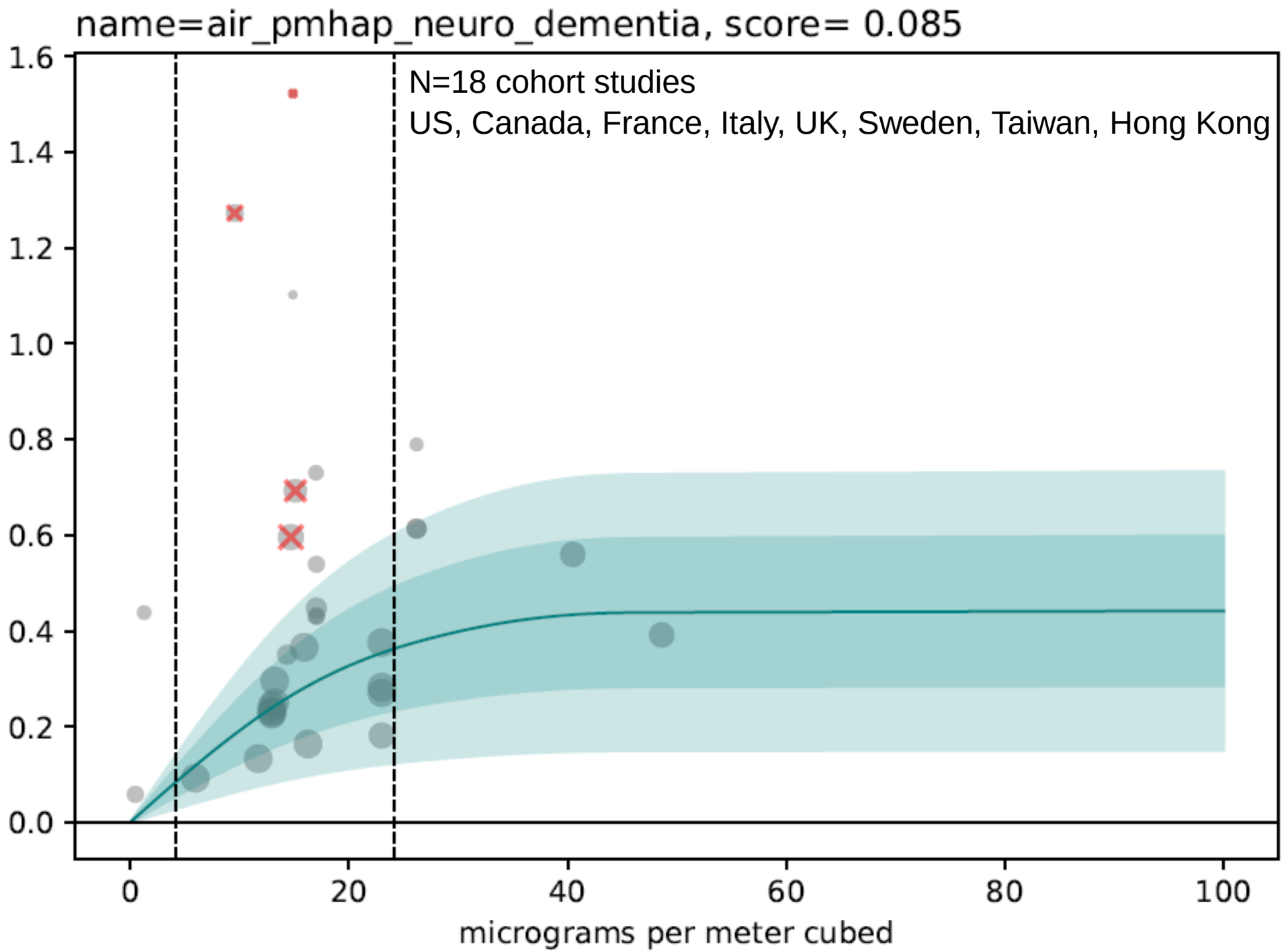
~Entire global population lives in areas > WHO AQG



Estimating disease burden from environmental risks




cvd_ihd
neo_lung
cvd_stroke
resp_copd
lri
t2_dm
Log(Relative Risk)
PM2.5 (µg/m3)


name=air_pmhap_neuro_dementia, score= 0.085
N=18 cohort studies
US, Canada, France, Italy, UK, Sweden, Taiwan, Hong Kong
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
micrograms per meter cubed

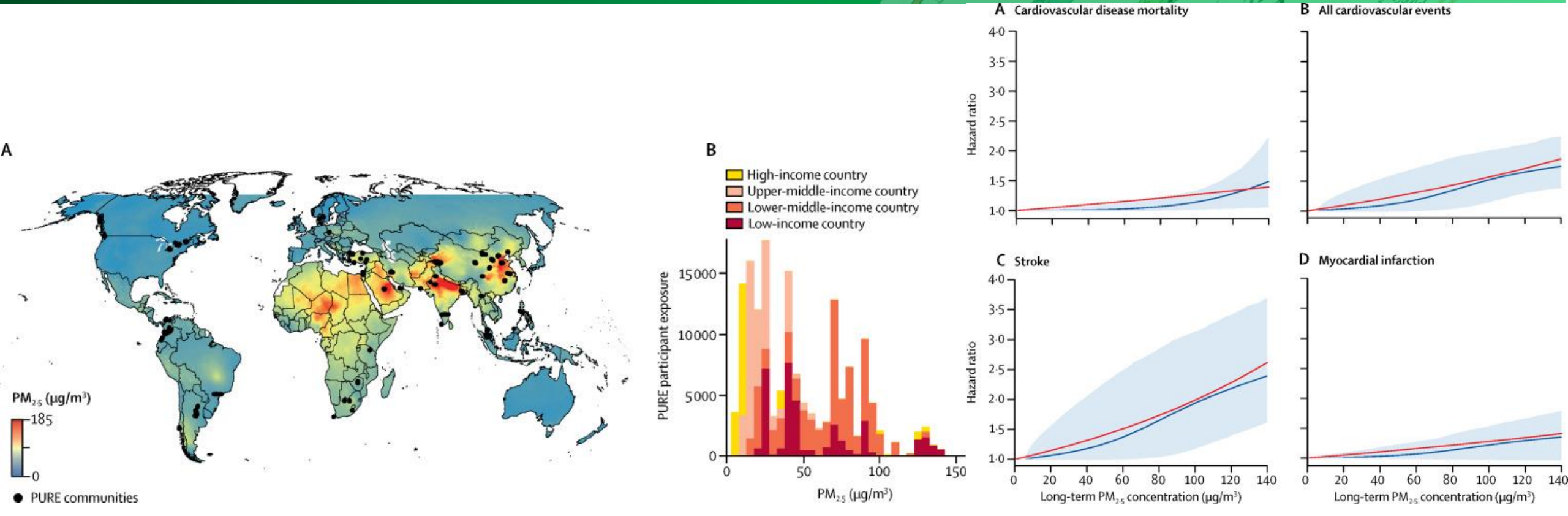
THE LANCET
Planetary Health

ARTICLES | VOLUME 4, ISSUE 6, E235-E245, JUNE 01, 2020

Associations of outdoor fine particulate air pollution and cardiovascular disease in 157 436 individuals from 21 high-income, middle-income, and low-income countries (PURE): a prospective cohort study

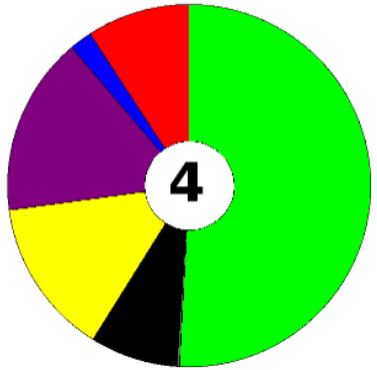
Perry Hystad, PhD • Andrew Larkin, PhD • Sumathy Rangarajan, MSc • Khalid F AlHabib, MBBS • Prof Álvaro Avezum, PhD • Kevser Burcu Tumerdem Calik, MD • et al. Show all authors

Open Access • Published: June, 2020 • DOI: https://doi.org/10.1016/S2542-5196(20)30103-0 • Check for updates



MAPLE

Kelowna



11/2017 – 03/2019

$PM_{2.5}$ / AOD (µg/m³)	22.1
AOD / b_{sp} (km)	7.5
b_{sp} / $PM_{2.5}$ (m²/g)	9.5

Downsview

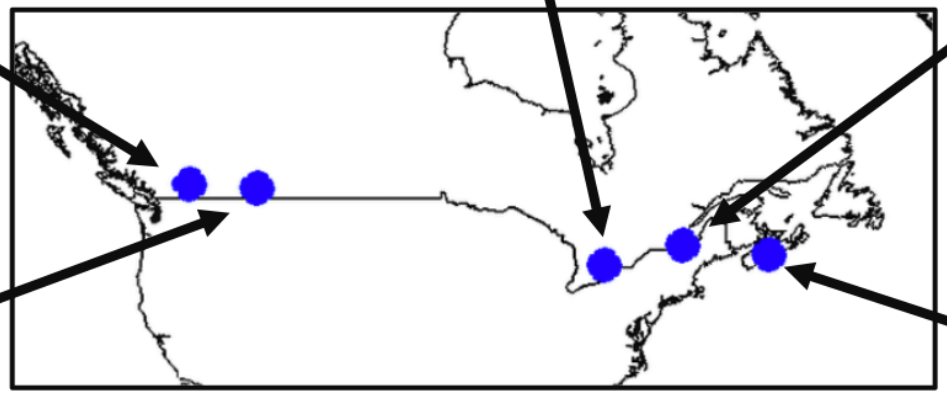
07/2017 – 08/2019

$PM_{2.5}$ / AOD (µg/m³)	27.7
AOD / b_{sp} (km)	11.2
b_{sp} / $PM_{2.5}$ (m²/g)	4.7

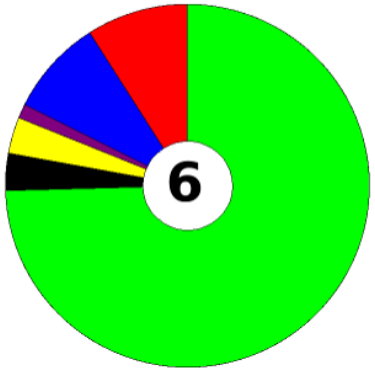
Sherbrooke

06/2017 – 08/2019

$PM_{2.5}$ / AOD (µg/m³)	30.2
AOD / b_{sp} (km)	12.7
b_{sp} / $PM_{2.5}$ (m²/g)	4.1



Lethbridge



08/2017 – 08/2019

$PM_{2.5}$ / AOD (µg/m³)	23.7
AOD / b_{sp} (km)	12.3
b_{sp} / $PM_{2.5}$ (m²/g)	4.3

$PM_{2.5}$	ASO_4
NH_4NO_3	RM
Sea Sal	TEO
Dust	EBC

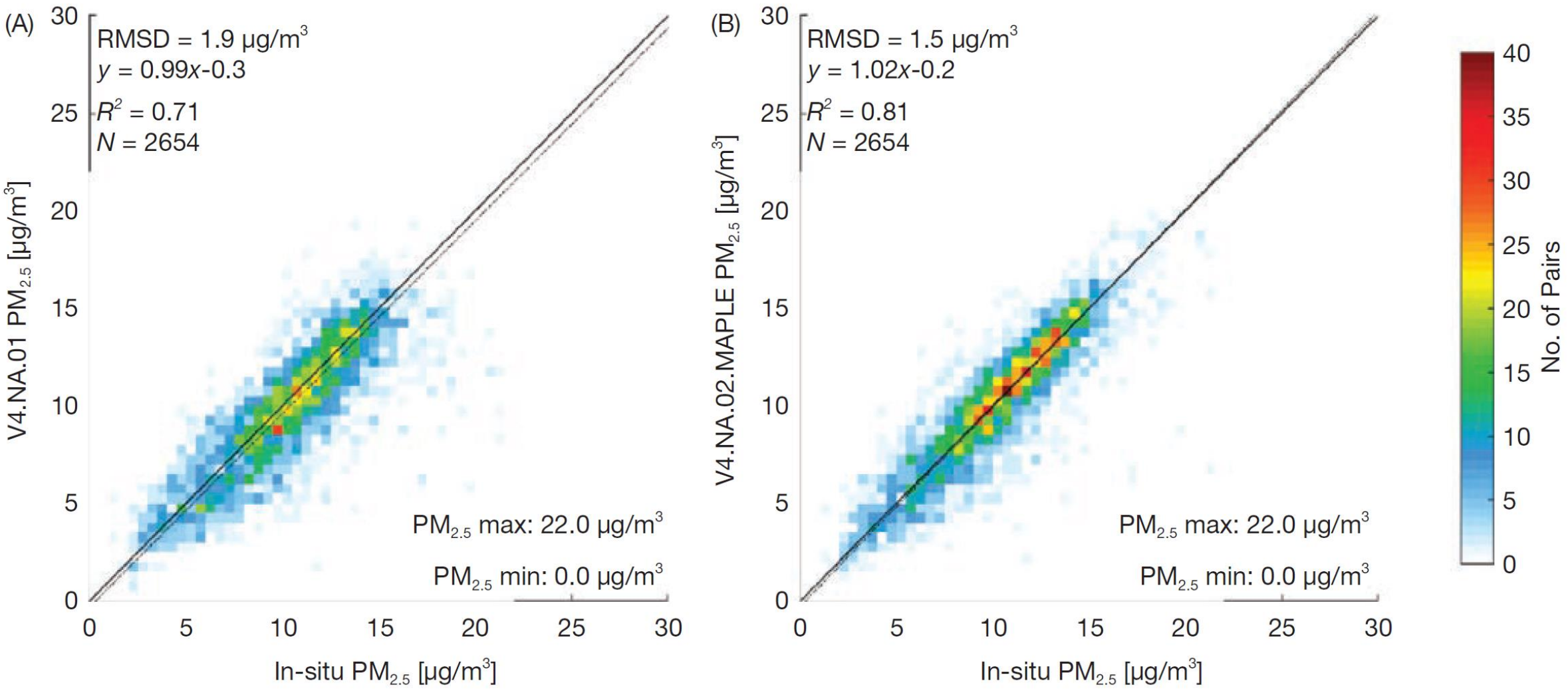
Halifax

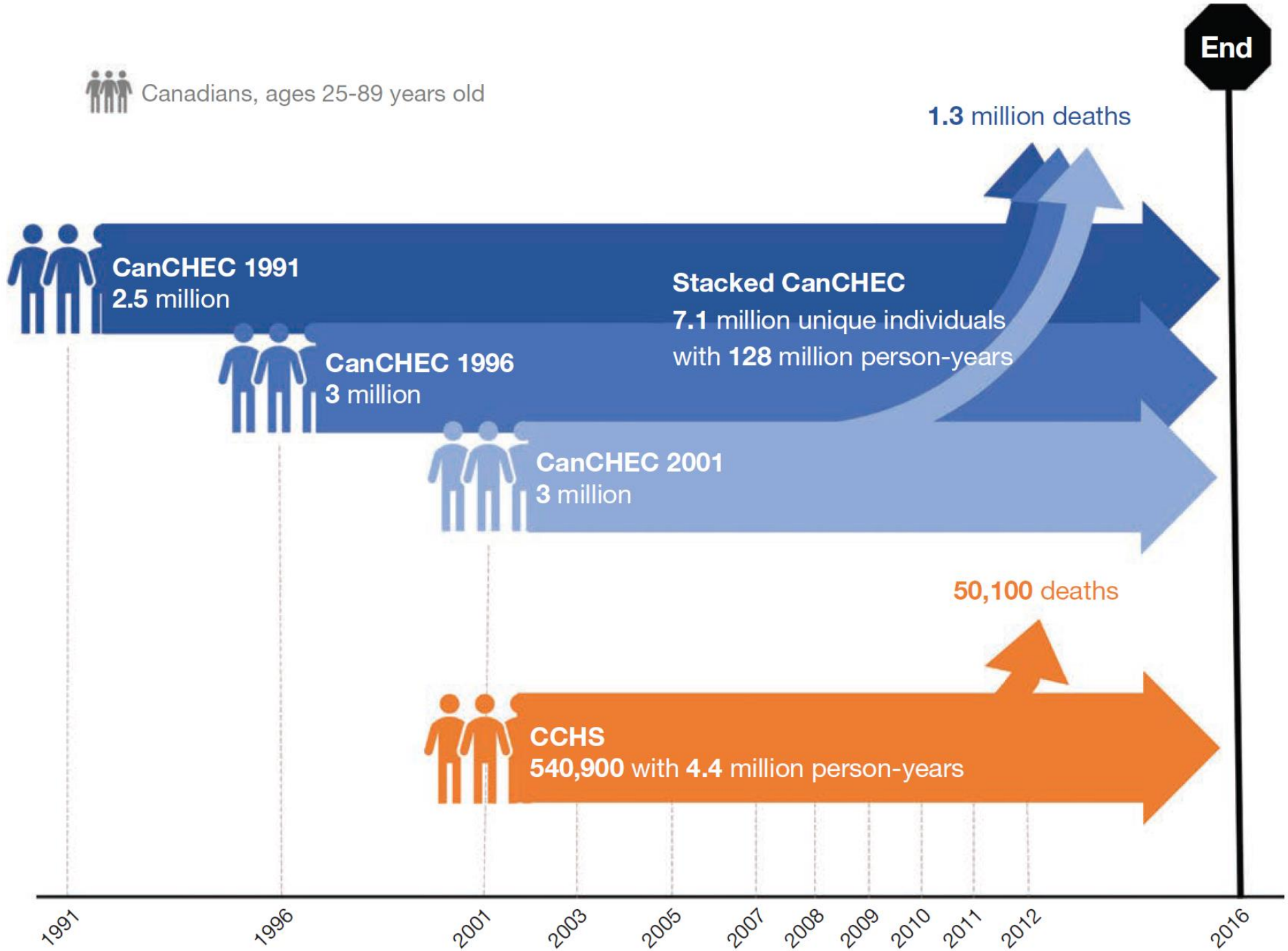
08/2017 – 08/2019

$PM_{2.5}$ / AOD (µg/m³)	26.3
AOD / b_{sp} (km)	12.6
b_{sp} / $PM_{2.5}$ (m²/g)	3.7

Phase 1

Phase 2




Canadians, ages 25-89 years old
End
1.3 million deaths
CanCHEC 1991
2.5 million
CanCHEC 1996
3 million
CanCHEC 2001
3 million
Stacked CanCHEC
7.1 million unique individuals
with 128 million person-years
50,100 deaths
CCHS
540,900 with 4.4 million person-years
1991
1996
2001
2003
2005
2007
2008
2009
2010
2011
2012
2016

MAPLE

Canadian Community

20% mandatory response to long-form census:

Canadian Community Health Survey

Satellite-base
1km x 1km

GEOS-Chem $PM_{2.5}$ simulation(1989-2016)
0.5° x 0.625°

$PM_{2.5}$ inferred fror
PM_{10} Measuremen
1989 – 1998

$PM_{2.5}$ Measuremen
1989 – 2016

(A) Stacked Cohort (Non-Accidental): eSCHIF+r's(z_0) (blue), Ensemble RCS (red)

Relative Risk

z_0=2.5μg/m^3

$PM_{2.5}$ (μg/m^3)

Hazard Ratio

$PM_{2.5}$ - μg/m^3

Shape Constrained Health Impact Function (SCHIF)
Cubic Spline (RCS)

$PM_{2.5}$ - μg/m^3

Pooled SCHIF

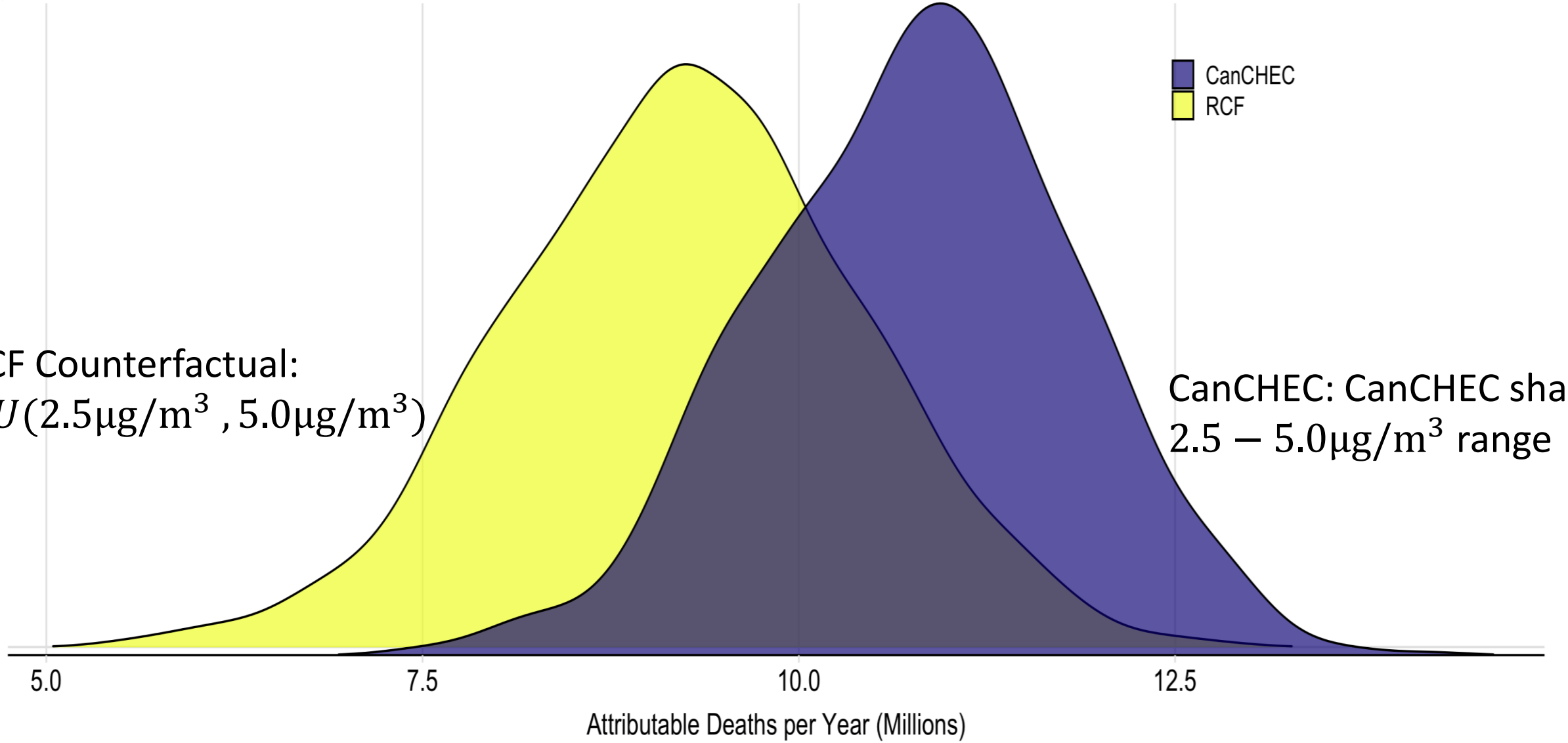
$PM_{2.5}$ - μg/m^3

CanCHEC

CCHS

Pappin et al., 2019; Christidis et al., 2019

Application of CanCHEC Shape → Additional 1.55 M (17% increase) deaths/yr globally



RCF Counterfactual:
$\sim U(2.5\mu g/m^3, 5.0\mu g/m^3)$

CanCHEC: CanCHEC shape
$2.5 - 5.0\mu g/m^3$ range

Weichenthal et al. Science Advances 2022

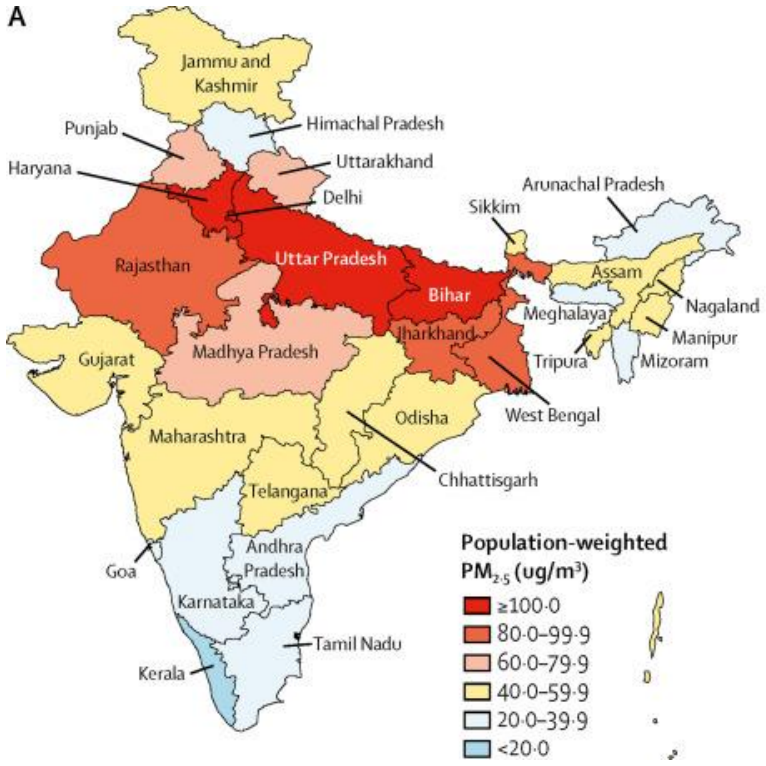
THE LANCET
Planetary Health

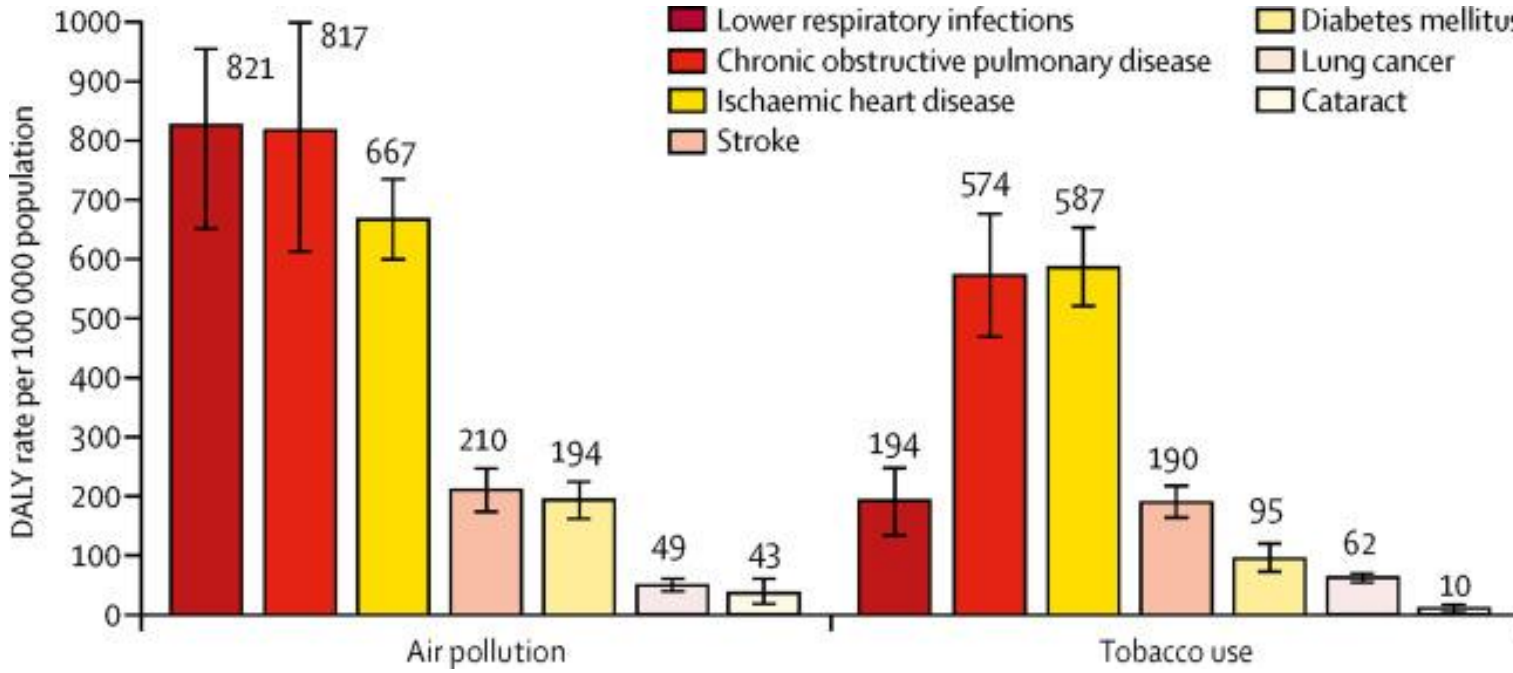
ARTICLES | VOLUME 3, ISSUE 1, E26-E39, JANUARY 01, 2019

The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study 2017

India State-Level Disease Burden Initiative Air Pollution Collaborators † • Show footnotes

Open Access • Published: December 05, 2018 • DOI: https://doi.org/10.1016/S2542-5196(18)30261-4 •





Global Burden of Disease – Major Air Pollution Sources (GBD-MAPS) Project

Goal: Identify major sources of global $PM_{2.5}$ pollution & quantify attributable disease burden

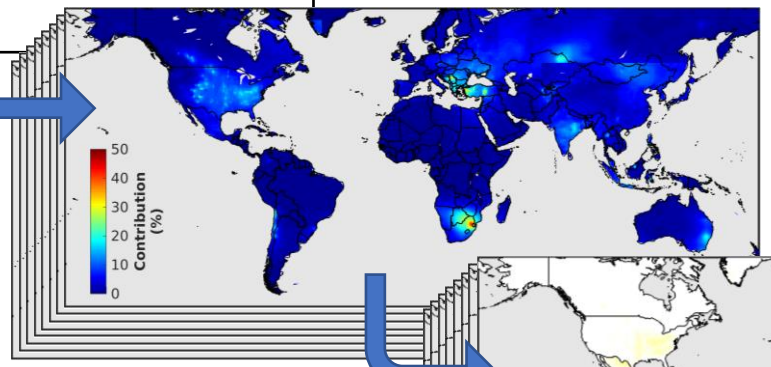
1 **CEDS Emissions**

+

2 GEOS-Chem

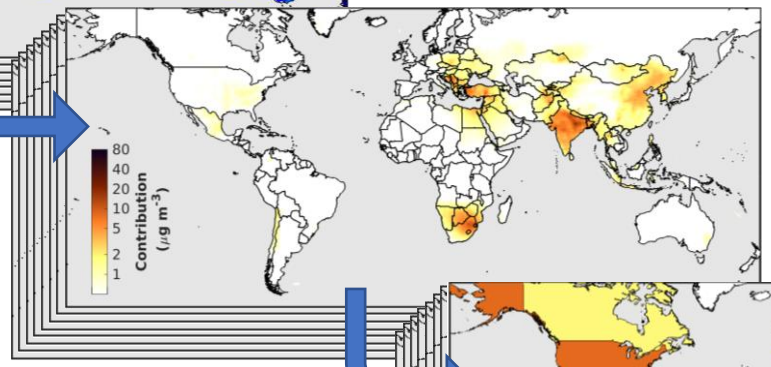
3

Modeled $PM_{2.5}$ Fractional Source Contribution



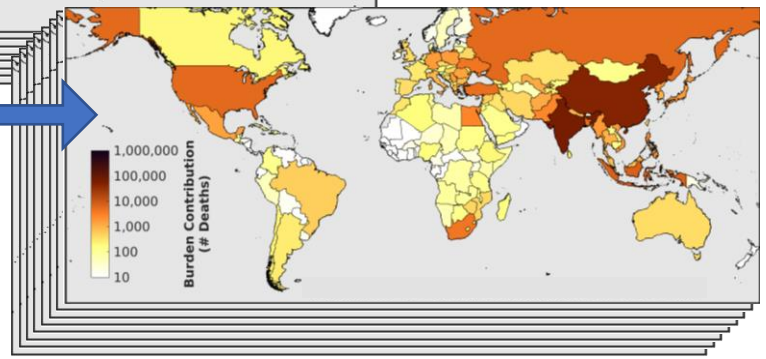
4

Absolute $PM_{2.5}$ Source Contribution



5

Disease Burden Source Contribution



Approach:

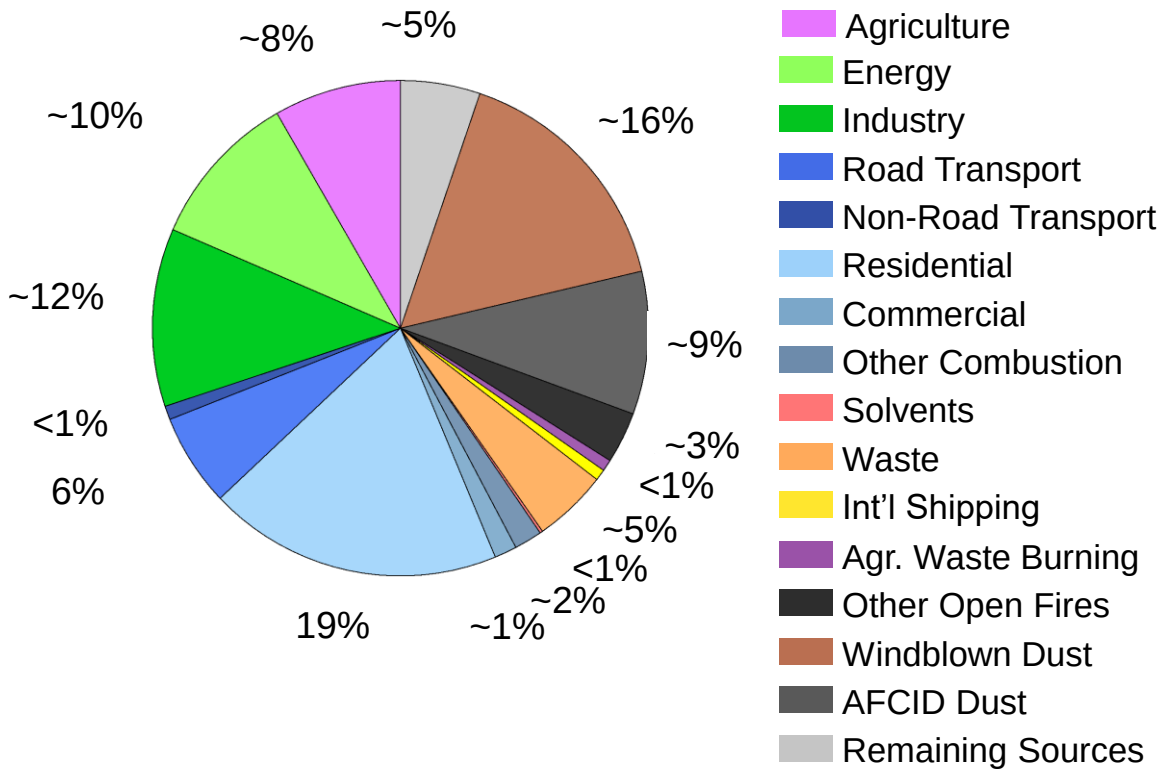
Conduct emissions sensitivity simulations with a global atmospheric chemistry transport model…

…integrate with $PM_{2.5}$ exposure estimates and concentration response relationships from the GBD to quantify source-specific disease burdens

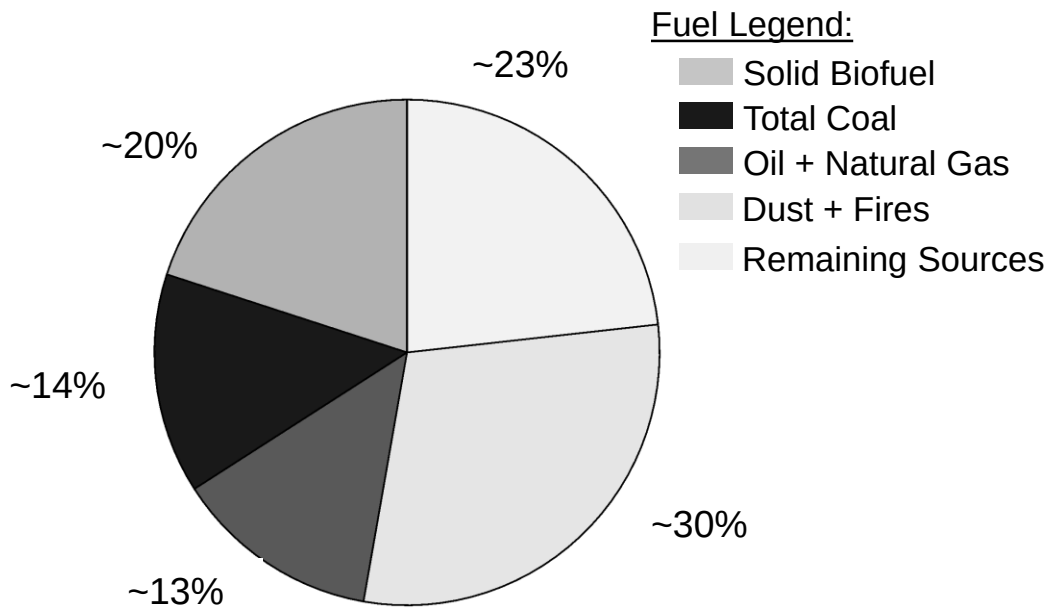
HEI
HEALTH EFFECTS INSTITUTE

Global fuel combustion contributes to ~50%; fossil fuels ~27%

2017 Global Sector Contributions



2017 Global Fuel-Type Contributions



Fossil-fuels contribute to 27%

Interactive data visualization

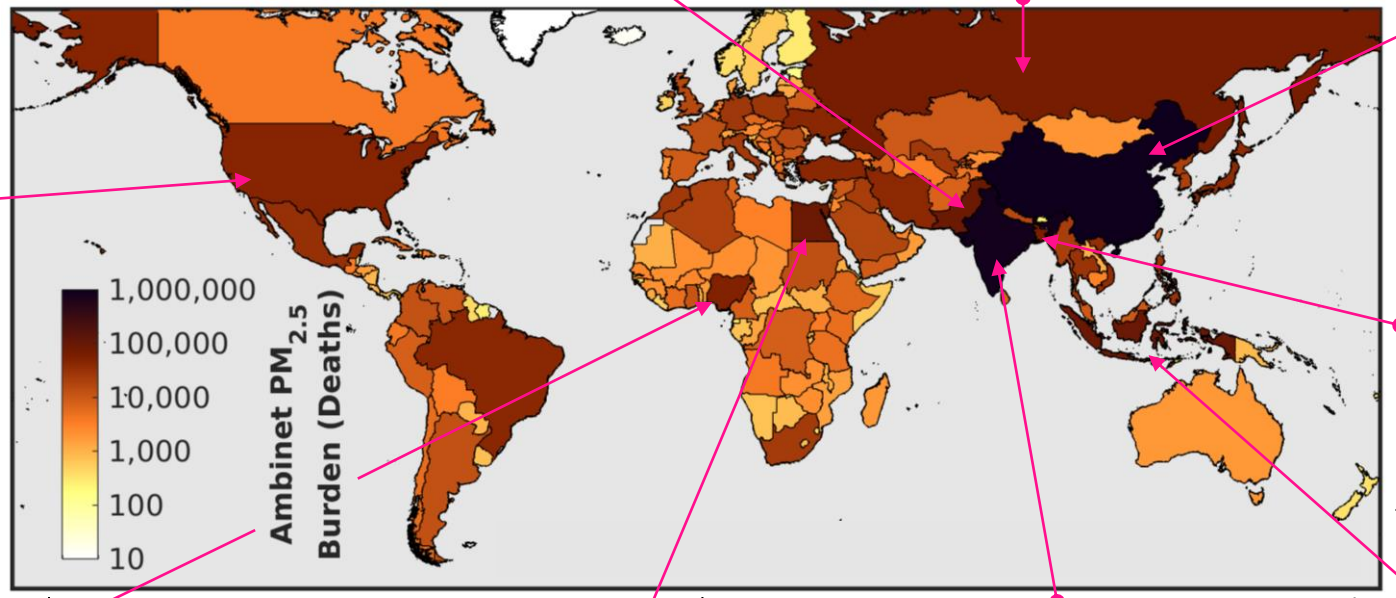
Global Average:
41.7 μg m^{-3} | 3,832,500 deaths

Pakistan:
59.7 μg m^{-3} | 86,500 deaths

Russian Federation:
10.9 μg m^{-3} | 68,500 deaths

China:
49.8 μg m^{-3} | 1,386,500 deaths

sector fuel disease
Relative Contributions



United States:
7.8 μg m^{-3} | 47,000 deaths

Bangladesh:
61.9 μg m^{-3} | 63,500 deaths

Nigeria:
64.2 μg m^{-3} | 50,500 deaths

Egypt:
65.8 μg m^{-3} | 88,000 deaths

India:
80.2 μg m^{-3} | 866,500 deaths

Indonesia:
18.0 μg m^{-3} | 94,000 deaths

https://gbdmaps.med.ubc.ca/

Sector Legend:
- Agriculture
- Energy (coal; remaining)
- Industry (coal; remaining)
- Non-road transport
- Road transport
- Residential (coal; biofuel; remaining)
- Commercial
- Other combustion
- Waste
- Solvents
- Int'l shipping
- Agr. waste burning
- Other fires
- AFCID dust
- Windblown dust
- Remaining sources

Fuel-Type Legend:
- Solid biofuel
- Total coal
- Liquid oil and natural gas
- Total dust & fires
- Remaining (non-comb.) sources

Disease Legend:
- COPD
- Type II Diabetes (DM)
- Lower Respiratory Infections (LRIs)
- Lung Cancer (LC)
- Ischemic Heart Disease (IHD)
- Stroke