Local pollution source information

Global satellite-based pollution estimates

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

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

Local sensor networks
Air pollution is a major risk factor for global health

4.8 M deaths ~7% of all deaths
$5 trillion/yr welfare losses
$225 billion/yr lost labour income

500K deaths
EXECUTIVE SUMMARY

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

Air pollution is one of the world’s 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 6.1 million deaths, or 27 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 particulate form originating from diverse sources. These common air pollutants, particulate matter (PM), ozone and nitrogen dioxide (NO2), are the focus of most existing programs, communication efforts, health impact assessments, and regulatory efforts. Air pollution can also be caused by pollution of outdoor sources 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 blood vessels of the heart, causing them to become narrow and hard. The heart, the movement of 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 who have the power to make change to protect the health of individuals and policymakers, which in turn results in a subsequent lack of concerted action.

Tackling Air Pollution Starts at Home
Rapidly developing countries critically need clean household energy

India’s Pollution Problem
India’s former secretary for the Ministry of Health and Family Welfare talks smog and health
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

\[
\log(PM_{2.5}^{st}) = \beta_0^{st} + \beta_1^{st} \log(SAT_s) + \beta_3^{..}P \times X_{st} + \varepsilon_{st}
\]

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/m$^3$

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


Entire global population lives in areas > WHO AQG
Estimating disease burden from environmental risks

Exposure level
- Risks
  - Age | Sex | Year | Location

Effect Size
- Risk-outcome
  - Age | Sex

Optimal Level
- Risk Exposure
  - Global

Disease-specific Burden

Population Attributable Fraction

Attributable Disease Burden

IHME | UNIVERSITY of WASHINGTON

Institute for Health Metrics and Evaluation
N=18 cohort studies
US, Canada, France, Italy, UK, Sweden, Taiwan, Hong Kong
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 Ranganathan, MSc  
Khalid F Alhlabib, MBBS  
Prof Alvaro Avezzù, PhD  
Kevser Burcu Tuner Deniz Calik, MD  
et al.  
Show all authors  
Open Access  Published: June, 2020  DOI: https://doi.org/10.1016/S2542-5196(20)30163-0  
Check for updates

A Cardiovascular disease mortality

B All cardiovascular events

C Stroke

D Myocardial infarction
(A) Stacked Cohort (Non-Accidental): eSCHIF$+\text{r's}(z_0)$ (blue), Ensemble RCS (red)

Relative Risk

$z_0=2.5\mu g/m^3$

PM$_{2.5}$ - $\mu g/m^3$

Pooled SCHIF

Canadian Community Health Survey

Pappin et al., 2019; Christidis et al., 2019
Application of CanCHEC Shape $\rightarrow$ 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 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

Open Access • Published: December 06, 2018 • DOI: https://doi.org/10.1016/S2214-109X(18)30261-4

Population-weighted PM$_{10}$ (µg/m$^3$)

- $100.0$
- $80.0-99.9$
- $60.0-79.9$
- $40.0-59.9$
- $20.0-39.9$
- $<20.0$

DALLY rate per 100,000 population

- Lower respiratory infections
- Chronic obstructive pulmonary disease
- Ischaemic heart disease
- Stroke
- Diabetes mellitus
- Lung cancer
- Cataract

Air pollution

- 821
- 667
- 210
- 194
- 49
- 43
- 190
- 95

Tobacco use

- 817
- 574
- 587
- 190
- 62
- 10

Institute for Health Metrics and Evaluation
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

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

2017 Global Sector Contributions

Sector Legend:
- Agriculture
- Energy
- Industry
- Road Transport
- Non-Road Transport
- Residential
- Commercial
- Other Combustion
- Solvents
- Waste
- Int’l Shipping
- Agr. Waste Burning
- Other Open Fires
- Windblown Dust
- AFCID Dust
- Remaining Sources

2017 Global Fuel-Type Contributions

Fuel Legend:
- Solid Biofuel
- Total Coal
- Oil + Natural Gas
- Dust + Fires
- Remaining Sources

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

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

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)
- Ischemic Heart Disease (IHD)
- Stroke

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