

# Reversal of trends in global fine particulate matter air pollution



Chi Li (chili@wustl.edu), Aaron van Donkelaar, Melanie S. Hammer, Erin E. McDuffie, Richard T. Burnett, Joseph V. Spadaro, Deepangsu Chatterjee, Aaron J. Cohen, Joshua S. Apte, Veronica A. Southerland, Susan C. Anenberg, Michael Brauer, Randall V. Martin



**Data & Methods**

- PM<sub>2.5</sub> exposure: van Donkelaar et al., (2021) v5.GL.03
- Population: GPW v4
- Age-, territory- and disease-specific deaths: GBD study 2019
- CRF (to derive PAF): GEMM (Burnett et al., 2018)
- Decomposition method: Geng et al. (2022)

## 1. China leads a post-2011 reduction in global PM<sub>2.5</sub> exposure, accompanied by tropospheric regions

Global or regional trends in PM<sub>2.5</sub> exposure were widely discussed, but **local (e.g., China) contributions** to global exposure have not yet been discussed.

We define the **normalized PM<sub>2.5</sub>** to quantify this contribution.

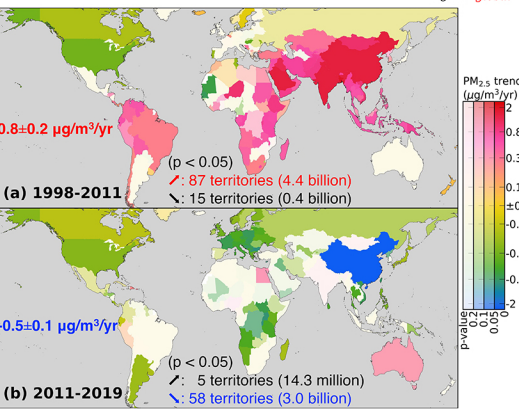


Fig. 1. Trends in population-weighted PM<sub>2.5</sub> for 204 WHO territories (transparency indicative of statistical significance).

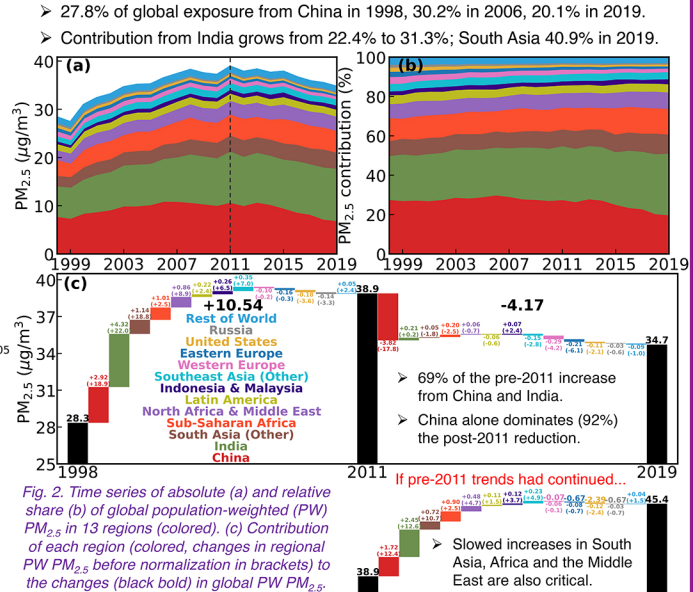


Fig. 2. Time series of absolute (a) and relative share (b) of global population-weighted (PW) PM<sub>2.5</sub> in 13 regions (colored). (c) Contribution of each region (colored, changes in regional PW PM<sub>2.5</sub> before normalization in brackets) to the changes (black bold) in global PW PM<sub>2.5</sub>.

## 2. Stagnation of global PM<sub>2.5</sub>-attributable deaths: exposure-driven reductions vs. demography-driven increases

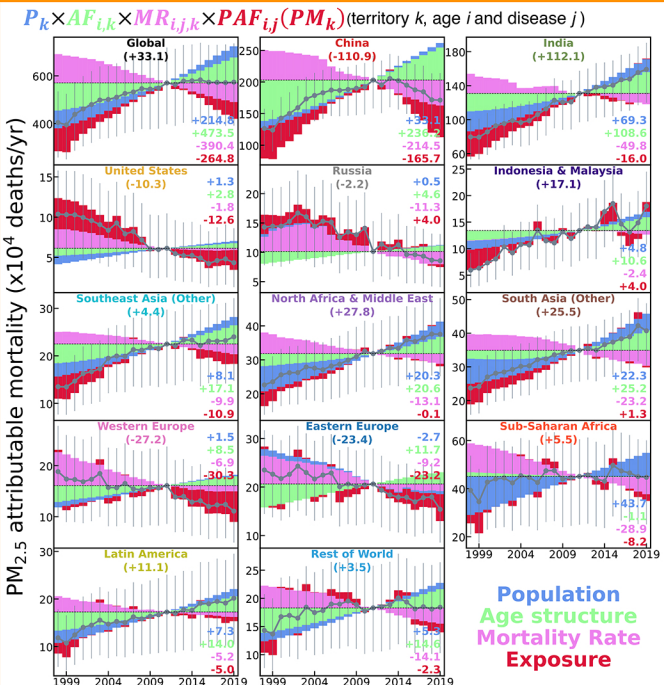


Fig. 3. Annual PM<sub>2.5</sub>-attributable deaths (grey, error bars indicate 95% CI) and changes (relative to 2011) due to four factors (colored). Numbers suggest accumulated changes after 2011.

Population structure, Mortality Rate, Exposure

## 3. Stronger health benefits among older population and under cleaner air

We derive the marginal benefits per unit mitigation using a **finite-difference approach**.

(territory  $k$ , age  $i$  and disease  $j$ )

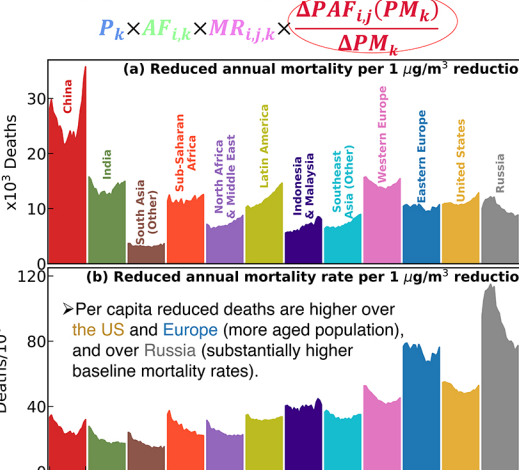


Fig. 4. Marginal benefits of reducing unit PM<sub>2.5</sub> for each year: (a) absolute death reduced; (b) death reduced per capita.

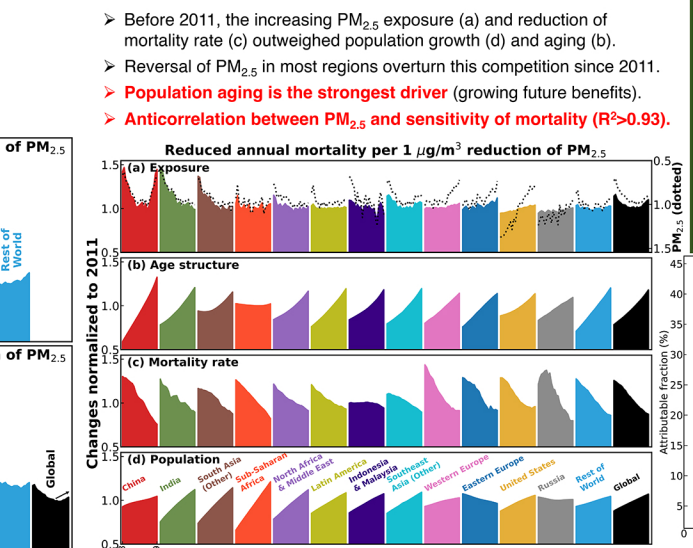


Fig. 5. Decomposition of Fig. 4a into changes due to four factors (normalized to 2011; dotted black lines are changes in PM<sub>2.5</sub>).

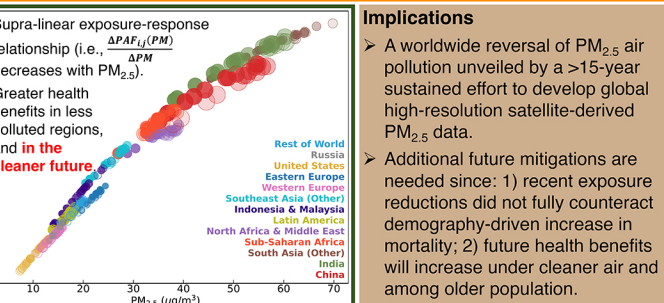


Fig. 6. Overall PAF vs. PM<sub>2.5</sub> (more transparent colors indicate more recent year; size represents population).

**Implications**

- A worldwide reversal of PM<sub>2.5</sub> air pollution unveiled by a >15-year sustained effort to develop global high-resolution satellite-derived PM<sub>2.5</sub> data.
- Additional future mitigations are needed since: 1) recent exposure reductions did not fully counteract demography-driven increase in mortality; 2) future health benefits will increase under cleaner air and among older population.

Funding: NASA HAQAST (80NSSC21K0508)