Particulate pollution from coal associated with double the risk of mortality than PM2.5 from other sources

November 23 2023

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Exposure to fine particulate air pollutants from coal-fired power plants (coal $PM_{2.5}$) is associated with a risk of mortality more than double that

of exposure to $PM_{2.5}$ from other sources, according to a new study led by George Mason University, The University of Texas at Austin, and Harvard T.H. Chan School of Public Health.

Examining Medicare and emissions data in the U.S. from 1999 to 2020, the researchers also found that 460,000 deaths were attributable to coal $PM_{2.5}$ during the study period—most of them occurring between 1999 and 2007, when coal $PM_{2.5}$ levels were highest. The study is published on November 23, 2023, in *Science*.

While previous studies have quantified the mortality burden from coal-fired power plants, much of this research has assumed that coal $PM_{2.5}$ has the same toxicity as $PM_{2.5}$ from other sources.

"$PM_{2.5}$ from coal has been treated as if it's just another air pollutant. But it's much more harmful than we thought, and its mortality burden has been seriously underestimated," said lead author Lucas Henneman, assistant professor in the Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering at Mason. "These findings can help policymakers and regulators identify cost-effective solutions for cleaning up the country's air, for example, by requiring emissions controls or encouraging utilities to use other energy sources, like renewables."

Using emissions data from 480 coal power plants in the U.S. between 1999 and 2020, the researchers modeled where wind carried coal sulfur dioxide throughout the week after it was emitted and how atmospheric processes converted the sulfur dioxide into $PM_{2.5}$. This model produced annual coal $PM_{2.5}$ exposure fields for each power plant. They then examined individual-level Medicare records from 1999 to 2016, representing the health statuses of Americans ages 65 and older and representing a total of more than 650 million person-years.

By linking the exposure fields to the Medicare records, inclusive of where enrollees lived and when they died, the researchers were able to understand individuals' exposure to coal $PM_{2.5}$ and calculate the impact it had on their health.

They found that across the U.S. in 1999, the average level of coal $PM_{2.5}$ was 2.34 micrograms per cubic meter of air (μg/m3). This level decreased significantly by 2020, to 0.07 μg/m3. The researchers calculated that a one μg/m3 increase in annual average coal $PM_{2.5}$ was associated with a 1.12% increase in all-cause mortality, a risk 2.1 times greater than that of $PM_{2.5}$ from any other source. They also found that 460,000 deaths were attributable to coal $PM_{2.5}$, representing 25% of all $PM_{2.5}$-related deaths among Medicare enrollees before 2009.

The researchers were also able to quantify deaths attributable to specific power plants, producing a ranking of the coal-fired power plants studied based on their contribution to coal $PM_{2.5}$'s mortality burden. They found that 10 of these plants each contributed at least 5,000 deaths during the study period. They visualized the deaths from each power plant in a publicly available online tool (https://cpieatgt.github.io/cpie/).

The study also found that 390,000 of the 460,000 deaths attributable to coal-fired power plants took place between 1999 and 2007, averaging more than 43,000 deaths per year. After 2007, these deaths declined drastically, to an annual total of 1,600 by 2020.

"Beyond showing just how harmful coal pollution has been, we also show good news: Deaths from coal were highest in 1999 but by 2020 decreased by about 95%, as coal plants have installed scrubbers or shut down," Henneman said.

"I see this as a success story," added senior author Corwin Zigler, associate professor in the Department of Statistics and Data Sciences at

UT Austin and founding member of the UT Center for Health & Environment: Education & Research. "Coal power plants were this major burden that U.S. policies have already significantly reduced. But we haven't completely eliminated the burden—so this study provides us a better understanding of how health will continue to improve and lives will be saved if we move further toward a clean energy future."

The researchers pointed out the study's continuing urgency and relevance, writing in the paper that coal power is still part of some U.S. states' energy portfolios and that global coal use for electricity generation is even projected to increase.

"As countries debate their energy sources—and as coal maintains a powerful, almost mythical status in American energy lore—our findings are highly valuable to policymakers and regulators as they weigh the need for cheap energy with the significant environmental and health costs," said co-author Francesca Dominici, Clarence James Gamble Professor of Biostatistics, Population, and Data Science at Harvard Chan School and director of the Harvard Data Science Initiative.

More information: Lucas Henneman et al, Mortality risk from United States coal electricity generation, *Science* (2023). DOI: 10.1126/science.adf4915. www.science.org/doi/10.1126/science.adf4915

Robert Mendelsohn et al, Measuring the impacts of air pollution, *Science* (2023). DOI: 10.1126/science.adl2935 www.science.org/doi/10.1126/science.adl2935

Provided by Harvard T.H. Chan School of Public Health