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Health effects of long-term exposure to levels of air pollution below government-recommended standards

Associations of mortality coincide with current EPA review of US national air quality standard

“Although air pollution concentrations have been declining over the past few decades in many higher-income countries, several studies published in the past decade have reported greater associations between risk of mortality and long-term exposures to relatively low concentrations [of fine particulate matter, 2.5 microns or smaller in diameter] $PM_{2.5}$,” according to the Health Effects Institute (HEI).

The United State Environmental Protection Agency (EPA) indicates that $PM_{2.5}$ has many sources. Some particles are “emitted directly from sources such as construction sites, unpaved roads, fields, smokestacks or fires.” However, “most particles form in the atmosphere as a result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industrial facilities and vehicles.”

Recognizing that “more stringent air quality standards and guidelines will likely be considered in the future,” HEI has funded three studies—in the United States, Europe and Canada—“to explore health effects from air pollution exposure at levels below government recommended standards.”

The US study, “Assessing health effects of long-term exposure to low levels of ambient air pollution: Implementation of causal inference methods” was led by Francesca Dominici, PhD, Professor of Biostatistics, Population Health and Data Science at Harvard Univer-



sity’s T.H. Chan School of Public Health and her colleagues. Results were published in January 2022.

A report from the study in Europe was released in September 2021 and final results from the study in Canada are expected later in 2022.

A focus on small cities and rural areas in the low-exposure subcohort

The four-year US study used public data to evaluate “the risk of mortality associated with exposure to low ambient air pollution concentrations in a cohort of 68.5 million older Americans.” All were recipients of Medicare, the United States government national health insurance program for Americans age 65 or older.

According to HEI documents and *The New York Times*, the main analysis determined the risk for the older US population as a whole.

However, in the low-exposure subcohort, the researchers purposely excluded participants in large areas of the Eastern US and likely most people in most major cities. Instead, they focused on smaller towns and rural areas that were not well monitored by the EPA, either because they are sparsely populated or because pollution levels are not considered as high as in cities or along the congested East Coast.

The researchers developed annual exposure models for $PM_{2.5}$, ozone (O_3) and nitrogen dioxide (NO_2) at a spatial resolution of 1 km x 1 km for the years 2000 to 2016 to estimate exposure for all study participants. They also conducted analyses of the exposure/health connection and presented results from three newly developed causal inference approaches and two traditional regression approaches for estimating the risk of dying associ-

ated with long-term exposures to the pollutants.

Associations between mortality and exposure to low concentrations of PM_{2.5}

The researchers reported increased risks of all-cause mortality of 6% to 8% per 10 µg/m³ increase in PM_{2.5} across the five approaches, with larger effect estimates in a low exposure subcohort. Stronger associations were found at exposure levels below the current US National Ambient Air Quality Standard (NAAQS) annual average exposure of 12 µg/m³. The researchers also concluded that the consistency of associations across methods provides stronger support than past studies for what is likely a causal effect between long-term exposure to PM_{2.5} and mortality.

In addition, they estimated the total number of deaths that could have been avoided among older Americans in a decade, if hypothetically, the US standards had followed the World Health Organization annual guideline [in effect at that time] of ≤ 10 µg/m³ and all zip codes in the US had complied. Using the most conservative hazard ratio across all statistical approaches, they determined that lowering the standards to 10 µg/m³ would have saved 143,257 lives

(95% CI 115,581 to 171,645) in one decade.

“If we were to reduce PM_{2.5}, we would be saving a substantial amount of lives. It’s highly significant,” said lead investigator Francesca Dominici in the article published by *The New York Times*

The study report was independently reviewed by the HEI Low-Exposure Epidemiology Studies Review Panel, which had no role in conducting or overseeing the study. In part, they concluded that it presented a “high-quality and thorough investigation into associations between risk of mortality and exposures to ambient air pollution in the United States, applying advanced statistical techniques to test rigorously whether the air pollution exposure actually cause[d] direct impacts on health.” At the same time, the panel expressed several “concerns about some of the approaches used, such as the quality of the exposure estimates in rural areas.”

“Studying areas that are not well monitored presented a challenge because it could be difficult to validate levels of exposure to pollution,” Jennifer L. Peel, PhD, MPH, Professor and Section Head of Epidemiology in the Department of Environmental and Radiological Health Sciences at Colorado State University, commented to *The New York Times*. Peel was not a mem-

ber of the research team but independently reviewed the study. She called the report “an amazing first step” and added that “overall, the study was the most comprehensive she had seen.”

Coinciding with EPA review of the US PM_{2.5} standard

HEI and *The New York Times* noted the study results have become available as the Biden Administration and the US EPA are considering whether to strengthen the US EPA National Ambient Air Quality Standards for PM_{2.5}.

Currently, it establishes the 24-hour average exposure limit at 35 µg/m³ and the annual average exposure limit at 12 µg/m³. In contrast, the World Health Organization air quality guidelines, which were updated in September 2021 for the first time in 15 years, have a 24-hour average exposure limit of 15 µg/m³ while the annual exposure limit is 5 µg/m³.

The US NAAQS were established in 1997 then revised in 2006 and 2012. The United States Clean Air Act requires the EPA to review the standards every five years. In a December 2020 final action following the most recent review, the Trump Administration chose not to strengthen the guidelines.

However, in June 2021, the EPA announced that it would “reconsider the previous administration’s decision to retain the particulate matter (PM) National Ambient Air Quality Standards (NAAQS)... because available scientific evidence and technical information indicate that the current standards may not be adequate to protect public health and welfare, as required by the Clean Air Act.” They further stated their “2020 Policy Assessment concluded that the scientific evidence and information support revising the level of the annual standard for the PM NAAQS to below the current level of 12 micrograms per cubic meter while retaining the 24-hour standard.”

The Health Effects Institute (HEI) is a nonprofit corporation and an independent research organization. Established in 1980, it aims to provide “high-quality, impartial and relevant science on the effects of air pollution on health. Its research is selected, overseen and peer reviewed by leading subject matter experts on environment and health without involvement of HEI’s public or private sponsors. Typically, it receives balanced funding from the US Environmental Protection Agency (EPA)

and the worldwide motor vehicle industry. In addition, other public and private organizations in the United States and around the world support its major projects or research programs.

HEI has funded more than 340 research projects in North America, Europe, Asia and Latin America, the results of which have informed decisions regarding carbon monoxide, air toxics, nitrogen oxides, diesel exhaust, ozone, particulate matter and other pollutants.”

As part of this process, the EPA explained, “it will develop a supplement to the 2019 Final Integrated Science Assessment (ISA) that will take into account the most up-to-date science, including new studies in the emerging area of COVID-related research.” In addition, in accordance with Executive Orders and guidance, the agency will be considering environmental justice during the rulemaking process.”

“Importantly, results of this study will be able to inform the EPA as to whether or not they should lower the National Ambient Air Quality Standards for PM_{2.5} in the United States,” Dominici told *The New York Times*.

The EPA is expected to propose a draft rule by the summer of 2022 and issue a final rule by the spring of 2023.

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