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Air Pollution and Neurocognitive Effects in Older Women

INTRODUCTION

Dementia is relatively common in elderly people. Because there are no cures, there has been much interest in identifying modifiable risk factors. Recently, epidemiological studies have begun to explore the etiological role of exposures to common environmental pollutants, including air pollution. Yet to date, few epidemiological studies have investigated neurocognitive effects of long-term exposure to air pollution in older people. There are many methodological challenges involved in conducting such research, including the potential for selection bias, misclassification of the outcome, and uncertainties in the exposure estimation; many challenges also stem from the nature of dementia, which can have a decades-long incipient phase.

Dr. Jiu-Chiuan Chen of the University of Southern California, a recipient of HEI's Walter A. Rosenblith New Investigator Award, and colleagues examined the association between long-term outdoor particulate air pollution exposure and neurocognitive outcomes and brain volumes of older women in the United States. They also examined effect modification by factors that may increase susceptibility, such as a history of cardiovascular disease.

APPROACH

Dr. Chen used data from women enrolled in the U.S.-based Women's Health Initiative Memory Study (WHIMS), which consisted of two randomized clinical trials of postmenopausal hormone therapy. Both trials were terminated early because of side effects, though follow-up continued. In total, 7,479 women were included in the current study, all community dwellers (i.e., not living in nursing or medical facilities), 65 to 80 years old, and free of dementia at baseline (1996–1999). The study assessed neurocognitive outcomes, namely, mild cognitive impairment and dementia, and brain volume measures. The report analyzed neurocognitive outcomes measured annually by standardized protocols including neurological tests until 2007. Brain volume measures for certain brain regions were obtained from a single structural magnetic resonance imaging (MRI) assessment in a subset (~20%) of participants during 2005–2006.

What This Study Adds

- Dr. Chen conducted a novel study examining the association between long-term exposure to ambient particulate air pollution and neurocognitive outcomes and brain volumes of older women in the United States.

- A high-quality neurocognitive outcome assessment, the inclusion of brain imaging data, and the availability of detailed individual-level covariate information were strengths of the study.

- The investigators observed that exposure to neither ambient fine particulate matter (PM2.5) nor diesel particulate matter was associated with mild cognitive impairment and/or dementia in older women. Some positive and negative associations were reported between particulate air pollution and brain volumes, but the analyses were exploratory, their clinical significance remains unclear, and the findings differ from previous research.

- Evidence from the current study, along with results of previous studies, provides impetus for further research given the implications of the potential effects of ambient air pollution on dementia for our aging population.

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Two PM exposure metrics were assessed: ambient $PM_{2.5}$ and diesel PM. Annual ambient $PM_{2.5}$ exposure was estimated at the residential address using a nationwide spatiotemporal model and U.S. EPA regulatory monitoring data for the years 1999–2007. Annual on-road diesel PM was obtained at the census-tract level from the U.S. EPA National-Scale Air Toxics Assessment database.
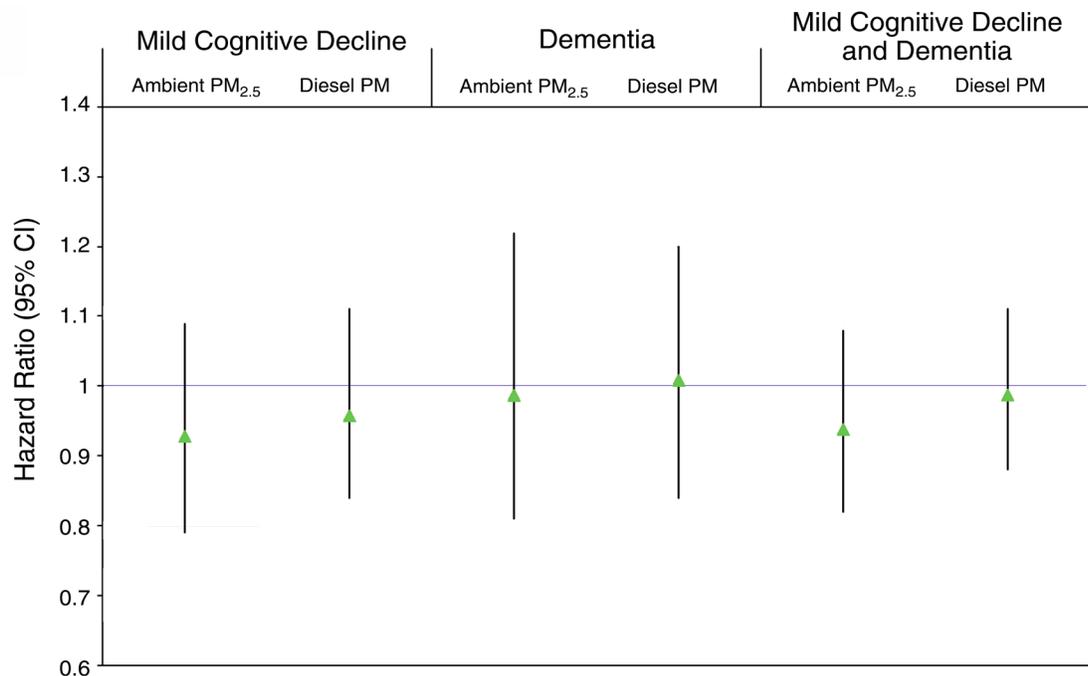
Neurocognitive and brain volume outcomes were first compared across exposure quartiles and then tested for significance using likelihood-ratio tests and analysis of covariance. Only statistically significant results were further investigated in Cox proportional hazard models (neurocognitive outcomes) and linear regression models (brain volumes) and adjusted for important confounders such as age, race, socioeconomic status, smoking, alcohol use, physical activity, body mass index, and some clinical characteristics.

MAIN RESULTS AND INTERPRETATION

In its independent review of the study, the HEI Review Committee concluded that Dr. Chen and colleagues conducted a novel study — one of the few to evaluate a potential relationship between long-term exposure to ambient particulate air pollution and neurocognitive outcomes and brain volumes. A high-quality neurocognitive outcome assessment, the inclusion of brain imaging data, and the availability of detailed individual-level covariate information were strengths of the study.

Chen and colleagues reported that exposure to neither ambient $PM_{2.5}$ nor diesel PM was associated with mild cognitive impairment and/or dementia in older women (see Statement Figure). Some positive and negative associations were reported between particulate air pollution and brain volumes, but the analyses were exploratory, their clinical significance remains unclear, and the findings differ from previous research.

The Committee had less confidence in the results for diesel PM than for ambient $PM_{2.5}$ because the exposure assessment was based on a screening tool that was considered less suitable for epidemiological studies and was likely prone to substantial measurement error. In addition, the effect modification analyses were hampered by lack of statistical power. Although the brain volume results were exploratory and the rationale for the statistical approach clearly described, the Committee questioned the emphasis on unadjusted findings in the report. Furthermore, it would have been useful to take additional steps to increase consistency in the brain volume analyses and reporting and to explore the potential for selection bias further. It should be noted that the number of air pollution studies on dementia-related outcomes remains small, and such studies are inherently difficult. Evidence from the current study, along with previous results, provides impetus for further research given the implications of the potential effects of ambient air pollution on dementia for our aging population.

Statement Figure. Association between neurocognitive outcomes and particulate air pollution in older women. Hazard ratio expressed per interquartile exposure range (3.9 µg/m^3 for $PM_{2.5}$, 0.35 µg/m^3 for diesel PM).