HEI

STATEMENT

Synopsis of Research Report 222

HEALTH EFFECTS INSTITUTE

Cardiometabolic Effects of Air Pollution, Noise, and Green Space in Denmark

BACKGROUND

Traffic emissions are an important source of urban air pollution, and exposure to traffic-related air pollution has been associated with various adverse health effects. The health effects of traffic-related air pollution continue to be an important factor affecting public health across the globe, especially for people living in cities and close to busy roadways. Exposure to traffic-related air pollution and other closely correlated factors, such as noise, lack of green space, and socioeconomic status might confound or modify the associated health effects. Therefore, it is important to understand the influence of those other factors on the associations between traffic-related air pollution and health to design more effective policies to protect people's health.

APPROACH

The overarching goal of Dr. Raaschou-Nielsen and colleagues' study was to investigate the associations between long-term exposure to four traffic-related air pollutants and the risk of cardiometabolic diseases and how these effects might vary given other related factors such as noise and green space. The investigators used data from three existing longitudinal cohort studies of Danish adults, covering roughly 2.6 million people. The three cohorts were a nationwide registry-based cohort and two smaller cohorts that had detailed individual-level information to evaluate the influence of lifestyle factors (the Danish National Health Survey cohort) and information on cardiometabolic biomarkers and blood pressure (Diet Cancer and Health – Next Generations cohort). Thus, the study benefited from two complementary sources of data, using one large cohort with less detailed information and two smaller cohorts with highly detailed information.

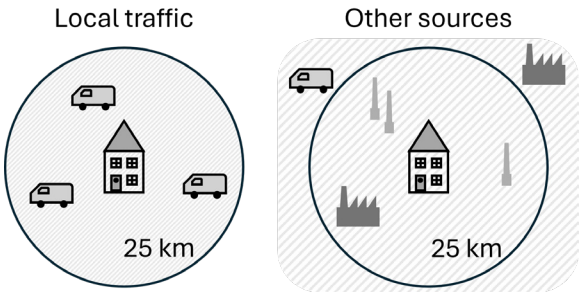
The investigators estimated exposure to four traffic-related air pollutants (fine particulate matter, nitrogen dioxide, ultrafine particles, and elemental carbon) using an advanced chemical transport model system. They also used a noise model to estimate exposure to noise, a high-resolution land use map to assess access to green space near the home, and Danish registries to estimate individual and neighborhood sociodemographic factors. Finally, they estimated air pollutant exposures from local traffic sources (less than 25 km away) and air pollutant exposures from all other sources, including nonlocal traffic, using the chemical transport model system (**Statement Figure 1**).

The study team focused on the following cardiometabolic outcomes: type 2 diabetes, heart attack, stroke, blood pressure, and related biomarkers (cholesterol, blood pressure, C-reactive protein, and blood sugar

What This Study Adds

- This study investigated four traffic-related air pollutants (fine particulate matter, nitrogen dioxide, ultrafine particles, and elemental carbon), noise, and green space in relation to cardiometabolic health in 2.6 million adults in Denmark.
- Individually, all air pollutants, noise, and lack of green space were associated with a higher risk of type 2 diabetes, stroke, and heart attack, while associations adjusted for other exposures were less strong.
- Air pollution from local traffic sources was more strongly associated with a higher risk of type 2 diabetes, while air pollution from all other sources was more strongly associated with a higher risk of heart attack and stroke.
- Exposures to traffic-related air pollutants, noise, and a lack of green space were associated with increases in cholesterol and blood pressure, which are known contributors to cardiometabolic disease.
- This study shows that exposures to traffic-related air pollution, noise, and a lack of green space are associated with a higher risk of cardiometabolic diseases, but that air pollutant sources, presence of other risk factors, and exposure to multiple other factors influence those risks.

This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr. Ole Raaschou-Nielsen at the Danish Cancer Institute and his colleagues. The complete report, Cardiometabolic Health Effects of Air Pollution, Noise, Green Space, and Socioeconomic Status: The HERMES Study, ©2024 Health Effects Institute, can be downloaded from *www. healtheffects.org/publications*.



Statement Figure 1. The investigators assessed exposure to air pollution from local road traffic within 25 km ("local traffic") and all other sources of air pollution, including nonlocal road traffic ("other sources").

concentrations). They used Cox proportional hazards models to investigate the associations between these air pollutants and contextual factors and cardiometabolic diseases. They also used multivariate linear regression models to investigate the associations between these air pollutants and cardiometabolic biomarkers and blood pressure.

Dr. Raaschou-Nielsen and colleagues conducted several multiexposure analyses with mutual adjustment for air pollution, noise, and green space. The investigators estimated additive effects (i.e., absolute risk) to assess interactions between these environmental factors.

KEY RESULTS

Adults in the nationwide cohort were exposed to average air pollutant concentrations around or below the US National Ambient Air Quality Standards and new European standards for annual fine particulate matter and nitrogen dioxide concentrations. For all four traffic pollutants, Dr. Raaschou-Nielsen and colleagues observed higher mean concentrations from other sources compared to mean concentrations from local traffic sources. Correlations were moderate to high across pollutants ($r > 0.73$) and sources (r: 0.42 to 0.72), but low to moderate for the relationships between air pollutants and traffic noise (r: 0.19 to 0.53) and air pollutants and lack of green space (r: –0.07 to 0.40).

In the nationwide cohort, the investigators found that higher ambient (outdoor air) concentrations of each of the four air pollutants were associated with higher risks of each of the cardiometabolic disease outcomes, confirming findings from other studies. For example, a 5-μg/m^3 increase in annual average fine particulate matter was associated with a 12% higher risk of type 2 diabetes, a 15% higher risk of heart attack, and a 22% higher risk of stroke (**Statement Figure 2**).

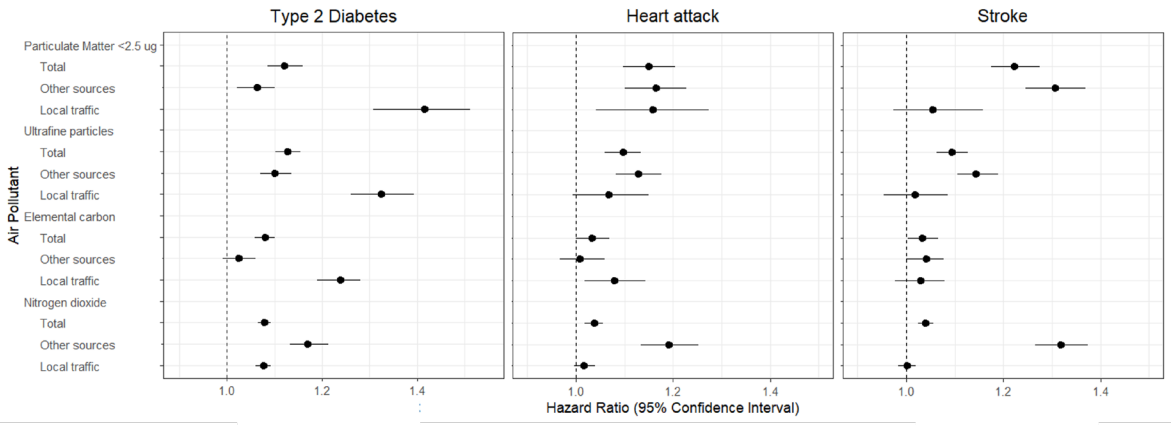
The investigators found that additionally adjusting for detailed lifestyle information beyond adjusting for multiple individual- and neighborhood-level registry-based sociodemographic factors did not meaningfully change the magnitude of the effects, presented as hazard ratios. Factors that did seem to have some modifying effect on cardiometabolic outcomes were gender, level of education, income, and experience of financial stress in the last 5 years. Furthermore, the air pollution source also had some effect on cardiometabolic outcomes: air pollution from local traffic sources was generally more strongly associated with a risk of type 2 diabetes, whereas air pollution from all other sources was more strongly associated with a risk of heart attack and stroke (Statement Figure 2).

The investigators observed consistent patterns of higher hazard ratios among single-exposure analyses than for the multiexposure analyses with mutual adjustment for air pollution, noise, and green space. In the multiexposure analyses, air pollution, noise, and a lack of green space all influenced the risk of type 2 diabetes and heart attack, whereas only air pollution and noise influenced the risk of stroke.

In the smaller Diet Cancer and Health – Next Generations cohort, Dr. Raaschou-Nielsen, and colleagues found that exposure to traffic-related air pollutants was associated with higher cholesterol and blood pressure, while associations with other biomarkers were mixed. Cholesterol and blood pressure are known contributors to cardiometabolic disease.

INTERPRETATION AND CONCLUSIONS

In summary, this study represents an important contribution to our knowledge about exposure to multiple, co-occurring environmental factors related to traffic concerning the risk of cardiometabolic diseases and their suspected biological mechanisms. This study found that higher levels of ambient traffic-related air pollutants, noise, and lack of access to residential green space are all individually associated with a higher risk of type 2 diabetes, heart attack, and stroke. However, the magnitude of the associations varied depending on the sources of air pollutants, exposure mixtures, and individual and neighborhood-level contextual factors. Additionally in this study, associations between exposure to individual pollutants and chronic cardiometabolic diseases were stronger compared to associations adjusted for other exposures. Finally, the study found associations between exposure to traffic-related air pollutants and increases in cholesterol and blood pressure, which are known contributors to cardiometabolic disease, supporting the primary findings.



Statement Figure 2. Associations between air pollutants per fixed unit increase and risk of type 2 diabetes, heart attack, and stroke among the Danish Nationwide Cohort. Air pollutant unit increase: particulate matter ≤2.5 µm in aerodynamic diameter per 5 µg/m^3, ultrafine particles per 10,000/cm^3, elemental carbon per 1 µg/m^3, and nitrogen dioxide per 10 µg/m^3.

The report presents important progress in better understanding exposure to multiple correlated traffic-related environmental factors in relation to cardiometabolic outcomes. The finding that air pollutants from local traffic sources were less strongly associated with increased risk of heart attack and stroke and more strongly associated with increased risk of type 2 diabetes than all other sources presents interesting differences that warrant further study to inform local regulations to protect public health. This study was unable to differentiate between sources of air pollution greater than 25 km away from the residence, and it is possible that the main contribution of all sources farther away could also be from traffic, yet from nonlocal sources. The ability to disentangle individual sources farther away would allow more direct comparisons and could facilitate further insights into the relative contribution of traffic and nontraffic sources at varying geospatial scales (i.e., near traffic vs. far traffic).

Other important contributions are the high-resolution spatiotemporal exposure assessment of noise and modeled ultrafine particle exposure — which is challenging and not readily available in many epidemiological studies — and the efforts toward modeling exposures to multiple environmental factors to improve understanding of the public health risks of joint exposures, better reflecting real-world exposure scenarios.

Ultimately, this study has documented that exposure to traffic-related air pollutants, noise, and a lack of green space is associated with an increased risk of type 2 diabetes, heart attack, and stroke, and the air pollutant sources, presence of other risk factors, and exposure to multiple other factors influence those risks.

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