HEI

STATEMENT

Synopsis of Research Report 207

HEALTH EFFECTS INSTITUTE

Air Quality Near a Freeway and an Urban Intersection

INTRODUCTION

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. However, exposure assessment is challenging because traffic-related air pollution is a complex mixture of many particulate and gaseous pollutants and is highly variable across locations and time. Developing accurate models of traffic-related air pollution for use in exposure assessment for epidemiological studies relies on understanding traffic activity and air flow at small spatial scales within cities.

Dr. H. Christopher Frey from North Carolina State University and his team proposed a study to explore how traffic activity metrics, land use parameters, and transport of pollutants influence near-road air pollutant concentrations. One question they posed was whether more detailed measurements of factors affecting near-road air pollutant levels can help with the development of models of concentrations of primary and secondary air pollutants within hundreds of meters of roads, and which of those measurements most improved the air quality model performance at different locations and times. They incorporated key concepts from various fields related to roads and air pollution, including transportation, mobile source emissions, traffic operations, and meteorology.

What This Study Adds

- The investigators conducted intensive measurement campaigns to explore detailed parameters that could potentially improve estimation of concentrations of six air pollutants (nitrogen oxides, nitrogen dioxide, ultrafine particles, black carbon, fine particles, and ozone) near a freeway and near an urban intersection.
- They developed parameters based on detailed real-time traffic intensity and novel traffic indices, real-world vehicle behavior (e.g., acceleration, breaking, and turning) and emissions, land use, and local meteorology.
- They developed statistical models of air pollutant concentrations based on these detailed parameters and output from a line source dispersion model reflecting traffic emissions on roads, meteorology, and other factors.
- Real-time local traffic, meteorological data, and dispersion model parameters contributed to statistical models of the six air pollutants near the freeway and urban intersection, with the parameters used in the final statistical models depending on the site and the pollutant.
- This study contributes a rich set of measurements on six air pollutants and shows that more detailed measurements can help with the development of enhanced near-road air quality models in specific situations.

APPROACH

The study aimed to explain variability in outdoor concentrations of six traffic-related air pollutants (nitrogen oxides, nitrogen dioxide, ultrafine particles, black carbon, fine particles, and ozone) at two sites near a heavily traveled freeway (140,000–145,000 vehicles per day) and a busy urban intersection (about 1,000 vehicles per day; Statement Figure). The investigators measured near-road air quality in both areas on selected days between July 2015 and May 2016. They used fixed and moveable monitors placed at various distances from traffic.

The investigators developed dispersion and statistical models of the measured air pollutants at both sites. They ran the U.S. Environmental Protection Agency's Research LINE source dispersion model (R-LINE) to test dispersion model output as inputs to the statistical models. They also tested many other potential statistical model inputs, including common inputs like distance to roads or land use, a new detailed assessment of land elevation and the built environment, and real-time local traffic and weather conditions. The study team compared different statistical models and selected as their final statistical models the simplest ones where the model predictions best matched the measurements (highest model R^2). The relative importance of all variables in the final statistical models was also reported.

This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr. H. Christopher Frey at North Carolina State University, Raleigh, North Carolina, and colleagues. This report was completed before Dr. Frey took a position with the U.S. Environmental Protection Agency. The complete report, *Characterizing Determinants of Near-Road Ambient Air Quality for an Urban Intersection and a Freeway Site*, © 2022 Health Effects Institute, can be obtained from HEI or our website (see next page).

Statement Figure. Aerial photography of the freeway and urban intersection sites. Yellow dots show locations of fixed-site air quality monitors. Imagery source: OpenStreetMap.

MAIN RESULTS AND INTERPRETATION

Frey and colleagues compiled a comprehensive database of traffic-related and land use variables from measurement campaigns in two study locations (a freeway and a busy urban intersection) in North Carolina. Air pollutant concentrations were higher near the freeway than the urban intersection and decreased with increasing distance from traffic at both sites. Statistical model performance varied by both pollutant and site. At the freeway site, the models had moderate performance for black carbon, moderate to good for ultrafine particles, nitric oxide, and nitrogen oxides, and good for fine particles; at the urban intersection site, the models had poor performance for fine particles, moderate for ultrafine particles, and good for ozone. Local and real-time weather and traffic were useful parameters in statistical models of some of the pollutants, especially near the freeway.

Some other new potential parameters explored by the investigators (e.g., built environment and elevation) were not included in the final models because they did not contribute to the model R^2, most likely because the study areas were very small. Inclusion of dispersion model parameters improved the statistical models of the pollutants most strongly related to traffic at the freeway site but were less useful for predicting fine particle concentration at the freeway site or any of the pollutants measured at the urban intersection site.

In its independent review of the study, the HEI Review Committee concurred with the investigators that this study demonstrated that detailed characterization can sometimes be useful for developing statistical models that estimate near-road air pollutant concentrations. The Committee concluded that strengths of the study were the detailed characterization of the study areas and incorporation of the perspectives from transportation and other fields into the study of near-road air quality, the use of novel traffic indices with distance-weighted traffic activity, and the use of dispersion model parameters as contributors to statistical models of air pollution. However, they noted that there was not enough variation in some of the new parameters to include them in the statistical models. Additionally, the two sites evaluated might not be representative of other locations, and it is unclear how the models for those two sites represent exposure of nearby populations to air pollution.

CONCLUSIONS

Although the statistical models developed for this study are specific to the locations where the measurements were made, the intense measurement campaigns and evaluations of the value of new parameters that described land use, emissions, and local weather in detail contributed to an ongoing discussion of which detailed measurements are most valuable for developing better near-road air quality models of traffic-related air pollutants. Additional studies — including some ongoing studies funded by HEI — will be needed to explore whether the effort put into developing more complex models of traffic-related air pollution will benefit exposure assessment for epidemiological studies.

HEALTH
EFFECTS
INSTITUTE

75 Federal Street, Suite 1400
Boston, MA 02110, USA
+1-617-488-2300 phone
+1-617-488-2335 fax
www.healtheffects.org