HEI STATEMENT

Synopsis of Research Report 236

Traffic-Related Air Pollution Associated with Restricted Fetal Growth

BACKGROUND

Traffic-related air pollution is a complex mixture of gases and particles emitted from the use of motor vehicles and includes a variety of pollutants such as nitrogen oxides, fine particulate matter, heavy metals, elemental carbon, and organic carbon. Sources include tailpipe emissions from vehicle exhaust and nontailpipe emissions such as tire and brake wear and resuspended road dust. Traffic-related air pollution is associated with numerous health effects, including adverse birth outcomes and slower fetal growth. However, many earlier studies of prenatal exposure lacked information on important confounding factors, including maternal smoking, body mass index, and traffic noise.

To evaluate the effects of prenatal exposure to traffic-related air pollution on fetal growth, HEI funded a study by Drs. Payam Dadvand and Jordi Sunyer of ISGlobal titled "Traffic-Related Air Pollution and Birth Weight: The Roles of Noise, Placental Function, Green Space, Physical Activity, and Socioeconomic Status (FRONTIER)" in response to HEI's *Request for Applications 17-1*: *Assessing Adverse Health Effects of Exposure to Traffic-Related Air Pollution, Noise, and Their Interactions with Socioeconomic Status*. Drs. Dadvand and Sunyer proposed to examine the effects of exposure to traffic-related air pollutants in pregnant women on fetal growth trajectories and birth weight in Barcelona, Spain, and to identify relevant windows of exposure during pregnancy. They planned to recruit a new cohort of 800 mother–infant pairs and evaluate the influence of noise, greenspace, stress, physical activity, and socioeconomic status, as well as the potential role of placental function.

APPROACH

Between 2018 and 2021, Dadvand, Sunyer, and colleagues recruited 1,080 women with singleton pregnancies during their first prenatal visit at about

What This Study Adds

- This study examined the effects of prenatal exposure to traffic-related air pollution on fetal growth and placental function in a newly established cohort of 1,080 women living in Barcelona, Spain.
- Exposure to nitrogen dioxide, black carbon, fine particles, and components of fine particles (copper, iron, and zinc) at home, at work, and during the commute was assessed using personal and home monitoring and land use regression and other modeling methods throughout pregnancy.
- The study found that increased exposure to all pollutants, except zinc, was associated with lower birth weight and increased odds of the infant being considered small for its gestation age. Changes in placental function suggest that fine particle exposure might affect fetal growth by increasing resistance to blood flow between the fetus and placenta.
- Results were similar after adjusting for traffic-related noise, or when evaluating personal home, workplace, and commute exposures separately, or when using land use regression models versus other exposure models. Future studies set in similar urban environments might consider simplifying exposure assessment measures when resources are limited.
- The most vulnerable periods of exposure were during the late first to early second trimesters and the late third trimester of pregnancy. The results confirm other research on birth outcomes and stress the importance of reducing air pollution exposures of pregnant women.

This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Drs. Payam Dadvand and Jordi Sunyer at the Barcelona Institute for Global Health (ISGlobal), Barcelona, Spain, and colleagues. Research Report 236 contains the detailed Investigators' Report and a Commentary on the study prepared by the HEI Review Committee.

12 weeks of gestation in Barcelona, Spain. They collected extensive information on participant health, lifestyle, and exposures from interviews, online surveys, and medical records. Fetal and newborn body size measurements were taken during two hospital visits at about 12 and 32 weeks of gestation and at two home visits shortly after the two hospital visits.

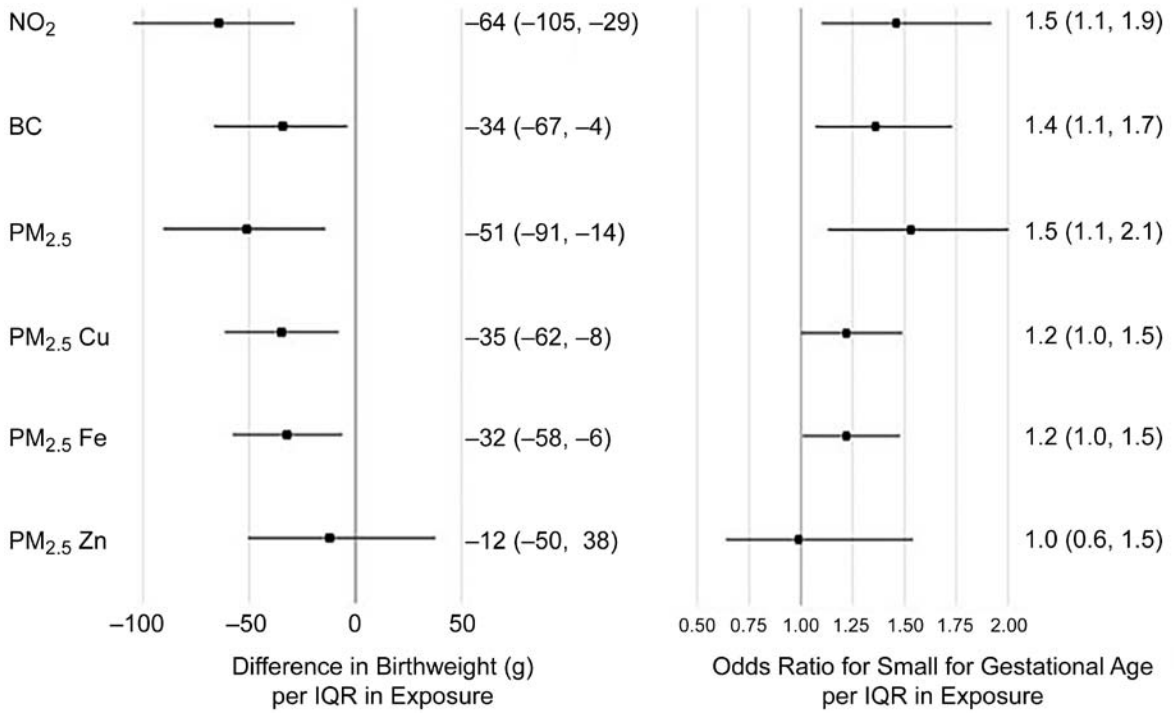
Dadvand and Sunyer conducted a comprehensive assessment to estimate exposure to traffic-related air pollutants. They used multiple exposure modeling methods (including land use regression models, dispersion modeling, and hybrid models), incorporated personal and home monitoring, and estimated time–activity patterns based on time spent at home, work, and commuting. For the entire pregnancy, they estimated exposure to nitrogen dioxide, black carbon, fine particles, and fine particle metal components, copper, iron, and zinc. They also estimated exposure to traffic-related noise, which might confound the association between traffic-related air pollution and fetal development.

They evaluated air pollution exposure in relation to birth weight measurements and whether the fetus was more susceptible to exposure during specific periods of gestation. They adjusted for numerous health and socioeconomic indicators, including body mass index and tobacco smoke exposure. Using mediation analysis, they also evaluated whether air pollution might affect fetal growth through changes in placental function, which was assessed by ultrasound measurements of blood flow.

KEY RESULTS

The final sample included 1,024 live births with complete data on exposure and outcomes. The median exposures during pregnancy for women who participated in the study were 37.2 μg/m^3 for nitrogen oxides and 17.1 μg/m^3 for fine particles. Their exposures to all pollutants were generally lowest at home and highest during commuting. The median traffic-related noise levels at home and work were about 65 decibels, which is a moderate noise level.

Higher exposure during pregnancy to outdoor concentrations of all pollutants except the zinc component of fine particles was associated with lower birth weight and increased odds of the baby being classified as small for their gestational age (**Statement Figure**). For context, the associations for nitrogen dioxide translate to a 64-g reduction in birth weight and 46% increased odds of being small for gestational age for every 15 μg/m^3 increase in exposure.



Statement Figure. Association between an interquartile range increase in traffic-related air pollutants and fetal growth based on the land use regression model exposure estimates. BC = black carbon; IQR = interquartile range.

The late first trimester to early second trimester was the most vulnerable window of exposure for all pollutants except black carbon and zinc. For black carbon, the late third trimester was the most vulnerable window. Findings were similar when traffic-related air pollutant exposure at home, at work, and during commuting were evaluated separately and when estimates from different exposure modeling methods were used, including estimates based only on residential address.

In models accounting for both traffic-related air pollution and noise exposure, similar associations were observed between the air pollutants and fetal growth outcomes. In those models, noise exposure itself was generally associated with lower birth weight, but the results were not statistically significant, suggesting that traffic noise was less important than traffic pollution.

Higher exposure to outdoor fine particle concentrations during pregnancy was associated with higher resistance to blood flow in the umbilical artery (which delivers blood between the fetus and placenta) during the third trimester of pregnancy. Dadvand and Sunyer estimated that this blood flow resistance explained 9.1% and 3.5% of the association of $PM_{2.5}$ with birth weight and being small for gestational age, respectively.

INTERPRETATION AND CONCLUSIONS

In its independent review of the study, the HEI Review Committee noted that the study implemented a high-quality design, including the recruitment of a new cohort of pregnant women, the documentation of detailed health and lifestyle information, and the repeated follow-up throughout pregnancy. Importantly, the investigators were able to adjust for smoking and body mass index, information that was lacking in many earlier studies and considered a major limitation in prior research. The results from this study will be useful in future systematic reviews and regulatory science assessments.

The Committee appreciated the comprehensive exposure assessment with information on noise, commuting patterns, and various modeling approaches. Findings were consistent, although not always statistically significant, across the various exposure assessment methods. The results suggested that exposure measurements based on outdoor concentrations at residential locations, as used in many epidemiological studies (thus without capturing work and commuting patterns), might capture exposures adequately.

Results in this study largely confirmed prior research demonstrating that traffic-related air pollutants are related to decreased fetal growth. Their effects on birth weight were smaller than the effects of active maternal smoking but were similar to the effects of environmental tobacco smoke exposure during pregnancy. This study adds to the limited literature on fine particle metal components; the association between iron and copper with lower birth weight confirms the role of metals in general, but needs further study, given that these are essential trace elements.

In summary, Dadvand, Sunyer, and colleagues observed that nitrogen dioxide, black carbon, fine particles, and iron and copper components of fine particles were associated with slower fetal growth. This study adds to the existing body of literature demonstrating that traffic-related air pollution during pregnancy can alter fetal development. The results stress the importance of reducing exposures to pregnant women. Future studies in similar urban environments might be able to simplify exposure assessments when resources are limited. Additional research is needed to clarify the effects of fine particle components.