Ambient Air Pollution and 16-Year Weight Change in African-American Women

Laura F. White, PhD,[1] Michael Jerrett, PhD,[2] Jeffrey Yu, MPH,[3] Julian D. Marshall, PhD,[4] Lynn Rosenberg, ScD,[3] Patricia F. Coogan, DsC[3]

Introduction: Substantial research has been dedicated to understanding the reasons for the dramatic rise in obesity rates in the U.S. in the last 2 decades. Animal studies and epidemiologic studies in children have suggested that air pollution might contribute to weight gain. This study investigates the association between ambient air pollution and weight gain over 16 years of follow-up (1995−2011) in a large cohort of African-American women in the U.S.

Methods: This study assessed associations of fine particulate matter, ozone, and nitrogen dioxide with weight gain using a linear random effects model. All analyses were conducted in 2015.

Results: There was no statistically significant association between weight change and fine particulate matter (mean weight change over 16 years per interquartile range [2.9 μg/m^3], 0.12 kg; 95% CI=−0.10, 0.35) and ozone (0.16 kg per interquartile range [6.7 ppb]; 95% CI=−0.11, 0.43). There was a small decrease in weight associated with nitrogen dioxide (−0.50 per interquartile range [9.7 ppb]; 95% CI=−0.77, −0.23).

Conclusions: The results do not provide support for an association of air pollution with weight gain in African-American adult women.
(Am J Prev Med 2016;51(4):e99–e105)

Introduction

Extensive research has focused on understanding the reasons for the substantial rise in U.S. obesity rates in the last several decades. Changes in energy intake and physical activity[1-3] have been identified as important causes.

Animal studies and epidemiologic studies in children have suggested that air pollution might be related to weight gain and obesity. Mouse models have shown an association of exposure to fine particulate matter ($PM_{2.5}$)[4-6] and benzo[a]pyrene[7] with metabolic dysfunction, including insulin resistance, inflammation, and central adiposity. Mice exposed to diesel exhaust prenatally had greater weight gain in adulthood.[8]

Increased prenatal exposure to polycyclic aromatic hydrocarbons was associated with higher BMI at age 5 years.[9] Several other studies in children and adolescents also suggest an effect of air pollution on BMI.[10] A cross-sectional study of total urinary polycyclic aromatic hydrocarbon metabolites in National Health and Nutrition Examination Survey participants aged 6−19 years found positive associations between polycyclic aromatic hydrocarbon levels and BMI, waist circumference, and obesity.[11] In two longitudinal cohorts of children in southern California, higher traffic density[12] and near-roadway pollution[13] were associated with higher BMI at age 18 years. In children enrolled in kindergarten or first grade in southern California, traffic pollution was associated with a 0.4-unit increase in annual BMI in those with the highest exposure relative to the lowest exposure.[14] The effect decreased as children neared adolescence. A small cross-sectional study of adults in Boston[15] found an association between serum leptin levels, a correlate with body fat content, and black carbon levels.

No epidemiologic studies of the relation of air pollution and weight have been conducted among adults.

The present analyses assess the association of levels of $PM_{2.5}$, nitrogen dioxide (NO_2), and ozone (O_3) with

From the [1]Department of Biostatistics, Boston University School of Public Health, Boston, Massachusetts; [2]Environmental Health Sciences, University of California, Los Angeles Fielding School of Public Health, Los Angeles, California; [3]Slone Epidemiology Center, Boston University, Boston, Massachusetts; and [4]Department of Civil, Environmental, and Geo- Engineering, University of Minnesota, Minneapolis, Minnesota

Address correspondence to: Laura F. White, PhD, Department of Biostatistics, Boston University School of Public Health, 801 Massachusetts Avenue, Boston MA 02118. E-mail: lfwhite@bu.edu.

0749-3797/$36.00
http://dx.doi.org/10.1016/j.amepre.2016.03.007

weight gain over 16 years of follow-up in the Black Women's Health Study (BWHS), a prospective study of African-American women from across the U.S. Previous BWHS studies found weight gain to be inversely associated with eating more fruits and vegetables and positively associated with eating more meat and fried foods,[16] lower levels of parental education and current education,[17] living in less dense versus more dense neighborhoods,[18] living in disadvantaged neighborhoods relative to wealthier neighborhoods,[19] and reporting more experiences of racism.[20]

Methods

Study Population

The BWHS was established in 1995, when 59,000 black women aged 21−69 years were recruited mainly from subscribers to *Essence* magazine, a general readership magazine targeted to black women.[21] The baseline questionnaire elicited information on demographic and lifestyle factors, reproductive history, and medical conditions. The cohort is followed biennially with mailed and web-based health questionnaires. Follow-up of the original cohort is complete for 88% of the potential person years through eight questionnaire cycles. The study protocol was approved by the IRB of Boston University School of Medicine. Participants indicate consent by completing and returning the questionnaires.

The present analyses included data from the baseline questionnaire (1995) and eight subsequent follow-up cycles (1997−2011). Women were excluded at baseline from the analytic cohort if they were aged >55 years (n=5,715), did not live in any of 56 metropolitan areas in the U.S. (n=5,302), had a history of cancer at baseline or during follow-up (n=5,249), reported baseline weight <80 pounds (36.32 kg) or >300 pounds (227 kg) (n=539), had a history of gastric bypass surgery (asked in 1999, n=181), had no follow-up (n=456), or had no pollutant data (n=5,458). Women were censored when they reached age 55 years (n=31,184 observations over follow-up), to limit follow-up to the ages at which most weight gain occurs in the BWHS.[16] Women were excluded from a cycle if they had reported giving birth within the past 2 years (n=7,612 follow-up observations), were missing information on SES (n=6,484), or did not provide information on their weight (n=67,850 follow-up observations). Overall, the 38,374 women contributed 144,580 observations over the 16-year period, with a median of four observations per woman (range, 1−8). Women excluded because they did not live in the 56 metro areas did not differ from the included women in terms of mean age, BMI, or prevalence of diabetes or hypertension at baseline.

Measures

Height, weight, and weight at age 18 years were reported at baseline and weight was updated on all follow-up questionnaires. A validation study among 115 participants found the Spearman correlation coefficient for self-reported weight (176 pounds) and of technician-measured weight (181 pounds) was 0.97 ($p<0.001$), and for self-reported height (64.4 inches) and technician-measured height (64.0 inches) was 0.93 ($p<0.001$).[22] Smoking history, alcohol consumption, parity, menopausal status, and hours/week spent in vigorous exercise (ascertained with: *On average, during the past year, how many hours each week did you spend in vigorous activity, such as basketball, swimming, running, aerobics?*) were obtained at baseline and updated on follow-up questionnaires. In 1995 and 2001, dietary data were obtained with a modification of the short-form Block−National Cancer Institute food frequency questionnaire.[23] Factor analysis of 35 food groups identified two dietary patterns: high intake of vegetables and fruit and high intake of meat and fried food.[16] Information was also obtained on household income (2003), educational attainment (1995, 2003), and perceptions and experiences of racism (1997) adapted from an instrument developed by Williams et al.[24] Two summary racism variables were created, an everyday racism score based on responses to five questions (e.g., *How often do people act as if they think you are not intelligent?*), and a lifetime racism score based on three questions about discrimination on the job, in housing, and by police.[20]

Residential addresses to which questionnaires were mailed from 1995 to 2009 were geocoded and linked to U.S. Census data at the block group level. A neighborhood SES score was created using factor analysis of seven Census variables (median household income; median housing value; percentage of households receiving interest, dividend, or net rental income; percentage of adults aged ≥25 years that completed college; percentage of families with children headed by a single woman; percentage of population living below the poverty line; and percentage African American), with higher scores indicating higher neighborhood SES.

Levels of $PM_{2.5}$ at participants' residential locations for 1999−2008 were estimated using a two-stage modeling strategy that incorporated land use regression (LUR) and Bayesian Maximum Entropy approaches.[25] Models with $PM_{2.5}$ measurements were developed from the Environmental Protection Agency's Air Quality System of 1,464 monitoring locations. LUR was used to construct a deterministic model that identified various measures of traffic, land use, and population as fixed predictors and then applied Bayesian Maximum Entropy methods to the set of monthly spatiotemporal residuals from the LUR model. Cross-validation based on leave-out samples of about 10% showed strong agreement between observed and predicted $PM_{2.5}$ levels (R^2=0.79). Annual NO_2 levels at BWHS participant residential locations at the block group level for 2000−2010 were estimated using a LUR model that incorporated fixed-site ambient NO_2 monitoring station data, satellite-derived estimates of ground-level NO_2 concentrations, and satellite- and ground-based land use data sets.[26] The LUR model was developed using measured annual mean concentrations at 369 monitoring stations and from 81,670 satellite-derived ground-level NO_2 estimates. The R^2 comparing measured with predicted NO_2 levels was 0.80. Ozone levels for the years 2007−2008 were estimated using the Environmental Protection Agency Models-3/Community Multiscale Air Quality model with a resolution of 12 km.[27] Estimates are made at the centroid of each Census tract in the coterminous U.S. daily estimates for 8-hour maximum levels were compiled into annual mean of daily peak concentrations. Validation analyses suggested that the model predicted ambient ozone concentrations well.[28] For example, correlations with held-out locations for daily predictions ranged from 0.61 to 0.86 at three sites in the eastern U.S.

For each pollutant, any given location was assigned the mean of all available values for that location (i.e., 1999−2008 for $PM_{2.5}$). At each questionnaire cycle, women were assigned the mean pollutant