Cartographer: Shannon Ball, PHPD Program
PH262: GIS for Public Health, Professor Stopka
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Highway Proximity, Ultrafine Particulate Matter Exposure, and Blood Pressure in Near-Highway Communities

Tufts University | School of Medicine

BACKGROUND

According to the 2010 Global Burden of Disease study, over 3.2 million deaths per year are attributable to ambient air pollution.[1] Of the components of air pollution, fine particulate matter ($PM_{2.5}$) ranks as the 13th leading cause of mortality worldwide, contributing to approximately 800,000 premature deaths per year.[2] One major source of particulate matter is automobile traffic.[2] Multiple studies have found associations between exposure to $PM_{2.5}$ and cardiovascular morbidity and mortality.[3,4,5]

While the health effects of fine particulate matter have been well explicated, much less is known about the effects of ultrafine particulate matter (UFP, $PM_{0.1}$). Acute studies have found that exposure to UFP induces cardiovascular changes, but few long-term studies have been conducted.[6,7]

The Community Assessment of Freeway Exposure and Health Study was designed to examine long-term exposure to UFP and cardiovascular disease (CVD) risk factors. A cross-sectional studies within CAFEH found an association between UFP and increased level of biomarkers of CVD.[8] In a similar but longitudinal analysis, our research team found that UFP was associated with increased blood pressure within the Boston Puerto Rican Health Study. Our objectives in this project are to explore the spatial relationship between highway proximity, UFP exposure, and blood pressure.

METHODS

CAFEH is a cross-sectional community based participatory research study of the relationship between highway related exposure to UFP and cardiovascular health. All participants in the CAFEH study were at least 40 years of age and were recruited from three near-highway neighborhoods in the Greater Boston Area (GBA). 418 study participants had the complete exposure and blood pressure data necessary for this analysis. Institutional review board approval was obtained, and all participants gave written informed consent.[9]

Demographics and Health Data

Household survey collected baseline demographic data, including age, sex, body mass index (BMI) and race/ethnicity. In addition, participants supplied time-activity information based on time spent in five micro-environments (inside home, outside home, school/work, commuting, and other). Our primary outcome variables were systolic blood pressure (SBP) and hypertension. For SBP, we averaged the measurements taken from the left and right arms. Participants were classified as hypertensive if they had a measured SBP above 140, a diastolic blood pressure (DBP) above 90, or if they reported taking medications to treat hypertension.

Exposure Assessment

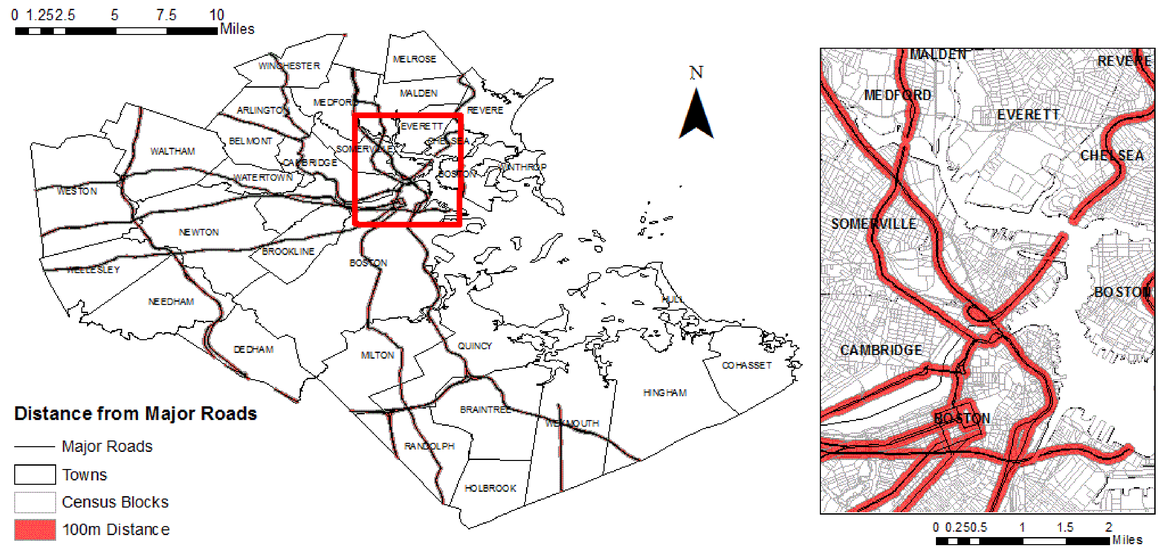
To obtain exposure measurements, a mobile monitoring platform was driven adjacent to the Interstate-93 (I-93) in Somerville between 2009 and 2010. The resulting air quality model was adjusted for temporal and spatial variables, allowing for the estimation of hourly ambient PNC at a 20-m resolution in near-highway neighborhoods. For each participant, the hourly residential PNC measurements were modified using particle filtration data and time-activity data provided by the participants. Time-activity adjusted (TAA)-PNC exposures were then averaged over the year prior to each participant's study visit to attain personal measures of exposure.

GIS Analysis

These maps used geocoded point data from CAFEH participants in Somerville, Malden, and Chinatown, in combination with 2010 census data and maps of towns and major roads from MassGIS. To protect the confidentiality of CAFEH participants, all identifiable outlier points were removed from the final maps. Figure 1 shows PNC exposure by participant. Although the available PNC exposure levels are adjusted for time-activity, they are still largely reflective of residential exposure. PNC exposure was categorized by quartiles calculated from PNC exposure data from the entire study population. Figure 2 shows cases of hypertension within the three communities. Figure 3 shows participant point data categorized by race, which was grouped into White, Asian, and Other.

UFP levels have been shown to decrease at 100m from major roads.[10] To estimate the population in the GBA living in this range, I selected all census blocks within 100m of major roads. I then used the statistics function to view both the total population living within these census blocks, and to calculate the percentage they represented of the total GBA population. In order to visually display this estimate in Figure 4, I created a 100m buffer around major roads within the GBA.

Figure 4. Areas Within 100m of Major Roads in the Greater Boston Area



RESULTS

Figure 1 demonstrates a clear positive relationship between highway proximity and levels of PNC exposure. Within Figure 2, however, there is no observable relationship between highway proximity and the number of cases of hypertension. This is reflective of the results of statistical analyses based on the same data, where in both unadjusted and adjusted models, we did not find a significant association between TAA-PNC and hypertension. Figure 3, displaying the racial demographics of our study population, demonstrates that the majority of the participants in Chinatown are Asian. When compared to Figure 1, Figure 3 also shows that the Asian population within our study had higher levels of PNC exposure than the White population. This observation, however, cannot be generalized to the greater population of the Boston area without further study. Figure 4 displays areas within 100m of major roads in the Greater Boston Area. Based on census block-level estimates, the total number of individuals living within 200m of a major road in the GBA is 289,576. This amounts to approximately 16% of the population within the GBA.

Figure 1. PNC Exposure

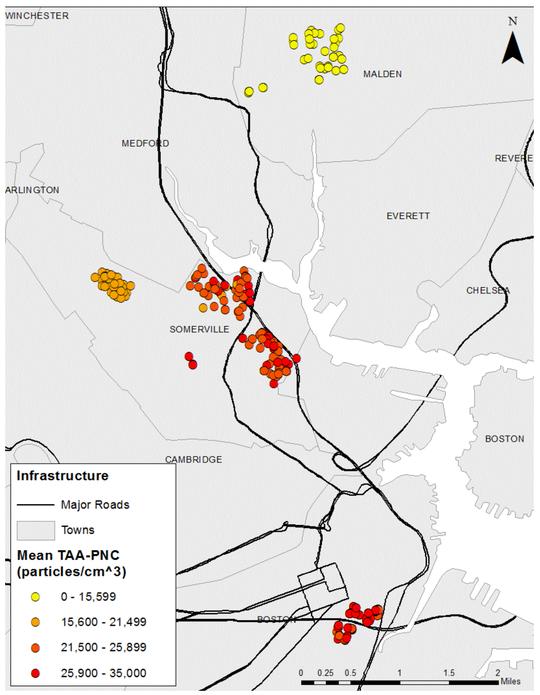


Figure 2. Cases of Hypertension

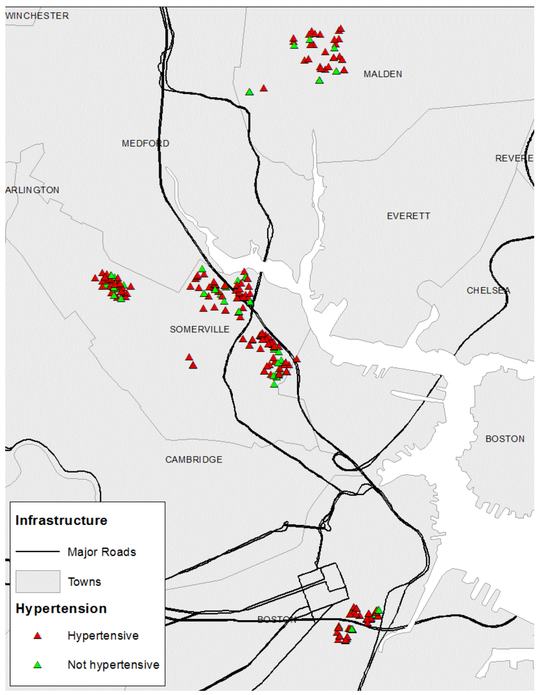
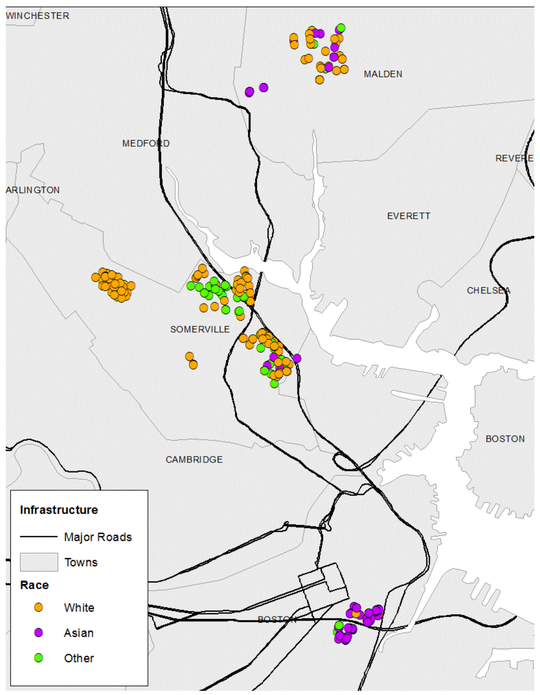


Figure 3. Racial Demographics



DISCUSSION

While Figure 1 shows a clear association between highway proximity and levels of PNC, no significant association was found between PNC exposure and measure of blood pressure in this data set. Although non-significant, the observed results are consistent with other cross-sectional studies performed within CAFEH. One weakness of this analysis is that while blood pressure is a predictor of hard clinic outcomes, it is itself a secondary outcome. In addition, this analysis is exploratory as opposed to hypothesis-driven, and we are thus underpowered to answer our research questions. Despite the lack of significance within our data, other studies suggest an association between UFP exposure and cardiovascular risk factors. Given that 16% of individuals in the GBA are potentially at risk from any health effects of UFP exposure, larger longitudinal studies should be conducted to study the impact of UFP exposure.

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