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Impact of transient truck and train traffic on ambient air and noise levels in underserved communities

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ABSTRACT

Traffic-related air and noise pollution on or near major roadways have been examined but these pollutants have not been extensively investigated away from major roadways in residential communities, especially in the United States. To evaluate the impact of trucks and trains passing nearby on air and noise pollution in residential areas during non-rush hours, we simultaneously measured concentrations of size-resolved airborne particulate matter (PM) and sound pressure levels as A-weighted equivalent (dBA) with frequencies in three underserved communities adjacent to industrial facilities in Houston, TX. We found that median concentrations for PM_1 (particle size ≤ 1 µm) and PM_{10} (particle size ≤ 10 µm) were highest when trucks passed by at sampling locations, followed by periods when trains passed by. PM_1 and PM_{10} concentrations were lowest at background (defined when there was no truck or train traffic near the monitoring location). Median $PM_{2.5}$ (particle size ≤ 2.5 µm) mass concentrations were 19.8 µg/m^3 (trains), 16.5 µg/m^3 (trucks), and 13.9 µg/m^3 (background). Short-term increases in noise were attributed to trains and trucks passing nearby as well. The median noise levels were the highest when trains passed by (66.7 dBA) followed by periods when trucks were in the vicinity of the monitoring locations (62.5 dBA); background levels were 58.2 dBA. The overall Spearman correlation coefficients between air and noise pollution were between 0.09 and 0.46. Hence, we recommend that both air pollutant and noise levels be concurrently evaluated for accurate exposure assessment related to traffic sources in residential communities.

1. Introduction

People living in urban environments may be concurrently exposed to air and noise pollution from various sources. This pollution is generated from passenger cars and trucks on roadways, industrial activities, and trains transporting goods to or from industrial facilities. Traffic-related airborne particulate matter (PM) levels are the highest on roadways and are elevated at locations near heavily trafficked roadways (Shu et al., 2014; Zhu et al., 2002). Moreover, ambient air PM is easily dispersed by wind and the levels of PM far (> 300 m) from major roadways have been measured to be 90% of those measured near the roadway (Zhu et al., 2002). Industrial sources are another important contributor to air pollution in urban areas. For example, Han et al. (2017) found that more than half of $PM_{2.5}$ in Baton Rouge, Louisiana was attributed to secondary sulfate and industrial emission sources. Another study determined that road dust and oil-refinery sources contributed more than 63% of PM_{10} in Houston, Texas (Bozlaker et al., 2013).

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Environmental noise in urban residential areas is positively associated with total traffic volume on roadways and the density of industrial facilities. For instance, King et al. (2016) found that the noise level measured on a sidewalk near a roadway in New York City was 41% higher than at a background site. Another study estimated that a traffic count of 40 vehicles/min increased the noise level by 20 dBA (A-weighted equivalent level for 16 h (7 AM to 11 PM)), compared with no traffic (Zuo et al., 2014). Elevations in traffic-related noise is heavily influenced by the number of trucks and buses (Ross et al., 2011). Furthermore, industrial sources also significantly increased noise levels in residential areas. In Toronto, Canada, an industrial facility area of 0.015 km^2 within 100 m of a residential area increased the measured noise level by approximately 10 dBA compared with similar communities without any industrial facilities within a 100-m radius (Zuo et al., 2014). Thus, communities near industrial sites may be seriously affected by traffic-related air and noise pollution which can contribute to adverse health outcomes.

Environmental exposure to air and noise pollution is an important risk factor for adverse cardiovascular outcomes. For example, cardiovascular disease (CVD) mortality and hospitalization are strongly associated with exposure to airborne PM and its constituents (Ito et al., 2011; Niu et al., 2013; Thurston et al., 2016). Ito et al. (2011) reported that $PM_{2.5}$ mass was significantly associated with an increase in CVD mortality of 1.0–2.0%. It is known that inhaled PM and its constituents induce systemic inflammation and oxidative stress resulting in a wide range of CVD effects (Gong et al., 2014; Roy et al., 2014; Weichenthal et al., 2014). Recent epidemiological studies about noise pollution in urban areas suggest that traffic-related noise pollution can increase the risk of cardiovascular disease (Barceló et al., 2016; Halonen et al., 2017; Vienneau et al., 2015). Barcelo et al. (2016) reported that noise exposure occurring throughout the day, evening, and nighttime was associated with a 2% increase in myocardial infarction mortality for males in Barcelona, Spain. Other studies showed that an increase of 5 dB in daytime traffic noise was significantly associated with a 3% increase in hypertension (Babisch, 2014; Babisch et al., 2012). The European Union established that noise pollution causes almost 8 million sleep disturbances and over 900,000 cases of hypertension each year in Europe (European Environment Agency, 2014).

Although noise consists of a wide range of frequencies, the impact of exposure to different noise frequencies is not well understood. When low frequency noise was the dominant component of sources, dBA measurements did not accurately represent the perceived loudness of noise (Leventhall, 2009). Another study found that perceived noise annoyance was associated with exposure to low-frequency noise (Torija and Flindell, 2015). Chang et al. (2011) observed that associations between noise exposure and risk for hypertension were strongest for low frequencies. Walker et al. (2016) also found that low frequency noise reduced the heart rate variability among 10 males in a controlled audio test room. Trucks and trains primarily generate low-frequency noise, which comes from their engines, contact with paved roads or rails when they are moving. Several studies have reported moderate correlation between traffic-related air pollutants and noise near major roadways (Allen et al., 2009; Shu et al., 2014) or street canyons (Can et al., 2011).

Urban residents typically spend more than 70% of their time in their homes (Peters et al., 2017; Su et al., 2015). Although air and noise pollution has been assessed adjacent to major roadways, the combined exposure to air and noise pollution in residential areas has not been well characterized. In Houston, where there is no formal zoning code, there are residential communities, which are located near industrial facilities and rail lines that generate truck and train traffic. These communities are often low-income and minority, and, hence share an unequal burden of air and noise pollution in the city. As articulated by the U.S. Environmental Protection Agency, environmental justice is achieved when all communities and people experience the same degree of protection from exposure to hazards (US EPA, 2018). Yet, a growing body of evidence suggests that health disparities among US communities have widened (Casey et al., 2017a; Grineski et al., 2017) and that underserved communities (defined as low-income, minority dominant, or less access to social infrastructure) are facing poorer environmental quality (Chakraborty et al., 2017; Gee and Payne-Sturges, 2004). Bell and Ebisu (2012) found that Non-white races have higher exposure to specific constituents of $PM_{2.5}$ and disparities in noise exposure have been reported as well (Carrier et al., 2016; Casey et al., 2017b). Houston neighborhoods widely vary in terms of sociodemographic, economic, and environmental quality because of different land-use patterns in and surrounding residential areas (Chakraborty et al., 2017; Collins et al., 2017). Thus, the objective of this study was to measure air and noise pollution in communities of mixed land use and to evaluate the transient impact of train and truck traffic on air and noise pollution in underserved communities.

2. Material and methods

2.1. Study area

The study neighborhoods were previously selected for a community-based participatory research (CBPR) project supported by the National Institute of Environmental Health Sciences (NIEHS) whose purpose is to measure and evaluate risks due to levels of metal air pollutants in four disadvantaged neighborhoods in Houston and apply public action plans to improve environmental health literacy and environmental quality in these communities. In our ancillary study, we conducted air and noise measurements in three of the four neighborhoods where trucks and trains routinely transport materials or commercial goods to and from the industrial facilities.

Within these neighborhoods, we selected sampling locations following these criteria: a residential area mostly consisting of private homes; at least one industrial facility within 400 m of where air and noise monitoring would occur; a rail track close by (within 100 m) but at least 500 m away from major highways. Fig. 1(a) shows the map of the three sampling locations selected for this study.

The indicators of demographics and environmental quality in these neighborhoods were obtained using the United States Census Bureau American Community Survey 2011–2015 Data (US Census Bureau, 2016) and the United States Environmental Protection Agency Environmental Justice Screening and Mapping Tool (EJSCREEN) Version 2016 (US EPA, 2016). EJSCREEN is an