Transportation Research Part D 49 (2016) 127–137

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

The cost of convenience; Air pollution and noise on freeway and arterial light rail station platforms in Los Angeles

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ARTICLE INFO

Article history:

Keywords:
Light rail transit
Particle count
Air pollution
Noise
Passenger exposure

ABSTRACT

Light rail transit (LRT) systems constitute one of the most sustainable public transportation modes and transit agencies have increasingly constructed LRT lines along the median of roadways to reduce land acquisition costs and traffic conflicts. Despite these conveniences, few studies have examined the air pollution and noise exposures for passengers on LRT station platforms within freeway or arterial medians. In response, we monitored particle number count (PNC) concentrations and noise levels on 17 station platforms in the Los Angeles metro system in summer 2012 and assessed differences between freeway and arterial platforms. We visited each station on average 7 times for approximately 19 min with two teams carrying a full set of instruments. As expected, impacts were higher on green line platforms in the center of a grade-separated freeway compared to blue line platforms in the center of an arterial due to being in close proximity to greater traffic volumes. Overall, freeway-arterial platform differences were 35,100 versus 20,000 particles/cm^3 for PNC and 83 versus 62 dBA for noise. This average noise intensity on green line platforms was four times that on blue line stations. We also found that PNC concentrations were significantly higher at open air monitoring platform positions compared to standing under a shade canopy (about 2000 particles/cm^3 higher), but that noise levels were significantly lower at open air positions compared to under canopy positions (about 3.2 dBA lower). Results identify important factors for transport planners to consider when locating and designing in-roadway LRT platforms.

1. Introduction

Providing reliable, safe, and comfortable public transport services could encourage a model shift away from car travel and help reduce congestion and vehicle-related air pollution (Bhattacharjee and Goetz, 2012; Houston et al., 2015). Light rail transit (LRT) systems constitute one of the most sustainable public transit modes given its high passenger capacity and low emissions of its electric vehicles. Although transit agencies have increasingly constructed LRT lines along the median

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http://dx.doi.org/10.1016/j.trd.2016.09.011
1361-9209/

of freeways or elevated above freeways to minimize traffic conflicts, increase train speeds and reduce land acquisition costs (Loukaitou-Sideris et al., 2013), our knowledge regarding air pollution and noise exposure for passengers on LRT platforms positioned above or within freeway or arterial medians remains limited.

Periods spent at above ground bus stops or stations could be associated with high levels of exposure to air pollution (Houston et al., 2013; Velasco et al., 2004) and elevated noise levels (Gershon et al., 2006) because of close proximity to traffic, and these hazards could be particularly troublesome for passengers on LRT freeway and arterial platforms. Even relatively brief periods spent in high traffic areas have been associated with a disproportionate amount of overall daily air pollution exposure (Dons et al., 2012; Fruin et al., 2008; Houston et al., 2013; King et al., 2016). Vehicle-related pollutants including fine particulate matter ($PM_{2.5}$) and particle number concentrations (PNC) are highly concentrated within and near high-traffic roadways (Fruin et al., 2008; Shu et al., 2014; Weber, 2009), and exposure to traffic, and related noise and air pollution, has been associated with adverse health effects including premature mortality, increased hospitalization, cardiac symptoms, lung cancer, hypertension, impaired respiratory health, and adverse pregnancy outcomes (Camusso and Pronello, 2016; Delfino, 2002; Lipfert and Wyzga, 2008). Previous studies have investigated the joint association of traffic-related air pollution and noise with human health, and have found interactive health effects of air pollution and noise (Beelen et al., 2009; Dadvand et al., 2014; Gan et al., 2012; Gehring et al., 2014; Huang et al., 2013). Previous studies have also examined the correlation between traffic-related air pollution and noise levels and indicate that PNC concentrations and noise are moderately correlated (Allen et al., 2009; Morelli et al., 2015), and that traffic-related noise is more correlated with count of smaller-sized particles (Can et al., 2011; Shu et al., 2014).

Most previous studies of air pollution in rail transit micro-environments have examined concentrations within trains and on underground subway platforms (Cheng et al., 2009; Colombi et al., 2013; Moreno et al., 2014; Xu et al., 2013). To our knowledge, only two previous sampling campaigns have measured air pollution concentrations for above ground rail transit stations. Aarnio et al. (2005) measured fine particulate matter ($PM_{2.5}$) in the Helsinki subway system and found that concentrations on underground subway stations were three to four times higher than those at above ground stations (Aarnio et al., 2005). Kam et al. (2011, 2013) measured PM_{10} and $PM_{2.5}$ concentrations within trains and on station platforms for both an underground metro red line (subway) and an above-ground metro gold line (LRT) in Los Angeles and found that PM_{10} and $PM_{2.5}$ concentrations on the subway's platforms and trains were about double those on LRT platforms and trains. Although they did not report significant differences in concentrations between the three LRT stations in a freeway median compared to other stations along the LRT line, they indicate that overall local traffic emissions and road dust were the main source of airborne PM on this line. To our knowledge, no previous study has examined PNC concentrations on LRT platforms.

Although several studies provide insights into noise levels within passenger trains and on underground subway platforms and the impact of station configuration and design on noise levels (Dinno et al., 2011; Gershon et al., 2006; Shimokura and Soeta, 2011), Loukaitou-Sideris and Schaffer (2014) provide the most extensive available assessment of noise levels of LRT station platforms. They found based on measurements on Los Angeles metro stations that levels on platforms in the freeway median were significantly greater than levels on non-freeway platforms, and that contextual factors such as the number, speed and type of vehicles nearby influenced noise levels. In addition, freeway stations located below the bridge of a crossing arterial were associated with higher levels (Loukaitou-Sideris and Schaffer, 2014).

The current study assessed transportation policies that promote the placement of LRT stations within freeway or arterial medians by monitoring air pollution and noise levels on platforms in the Los Angeles metro system. We compare PNC concentrations and noise levels on freeway and arterial LRT platforms and examine differences in exposure levels and correlations between impacts across platform positions (standing in open air, under a shade canopy, and under an arterial). We also use regression techniques to assess factors associated with exposure to platform PNC and noise exposure including adjacent roadway type (freeway versus arterial), platform position, meteorology, and time of day. Results provide important insights into the implications of station location and design and suggest that there is a cost of convenience when public transport planners place LRT platforms in the center of high-traffic roadways to reduce land acquisition costs and traffic conflicts.

2. Study design and methods

2.1. Sampling campaign

We monitored air pollution and noise levels on LRT station platforms of the green and blue metro lines in Los Angeles County (Fig. 1) on Tuesdays, Wednesdays and Thursdays from August 14 through September 5, 2012, during a 4-h period from morning to early afternoon for five non-consecutive weekdays (Table 1). Two teams of two staff researchers each carried a full set of instruments in portable cases, travelled together on the same light rail train, and exited the train at each station to conduct platform measurements concurrently. Seventeen station platforms were monitored multiple times and, depending on the train arrival and departure schedule, the average platform monitoring period was 19 min (Table 2). On average, we monitored each station 7 times. We obtained 4346 min of PNC measurements (on average 256 min per station) and 3298 min of noise measurements (on average 194 min per station). Staff kept a log of activities (i.e. station position, time on platform, etc.) and recorded pertinent microenvironment conditions (i.e. tobacco smoking, construction noise, etc.) that would potentially affect observed measurements.