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The uneven distribution of environmental burdens and benefits in Silicon Valley's backyard

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ABSTRACT

Inequalities in the exposure to environmental burdens and access to environmental benefits are an environmental justice concern for urban and regional environmental planning. Recent studies have assessed the exposure of different populations to a combination of environmental hazards through GIS-based Cumulative Environmental Impact Assessments (CEIA). The contribution of this study is the development of a CEIA, which incorporates the distance-based impact of transportation, the cumulative impact of environmental hazards, and access to environmental benefits for Santa Clara County (SCC), a highly diverse and rapidly developing region also known as 'Silicon Valley'. Our results show that social vulnerability, cumulative environmental hazards, and environmental benefits exhibit distinct spatial patterns in SCC. High environmental hazard values are found along freeway and railroad corridors with substantial industrial legacies, while environmental benefit scores are generally higher in the suburban periphery. Correlations indicate that socially vulnerable populations in SCC are predominantly hispanic and are more likely to be exposed to environmental hazards, while white and wealthier populations are more likely to have access to environmental benefits. The results from this study may serve to develop community-based initiatives for neighborhood improvement and environmental-justice-based regional planning and public health policy reform.

Introduction

The links between exposure to environmental pollutants and public health outcomes (Bernstein et al., 2004; Brunekreef & Holgate, 2002; Kampa & Castanas, 2008), and the unequal distribution of environmental hazards as a key environmental justice concern have been recognized by researchers, activists, and government agencies in the U.S. (Bullard, 2000; EPA 2013; Laumbach & Kipen, 2012; Mohai, Pellow, & Roberts, 2009; Morello-Frosch, Pastor, Porras, & Sadd, 2002). Sources of environmental hazards include releases from highly toxic hazardous waste or superfund sites, as well as the collective effects of the generally lower-toxicity and non-point source emissions from standard modern–day activities, such as transportation, and agriculture. Air pollution, in particular, is an important independent environmental risk factor linked to respiratory and cardiovascular diseases, reduced birth weight, cancer, premature death and learning difficulties (EPA, 2011; Rosenbaum, 2013), and effects of air pollution on health have been identified for very low levels of exposure (Brunekreef & Holgate, 2002).

People of color and economically disadvantaged communities, often experience disproportionate exposure to environmental hazards and their associated negative health outcomes (Bullard, 1996; Mohai et al., 2009; Morello-Frosch et al., 2002; Morello-Frosch, Zuk, Jerrett, Shamasunder, & Kyle, 2011; O'Neill et al., 2003; Pastor, Sadd, & Hipp, 2001; Pastor, Sadd, & Morello-Frosch, 2004). Brown et al. (2003) found higher rates of asthma, linked to transportation sources (Rosenbaum, 2013), among low income and racial minority populations in US cities. Garcia et al. (2013) cited government reports estimating 2400 premature deaths and 62,000 cases of asthma among residents living close to California's marine ports, rail yards, and connecting highways. Maantay (2007) documents that New York City residents living within close proximity of noxious land uses were up to 66% more likely to be hospitalized for asthma, 30% more likely to be poor, and 13% more likely to be a person of color. In minority and low-income communities, the stressors associated with low social and economic status, may

Abbreviations: SCC, Santa Clara County; CEIA, Cumulative Environmental Impact Assessment; SVI, Social Vulnerability Index; EHI, Environmental Hazards Index; EBI, Environmental Benefits Index; CEI, Cumulative Environmental Index.

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compound the effects of environmental hazard exposure in minority and low-income communities, and may be linked to the persistence of health disparities (Mohai et al., 2009; O'Neill et al., 2003).

The documentation of uneven exposures to environmental toxics has spurred the development of cumulative impact screening methodologies by researchers (Morello-Frosch, Pastor, & Sadd, 2001) and environmental regulators (Cal EPA, 2014). Almost exclusively, these are based on spatial analysis using Geographic Information Systems (GIS). Early approaches (Krieg & Faber, 2004; Morello-Frosch et al., 2001; Pastor, Sadd, & Morello-Frosch, 2004) focused on individual types of environmental burdens. More recently, it has been recognized that assessments based on single sources have failed to account for the multiple environmental and social stressors which may act synergistically to harm health (Corburn, 2005; Morello-Frosch et al. 2002; Sadd, Pastor, Morello-Frosch, Scoggins, & Jesdale, 2011). In response, government agencies in collaboration with academic partners (CARB, 2010; OEHHA, 2010; Pastor, Morello-Frosch, & Sadd, 2010; Sadd et al., 2011) have developed expanded screening tools for cumulative environmental impacts and corresponding frameworks to assess the results. Cumulative environmental impacts represent the combined public health exposures of environmental effects stemming from the sum of all emissions and discharges from all sources in a given geographic area (OEHHA, 2010). Cumulative environmental impact assessments (CEIAs) analyze the complex relationships between the distribution and characteristics of environmental pollutants and diverse populations. All releases are integrated, whether they occur routinely or accidently, sensitive populations and socio-economic factors are considered (OEHHA, 2010), and spatial analysis is used to link human health exposures and sometimes health outcomes to land use patterns. However, causally linking environmental hazards with adverse health effects is problematic, due to the temporal and spatial distribution of multiple emissions sources, their varying toxicity, and the exposure of these to diverse populations (Morello-Frosch et al., 2001). Instead, CEIAs are used to determine a relative impact based on distance from an emission source.

CEIA work has been driven by concerns about the disproportionate effects of health outcomes associated with air pollution and to corresponding mandates by recent legislation (i.e. the California's Global Warming Solutions Act (AB32) of 2006). The assessments result in the identification of low-income, highly impacted census tracts in each district. In this context, Sadd et al. (2011) and the California Air Resources Board (CARB) present an environmental justice screening method (EJSM) that examines local patterns of social and environmental stressors relying on publicly available data taking into account 23 indicator metrics. While the study by Sadd et al. is one of the most comprehensive in terms of social indicators and environmental factors, it does not explicitly incorporate the pollution and noise effects of freeways, pesticide applications, or the environmental benefits of green spaces. On the national scale, the CEIA tool by the U.S. EPA (EJSEAT 2014) uses 18 cumulative impact metrics to identify areas of disproportionately high environmental burdens nationwide. At the time of this writing, EJSEAT is under review and developed for internal use only, and thus of limited value for community-based CEIAs by other researchers. Due to the requirement for national consistency, EJSEAT relies mainly on EPA-generated state- and nationwide data, disregarding neighborhood-scale variations. In April 2014, the California EPA released the first public draft of EnviroScreen2.0, a California statewide CEIA that assigns environmental health impact scores per census tract (Cal EPA-OEHA, 2014). EnvironScreen2.0 uses a weighting system for water and air pollutants, social stressors and health indicators, and notably, associates a rating of toxicity for each source. Results indicate large cumulative environmental burdens in Central Valley agricultural communities and large discrepancies in cumulative scores in urbanized regions.

To date, potentially important components, such as environmental benefits and the proximity to busy roadways, have not been integrated into CEIAs. Green spaces accessible to urban populations provide a range of ecosystem services and contribute to the quality of life, especially in terms of health outcomes. Green spaces exhibit great diversity as measured by size, vegetation cover, species richness, environmental quality, and facility services (Dahmann, Wolch, Joassart-Marcelli, Reynolds, & Jerrett, 2010; Fuller & Gaston, 2009; Wolch, Byrne, & Newell, 2014), and thus in the quantity and quality of ecosystem services and benefits they provide. Ecosystem services include air and water filtration, pollution removal, storm water infiltration, groundwater renewal, noise attenuation, cooler air temperatures, and the production of food (Nowak, Crane, & Stevens, 2006; Roy, Byrne, & Pickering, 2012; Wolch et al., 2014). As the benefits of urban green spaces on public health have been documented (Dai, 2011; Jennings, Johnson-Gaither, & Gragg, 2012), their uneven distribution has been recognized as an environmental justice issue (Abercrombie et al., 2008; Jennings et al., 2012).

A large number of studies have documented linkages between the proximity to parks, attractiveness of a park (trees, less traffic) and physical activity (i.e. Evenson, Wen, Hillier, & Cohen, 2013; Giles-Corti et al., 2005; Gordon-Larsen, Nelson, Page, & Popkin, 2006; McCormack, Rock, Toohey, & Hignell, 2010). In addition, urban parks and green spaces reduce stress, allow residents to encounter plants and animals, recuperate, and experience solitude. Children's development is supported and behavioral problems are reduced through access to parks and open spaces (Kahn & Kellert, 2002). By contrast, increased walking and cycling in neighborhoods with high air pollution levels increase the residents' exposure (de Nazelle, Rodriguez, & Crawford-Brown, 2009), and a lack of access to parks and open space has been recognized as negatively affecting the health outcomes in a community (OEHHA, 2010). Despite this growing literature on the importance of parks and open spaces for community well-being and studies correlating socio-demographic variables with proximity to parks (Boone, Buckley, Grove, & Sister, 2009; Kabisch & Haase, 2014; Wen, Zhang, Harris, Holt, & Croft, 2013), there is no consensus about how to measure green space access (Sister, Wolch, & Wilson, 2010), quantify the qualities of a park (Cohen, Potchter, & Schnell, 2014), or how to assess the effects of very heterogeneous parks and green spaces on a neighborhood.

Air pollution from transportation and small-area sources has been found to match or exceed that of large-facility pollution emissions in many urban settings (Morello-Frosch et al., 2001). Busy roadways are emitters of air and noise pollution, and they decrease walkability, neighborhood cohesion, safety for children, and plant and animal diversity in the surrounding areas. Although the emissions and the noise impact from roads and freeways has been shown to inversely vary with distance and have been linked to adverse health effects, their distance-based impact thus far has not been explicitly incorporated into CEIAs. Instead, the impact of traffic pollutants is usually gleaned from interpolated measurements or regional models in relationship to socially vulnerable populations (Morello-Frosch et al., 2001; Pastor et al., 2010; Sadd et al., 2011; Su et al., 2009). At the census tract and neighborhood scale, this approach is hindered by the limited number of government monitoring stations. In addition, prior efforts have focused on the regional to national scale, with a particular emphasis on southern California, while the local, neighborhood scale is the primary concern for EJ advocates, land-use planning decisions, and