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Race, deprivation, and immigrant isolation: The spatial demography of air-toxic clusters in the continental United States

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ABSTRACT

This article contributes to environmental inequality outcomes research on the spatial and demographic factors associated with cumulative air-toxic health risks at multiple geographic scales across the United States. It employs a rigorous spatial cluster analysis of census tract-level 2005 estimated lifetime cancer risk (LCR) of ambient air-toxic emissions from stationary (e.g., facility) and mobile (e.g., vehicular) sources to locate spatial clusters of air-toxic LCR risk in the continental United States. It then tests intersectional environmental inequality hypotheses on the predictors of tract presence in air-toxic LCR clusters with tract-level principal component factor measures of economic deprivation by race and immigrant status. Logistic regression analyses show that net of controls, isolated Latino immigrant-economic deprivation is the strongest positive demographic predictor of tract presence in air-toxic LCR clusters, followed by black-economic deprivation and isolated Asian/Pacific Islander immigrant-economic deprivation. Findings suggest scholarly and practical implications for future research, advocacy, and policy.

1. Introduction

Sociological research on environmental inequality has developed over the last 40 years to illuminate the factors that contribute to disparities in the social and spatial distribution of environmental health threats in the United States (Mohai et al., 2009). Despite the volumes of valuable insights this research has produced, there exist three important research gaps in the literature that may hinder further scholarly and regulatory understandings of the demographic and spatial dynamics of cumulative environmental health risks from air-toxic emissions in the U.S. The first gap has to do with our understanding of the demographic dynamics of environmental inequality outcomes. Resembling the broader "race-versus-class" debate in sociology (Massey and Denton, 1993; Wilson, 1978, 1987, 1996), this line of inquiry has contemplated and illuminated how and under what circumstances local racial or class composition are associated with proximity to one or more environmental hazards (e.g., Anderton et al., 1994; Downey and Hawkins, 2008; Mohai and Saha, 2007; Smith, 2007, 2009). However, we know remarkably little about the interaction between such factors and unequal patterns of immigrant incorporation in an era of rapid Asian and Latino immigrant settlement in the U.S. (Logan and Zhang, 2010).

Second, the literature has developed new ways to assess the unequal "cumulative impact" and environmental health risks associated with toxic emissions and other environmental hazards at the local level. For example, scholars are now developing innovative assessments of cumulative impact by analyzing the spatial concentration of multiple environmentally

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harmful land uses (Downey, 2006; Elliott and Frickel, 2013; Sicotte, 2010) and the dispersion of toxicity-weighted health risks of air emissions from stationary (e.g., factories) and mobile sources (e.g., vehicles) (Chakraborty, 2009; Gilbert and Chakraborty, 2011; Pastor et al., 2005; Sadd et al., 2011; Su et al., 2009). However, these innovations are generally limited to case studies of cities, metropolitan areas, or states in an effort to maximize internal validity and develop causal explanations regarding the local and regional production of environmental inequality. Nonetheless, a research gap remains in our understanding of national patterns of concentrated cumulative health risks from air-toxic emissions from stationary *and* mobile sources that are of increasing concern in the fields of environmental health and justice across the United States (Liévanos, 2012; Turaga et al., 2011; Zhu et al., 2008).

The third research gap concerns the spatial dynamics of environmental inequality outcomes. Corresponding with the broader "spatial turn" in the social sciences (Goodchild et al., 2000), recent research has advanced various "distance-based" methods to better capture community proximity to environmental health threats (Mohai and Saha, 2007). Related research has "scaled-up" the analytical lens by documenting significant associations between racial residential segregation and unequal cumulative health risks of air-toxic emissions from stationary sources (Downey, 2007; Downey et al., 2008) and stationary and mobile sources (Morello-Frosch and Jesdale, 2006) within metropolitan areas across the U.S. Still, these studies might be sensitive to "edge effects" (Dubin, 2009): the influence on spatial dynamics within local contexts by spatial processes occurring outside such boundaries. An alternative middle ground approach might start with census tract-level cumulative air-toxic health risk data and explore how patterns of spatial dispersion and clustering emanate from focal tracts out to various geographic extents irrespective of metropolitan boundaries.

This article employs a spatial–demographic approach informed by relevant sociological theory, environmental inequality studies, and recent innovations in spatial pattern analysis to address the three gaps in previous research outlined above. As advanced by Voss (2007:458), spatial demography is "the formal demographic study of areal aggregates, i.e., of demographic attributes aggregated to some level within a geographic hierarchy." This study is guided by two primary research questions: Where are air-toxic health risk clusters in the United States? What is the relationship between the probability of tract presence within air-toxic health risk clusters and tract race, class, and immigrant status?

The research questions are addressed by first drawing on tract-level 2005 U.S. Environmental Protection Agency (EPA) National Air Toxic Assessment (U.S. EPA, 2011) data on estimated lifetime cancer risk (LCR) of cumulative ambient air-toxic emissions from stationary and mobile sources across the continental U.S. These data are analyzed with geographic information systems (GIS) and procedures of spatial cluster analysis that have yet to be incorporated in sociological research despite attention to analogous forms of spatial clustering (e.g., Logan et al., 2002). This portion of the study thus has broader implications for spatially-oriented social science research in addition to its more substantive insights regarding environmental inequality and the spatial clustering of cumulative air-toxic health risk across the U.S. Second, it test intersectional environmental inequality hypotheses on the relationship between race, class, and immigrant status with logistic regression analyses and data from the 2000 U.S. Census of population and housing and the U.S. Geological Survey 1999 road and 2001 land cover datasets. Results show that net of controls, the isolated Latino immigrant-economic deprivation factor variable is the strongest positive demographic predictor of tract presence in air-toxic LCR clusters, followed by black-economic deprivation and isolated Asian/Pacific Islander immigrant-economic deprivation.

The remainder of this paper is organized as follows. First, it briefly reviews the literature on the spatial and demographic dimensions of environmental inequality outcomes then derives testable hypotheses from that literature to guide the analysis. A description of the data and methods used is followed with a review of the study's findings and discussion of its scholarly and practical implications.

2. Literature review

2.1. Theorizing the spatial dimensions of environmental inequality outcomes

Two general theoretical frameworks can inform the study of the spatial dimensions of environmental inequality outcomes. The first may be called spatial interdependence theory, which views space as *continuous*. Within this view, spatial sub-units (e.g., census tracts) are understood as interrelated parts of the broader spatial context of which they belong (e.g., proximate tracts and metropolitan areas). As Morenoff (2003) elaborates, one spatial unit of analysis "may be reinforced, exacerbated, moderated, or counteracted by the characteristics of adjacent and proximate [units]" (pp. 984–5). However, he makes an important distinction between processes of spatial diffusion and spatial externalities. Diffusion "describes a spatial process intrinsic to a given outcome (e.g., a contagious disease) such that once the outcome occurs in a geographic area it is also likely to occur in surrounding areas" (Morenoff, 2003:985; see also Tolnay et al., 1996). In contrast, spatial externalities are said to occur when a spatial unit is affected by processes occurring across spatial units in the extra local environment rather than by processes internal to the spatial unit (Morenoff, 2003). Regardless of the form of spatial interdependence, a key principle within this framework is that of "distance-decay," or the phenomenon whereby the interdependence between a focal spatial sub-unit and its attributes on neighboring sub-units and their attributes declines to zero as distance increases from the focal sub-unit (Downey, 2006; Tobler, 1970). The nature of distance-decaying spatial interdependencies between spatial sub-units thus highlight the salience of edge effects, as defined above, and as illustrated in the analysis below.