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The burden of carcinogenic air toxics among Asian Americans in four US metro areas

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Abstract

This study investigated disparities in residential exposure to carcinogenic air pollutants among Asian Americans, including Asian ancestry subgroups, in four US metro areas with high proportions of Asians, i.e., Honolulu, Los Angeles, San Francisco Bay Area, and Seattle. Generalized estimating equations adjusting for socioeconomic status, population density and clustering show that a greater proportion of Asian Americans in census tracts was associated with significantly greater health risk in all four metro areas. Intracategorical disparities were uncovered for Asian ancestry. A greater proportion Korean was positively associated with risk in four metro areas; greater proportion Chinese and Filipino were positively associated with risk in three of the four metro areas. While Asian Americans are infrequently examined in environmental justice research, these results demonstrate that Asian Americans experience substantial distributional environmental injustices in these four metro areas and that ancestry is an important dimension of intracategorical complexity.

Keywords

Asian Americans; environmental justice; hazardous air pollutants (HAPs)

INTRODUCTION

In metro areas across the US, Black and Latino/a populations tend to experience greater exposure to health-harming environmental toxics than Whites (Downey 2006a, 2006b, 2007; Mohai, Pellow, and Roberts 2009). A focus on Asian Americans has been nascent in the environmental justice (EJ) literature in recent years (Grineski, Collins, and Morales 2017), but there are competing hypotheses regarding the extent of Asian American environmental inequalities. More complete analyses of environmental injustices borne by Asian Americans are warranted because Asian Americans are the fastest growing racial/ethnic group in the US

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(Pew Research Center 2016), and they experience health disparities linked to environmental conditions (Chen 2005).

This paper tests competing hypotheses about environmental health risks for Asian Americans and explores intracategorical environmental inequalities for Asian Americans based on country of ancestral origin. We conduct parallel generalized estimating equation (GEE) analyses predicting residential lifetime cancer risks (LCR) from hazardous air pollutants (HAPs) in four metro areas with sizable Asian American populations—Honolulu, HI, the San Francisco Bay Area, CA, Los Angeles, CA, and Seattle, WA—at the census tract level using the 2011 National Air Toxics Assessment. Shifting focus from the nationwide assessment featured in Grineski, Collins and Morales (2017) to these four prominent Asian American metropolitan areas in the US West, which have been studied to varying extents in the environmental inequality literature, our analysis enables assessment of Asian Americans' disproportionate risks to carcinogenic HAPs as well as risk disparities within this heterogeneous population based on membership in ancestral subgroups.

This focus on ancestry contributes to a growing body of research that advances an "intracategorical" approach to studying the complexity of neighborhood-level environmental inequality outcomes associated with the spatial concentration of different sub-populations of racialized groups in the US. The theoretical origins of this approach lie in the work of intersectionality scholars, particularly Leslie McCall (2005): 1774), who defined "intracategorical" complexity studies as those that "focus on particular social groups at neglected points of intersection [within a social group]... in order to reveal the complexity of lived experience within such groups." This approach differs from analyses of "intercategorical" complexity, understood as the "relationships of inequality among social groups and changing configurations of inequality along multiple and conflicting dimensions" (McCall 2005:1773). The intercategorical focus is represented in many environmental inequality outcomes studies (Liévanos 2015; Liévanos 2017; Downey and Hawkins 2008). Collins et al. (2011) was the first quantitative study to explicitly apply the intracategorical analytical framework to the unequal distribution of carcinogenic hazardous air pollutants associated with the spatial concentration of different sub-populations of Latino/as in El Paso, Texas. This theme was carried through to other studies (Grineski, Collins, and Chakraborty 2013; Grineski et al. 2016; Chakraborty, Grineski, and Collins 2016), focused on Latino/as in different US cities and to a national study of the US Asian population (Grineski, Collins, and Morales 2017).

Asian Americans are an important group to examine in studies of EJ from both intercategorical and intracategorical perspectives. There are over 18 million Asian Americans in the US, comprising 6% of the total population. Three-quarters of adults who identify as being of Asian racial background in the US are foreign-born (Pew Research Center 2016). Asian Americans have the highest incomes and levels of education of all racial groups in the US (Pew Research Center 2016). Half of Asian American adults have a college degree compared to one-quarter of all Americans, and the median annual household income among Asian Americans is $66,000 compared to the national average of $49,800 (Pew Research Center 2016). These statistics underscore why Asian Americans are often called the "model minority" (McGowan and Lindgren 2006). Despite this designation, they still experience health disparities relative to Whites (Huang et al. 2012; Ibaraki, Hall, and Sabin 2014). For example, while cancer is the leading cause of death for Asian Americans (Chen 2005; CDC 2010), physicians recommend preventative cancer screenings to Asian patients at a substantially lower rate than other groups, in part because of the model minority stereotype (Ibaraki, Hall, and Sabin 2014).

ASIAN AMERICANS AND ENVIRONMENTAL INEQUALITY: CURRENT KNOWLEDGE, COMPETING HYPOTHESES

When seeking to explain racial/ethnic patterns of environmental inequality intercategorically, two theses are particularly relevant to this study. First, the racial income inequality thesis asserts that socioeconomic status explains racial differences in exposure to environmental hazards (Oakes, Anderton, and Anderson 1996). The premise is that since property values and rents are lower in environmentally hazardous neighborhoods, those locales are more financially accessible to low income populations, which are disproportionately composed of racial/ethnic minority individuals, and undesirable to more affluent populations, which are disproportionately White (Crowder and Downey 2010). Extending this logic, Asians are presumably more able to avoid polluted neighborhoods, since, like Whites, they have relatively high levels of income and education; this assertion gives rise to our first hypothesis:

H_1 Asian Americans will experience similar environmental risks relative to Whites.

Some previous studies provide support for this hypothesis. In a nationally representative study, researchers found that while Asian Americans were less likely than Whites to live near industrial facilities, the significance of this finding attenuated with the addition of socioeconomic status, as predicted by the racial income inequality thesis (Oakes, Anderton, and Anderson 1996), so that risk levels were not significantly different. Jones and colleagues (2014) found that Chinese Americans had similar $PM_{2.5}$ and NO_x levels to Whites in Los Angeles, but lower $PM_{2.5}$ and NO_x exposures than Whites in Chicago, after adjustments for income and other variables. They also determined that living in neighborhoods where Asian Americans were underrepresented or overrepresented was not associated with $PM_{2.5}$ or NO_x concentrations (Jones et al. 2014). This suggests the absence environmental inequalities related to Asian American composition in neighborhoods of these cities.

A second explanation for environmental inequalities of relevance for a study of Asian Americans is the racial residential discrimination thesis (Bullard 1993). This thesis asserts that minority groups are disproportionately exposed to environmental hazards because of historical and contemporary racial discrimination that has marginalized minorities within polluted neighborhoods (Pais, Crowder, and Downey 2014). This thesis is supported by findings indicating that racial inequalities in exposure persist when controlling for socioeconomic status (Crowder and Downey 2010; Ringquist 2005).

When Asian Americans are viewed as a disadvantaged minority group relative to Whites, this supports the expectation that they will face environmental inequalities. Indeed, a body of research problematizes the model minority label as applied to Asian Americans. There is persistent racial subordination of Asian Americans in US society, which is reflected in the ‘perpetual foreigner’ trope (Kim 1999; Xu and Lee, 2013). Additionally, national income comparisons are misleading due to the urban nature of the Asian American population and the fact that there are higher concentrations of Whites than Asians living in rural areas where incomes and costs of living are lower (Fong 2008). And, while Asian Americans do have high levels of educational attainment, they earn less than their White counterparts at each level of education (Fong 2008), and do as poorly as other racial/ethnic groups in gaining management and executive jobs (Chin 2016). Given this evidence, our second and competing hypothesis is:

H_2: Asian Americans will experience greater environmental risks than Whites.

In-line with the second hypothesis, risk for Asian Americans was first observed in the landmark study commissioned by the United Church of Christ (1987). Twenty years later, in a follow-up report, percentages of Asians in neighborhoods hosting commercial hazardous waste facilities were 1.8 times greater in host vs. non-host neighborhoods (Bullard et al. 2007). Many other studies have revealed that Asian Americans face risks from environmental hazards (Liévanos 2015; Clark, Millet, and Marshall 2014; Cushing et al. 2015; Morello-Frosch and Jesdale 2006; Downey et al. 2008; Payne-Sturges and Gee 2006; Houston, Li, and Wu 2014; Su et al. 2011; Grineski, Collins, and Morales 2017).

When seeking to understand racial/ethnic patterns of environmental inequality, recognizing the intracategorical diversity that exists within minority populations is important. The critique of the model minority label highlights the substantial diversity that exists within the US Asian population (Nicolaides 2015), and the fact that Asian Americans are not a monolithic group. Considering Asian Americans as one socially (dis)advantaged group may conceal disparate environmental health risks experienced by particular Asian ancestral subgroups. For example, while many highly educated South Asians have recently migrated to the US to work in the tech industry, a sizable number of Southeast Asians entered the US as low-income refugees after the Vietnam war (Pew Research Center 2016; Rumbaut 2000). Despite these differences, Asian ancestry is rarely examined in studies of environmental health disparities (Gordon, Payne-Sturges, and Gee 2010). A review of this limited literature (presented next) orients the third hypothesis, which is:

H_3: Environmental risks for Asian Americans will vary based on ancestral origin with Chinese, Japanese, Koreans and South Asians facing increased risk.

Related to this hypothesis, a study in California found that Korean and Japanese American women faced substantial exposure to mammary gland carcinogens in their neighborhoods, even though the risks for White women as compared to Asian American women aggregated into one category were similar overall (Quach et al. 2014). In the US more generally, neighborhoods with higher (vs. lower) proportions of Chinese, Korean, and South Asian residents had significantly greater cancer risk burdens relative to Whites (Grineski, Collins, and Morales 2017). While few studies have examined environmental health disparities within the Asian American population, research on the US Hispanic/Latino population supports the hypothesis that intracategorical differences will likely be present for Asian Americans (Grineski, Collins, and Chakraborty 2013; Grineski et al. 2016; Chakraborty, Grineski, and Collins 2016; Collins et al. 2011). While there is some evidence that Asian Americans face disproportionate exposure to environmental hazards in the US, the research has received little attention and findings have been underemphasized relative to the research on Hispanic/Latino and Black Americans. Very little is known about intra-ethnic environmental inequalities despite the diversity of the Asian American population and the important implications for the health of Asian Americans.

DATA AND METHODS

Selection of the Study Areas

Using 2010 US Decennial Census data, we selected the four metro areas for inclusion in this study based on the percentage of their population of Asian race. Tables 1 and 2 and Figure 1 compare the total and Asian American populations across the four metro areas and the US.

We selected Honolulu, as it has the highest percentage of Asian Americans (43%) of all US metro areas. While the Chinese were the first Asian group to settle on the island of Oahu, the Japanese outnumber other Asian groups today. Honolulu is unique compared to other US metros in that Asians dominate commercial and professional life (Zhou, Tseng, and Kim 2008). To our knowledge, a quantitative EJ study has never been conducted on Honolulu, even though the metro area suffers from industrial and energy-related activities, brownfields, polluted runoff, and traffic-related pollution common in large US metro areas (Environmental Protection Agency 2016b).

The next two metro areas with the highest percentages of Asian Americans were San Jose-Sunnyvale-Santa Clara (31%) and San Francisco-Oakland-Hayward (23%). Because they are geographically contiguous, we combined them into a seven-county Bay Area (25%) and analyzed them as our second study area. The Asian American population in the Bay Area is rapidly growing and demographers have predicted that Asians will become San Francisco's largest racial/ethnic group within a few decades (Allen and Turner 2011). The growth has been driven in part by the demand for jobs in the technology sector, as Asian Americans make up half of the Bay Area's tech workforce, which depends on both low- and high-skilled Asian immigrants (Pamuk 2004). Major air pollution concerns in the Bay Area stem from the tech industry (Park and Pellow 2002), its position as a product movement corridor, and transportation networks serving its large and dense population.

Previous studies have documented environmental inequalities for low income, Hispanic and Black neighborhoods in the Bay Area (Fisher, Kelly, and Romm 2006; McClintock 2012; Szasz and Meuser 2000). These inequalities have given rise to multiracial coalitions seeking to achieve environmental justice (Shah 2011), despite the challenges of building a common consciousness among marginalized people with marked differences in terms of geography, immigration history, race, class, gender, and generation (Shah 2008). To date, the most comprehensive quantitative study on environmental inequality and air pollution in the Bay Area found that densely populated census tracts characterized by relatively low income and a larger share of immigrants and people of color were disproportionately burdened by risks from toxic air releases from factories and from cancer-causing and respiratory illness-inducing air toxics (Pastor, Sadd, and Morello-Frosch 2007). The percentage of the census tract population that was Asian was not significantly related to presence of factories in their study, but was correlated with greater cancer and respiratory risk from air toxics (Pastor, Sadd, and Morello-Frosch 2007). While not focused on air pollution, a study including the San Francisco Bay area found that socioeconomically disadvantaged Blacks and linguistically isolated and socioeconomically disadvantaged Latinos were the primary determinants of block group level health hazards from proximate surface water toxic releases; a measure of Asian-Pacific Islander disadvantage was a positive predictor of risk, but was not statistically significant (Liévanos 2017).

The metro area with the fourth largest percentage of Asian Americans in the US is Los Angeles-Long Beach-Santa Ana (15%), which we selected as our third study area. Over the last decade, the Asian American population in Los Angeles grew twice as fast as the Latino population, and five times faster than the general population. Chinese Americans are the largest Asian subgroup in Los Angeles, but South Asian Americans are the fastest growing subgroup. Despite the high social standing of many Asian Americans in Los Angeles, there are also many undocumented Asian immigrants (Sakaguchi et al. 2013). There have been more environmental inequality studies conducted in Los Angeles than in our other areas, and zones containing high concentrations of low income and minority people have been shown to bear significantly greater environmental burdens than affluent and predominantly White zones (Su et al. 2009; Marshall 2008; Pastor, Sadd, and Morello-Frosch 2004). An analysis of the 35 square mile Los Angeles-Long Beach port complex included the Asian population as a variable of interest; results indicated that parcels in block groups with higher percentages of nearby Asian/Pacific Islander residents had greater exposure to vehicular fine particulate matter (Houston, Li, and Wu 2014).

Finally, we selected Seattle-Tacoma-Bellevue, which is 11% Asian. This metro area ranks just behind three other California metro areas. To increase geographic diversity in the selection of our study areas, we bypassed those three areas for Seattle, since we already selected two CA-based study communities. Seattle has a longstanding Asian American population, as the first Chinese migrants settled in the area in the 1860s (Ong, Fujita, and Chin 1977), about 10 years after they settled in California. The Chinese were followed by Japanese and Filipinos (Nee and Sanders 1985). A few quantitative environmental inequality studies have been conducted in Seattle. One identified social clusters and then related those to industrial risks through time. The study found that even as Seattle deindustrialized, minority and working class residents remained concentrated in the neighborhoods with Seattle's worst industrial pollution risks (Abel and White 2011). A second study revealed that lower levels of median household income and higher percentages of immigrants in census tracts were associated with higher levels of traffic- associated pollution (Su et al. 2010).

The selection of these four metro areas allows us to develop comparative understanding of relationships between Asian Americans and environmental health hazards while examining 29% of Asians in the US. Most EJ studies have not examined several metro areas, and have instead reported results for one metro area or the US as a whole. The drawback to the national approach is that context-specific explanations for findings in particular places cannot be presented; with one city, those contextual understandings can be developed, but the focus on one place limits the potential for generalizability. With this paper, we seek out some middle ground between the two approaches. The examination of four metro areas allows us to draw inferences based on a comparison of findings across multiple contexts and to situate plausible explanations for results based on contextual historical knowledge of the study sites.

Dependent Variable: Exposure to carcinogenic HAPs

We used the US Environmental Protection Agency's (EPA) 2011 National Air Toxics Assessment (NATA) database, which was released in 2015 (Environmental Protection Agency 2016a) to measure census tract-level lifetime cancer risk (LCR) exposure estimates for all tracts in the four metro areas (see Figure 2). The NATA includes 180 specific substances identified in the Clean Air Act Amendments of 1990 that are known to or suspected of causing cancer and other serious health problems. Inputs on HAP emissions in the NATA come from the 2011 National Emissions Inventory, the Mercury and Air Toxics Rule (MATS) test data, the Toxics Release Inventory, and state, local and tribal agencies' emissions inventories; a multi-step methodology is used to generate estimates of cancer risk (Environmental Protection Agency 2016a). The 2011 NATA estimates potential cumulative risks to public health from HAP exposure from mobile and stationary sources. These data are commonly used in fine-scale studies of environmental inequality (e.g., Chakraborty et al., 2014; Quach et al., 2014). LCR is a measure of the number of residents living in a census tract that would be diagnosed with cancer due to continuous HAP exposure throughout their life, per million residents, above and beyond the cancer rate for an unexposed population.

Independent Variables: Sociodemographic Characteristics

We used the 2010 US Decennial Census to assess tract-level sociodemographic characteristics, except in the case of median household income, which we drew from the 2012 American Community Survey (ACS) 5-year estimates. Descriptive statistics of all analysis variables are included in Table 3.

Race/ethnicity was measured using six indicators: the proportions of census tract residents identified as being Hispanic or Latino (any race), White non-Hispanic, Black non-Hispanic, Pacific Islander/Native Hawaiian non-Hispanic, Multi-racial/Other non-Hispanic (which includes American Indians), and Asian non-Hispanic. For these six indicators, the reference category is proportion of residents that are non-Hispanic White. Because it is our focal variable, the proportion of the population that is of Asian race is mapped in Figure 3.

We also examined specific racial categories within the Asian alone race variable (which map to Asian ancestry groupings) to capture an important axis of Asian ethnic heterogeneity. We created seven categories: Chinese, South Asian (i.e., Indian, Pakistani, Bangladeshi, Nepalese and Sri Lankan), Filipino, Southeast Asian (i.e., Cambodian, Laotian, Hmong, and Vietnamese), Korean, Japanese, and other Asians (which groups Bhutanese, Burmese, Thai, Malaysian, Indonesian, Taiwanese and other (specified and non-specified) together due to small counts). This measure includes all Asian Americans who reported one ancestry or no specific Asian ancestry; those who reported more than one ancestry are excluded due to how the census collates these data, which counts individuals with multiple ancestries multiple times. Using census tract 2010 population counts for those Asian categories as numerators and the total 2010 tract population as the denominator, we constructed seven proportion variables in each metro area. Note that these variables gauge racial/ethnic identity and heritage rather than place of birth and are interpreted in reference to the proportion of non-Hispanic Whites.

Apart from race/ethnicity, we also adjusted for socioeconomic status and crude population density (i.e., 2010 population divided by the tract area in square kilometers). Socioeconomic status was measured using median household income and the proportion of renter-occupied housing units (Pastor, Morello-Frosch, and Sadd 2005; Chakraborty et al. 2014) . We also included median income squared in the model because the relationship may be curvilinear (Chakraborty et al. 2014; Pastor, Morello-Frosch, and Sadd 2005). Despite data reliability issues with the ACS median income variable (Folch et al. 2016), it remains the best available tract-level estimate of household income for use in this analysis. We considered median household income estimates as reliable and incorporated them in our analysis if they had coefficients of variation (calculated by dividing the error surrounding the estimate by the median income estimate) that were >0.5 (Liévanos 2018). Tracts with coefficients of variation for median income that were ≥5, less than 500 people, less than 200 households, or missing data for any analysis or clustering variable (to be described below) were removed to ensure that all variables were reliable. We removed 57 tracts in Honolulu (analysis n=187), 89 in the Bay Area (analysis n=1319), 182 in Los Angeles (analysis n=2748), and 16 in Seattle (analysis n=709).

Analytical Procedures

We specified eight generalized estimating equations with robust covariance estimates (GEEs), applying two models in each study site. GEEs extend the generalized linear model to the analysis of clustered data, and they relax several assumptions of traditional regression models, including normality of variable distribution (Liang and Zeger 1986; Zeger and Liang 1986; Nelder and Wedderbum 1972). For more information, including equations, see Zorn (2001). In order to fit a GEE, clusters of observations must be specified, wherein it is assumed that observations within a cluster are correlated, while observations from different clusters are independent. We defined clusters using 2012 ACS five-year estimates for median year of housing construction (using the provided categories: “2000 or later”, “1990 to 1999”, “1980 to 1989”, “1970 to 1979”, “1960 to 1969”, “1950 to 1959”, “1940 to 1949”, and “1939 or earlier”) by 8 categories of median value of housing stock. We determined the category breaks for value of housing stock by creating 8 equal groups of tracts for all four metro areas combined, which were “under $265,550”, “$265,551 to 323,600”, “$323,601 to 369,050”, “$369,051 to 431,100”, “$431,101 to 520,250”, “$520,251 to 625,000”, “$625,001 to 804,200”, and “$8,04201 through 1,000,000 or more”. This yielded 38 clusters in Honolulu, 62 clusters in the Bay Area, 63 clusters in Los Angeles and 59 clusters in Seattle. This cluster definition method was selected because it corresponds with spatial and temporal dimensions of the built environment that are associated with the historical-geographical formation of environmental injustice (Pulido 2000). GEEs require the specification of an intracluster dependency correlation matrix (Liang and Zeger 1986; Zeger and Liang 1986). In this case, we specified the exchangeable correlation matrix, which assumes constant intracluster dependency (i.e., compound symmetry), so that all the off-diagonal elements of the correlation matrix are equal.

To select the best fitting models, we estimated a series of GEEs by varying the model specifications. We tested normal, gamma and inverse Gaussian distributions with logarithmic and identity link functions, which are appropriate options for our dependent variable, which is positively-scaled, continuous, and non-normally distributed. An identity link function means the relationships are predicted directly, while a logarithmic link function predicts relationships based on a natural log function (Garson 2012). We present results from GEEs with inverse Gaussian and logarithmic link function specifications for all four metro areas, given that this was the best fitting specification based on quasi-likelihood under the independence model criterion (QIC) values. The quasi-likelihood estimating equations have the general form

$$\sum_i \left(\partial \mu_i \Big/ \partial \boldsymbol{\beta} \right)' \nu(\mu_i)^{-1} [y_i - \mu_i(\boldsymbol{\beta})] = \mathbf{0}$$

where $\mu_i = g^{-1}(X' \beta)$ is the link function with $g = log$, the distribution of y_i is inverse Gaussian, and the GEE estimator $(\hat{\boldsymbol{\beta}})$ is the solution to these equations. The resulting covariance of the GEE is given by

$$\boldsymbol{V}_{G,n} = n \left[\sum_i \boldsymbol{D}_i' \boldsymbol{V}_i^{-1} \boldsymbol{D}_i \right]^{-1} \left[\sum_i \boldsymbol{D}_i' \boldsymbol{V}_i^{-1} cov(\boldsymbol{Y}_i) \boldsymbol{V}_i^{-1} \boldsymbol{D}_i \right] \left[\sum_i \boldsymbol{D}_i' \boldsymbol{V}_i^{-1} \boldsymbol{D}_i \right]^{-1}$$

and is assumed to be compound symmetric.

We began with Model 1, a traditional EJ model that includes the proportion of tract residents in each racial/ethnic minority group, socioeconomic status, and population density Then, in Model 2, we replaced proportion Asian with the seven Asian ancestry proportion variables. We *examined possible multicollinearity among the analysis variables; based on variance inflation factor, tolerance, and condition index criteria, inferences from the GEEs are not affected by multicollinearity.* All independent variables were standardized before inclusion in the GEEs.

RESULTS

Table 4 presents results for Model 1. Positive coefficients for the race/ethnicity variables suggest increased LCR. The key finding is that proportion Asian was a positive and significant (p<.05) predictor of LCR, controlling for the other covariates in Honolulu, Los Angeles, the Bay Area, and Seattle. Proportion Hispanic was positive and significant in Los Angeles and Seattle. Proportion Black was significant and positive in Los Angles. Proportion Pacific Islander was negative and significant in Los Angeles and the Bay Area, and positive and significant in Seattle. The findings for Multi-racial/Other were negative and significant in Honolulu. Population density was positive and significant in all four study communities. Proportion renter-occupied housing units was positive in all sites and significant in all except for Honolulu. In Seattle, the direct effect and quadratic term for median household income were both significant. Overall, population density was the most important predictor of LCR in these metro areas, as evidenced by that variable having the largest effect size in three of the four metros, and the second largest effect size in the other (Los Angeles).

Table 4 also reports the results for Model 2, which are also summarized in Table 5. South Asian was negative and significant in Honolulu and Seattle. Chinese was positive and significant in Honolulu and Los Angeles, but negative and significant in Seattle. Filipino was positive and significant in Honolulu, Los Angeles and Seattle, but negative and significant in the Bay Area. Japanese was positive and significant in the Bay Area and Seattle. Korean was positive and significant in Los Angeles. Southeast Asian was positive and significant in the Bay Area and Seattle, and negative and significant in Los Angeles. Other Asian was negative and significant in the Bay Area. In terms of the race/ethnicity findings, they were the same in significance and direction as Model 1 with the exception of proportion Pacific Islander, which became non-significant in the Bay Area. In terms of the control variables, the associations were the same in significance and direction as Model 1, except that income was not significant in Honolulu.

DISCUSSION AND CONCLUSIONS

Environmental risks for Asian Americans

We found that Asian Americans were disproportionately burdened by cancer-causing air pollutants relative to Whites in all four study areas, even when accounting for population density and clustering, which aligns with H_2 and not H_1. H_1 stated that Asian Americans will experience similar environmental risks relative to Whites, while H_2 suggested that Asian Americans will experience greater environmental risks than Whites. Associations in these four Asian dominant metros align with findings from a national study (Grineski, Collins, and Morales 2017). Counter to the racial income inequality thesis (Oakes, Anderton, and Anderson 1996), results suggest that Asian Americans are not subject to the same risk as Whites, even when accounting for household income, and that they live in more carcinogenic neighborhood environments. The findings align more with the racial discrimination thesis (Pais, Crowder, and Downey 2014), since the Asian American variable was significant above and beyond the effects of income. It is worth noting that this is the first quantitative environmental justice (EJ) study conducted in Honolulu, where Asian was our only significant race finding, apart from ‘other’ race. While two previous studies’ findings align with H_1, both examined relatively small Asian populations and different hazards than we did here. Jones and colleagues (2014) examined residential $PM_{2.5}$ and NO_x concentrations for 665 Chinese people living in Los Angeles and Chicago, while Crowder and Downey (2010) studied proximity to industrial facilities and 130 Asian people scattered across the US.

Based on extant research, Asian Americans have more often than not been shown to face disproportionate risk to environmental hazards in the US relative to Whites, which dovetails with our findings in support of H_2. For example, Downey et al. (2008) demonstrated that

Asian Americans were notably burdened in some US metro areas and a national-level study found Asian Americans to be significantly exposed to residential carcinogenic hazardous air pollutants (HAPs) relative to Whites (Grineski, Collins, and Morales 2017). However, most studies reporting marked inequities for Asian Americans have under-emphasized this in terms of their discussion of findings and framing of study implications. And many other studies, including some of our own, do not include an Asian variable. Apart from concerns about small counts of Asian Americans in some study areas, one potential explanation for this is that it is a discursive legacy of the deployment the "model minority" myth since the 1960s, when this label was first constructed to undermine arguments for race-specific policies to promote the status of disadvantaged minorities (Yi et al. 2016; McGowan and Lindgren 2006). A logical extension of accepting this discourse as fact is that experiences of environmental injustice among Asian Americans are rendered inexplicable, since it is taken for granted that Asian Americans share high status with Whites.

While population-level statistics have documented high levels of education and income among Asian Americans, these numbers conceal the systemic racism that Asians have experienced in the US over the past 150 years (Chou and Feagin 2015; Hartlep 2013; Fong 2008). Prevalent racism and discrimination against Asian Americans may be part of why we did not find support for the racial income inequality thesis in this paper (H_1). Whites have valorized Asian Americans relative to Blacks on cultural and/or racial grounds in order to dominate both groups (Kim 1999). As Xu and Lee (2013: 1364) report, "the American public simultaneously lauds Asians as the 'model minority' and marginalizes them as 'outsiders'." This contradictory racial characterization is reflected across national statistics showing the high socioeconomic status of Asians Americans in the US, racialized images of Asian Americans as perpetual foreigners (Xu and Lee 2013), and possibly through the inadequate attention paid to the environmental inequalities faced by Asian Americans.

Relatedly, it should be recognized that the EJ movement itself—and the attendant research on environmental health disparities that the EJ movement spawned—is a political-racial project connecting Civil Rights concerns about racial inequality to environmental conditions (Pulido 1996). It should thus come as no surprise that the dominant framing of EJ in the US has been one of low-income Blacks, and more recently Latinxs, facing environmental injustices in their neighborhoods, with Whites being environmentally privileged. This framing has meant that even when Asian Americans have mobilized against environmental health risks in their communities (Leong 1995/1996; Sze 2004), their efforts have received less attention by scholars and other EJ activists (Sze 2004). In cities across the US, Asian American communities have mobilized against hazards in their communities, halting an expansion at a Chevron refinery in Richmond, CA (Asian Pacific Environmental Network 2012); saving Boston's Chinatown from demise (Leong 1995/1996); and contributing to more just rebuilding efforts in New Orleans following Hurricane Katrina (Community-Wealth 2017). While there have certainly been instances of Asian American EJ activism, the lack of recognition appears to have contributed to an inattention to Asian Americans in EJ research.

Clarifying intracategorical environmental inequalities

In addition to the finding that Asian Americans face significant lifetime cancer risks (LCR) from HAPs in these four metro areas, we examined associations between Asian American ancestry and LCR in each metro area and found differences, as suggested by H_3, which stated that environmental risks for Asian Americans will vary based on ancestral origin with Chinese, Japanese, Koreans and South Asians facing increased risk. Taking an intracategorical lens (McCall 2005) to examine ancestry-based disparities improves upon a traditional intercategorical approach to examine environmental injustices between racial/ethnic groups. This lens is important since racial/ethnic groups are internally stratified based on ancestry, language, nativity, citizenship, gender, and age (Collins et al. 2011). In drawing attention to how some subgroups experience relative advantages or disadvantages, an intracategorical approach clarifies how race/ethnicity intersects with other dimensions of sociospatial inequality, in this case ancestry, to shape unequal environmental health risks.

Across the four metro areas, there were some similarities and differences with regards to the risk profile of the ancestry groups (see Table 5). Korean ancestry was positively associated with LCR in all four metro areas, but the coefficient was statistically significant only in Los Angeles. Chinese ancestry was statistically significant and positive in Los Angeles and Honolulu, positive in the Bay Area, and negatively and significantly related to LCR in Seattle. Japanese ancestry was positively and significantly associated with LCR in the Bay Area and Seattle, the coefficient was negative in Los Angeles and Honolulu. The South Asian coefficient was negative and significant in Honolulu and Seattle, and positive in the Bay Area and Los Angeles. The associations with LCR for Filipino and Southeast Asian Americans were highly variable across the four metro areas, with coefficients being significant in opposite directions between two or more metro areas. While the Filipino coefficient is positive and significant in Honolulu, Los Angeles and Seattle, it is negative and significant in the Bay Area. Associations between Southeast Asian and LCR are positive and significant in Seattle and the Bay Area, positive in Honolulu, and negative and significant in Los Angeles.

Korean Ancestry—Korean ancestry was positively associated with LCR across the four metro areas (but statistically significant only in Los Angeles), aligning with H_3. These positive associations relate to the economic pursuits of this group. Korean Americans have tended to settle in poor, commercially underserved, central city neighborhoods, where they operate small businesses (Lee 2000), as they have in South Central Los Angeles. Entrepreneurship has contributed to their upward social mobility (Lee 2000; Kim 2014), but our results suggest that it has come with an environmental health consequence of heightened residential exposure to carcinogenic HAPs. Carcinogenic environmental risks for Korean American women were also found statewide in California (Quach et al. 2014).

Chinese Ancestry—The Chinese coefficient was statistically significant and positive in Los Angeles and Honolulu and positive in the Bay Area, as predicted by H_3. However, Chinese ancestry was negatively and significantly related to LCR in Seattle. The findings from Los Angeles, Honolulu, and the Bay Area conform to a general pattern of risk for Chinese Americans found in a national study (Grineski, Collins, and Morales 2017). Their risk in these metro areas stems from their longstanding urban settlement, racism and discrimination (Tsai 1986), and their continued desire to live near co-ethnics (Walton 2015). Chinese immigrants are usually drawn to dense urban contexts (Zhou, Tseng, and Kim 2008). For example, in greater Los Angeles, where we found neighborhoods with high concentrations of Chinese to be at significantly heightened risk, the historic Chinatown is located within the City of Los Angeles, and a Chinese 'ethnoburb' extends northwest of it, into the San Gabriel Valley (Nicolaides 2015). The San Gabriel Valley is just inside the pollution-trapping mountains ringing Los Angles and thirty percent of its residents are Chinese American (Lin and Robinson 2005).

Different from the other three metro areas, the protection of Chinese Americans in Seattle from residential carcinogens might be due to the long history of Asian immigration. Chinese were the first Asian group to migrate to Seattle, but Japanese immigrants came to reside centrally and occupy jobs held by Chinese immigrants after 1880, when Chinese immigration was restricted (Wierzbicki 1997). WWII provided opportunities for upward economic mobility and residential dispersion for Chinese Americans, as Seattle's Japanese population was scapegoated. During the latter part of the 20th century, Chinese newcomers moved to Seattle with high socioeconomic status and accumulated wealth and settled in more peripheral parts of the city (Wierzbicki 1997).

Japanese Ancestry—In line with H_3, the Japanese American population experienced disproportionate risk in the Bay Area and Seattle. In Los Angeles and Honolulu, the Japanese American population is larger than it is in the Bay Area and Seattle (see Table 2), but the Japanese coefficients were not significant (as was also the case in the national study, see Grineski, Collins and Morales (2018)). The lack of risk disparities in those two metro areas is likely related several historical features of the Japanese American experience in the US. First, the Japanese American population is largely suburban (Lam 1986) and dispersed. After internment during WWII, many Japanese people returned to Japan (Kitano and Daniels 1995), and those who stayed in the US scattered and did not resettle in enclaves (Daniels 2011). Second, the Japanese community in the US was historically involved in agriculture (Nishi 1995). In Los Angeles, for example, there are concentrations of Japanese American people in the formerly agricultural areas of Gardena and Torrance. Third, Japanese companies have been sending their employees to work in Japanese-owned businesses and offices located in the US, many of which are located in suburban areas (White, Fong, and Cai 2003). Toyota, for example, was headquartered in the heavily Japanese Torrance (Los Angles metro area) from 1982-2014.

In contrast to the other two metro areas, in Seattle, a large component of the Japanese American population resides in the Chinatown-International District (C-ID), located downtown, which includes Nihonmachi, Seattle's historic Japantown. Since Chinese immigration occurred early in Seattle, the federal law banning Chinese immigration in 1880 created residential options in the C-ID and employment opportunities for Japanese immigrants until 1924 when their migration was also restricted (Wierzbicki 1997). In the six decades that followed, Japanese immigrants were more entrepreneurially-oriented than the Chinese (Taylor 1991) and more likely to live in the centrally-located Chinatown-International District (C-ID). After the forced relocation of Japanese Americans during

WWII, a large number of Japanese Americans moved out of Nihonmachi (Takami 1998), but developed a housing and retail enclave closer the core of the C-ID (Abramson, Manzo, and Hou 2006). Similarly, in the Bay Area, many Japanese Americans reside in the Japantown districts and operate family-operated businesses (Sowell 1981; Bonacich and Modell 1980). The two major Japanese enclaves in Northern California are located in the Bay area, central San Francisco and central San Jose (Kiefer 1974).

South Asian Ancestry—The South Asian coefficient was negative and significant in Honolulu and Seattle, suggesting this group faces reduced LCR relative to Whites. Many South Asian immigrants, especially Indian immigrants, moved to the US with high levels of education, professional training, or financial resources that are needed in knowledge-based industries (Skop and Li 2005). According to a national report, 87% of South Asian Americans are foreign-born and one- third are employed in science and engineering fields (Pew Research Center 2016). Those attributes shape their settlement patterns. In fact, South Asian Americans are more likely to be suburbanites than other racial or ethnic groups (Skop and Li 2005; Logan 2001). In Seattle, most high-tech companies are located in suburban areas. For example, Microsoft Corporation moved its headquarters to suburban Redmond in 1986, where it is now the largest employer (Microsoft 2016). Following those high-tech companies, many South Asian professionals moved to the eastside of the Seattle metro area (e.g., Redmond and Bellevue), which is far from the central city and less polluted.

Filipino Ancestry—While the Filipino coefficient is positive and significant in Honolulu, Los Angeles and Seattle, it is negative and significant in the Bay Area. Filipino Americans' overrepresentation in the health care sector and their historical ties to the US military have influenced their settlement patterns in these four metro areas and in the US more generally (McNamara and Batalova 2015). Filipinos have high rates of immigration to the US and the majority of migrants are highly educated professionals (McNamara and Batalova 2015) who speak English very well (Pew Research Center 2016). However, Filipinos have difficulty finding jobs commensurate with their skills (White, Fong, and Cai 2003).

In Los Angeles, for example, where the Filipino coefficient was positive and significant, Filipinos settled centrally when they first arrived in Los Angeles in the 1920s (Montoya 2009), and they continue to reside centrally, not far from Chinatown. In Seattle (where the Filipino coefficient was also positive and significant), many Filipino Americans live in the C-ID, among Japanese and Chinese neighbors (Abramson, Manzo, and Hou 2006). However, in the Bay Area, where the coefficient was negative and significant, many Filipino Americans settled in Daly City, which is just south of San Francisco in the Colma hills near the coast. The area developed rapidly as an affordable housing market post-WWII and is home to a large hospital complex. Affordable housing in a costly market and jobs in the health care sector likely attract Filipinos to this area. Today over one-third of the residents in Daly City are Filipino and Daly City has the highest concentration of Filipinos of any mid-sized city in North America (Vergara Jr. 2009). Residence outside of the traditional urban core has protected Filipino Americans in the Bay Area from the highest levels of cancer risks from HAPs.

Southeast Asian Ancestry—The change in associations between LCR and the Southeast Asian variable across the metro areas is perhaps our most surprising ancestry finding. While the relationship was negative and significant in Los Angeles, the positive and significant associations between Southeast Asian and residential cancer risk from HAPs in Seattle and the Bay Area (and the positive relationship in Honolulu) likely relate to the status of many Southeast Asians as poor refugees upon entry to the US (Rumbaut 2000). Refugees tend to settle in more socially disadvantaged neighborhoods than voluntary migrants (Phillip 2010). Compared to other Asian Americans, Southeast Asian Americans are more likely to be supported by government assistance programs, have minimum wage jobs, and work in the informal economy (Gold and Kibria 1993; Rumbaut 2000). This was especially true of the second wave of Vietnamese refugees arriving in the US between 1978-80 (Fong 2008).

Their socioeconomic marginality and reliance on government assistance may have led them to highly polluted, central-city neighborhoods. In Seattle, where the coefficient was positive and significant, the highest concentrations of Southeast Asian Americans are near the downtowns of Seattle and Tacoma, and their concentrations are much lower in the suburban portions of the metro area. In the Bay Area, where the coefficient was also positive and significant, Southeast Asians are clustered on the east side of San Jose.

By contrast, in Los Angeles, where the coefficient was negative and significant, Southeast Asian Americans (who are primarily Vietnamese) are concentrated in largely suburban Orange County. The suburbs surrounding Los Angeles are just as ethnically diverse as the those in the city proper and suburban Vietnamese people outnumber urban Vietnamese people (Logan, Zhang, and Alba 2002). The city of Westminster (in Orange County) is the center of overseas Vietnamese life, and it was settled by first wave refugees in 1975. Unlike the second wave, the first wave included high ranking government and military workers who were educated, urban elites (Fong 2008). What is now Little Saigon (located in Westminster and Garden Grove) was a predominately White middle-class area with agricultural remnants prior to the 1970s, when it experienced decline. The incoming Vietnamese people revitalized the area by opening businesses in formerly White-owned storefronts. Being that the thriving center of Vietnamese life in the Los Angeles metro area is in suburban Orange County and not within the city limits of Los Angeles, this subgroup is relatively protected from cancer-causing HAPs in a way that they are not in Seattle and the Bay Area.

Limitations and Implications

While calling attention to previously underemphasized environmental inequalities for Asian Americans, this study was cross-sectional and conducted in four metro areas of the US West. It is notable that we found these injustices even among a sample of liberal western US metro areas with progressive environmental policies. Future studies could use a different approach to selecting MSAs to capture a greater geographical spread, but would need to be cognizant of selecting MSAs with enough Asian Americans to be feasible. While we took action to mitigate data quality issues with ACS income data following CalEnviroScreen (Liévanos 2018), the fact remains that ACS income estimates are less reliable in lower income areas and in the southern US (Folch et al. 2016). Our focus was not on the US South, but given that our solution was to remove tracts with less reliable income estimates, we may have removed tracts from our study areas in a non-random manner (with the likelihood of removal being greater for lower income tracts). Removing lower income tracts may have attenuated patterns of environmental injustice uncovered in our analyses. The NATA LCR estimates used are based on an additive model, but HAPs may operate synergistically. The NATA risk estimates do not consider residents' diurnal movements in and out of their tracts of residence nor their length of residence. Future studies should employ measurement techniques that take people's daily movements into account and focus on different types of environmental health risks than those studied here. Our focus was also solely on environmental harm; future research should also examine environmental privilege, such as access to environmental amenities.

The findings in this study, alongside results from other studies (Liévanos 2015; Clark, Millet, and Marshall 2014; Cushing et al. 2015; Morello-Frosch and Jesdale 2006; Houston, Li, and Wu 2014; Grineski, Collins, and Morales 2017), demonstrate that Asian Americans experience environmental inequality in the US. Our results also underscore the importance of taking an intracategorical approach by disaggregating this highly heterogeneous population into relevant subgroups, as aggregation masks important within-group inequalities. It is troubling that the environmental injustices burdening Asian Americans have been less often named as such in academic or policy arenas, leaving fewer options for them to be redressed. The environmental injustices experienced by Asian Americans highlighted here, which have been de-emphasized in much prior research, should draw attention to possibilities for other erasures within environmental health research and within other sociological subfields. For example, same-sex couples were recently found to experience serious environmental health disparities nationwide (Collins, Grineski, and Morales 2017), yet had not been previously examined despite the public availability of data to support such analyses. Health disparities for Asians unrelated to the ambient environment may also be substantial (Ibaraki, Hall, and Sabin 2014; Huang et al. 2012), but they must be thoroughly investigated by social scientists to be illuminated. To conclude, social scientists must not allow hegemonic academic and popular ideologies to shape our research agendas to the detriment of those whose experiences of inequalities we are obliged to name and address.

REFERENCES

Abel Troy D., and White Jonah. 2011 'Skewed Riskscapes and Gentrified Inequities: Environmental Exposure Disparities in Seattle, Washington', American Journal of Public Health, 101: 246–54.

Abramson D, Manzo L, and Hou J. 2006 'From ethnic enclave to multi-ethnic translocal community: Contested identities and urban design in Seattle's Chinatown-International District', Journal of Architectural and Planning Research, 23: 341–60.

Allen James P., and Turner Eugene. 2011 'Patterns of Population Change in California, 2000–2010', The California Geographer, 51: 37–65.

Asian Pacific Environmental Network. 2012 'Richmond', Accessed 14 February http://apen4ei.org/what-we-do/organizing/Richmond/.

Bonacich E, and Modell J. 1980 The economic basis of ethnic solidarity: Small business in the Japanese American community (University of California Press).

Bullard Robert. 1993 Confronting Environmental Racism (South End Press: Boston).

Bullard Robert D., Mohai Paul, Saha Robin, and Wright Beverly. 2007 "Toxic Wastes and Race and Toxic Wastes and Race at Twenty" In, edited by United Church of Christ, 175 Cleveland.

CDC. 2010 'Leading Causes of Death by Age Group, Race/Ethnicity Males, United States, 2010', Accessed 14 July 2016 https://www.cdc.gov/men/lcod/2010/lcodrace ethnicitymen2010.pdf.

Chakraborty J, Collins Timothy W., Montgomery Marilyn C., Grineski SE, and Hernandez Maricarmen. 2014 'Comparing Disproportionate Exposure to Acute and Chronic Pollution Risks: A Case Study in Houston, Texas', Risk Analysis, 34: 2005–20. [PubMed: 24913274]

Chakraborty Jayajit, Grineski Sara E., and Collins Timothy W.. 2016 'Cancer risks from exposure to vehicular air pollution: a household level analysis of intra-ethnic heterogeneity in Miami, Florida', Urban Geography.

Chen Moon S. 2005 'Cancer Health Disparities among Asian Americans', Cancer, 104: 2895–903. [PubMed: 16270313]

Chin Margaret M. 2016 'Asian Americans, Bamboo Ceilings and Affirmative Action', Contexts, 15: 70–73.

Chou Rosalind S., and Feagin Joe R.. 2015 Myth of the model minority: Asian Americans facing racism (Paradigm Publishers: Boulder, CO).

Clark LP, Millet DB, and Marshall JD. 2014 'National Patterns in Environmental Injustice and Inequality: Outdoor NO2 Air Pollution in the United States', Plos One, 9.

Collins Timothy, Grineski Sara, Chakraborty Jayajit, and McDonald Yolanda. 2011 'Understanding environmental health inequalities through comparative intracategorical analysis: Racial/ethnic disparities in cancer risks from air toxics in El Paso County, Texas', Health and Place, 17: 335–44. [PubMed: 21163683]

Collins Timothy W., Grineski Sara E., and Morales Danielle X.. 2017 'Environmental injustice and sexual minority health disparities: A national study of inequitable health risks from air pollution among same-sex partners.', Social Science & Medicine, 191: 38–47. [PubMed: 28888127]

Community-Wealth. 2017 'Mary Queen of Vietnam Community Development Corporation', Democracy Collaborative, Accessed February 14 http://community-wealth.org/content/mary-queen-vietnam-cdc.

Crowder K, and Downey L. 2010 'Inter-neighborhood migration, race, and environmental hazards: Modeling microlevel processes of environmental inequality', American Journal of Sociology, 115: 1110–49.

Cushing L, Faust J, August LM, Cendak R, Wieland W, and Alexeeff G. 2015 'Racial/Ethnic Disparities in Cumulative Environmental Health Impacts in California: Evidence From a Statewide Environmental Justice Screening Tool (CalEnviroScreen 1.1)', American Journal of Public Health, 105: 2341–48. [PubMed: 26378826]

Daniels R 2011 Asian America: Chinese and Japanese in the United States Since 1850 (University of Washington Press: Seattle).

Downey L 2006a 'Environmental inequality in metropolitan America in 2000', Sociological Spectrum, 26: 21–41. [PubMed: 21909177]

———. 2006b 'Environmental racial inequality in Detroit', Social Forces, 85: 771–96.

———. 2007 'US metropolitan-area variation in environmental inequality outcomes', Urban Studies, 44: 953–77. [PubMed: 21909171]

Downey Liam, Summer DuBois Brian Hawkins, and Walker Michelle. 2008 'Environmental Inequality in Metropolitan America', Organization & Environment, 21.

Downey Liam, and Hawkins Brian. 2008 'Race, Income, and Environmental Inequality in the United States', Sociological Perspectives, 51: 759–81. [PubMed: 19578560]

Environmental Protection Agency. 2016a '2011 NATA: Assessment Results', Accessed 8 July 2016 https://www.epa.gov/national-air-toxics-assessment/2011-nata-assessment-results.

———. 2016b 'News Releases by State: HAWAII', Accessed October 10 https://vosemite.epa.gov/opa/admpress.nsf/Press%20Releases%20Bv%20State!QpenView&RestricttoCategory=HL

Fisher JB, Kelly M, and Romm J. 2006 'Scales of environmental justice: Combining GIS and spatial analysis for air toxics in West Oakland, California', Health & Place, 12: 701–14. [PubMed: 16243580]

Folch David C., Daniel Arribas-Bel Julia Kischinsky, and Spielman Seth E.. 2016 'Spatial Variation in the Quality of American Community Survey Estimates', Demography, 53: 1535–54. [PubMed: 27541024]

Fong Timothy. 2008 The Contemporary Asian American Experience: Beyond the Model Minority (Pearson: Upper Saddle River, New Jersey).

Garson G 2012 Generalized linear models and generalized estimating equations (Statistical Associates Publishing: Asheboro, NC).

Gold S, and Kibria N. 1993 'Vietnamese refugees and blocked mobility', Asian and Pacific Migration Journal, 2: 27–56. [PubMed: 12317967]

Gordon Lauren, Devon Payne-Sturges, and Gilbert Gee. 2010 'Environmental Health Disparities: Select Care Studies Related to Asian and Pacific Islander Americans', Environmental Justice, 3: 21–27.

Grineski SE, Collins Timothy W., and Chakraborty Jayajit. 2013 'Hispanic heterogeneity and environmental injustice: Intra-ethnic patterns of exposure to cancer risks from vehicular air pollution in Miami', Population and Environment, 35: 26–44. [PubMed: 23935236]

Grineski Sara E., Collins Timothy, Chakraborty Jayajit, and Montgomery Marilyn C.. 2016 'Hazard Characteristics and Patterns of Environmental Injustice: Household-level Determinants of Environmental Risk in Miami, Florida', Risk Analysis, 10.1111/risa.12706.

Grineski Sara E., Collins Timothy W., and Morales Danielle X.. 2017 'Asian Americans and disproportionate exposure to carcinogenic hazardous air pollutants: A national study', Social Science & Medicine, 185: 71–80. [PubMed: 28554161]

Hartlep ND 2013 The Model Minority Stereotype: Demystifying Asian American Success. (Information Age Publishing: Charlotte).

Houston D, Li W, and Wu J. 2014 'Disparities in Exposure to Automobile and Truck Traffic and Vehicle Emissions Near the Los Angeles-Long Beach Port Complex', American Journal of Public Health, 104:156–64. [PubMed: 23678919]

Huang Keng-Yen, Calzada Esther, Cheng Sabrina, and Brotman Laurie Miller. 2012 'Physical and Mental Health Disparities among Young Children of Asian Immigrants', Journal of Pediatrics, 160: 331–36.e.l. [PubMed: 21907351]

Ibaraki AY, Hall GCN, and Sabin JA. 2014 'Asian American Cancer Disparities: The Potential Effects of Model Minority Health Stereotypes', Asian American Journal of Psychology, 5: 75–81.

Jones MR, Diez-Roux AV, Hajat A, Kershaw KN, O'Neill MS, Guallar E, Post WS, Kaufman JD, and Navas-Acien A. 2014 'Race/Ethnicity, Residential Segregation, and Exposure to Ambient Air Pollution: The Multi-Ethnic Study of Atherosclerosis (MESA)', American Journal of Public Health, 104: 2130–37. [PubMed: 25211756]

Kiefer CW . 1974 Changing cultures, changing lives: An ethnographic study of three generations of Japanese Americans (Jossey-Bass: San Francisco).

Kim Claire Jean 1999 'The racial triangulation of Asian Americans.', Politics & Society, 27: 105–38.

Kim I 2014 New Urban Immigrants: The Korean Community in New York (Princeton University Press: Princeton, NJ).

Kitano Harry., and Daniels R. 1995 Asian Americans: Emerging Minorities (Prentice-Hall: Englewood Cliffs, NJ.).

Lam FKS 1986 'Residential segregation of Chinese and Japanese-Americans in the United States suburban areas: 1960, 1970, and 1980', Purdue University.

Lee Jennifer. 2000 'Striving for the American Dream: Struggle, Success, and Intergroup Conflict among Korean Immigrant Entrepreneurs' in Zhou Min and Gatewood JV (eds.), Contemporary Aslan America (New York University Press: New York).

Leong Andrew. 1995/1996 'The struggle over parcel C: How Boston’s Chinatown won a victory in the fight against institutional expansionism and environmental racism', Amerasia Journal, 21: 99–119.

Liang K, and Zeger S. 1986 'Longitudinal data analysis using generalized linear models', Biometrika, 73: 13–22.

Liévanos RS 2015 'Race, deprivation, and immigrant isolation: The spatial demography of air-toxic clusters in the continental United States', Social Science Research, 54: 50–67. [PubMed: 26463534]

———. 2018 'Retooling CalEnviroScreen: Cumulative Pollution Burden and Race-Based Environmental Health Vulnerabilities in California', International Journal of Environmental Research and Public Health, 15: doi:10.3390/ijerphl5040762.

Liévanos Raoul S. 2017 'Sociospatial Dimensions of Water Injustice: The Distribution of Surface Water Toxic Releases in California's Bay-Delta', Sociological Perspectives, 60: 575–99.

Lin Jan, and Robinson Paul. 2005 'Spatial disparities in the expansion of the Chinese ethnoburb of Los Angeles', GeoJournal, 64: 51–61.

Logan JR 2001 “From many shores: Asians in census 2000” In, edited by Lewis Mumford Center for Comparative Urban and Regional Research, 9 Albany, NY: University at Albany.

Logan John R., Zhang Wenquan, and Alba Richard D.. 2002 'Immigrant Enclaves and Ethnic Communities in New York and Los Angeles', American Sociological Review, 67: 299–322.

Marshall JD 2008 'Environmental inequality: Air pollution exposures in California’s South Coast Air Basin', Atmospheric Environment, 42: 5499–503.

McCall Leslie. 2005 'The Complexity of Intersectionality', Signs, 30: 1771–800.

McClintock N 2012 'Assessing soil lead contamination at multiple scales in Oakland, California: Implications for urban agriculture and environmental justice', Applied Geography, 35: 460–73.

McGowan MO, and Lindgren J. 2006 'Testing the model minority myth. ', Northwestern University Law Review, 100.

McNamara Keith, and Batalova Jeanne. 2015 'Filipino Immigrants in the United States', Migration Information Source, E Pub: Not Available.

Microsoft. 2016 'Fast Facts About Microsoft', Accessed 8 December 2016 http://news.microsoft.eom/facts-about-microsoft/#sm.0001tmnrep75te8vx5dl3z2rb5brw.

Mohai P, Pellow DN, and Timmons Roberts J. 2009 'Environmental Justice', Annual Review of Environment and Resources, 34: 405–30.

Montoya Carina Monica 2009 Los Angeles's Historic Flllplnotown (Arcadia: Charleston, South Carolina).

Morello-Frosch R, and Jesdale BM. 2006 'Separate and unequal: Residential segregation and estimated cancer risks associated with ambient air toxics in US metropolitan areas', Environmental Health Perspectives, 114: 386–93. [PubMed: 16507462]

Nee Victor, and Sanders Jimy. 1985 'The road to parity: determinants of the socioeconomic achievements of Asian Americans', Ethnic and Racial Studies, 8: 75–93.

Nelder J, and Wedderburn R. 1972 'Generalized linear models', Journal of the Royal Statistical Society, Series A, 135: 370–84.

Nicolaides Becky M. 2015 'Introduction: Asian American Suburban History', Journal of American Ethnic History, 34: 5–17.

Nishi SM 1995 'Japanese Americans' in Min PG (ed.), Asian Americans: Contemporary Trends and Issues (Sage: Beverly Hills, CA).

Oakes John Michael, Anderton Douglas L., and Anderson Andy B.. 1996 Á Longitudinal Analysis of Environmental Equity in Communities with Hazardous Waste Facilities', Social Science Research, 25: 125–48.

Ong Paul M., Fujita Joanne T., and Chin Sam. 1977 Asians in Washington: A Statistical Profile (Washington State Commission on Asian American Affairs: Olympia, WA).

Pais J, Crowder K, and Downey L. 2014 'Unequal Trajectories: Racial and Class Differences in Residential Exposure to Industrial Hazard', Social Forces, 92: 1189–215.

Pamuk A 2004 'Geography of immigrant clusters in global cities: a case study of San Francisco', International Journal of Urban and Regional Research, 28: 287–307.

Park Lisa Sun-Hee, and Pellow David. 2002 The Silicon Valley of Dreams: Environmental Injustice, Immigrant Workers, and the High-Tech Global Economy (New York University Press: New York).

Pastor M, Sadd JL, and Morello-Frosch RA. 2004 'Waiting to inhale: The demographics of toxic air releases in 21st century California', Social Science Quarterly, 85: 420–40.

Pastor Manuel, Morello-Frosch Rachel, and Sadd James L.. 2005 'The air is always cleaner on the other side: Race, space, and ambient air toxics exposures in California', Journal of Urban Affairs, 27: 127–48.

Pastor Manuel, Sadd James, and Morello-Frosch Rachel. 2007 “Still Toxic After All These Years: Air Quality and Environmental Justice in the San Francisco Bay Area.” In, 1–24. Santa Cruz, CA: Center for Justice, Tolerance & Community, University of California, Santa Cruz.

Payne-Sturges Devon, and Gee Gilbert C.. 2006 'National environmental health measures for minority and low-income populations: tracking social disparities in environmental health.', Environmental Research, 102: 154–71. [PubMed: 16875687]

Pew Research Center. 2016 'The Rise of Asian Americans', Accessed 25 July 2016 http://www.pewsocialtrends.org/asianamericans-graphics/.

Phillip C 2010 'Explaining the Refugee Gap: Economic Outcomes of Refugees versus Other Immigrants', Journal of Refugee Studies, 3: 377–97.

Pulido Laura. 1996 Á Critical Review of the Methodology of Environmental Racism Research', Antipode, 28: 142–59.

———. . 2000 'Rethinking Environmental Racism: White Privilege and Urban Development in Southern California', Annals of the Association of American Geographers, 90: 12–40.

Quach T, Liu RL, Nelson DO, Hurley S, Von Behren J, Hertz A, and Reynolds P. 2014 'Disaggregating Data on Asian American and Pacific Islander Women to Provide New Insights on Potential Exposures to Hazardous Air Pollutants in California', Cancer Epidemiology Biomarkers & Prevention, 23: 2218–28.

Ringquist EJ 2005 'Assessing evidence of environmental inequities: A meta-analysis', Journal of Policy Analysis and Management, 24: 223–47.

Rumbaut R 2000 'Vietnamese, Laotian, and Cambodian Americans' in Zhou Min and Gatewood JV (eds.), Contemporary Aslan America (New York University Press: New York).

Sakaguchi Kristin, Ichinose Dan, Hung Betty, Lee Joanna, Stephens Pamela, Le An, and Masaoka Mark. 2013 “A Community of Contrasts: Asian Americans, Native Hawaiians and Pacifc Islanders in Los Angeles County" In, 36 Los Angeles, CA: Asian Americans Advancing Justice – Los Angeles

Shah Bindi. 2008 '‘Is yellow black or whiteP’Inter-minority relations and the prospects for cross-racial coalitions between Laotians and African Americans in the San Francisco Bay Area', Ethnicities, 8: 463–91.

———. 2011 Laotian Daughters: Working toward Community, Belonging, and Environmental Justice (Temple University Press: Philadelphia).

Skop E, and Li W. 2005 'Asians in America's suburbs: Patterns and consequences of settlement', Geographical Review, 95: 167–88.

Sowell T 1981 Ethnic America: A history (Basic Books).

Su JG, Morello-Frosch R, Jesdale BM, Kyle AD, Shamasunder B, and Jerrett M. 2009 'An Index for Assessing Demographic Inequalities in Cumulative Environmental Hazards with Application to Los Angeles, California', Environmental Science & Technology, 43: 7626–34. [PubMed: 19921871]

Su Jason G., Jerrett Michael, de Nazelle Audrey, and Wolch Jennifer. 2011 'Does exposure to air pollution in urban parks have socioeconomic, racial or ethnic gradients?', Environmental Research, 111: 319–28. [PubMed: 21292252]

Su Jason G., Larson Timothy, Gould Timothy, Cohen Martin, and Buzzelli Michael. 2010 'Transboundary air pollution and environmental justice: Vancouver and Seattle compared', GeoJournal, 75: 595–608.

Szasz Andrew, and Meuser Michael. 2000 'Unintended, Inexorable: The Production of Environmental Inequalities in Santa Clara County, California', American Behavioral Scientist, 43: 602–32.

Sze Julie. 2004 'Asian American Activism for Environmental Justice', Peace Review, 16: 149–56.

Taylor Q 1991 'Blacks and Asians in a white city: Japanese Americans and African Americans in Seattle, 1890–1940', The Western Historical Quarterly: 401–29.

Tsai Shih-Shan Henry. 1986 The Chinese Experience in America (Indiana University Press: Bloomington, IN).

United Church of Christ. 1987 “Toxic Waste and Race in the United States” In, 86 New York.

Vergara Benito M. Jr. 2009 Pinoy Capital: The Filipino Nation in Daly City Asian American History and Culture (Temple University Press: Philadelphia).

Walton Emily. 2015 'Making Sense of Asian American Ethnic Neighborhoods: A Typology and Application to Health', Sociological Perspectives, 58: 490–515.

White MJ, Fong E, and Cai Q. 2003 'The segregation of Asian-origin groups in the United States and Canada', Social Science Research, 32: 148–67.

Wierzbicki Susan. 1997 "The Assimilation of Asians in Seattle" In Population Association of America, 70 Washington D.C.

Xu Jun, and Lee Jennifer C.. 2013 'The marginalized" model" minority: An empirical examination of the racial triangulation of Asian Americans', Social Problems, 91: 1363–97.

Yi SS, Kwon SC, Sacks R, and Trinh-Shevrin C. 2016 'Commentary: Persistence and Health-related Consequences of the Model Minority Stereotype of Asian Americans', Ethnicity & Disease, 26: 133–38. [PubMed: 26843806]

Zeger S, and Liang K. 1986 'Longitudinal data analysis for discrete and continuous outcomes', Biometrics, 42: 121–30. [PubMed: 3719049]

Zhou Min, Tseng Yen-Fen, and Kim Rebecca Y.. 2008 'Rethinking Residential Assimilation: The Case of a Chinese Ethnoburb in the San Gabriel Valley, California', Amerasia Journal, 34: 55–83.

Zorn C . 2001 'Generalized estimating equation models for correlated data: A review with applications', American Journal of Political Science, 45: 470–90.

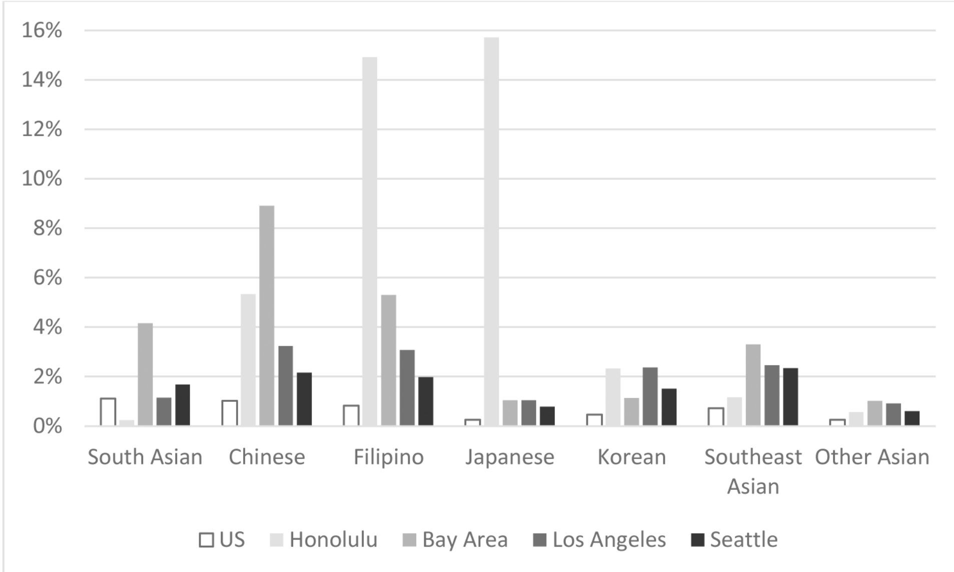

Figure 1.

Percent of Total Population in Each Asian Ancestry Category in the U.S. and Four Metro Areas (2010)

Source: US Census 2010

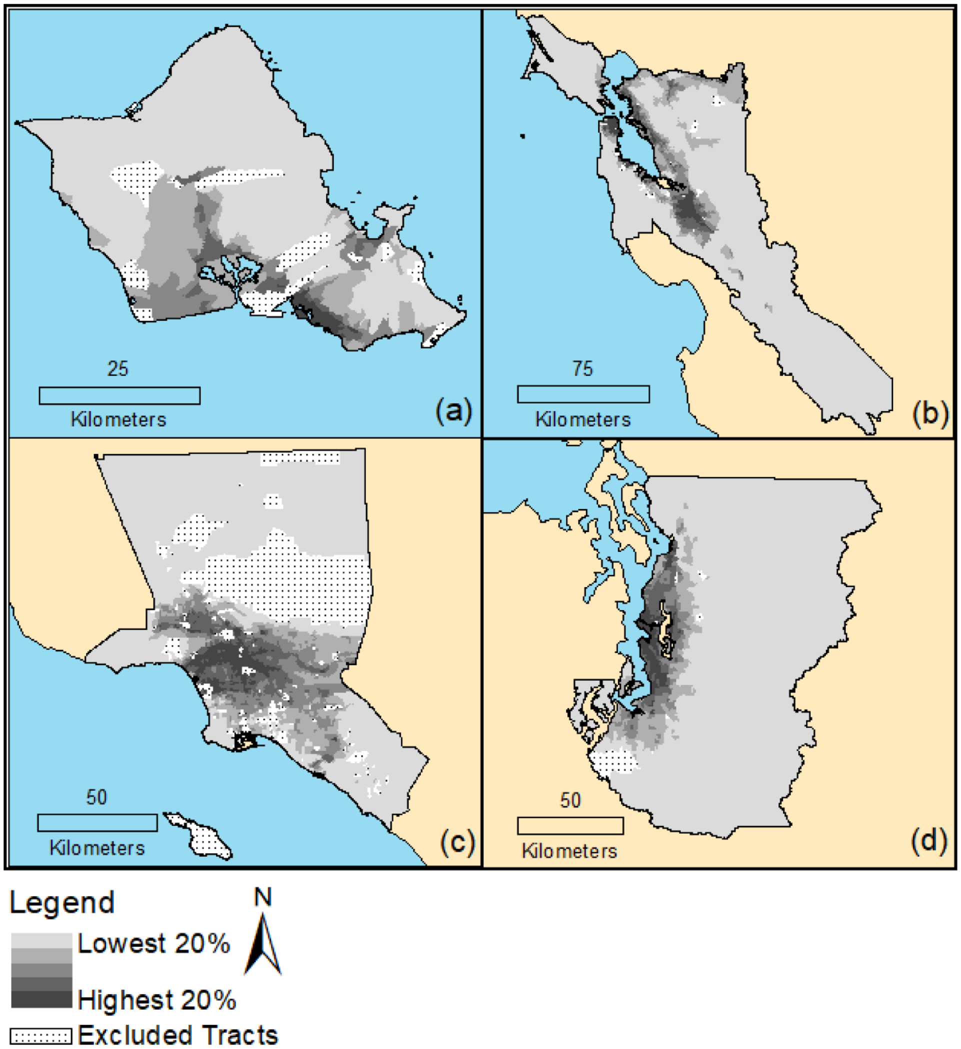

Figure 2.

Total Cancer Risk from Hazardous Air Pollutants (2011) in Census Tracts in (a) Honolulu, (b) the Bay Area, (c) Los Angeles, and (d) Seattle

Note: Tracts that were excluded due to missing data and small counts are not mapped.

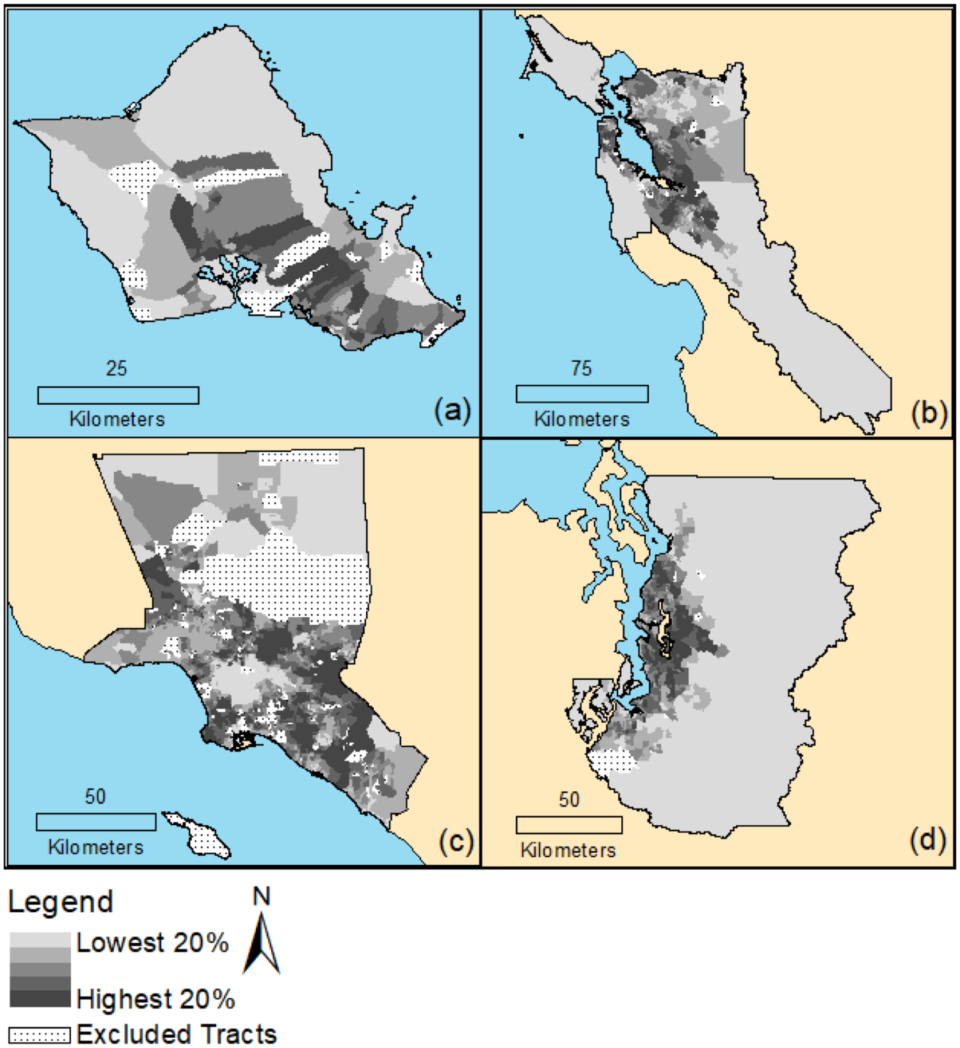

Figure 3.

Proportion Asian (2010) in Census Tracts (a) Honolulu, (b) the Bay Area, (c) Los Angeles, and (d) Seattle

Note: Tracts that were excluded due to missing data and small counts are not mapped.

Table 1.

Profile of the Total and Asian Population in the U.S. and the Four Metro Areas

	US		Honolulu		San Francisco Bay Area[1]		Los Angeles		Seattle	
	Total	Asian	Total	Asian	Total	Asian	Total	Asian	Total	Asian
Population count	308,745,538	14,465,124	953,207	410,019	6,172,302	1,561,380	12,828,837	1,858,148	3,439,809	389,309
Median HH income	$53,046	$68,950	$72,292	$71,198	$80,729	$93,603	$60,583	$67,199	$67,437	$69,157
% renter occupied housing units	33	36	41	28	42	36	47	41	35	32
% ≥bachelor's[2]	29	50	32	32	45	53	31	50	37	48
% foreign born	13	67	20	35	32	65	34	67	17	66
% speak English < 'verv well'[3]		35		25		36		41		37

Source: 2010 U.S. Census; American Community Survey 2008-12.

[1]Values are population-weighted average of the two Metropolitan Statistical Areas.

[2]Universe: Population: 25 years and over

[3]Universe: Foreign bom Asian population: 5 years and over

Table 2.

Population Counts of Asian Ancestry Groups in the U.S. and Four Metro Areas

	US	Honolulu	Bay Area	Los Angeles	Seattle
South Asian	3,426,385	2,234	256,684	147,605	57,819
Chinese	3,137,061	50,833	549,805	416,042	74,180
Filipino	2,555,923	142,238	327,334	393,170	67,911
Japanese	763,325	149,701	64,578	134,563	27,128
Korean	1,423,784	22,179	70,186	304,198	52,113
Southeast Asian	2,218,860	11,094	204,180	316,240	80,388
Other Asian	788,765	5,424	62,977	116,639	20,919

Source: 2010 Decennial Census

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Table 3.

Descriptive Statistics

	Honolulu (n=187)			Bay Area (n=1319)			Los Angeles (n=2748)			Seattle (n=705)		
	Min.	**Max.**	**Mean**	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**	**Mean**
DEPENDENT VARIABLE												
Total Cancer Risk	24.92	85.94	37.79	15.69	13 2.13	39.98	19.67	11 4.02	49.31	16.84	16 5.90	49.12
INDEPENDENT VARIABLES												
Median Income	23136	157924	79044.25	11655	233917	86815.81	12426	231648	64918.03	13563.00	190833	72252.30
Proportion Renter Occupied Housing Units	0.06	1.00	0.38	0.04	1.00	0.43	0.03	1.00	0.48	0.05	0.97	0.35
Proportion Hispanic	0.00	0.19	0.07	0.01	0.90	0.23	0.03	0.99	0.45	0.02	0.44	0.09
Proportion Black	0.00	0.11	0.01	0.00	0.65	0.07	0.00	0.90	0.07	0.00	0.39	0.05
Proportion Asian	0.04	0.81	0.47	0.00	0.90	0.24	0.00	0.87	0.14	0.00	0.63	0.11
Proportion Pacific Islander/Nat. Haw.	0.00	0.45	0.08	0.00	0.14	0.01	0.00	0.05	0.00	0.00	0.07	0.01
Proportion Multi/ Other Race	0.01	0.37	0.18	0.00	0.08	0.04	0.00	0.07	0.02	0.02	0.28	0.05
Population Density (km^2)	45.99	33905.90	4926.95	0.74	62357.29	4324.23	2.74	36482.53	4646.59	1.78	19740.56	1793.01
Asian Ancestry Groups												
Proportion South Asian	0.00	0.02	0.00	0.00	0.45	0.04	0.00	0.19	0.01	0.00	0.35	0.02
Proportion Chinese	0.00	0.53	0.06	0.00	0.87	0.09	0.00	0.72	0.03	0.00	0.40	0.02
Proportion Filipino	0.00	0.75	0.14	0.00	0.54	0.05	0.00	0.41	0.03	0.00	0.15	0.02
Proportion Korean	0.00	0.24	0.03	0.00	0.09	0.01	0.00	0.59	0.02	0.00	0.13	0.01
Proportion Japanese	0.01	0.49	0.18	0.00	0.09	0.01	0.00	0.33	0.01	0.00	0.07	0.01
Proportion Southeast Asian	0.00	0.09	0.01	0.00	0.48	0.03	0.00	0.71	0.02	0.00	0.24	0.02
Proportion Other Asian	0.00	0.03	0.01	0.00	0.12	0.01	0.00	0.17	0.01	0.00	0.07	0.01

Table 4.

GEEs[1] predicting tract-level cancer risk

Metro Area:	Honolulu		Bay Area		Los Angeles		Seattle	
Model:	1	2	1	2	1	2	1	2
	B	B	B	B	B	B	B	B
Intercept	3.626***	3.631***	3.673***	3.675***	3.891***	3.889***	3.897***	3.892***
Income	−0.060	−0.036	.050	.049	−.011	−.017	0.191***	0.179***
Income Squared	0.015	−0.007	−.030	−.031	−.004	−.002	−0.121**	−0.099*
Prop. Renter Occupied	0.029	0.019		087***	.060***	.058***	0.101***	0.123***
Prop. Hispanic	0.018	−0.001	.016	.019	.025**	.022**	0.039***	0.032***
Prop. Black	0.046	0.054*	.012	.015	019***	017***	−0.005	−0.035*
Prop. Pacific Islander	0.022	0.006	−.014*	−.006	−.020***	−.018***	0.015*	0.016*
Prop. Other Race	−0.062***	−0.037	.008	.017*	−.004	−.005	−0.003	−0.004
Pop Density	0.112***	0.100***	.136***	137***	039***	037***	0.240***	0.231***
Prop. Asian	0.057***		.012*		024***		0.041***	
Prop. South Asian		−0.024**		.005		.002		−0.021**
Prop. Chinese		0.034**		.013		.020***		−0.029*
Prop. Filipino		0.056***		−.027***		−-.011***		0.037***
Prop. Japanese		−0.007		.028***		−.001		0.055***
Prop. Korean		0.041		.011		.015***		0.001
Prop. Southeast Asian		0.009		044***		−.009**		0.038***
Pron. Other Asian		0.021		−.019*		.001		0.001

[1] Inverse Gaussian with Log Link was used for all eight models.

Note: Model 1 includes proportion Asian, and Model 2 substitutes that variable for the seven selected racial categories within the Asian racial group. All race/ethnicity variables are interpretable in reference to proportion non-Hispanic white. “B” refers to the standardized beta coefficient or parameter estimate.

* $p<.05$

** $p<.01$.

***$p<.001$

Table 5.

Summary of Ancestry Findings (based on Table 4, Model 2s)

Metro Area:	Honolulu	Bay Area	Los Angeles	Seattle
South Asian	(−)	+	+	(−)
Chinese	(+)	+	(+)	(−)
Filipino	(+)	(−)	(+)	(+)
Japanese	−	(+)	−	(+)
Korean	+	+	(+)	+
Southeast Asian	+	(+)	(−)	(+)
Other Asian	+	(−)	+	+

Key:

(+) Greater proportion of this ancestry group relative to proportion White is associated with higher LCR (p<.05)

(−) Lower proportion of this ancestry group relative to proportion White is associated with higher LCR (p<.05)

+ Greater proportion of this ancestry group relative to proportion White is associated with higher LCR (p≥.05)

− Lower proportion of this ancestry group relative to proportion White is associated with higher LCR (p≥.05)