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Ancestry-based intracategorical injustices in carcinogenic air pollution exposures in the United States

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Abstract

Previous studies of US environmental inequalities have focused on racial/ethnic differences in air pollutant exposure. Few have applied an intracategorical framework, which enables the identification of within-group differences through the examination of subgroups. We applied this framework to examine exposure disparities between 26 ancestry/ethnic origin groups within five US racial/ethnic categories. Data come from the US Census, American Community Survey, and National Air Toxics Assessment. We calculated national population-weighted lifetime cancer risk (LCR) scores from residential exposure to hazardous air pollutants. Results showed that Americans of Dominican, Ethiopian, and Somali descent have the highest total LCR scores at 53.1, 49.2, and 48.3 estimated excess cases of cancer per one million people, respectively. Use of the intracategorical framework enabled characterization of disparate risks that would be overlooked based on the conventional assumption that racial/ethnic environmental inequalities conform to broad, homogenous categories. Intracategorical studies can inform interventions by identifying environmentally-disadvantaged socio-demographic groups.

Keywords

ancestry; environmental inequality; environmental justice; hazardous air pollutants; intracategorical inequality

Introduction

Decades of research on patterns of distributional environmental injustices in the US have found that members of minority racial/ethnic groups (e.g., African-American and Hispanic people) face greater risks from air pollution than do Whites (Ard 2015; Downey and Hawkins 2008; Pais, Crowder, and Downey 2014). These studies tend to focus on differences between broad racial/ethnic categories, or *intercategorical* inequalities. While important, this focus masks within-group inequalities that can emerge when these large

racial/ethnic groups are disaggregated based on relevant social differences. Building off recent research on disparate exposures within Hispanic and Asian populations (e.g., Chakraborty, Collins, and Grineski 2017; Grineski et al. 2019), this study characterizes *intracategorical* environmental inequalities for a broad suite of racial/ethnic groups (i.e., Asians, Hispanics, Native Americans, Blacks, and Whites) in the US, with a focus on 26 ancestry/ethnic origin groupings. The national scale of analysis elevates the policy relevance of the findings and allows for clarification regarding generalized patterns than transcend local or regional particularities.

Most studies focusing on racial/ethnic differences in air pollution exposure utilize variables on broad compositional characteristics, such as the percent of census tract residents who are Black or Hispanic, when assessing environmental inequalities (Ard 2015; Bell and Ebisu 2012; Chakraborty 2009; Downey and Hawkins 2008; Gray, Edwards, and Miranda 2013). This is a problem considering that there are differences within racial/ethnic groups that are not accounted for when those variables are utilized in studies. For example, there are substantial within-group differences in the US Hispanic/Latino population depending on ancestral country of origin, e.g., between Cuban and Mexican Americans. The emphasis on Black and Hispanic Americans in US environmental justice research has also tended to direct attention away from Asian Americans. Considering Asians are the fastest growing minority group in the US, it is important to include them in studies of environmental inequalities (Grineski, Collins, and Morales 2017; Grineski et al. 2019).

While the majority of research looking at racial/ethnic disparities in exposure has been conducted in the US, there is a small body of research in other countries that has also found that racial/ethnic minorities are disproportionately exposed to air pollution (Buzzelli and Jerrett 2004; Hajat, Hsia, and O'Neill 2015; Mitchell and Dorling 2003; Pearce, Kingham, and Zawar-Reza 2006). The majority of EJ research done outside of the US however has not examined race/ethnicity, instead focusing on socioeconomic status (Hajat, Hsia, and O'Neill 2015; Mitchell and Dorling 2003).

Intracategorical Framework

Our consideration of race/ethnicity as a multidimensional concept is oriented by an *intracategorical* approach. This reflects the growing focus in environmental sociology on intersectional and intracategorical environmental justice scholarship (Malin and Ryder 2018). The intracategorical approach primarily seeks to identify issues of sources of inequality within groups, and it stems from the intersectionality approach that Crenshaw introduced in the 1980's (McCall 2005). As described by McCall (2005: 1773), intracategorical approach “focus on particular social groups at neglected points of intersection...in order to reveal the complexity of lived experience within such groups.” Essentially, this approach works outwards by first targeting an experience (e.g., exposure to air pollution) and then seeking to understand how social positioning influences the phenomenon (McCall 2005: 1787). This approach fosters novel understandings since it can reveal people's experiences of injustices within their respective groups (Kaushik and Walsh 2018). This is in contrast to *intercategorical* approaches, which “provisionally adopt existing analytical categories to document relationships of inequality among social groups

and changing configurations of inequality” (Nash 2008: 6). Put simply, intercategory approaches are useful for determining differences between groups, but they obfuscate other dimensions of inequality that shape disparate experiences within those groups. Thus, an intracategorical approach brings to light inequalities that would be masked by treating groups as monolithic categories, enabling the identification of within group differences through the examination of subgroups (Kaushik and Walsh 2018). By utilizing an intracategorical approach, we address an aggregation bias problem that stems from the examination of broad racial/ethnic groupings. Approaches like this that are sensitive to intra-racial/ethnic inequalities can advance knowledge in environmental justice research while contributing to practical actions to reduce environmental inequalities through the identification of particularly marginal subgroups (Malin and Ryder 2018).

Intracategorical Studies of Environmental Injustice

Environmental justice studies that have applied an intracategorical approach have previously examined heterogeneity within Asian and Hispanic American populations. This approach was first introduced to environmental inequality research by Collins and colleagues (2011), who examined unequal risk to hazardous air pollutants (HAPs) among Hispanic people in El Paso, Texas. They identified several socio-demographic axes of difference that influenced risk within the Hispanic population, e.g., lack of English proficiency, foreign-birth, older age, and low social class. This initial effort led to subsequent intracategorical studies (e.g., Grineski, Collins, and Chakraborty 2013; Grineski et al. 2015; Chakraborty, Grineski, and Collins 2017), which applied the approach to Hispanic populations in several US cities. While the majority of previous studies of intracategorical environmental inequality have emphasized that particular socio-demographic characteristics influence differences in exposures within Hispanic populations, two recent studies extended the approach to examine environmental injustices affecting subgroups within the Asian American population based on ancestry, nativity and language (Grineski, Collins, and Morales 2017; Grineski et al. 2019). However, more intracategorical research on environmental inequalities is needed that includes other populations.

One nascent strand of intracategorical research focuses on ethnic ancestry as an axis of inequality that may be important in shaping disparate patterns of exposure. Ancestry is a sub-category within broad racial/ethnic groupings. Colombian Americans, for example, are a subcategory of Hispanic Americans and individuals belong to both a racial/ethnic group and a specific ancestry group. There has been limited research on the relationship between air pollution and ancestry, although two studies have examined ancestral environmental inequalities within Hispanic populations in Miami, Florida. An individual-level study found that people of Cuban descent were more likely to experience disproportionate residential exposure to traffic-related air pollution in Miami than were non-Hispanic Whites (Chakraborty, Collins, and Grineski 2017). A census tract level study found that Miami neighborhoods with higher percentages of people of Cuban and Colombian ancestry (relative to non-Hispanic Whites) had higher levels of traffic pollution, but those with high percentages of people of Mexican descent had lower levels (Grineski, Collins, and Chakraborty 2013). While several prior environmental justice studies have examined ancestral sub-categories within Hispanic populations, none have been national in scope.

Similarly, few studies have examined ancestral environmental inequalities within the Asian American population. A national study found intra-ethnic differences in relation to cancer risk from hazardous air pollution; neighborhoods with higher percentages of residents with Chinese, Korean, and South Asian ancestry had significantly higher risk (Grineski, Collins, and Morales 2017). In California, women of Japanese and Korean ancestry had elevated exposures to carcinogens linked to breast cancer (Quach et al. 2014). Most recently, Grineski et al. (2019) applied an intracategorical approach to study HAP exposure for Asian Americans based on ancestral origin in four US metro areas with substantial Asian composition. Results underscored the importance of applying an intracategorical approach, as historical context and sociodemographics played key roles in shaping risk disparity profiles for people of different Asian ancestral backgrounds across the four localities (Grineski et al. 2019).

Gaps in Intracategorical Environmental Justice Scholarship

While researchers have examined to a limited extent intracategorical environmental inequalities within US Asian and Hispanic populations based on ancestry, other racial/ethnic categories remain unexamined from this perspective, leaving a gap in the environmental justice literature. Little knowledge exists regarding intracategorical environmental inequalities based on ancestry within Indigenous, Black, and White populations in the US. There may be ancestral inequalities within Native American populations, even though they are a relatively small segment of the total US population, and Native Americans do not emerge as a risk group in US national-level studies of air pollution hazard (Liévanos 2019; Grineski, Collins, and Morales 2017). However, patterns of injustice with respect to Native Americans and LCR may be particularly acute in the mid-Atlantic states of Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia (Liévanos 2019). In the US more generally, Native Americans reside both on and off reservations and tend to suffer from a lack of access to quality health care, lower educational attainment, and higher rates of unemployment and poverty when compared to other racial/ethnic groups (Lynch and Stretesky 2012). These factors leave this population vulnerable to corporations who are seeking to exploit their land at the cost of their health, which has been done repeatedly, but not equally across Native American tribes (Vickery and Hunter 2016). There are many cases of rural Native Americans living in close proximity to hazardous sites (e.g., mines), which often pollute the nearby water, soil, and air (Lynch and Stretesky 2012; Shriver and Webb 2009).

Black Americans are diverse in terms of their sociodemographic characteristics and ancestral origins, such that exposure may very well differ among Black ancestral groups. For example, some Black Americans are new immigrants from the West Indies, others are refugees from Somalia, and others are multigenerational US citizens (Hilaire 2006; Logan 2007). While not focused on ancestral inequalities, clusters of US census tracts housing economically deprived Black Americans face disproportionate air-toxic LCR (Liévanos 2015; 2019).

Hypothetically, an intracategorical analysis may have the most power to expose hidden inequalities when applied to the majority group, who are commonly perceived to be protected against environmental inequalities. This is particularly relevant to people from

Arab backgrounds, who are racially classified as “White” (Arab American Institute, 2010). From the periods of pre- to post-9/11 America, people from Arab and Middle Eastern backgrounds transitioned from being treated as ‘almost White’ and nearly invisible as a racialized group to being a visible racial minority (Gualtieri 2004). 9/11 served as a turning point for anti-Arab racism in the US, causing a change in how these diverse communities are represented and treated (Jarmakani 2009). Environmental injustice may be one manifestation of this disparate treatment as a new study revealed that Arab enclaves had significantly elevated cancer risk from HAPs in the US (Grineski, Collins, and Rubio, 2019). Moving forward, an intracategorical approach can continue to make these Americans visible when studying race/ethnicity and environmental injustice.

In sum, this study addresses a gap in the literature by examining ancestral inequalities within Hispanic and Asian populations at the national-level for the first time, and by examining ancestral inequalities within Native American, Black, and White populations for the first time at any level. We accomplish this through a comprehensive intracategorical environmental inequality examination of myriad ancestry groupings across all broad racial/ethnic categories in the US that is national in scope. We answer the question: *how does population-weighted lifetime cancer risk from hazardous air pollutants differ between racial/ethnic and ancestry groups based on exposure estimates from all pollutant emission sources, point sources, and on-road mobile (vehicular) sources?*

Data

Independent Variables: Race/Ethnicity and Ancestry

Our study area includes all census tracts within the United States and the District of Columbia ($n=72,526$). Social data on race/ethnicity and ancestry were gathered from the 2010 Decennial Census and is supplemented with 2009–2013 American Community Survey (ACS) 5-year estimates. We selected the 2009–2013 estimates since they center on 2011, which is the same year as the air pollution data. We used 2010 Census data whenever possible since it does not rely on a sample; however, for some ancestries, ACS data are the only available source of the information (U.S. Census Bureau 2014). The two datasets are compatible, except in the case of people with multiple ancestries, which are collated differently. For that reason, we did not include any of the “other” categories such as “Other Hispanic” and “Other Arab” as they were calculated differently in the two datasets. For the ACS, a variable such as “Other Arab” included people of multiple ancestries, while the 2010 census put people with multiple ancestries into a different variable, counting them multiple times for each of their chosen ancestry groups (U.S. Census Bureau 2010). Thus, people who identified themselves as having multiple or ‘other’ ancestries in the Census or ACS were not examined in this paper.

From the 2010 Census, we used responses to two questions to create the race/ethnicity and ancestry variables. Respondents were asked if they were of Hispanic, Latino or Spanish origin and the affirmative response options provided were Mexican, Cuban, Puerto Rican, and the command to write-in another Hispanic, Latino or Spanish origin, as applicable (U.S. Census Bureau 2011a). Then they were asked to identify their race (U.S. Census Bureau 2011b). Response options provided were White; Black; American Indian or Alaska

Native (with the command to write-in one's tribal affiliation) (U.S. Census Bureau 2011c); six specific Asian origins (i.e., Asian Indian, Chinese, Filipino, Japanese, Korean, or Vietnamese), and one write-in space to specify a different Asian race (U.S. Census Bureau 2011d); three specific Pacific Islander origins (i.e., Native Hawaiian, Guamanian or Chamorro, or Samoan), and one write-in space to specify a different Pacific Islander race (U.S. Census Bureau 2011e); and finally 'some other race', with the command to specify what that is. The Census collated responses to these two questions to create the race/ethnicity variables that we use here: non-Hispanic Black, Asian, White, Native American, Pacific Islander, and two or more races, and Hispanic (of all races). They also used these two questions to create specific ancestry variables for Asian, Hispanic, Pacific Islander, and Native American subgroups, of which 26 "specific races" or ancestries are used in this paper (see Table 1, under column heading 'specific origins included').

The ACS collects ancestry data in a separate item from race/ethnicity using the question, "What is this person's ancestry or ethnic origin?" It is open response. The ACS coded the data and provided ancestry information for a total number of 173 groups, of which 27 were used in this study. The 27 ancestries (see Table 1, under column heading 'specific origins included') apply to the non-Hispanic Black and non-Hispanic White population.

Table 1 presents all ancestries included in the paper and their data source. Table 2 provides population counts for each group. To create meaningful categories for analysis, the ancestries were grouped based on size, geographic region, and religious or cultural similarities, following Perez et al. (2009) for the Hispanic ancestry groups and Grineski, Collins, and Morales (2017) for the Asian ancestry subgroups. We did not group the largest categories. So, people of Mexican, Puerto Rican, and Cuban ancestry were considered alone for the Hispanic population, while those of Chinese, Filipino, and Asian Indian ancestry were examined separately for the Asian population. Navajo, Cherokee, and Chippewa were considered separately within the Native American population, as were West Indian, Nigerian, Ethiopian, and Somalian for the Black population. For the non-Hispanic White population, we considered Arabic and Middle Eastern as separate groups.

Dependent Variables: Hazardous Air Pollutants

Pollution data come from the United States Environmental Protection Agency's (EPA) 2011 National Air Toxics Assessment (NATA), released in 2015 (Environmental Protection Agency 2016). Because of our reliance on 2010 Census data, we have not used the temporally misaligned 2014 NATA, which were released in late 2018. The NATA measures lifetime cancer risk across the US due to exposure to hazardous air pollutants (HAPs) at the tract-level. The cancer risks were calculated utilizing a multi-step approach. The 2011 National Emissions Inventory classifies HAPs as cancer causing agents based on the Clean Air Act Amendments; there are 180 substances measured by the NATA following the classifications (Environmental Protection Agency 2016). Unit risk estimates (URE) are upper bound estimates utilized to predict the probability of an individual contracting a HAP related cancer over a 70-year lifespan due to the concentrated exposure to one microgram of a HAP per cubic meter of air. In order to calculate population-weighted mean lifetime cancer risk (LCR) related to a HAP, inhalation reference concentrations and exposure concentration

estimates are combined for each census tract. The risks for the HAPs are added together to estimate a LCR measure in persons per million for each census tract. The probability of contracting a HAP related cancer is estimated using upper bound estimates over a 70-year lifetime being exposed to HAPs.

The NATA is a reliable source in determining cancer risks that are associated with HAPs that are emitted from multiple sources (Chakraborty, Maantay, and Brender 2011). The NATA enables examination of cancer risks from different sources. We examine (1) total LCR, which is a summation of point stationary, non-point stationary, on-road mobile, non-road mobile, background, and secondary source variables; (2) point stationary LCR, which stems from refinery, factory, and power plant emissions; and (3) on-road mobile LCR, which includes emissions from cars, trucks, busses, and any other vehicles on roads or highways (Environmental Protection Agency 2016). Figure 1 depicts the distribution of LCR by source across US census tracts.

Methods

We calculated population-weighted mean LCR for each racial/ethnic and ancestry group and the total population, following prior studies (Clark, Millet, and Marshall 2014; Collins, Grineski, and Morales 2017; Grineski, Collins, and Morales 2017). We chose to use this bivariate analysis approach, which determines LCR for each group, in order to reliably examine ancestry groups with small counts. The small counts for some ancestry groups at the tract-level nationwide make a more traditional multivariate census-tract level analysis relying on variables that correspond to a percentage of the tract's population untenable. Additionally, a bivariate analysis approach enables basic description of actual differences in population-weighted mean LCRs across the US by racial/ethnic and ancestral group, which is especially useful since many of these groups have not received analytical attention in prior environmental justice studies.

We created three population-weighted mean LCR measures for each racial/ethnic and ancestry group, one for each source. We began with a census tract-level dataset. First, we multiplied the total population of each group in each census tract by the total LCR score for each corresponding tract. Second, we summed those group-specific population * LCR values for all census tracts. Third, we summed the census tract populations of each group to create a total population figure for each group. Fourth, we divided the group-specific population * LCR values by the total population of each group. For example, we divided 651,023,812.55 (the summed tract-level Asian population * LCR values) by 14,674,252 (the total Asian population), which yielded 44.365. This is the population-weighted mean LCR for Asians Americans in the US, for whom we estimate 44.4 additional or excess cases of cancer per million due to HAP exposure. We applied the same process for point and on-road sources.

Results

Table 3 and Figure 2 present the population-weighted mean LCR scores for the racial/ethnic and ancestry groups. In Table 3, the ancestry groups are listed in rank order from high-to-

low for total LCR within each racial/ethnic group, with the value for the racial/ethnic group listed above the corresponding ancestral sub-groups.

In terms of the racial/ethnic groups, the two groups with the highest LCRs from HAPs were Non-Hispanic Blacks (**45.638**) and Non-Hispanic Asians (**44.365**) while the two groups with the lowest population-weighted total LCR were Non-Hispanic Whites (**38.300**) and Non-Hispanic Native Americans (**36.816**). Given that the national average for total LCR is **39.999**, Blacks have LCR scores that are 14% higher than average while Asians have total LCR scores that are 11% higher than average. Non-Hispanic Blacks (**1.464**) and Non-Hispanic Whites (**0.918**) had the highest LCR from point source HAPs, while Non-Hispanic Native Americans (**0.603**) and Non-Hispanic Pacific Islanders (**0.499**) had the lowest. The national average for point source LCR is **0.973**, meaning that Blacks have point source LCR scores that are 50% higher than the national average. Non-Hispanic Asians (**9.626**) and Non-Hispanic Blacks (**8.798**) had the highest LCR from on-road HAPs, while Non-Hispanic Whites (**6.600**) and Non-Hispanic Native Americans (**5.790**) had the lowest. The national average for on-road LCR is **7.222**, meaning that the on-road LCR scores for Asians and Blacks are 33% and 22% higher, respectively, than the average. Hispanic people overall fell in the middle for their respective LCRs from HAPs in comparison to the non-Hispanic Whites and those groups with the highest risks.

For ancestry, the groups with the highest total LCR from HAPs are people with Dominican (**53.102**), Ethiopian (**49.177**), or Somalian (**48.257**) ancestry. These are well above the national average, with Dominicans having total LCR scores that are 33% higher than average. For Ethiopians and Somalians, their total LCR scores are 23% and 21% higher than the average, respectively. The three lowest groups are those with Native Alaskan (**33.260**), Chippewa (**27.288**), and Navajo (**26.932**) ancestries, which fall well below the national average (**39.999**).

The people with the highest LCR from point source HAPs are those of Somalian (**1.142**) or Arab (**1.115**) ancestry. As compared to the national average (**0.973**), these scores are 17% higher for Somalians and 15% higher for Arab Americans. Those with the lowest point LCR are of Polynesian (**0.399**), Navajo (**0.275**), and Alaskan Native (**0.129**) ancestry.

The groups with the highest LCR from on-road HAPs are those of Dominican (**14.929**), Somalian (**12.997**), and Ethiopian (**11.421**) ancestry. These values are extremely high with respect to the national average (**7.222**): i.e., 107%, 80% and 58% higher for Dominicans, Somalians and Ethiopians, respectively. The groups with the lowest risks are Navajo (**3.386**), Chippewa (**4.547**) and Combined American Native Tribes (**4.674**).

Discussion

The analysis generated novel findings regarding intracategorical environmental inequalities based on ancestral origins. To aid in interpretation of findings, Figure 3 depicts tract-level clusters of select ancestry groups to be discussed. To begin, the environmental injustice of the greatest magnitude captured in this study occurred with respect to on-road emissions and the US Dominican population. The findings for the alarming LCRs from HAP exposures

that burden the US Dominican population would not have been uncovered had Hispanics been analyzed as a homogenous group. Risks for Dominicans have also not emerged in the two studies of ancestral environmental inequalities in Miami, where they are not a contextually dominant group (Grineski, Collins, and Chakraborty 2013; Chakraborty, Collins, and Grineski 2017). Nationally, we found that Dominican Americans experienced extremely high total and on-road LCR from HAPs, when compared to other ancestry groups and to the general population. Due to the limited amount of quantitative research on environmental injustices faced by Dominican Americans nationwide, it is uncertain why they face such high risks. Dominicans are the fifth largest Hispanic group in the US. There have been environmental health studies focusing on Dominican children in New York City, where many Dominicans live (see Figure 3), which have found that they face high exposure to traffic and stationary sources of pollution that can cause health problems, both in the short term and eventually later on in life (Jung et al. 2017; Patel et al. 2011).

People with Somali and Ethiopian ancestry also experienced high total and on-road LCRs. Somalis also had the highest point LCR in comparison to all other ancestries. The Somali population in the US is of low socioeconomic status, composed of a high proportion of foreign-born individuals, and typically dark-skinned. More than a third of Somalis do not have a high school diploma. Somali women are less likely to participate in the workforce than other women, and nearly half of all Somali immigrants in the US live below the federal poverty line (McCabe 2011). These socioeconomic factors likely constrain where Somali immigrants are able to reside, leading to their increased exposure to carcinogenic HAPs. The LCR for Ethiopians and Somalis is reflective of risks for Black Americans more generally. Logan (2007) found that Ethiopians and Somalis tend to form their own ethnic enclaves within Black communities in US cities, such is the case in Minneapolis, Los Angeles-Long Beach, and Dallas. Our results show that their LCRs from HAPs are substantially greater than Black Americans in general, suggesting that these enclaves are in particularly polluted urban zones.

Findings from this study indicate that those of Chinese ancestry experience high total LCR from HAPs (i.e., total LCR scores are 16% higher than the national average), which was also found in another national study that compared Chinese Americans to those of other Asian ancestries (Grineski, Collins, and Morales 2017). People of Chinese ancestry have long made the US their home, and have long been discriminated against. Thus, many Chinatowns are now located in longstanding central city areas (Liu and Geron 2008). While some Chinese Americans have the financial ability to access less polluted residential areas, e.g., in wealthy predominantly White neighborhoods, many are still drawn to living in Asian enclaves, possibly due to discrimination and historical settlement patterns within the U.S. (Walton 2015). Because of this, their total and on-road LCRs from HAPs are among the highest in the analysis. South Asians fall just behind the Chinese in terms of total and on-road LCR within the Asian group. Their high LCR from HAPs may relate to their urban residence and presence in the science and engineering sectors of the workforce (Pew Research Center 2016).

Native Americans faced lower LCRs from HAPs than other racial/ethnic groups. However, it is notable that those of Cherokee ancestry have total LCR scores that are 5% higher than

the US national average and also much higher than the other tribes examined (e.g., 27% higher than those with Chippewa ancestry). Those of Cherokee descent predominantly reside in the southern United States, with the majority living in Oklahoma and western North Carolina (Cherokee Nation 2019) (see Figure 3). This regional pattern of residence overlaps with a concentration of relatively high LCR from HAPs in the southern US (see Figure 1). Nonetheless, elevated LCRs for Native Americans were not found in the South Central EPA region, which includes Oklahoma, based on an analysis of 2005 LCR and 2000 census data (Liévanos 2019). This means that breaking out Native Americans based on ethnic origins (e.g., Cherokee) might be a particularly important when examining Native Americans and environmental injustice.

We found that Arab Americans rank second for LCR from point source HAPs and have point LCRs that are 15% higher than the national average. Arab Americans' high LCR from point source HAPs likely stems partly from their settlement patterns. Most studies focusing on Arab Americans have examined their enclaves in Michigan, Minnesota, California, and Virginia (Abuelezzam, El-Sayed, and Galea 2018), although there are clusters of Arab Americans living in other parts of the US such as in New York City, Chicago, and Oklahoma City (see Figure 3), which are all metro areas with substantial point source pollution. At a general level, newly arriving Arab immigrants tend to settle in urban areas (Johnson et al. 2010), which typically contain more sources of pollution (Leichenko and Solecki 2008). Given the negative racialization of Arab Americans in the US in the aftermath of 9/11 (Jarmakani 2009), this may influence where they decide to live and work, possibly adding to their increased point source LCR, since they may have become increasingly concentrated away from other Whites in enclaves that are also home to smoke-stack industries.

Limitations

While our intracategorical findings more comprehensively characterize environmental inequalities based on ancestry across the US than any prior study, our analyses did not consider how socioeconomic status, nativity, or English-language proficiency might intersect with ancestry, since those data are not publically available by ancestry in the US Census or ACS. The use of individual level data would better enable such analyses. Examining the intersections of ancestry with other dimensions of social inequality would allow us to more fully contribute to the project of emphasizing intersectionality in environmental justice scholarship by enhancing knowledge and informing effective interventions (Malin & Ryder 2018). We minimized our use of ACS data as much as possible due to concerns about error in the estimates (Folch et al. 2016), but we used ACS data in order to include ancestries within the non-Hispanic Black and non-Hispanic White racial groups. We determined that the benefits of including those groups outweighed concerns about data quality. While it has been recommended to calculate coefficients of variation (calculated by dividing the error surrounding the estimate by the estimate) and then to remove tracts with high values (Liévanos 2019), that was not practical here since the majority of tracts had small counts of the ancestry group under study. However, we did not conduct a census tract-level analysis. Instead, we aggregated data from tracts to the national level, as a way to minimize the threat of bias. While the national scale of this study is a strength that elevates the policy relevance of the findings and allows for clarification regarding generalized patterns than

transcend local or regional particularities, it is the case that locally and regionally specific patterns are washed out in national level analysis. Future qualitative research on residential decision-making could also provide important explanatory insight regarding the patterns documented here.

Conclusions

This study extended the application of an intracategorical frame to environmental justice research, which shed light on within group differences, specifically, in terms of how LCRs from HAPs varied based on racial/ethnic ancestry groupings across the US. The intracategorical analysis approach yielded novel findings regarding especially amplified air pollution health risks faced by particular ancestral sub-groups, which have important practical implications. The power of intracategorical analyses is in their power to uncover existing disparities that are initially masked (Kaushik and Walsh 2018). Many of the ancestry groups studied here have been subsumed within larger racial/ethnic groups in all prior environmental justice studies.

Among those groups, we documented heretofore concealed patterns, e.g., that Dominicans faced the highest total LCR from HAPs, which was substantially higher than the total LCRs found for other Hispanic/Latino groups. And while Native Americans overall exhibited relatively low LCRs from HAPs, we found the Cherokee group to be an important high risk outlier. Within the Black population, the four ancestry groups examined—Ethiopian, Somalian, Nigerian and West Indian groups—faced some of the highest LCRs in the study, which was not entirely surprising based on what we know from prior studies about disproportionate exposure to pollution among Black Americans (Ard 2015; Downey and Hawkins 2008; Pais, Crowder, and Downey 2014). However, it is important to note how intersecting axes of social difference within the ancestral groups we examined may serve to amplify or attenuate their risks to LCR from HAPs. For example, the low educational attainment, foreign birth, and limited English-language proficiency of many Somalian Americans (McCabe 2011) likely intersects with their dark skin to shape their particularly high LCR from HAPs. As another example, West Indian Americans typically have relatively high SES (Crowder 1999), which likely influences that fact that they face relatively lower LCR from HAPs than those categorized as being of Black American race more generally. Lastly, within the non-Hispanic White populations, Arab Americans were found to be at particularly high LCR for exposure to point source HAPs, which may reflect their social and environmental marginalization in the post-9/11 era. This paper emphasizes the use of an intracategorical approach and the value it brings to environmental justice research.

Studies documenting new patterns of distributive environmental inequalities, like this one, as well as studies that have attempted to explain such patterns, have continued to move the EJ literature forward in dialogue. Future studies should aim to incorporate an intracategorical approach in order to enhance knowledge of environmental injustices experienced by particular social subgroups and to inform practical interventions that reduce their risks. These practical interventions may be well-placed in ethnic enclaves, as the risks highlighted here for people several different ancestry groupings may derive from residential clustering.

Our intracategorical analyses also highlighted that two immigrant/refugee populations--Somalians and Ethiopians and their descendants--are unequally and extremely burdened by HAPs. This exposure is a health risk factor that has been missed by researchers and clinicians in the area of immigrant and refugee health. Frameworks for understanding immigrant and refugee population health are robust with regards to social factors that constrain health (e.g., poverty, lack of insurance, acculturative stress, and discrimination) (Edberg, Cleary, and Vyas 2011). Environmental exposures are notably missing from these frameworks, potentially due to a lack of intracategorical environmental health research, and it is unclear how they might interact and synergize with these myriad social stressors. Stress in particular makes the human body more vulnerable to environmental insults (Gee and Payne-Sturges 2004). Our results suggest that community programs and medical providers serving immigrant and refugee populations need to be sensitive to how residential environmental exposures might increase people's susceptibility to illness or cause it directly. This is just one example of how the identification of intracategorical environmental injustice can be practically useful.

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Figure 1. Lifetime cancer risk (LCR) values for total, point and on-road sources for US census tracts, 2011

Note: The units for population-weighted mean LCR are excess cases of cancer, , related to hazardous air pollutant (HAP) exposure, per 1 million people over a 70-year lifespan.

Figure 2.
Graphical depiction of the population-weighted mean LCR for racial/ethnic and ancestry groups in the US (derived from Table 3)
Note: The units for population-weighted mean LCR are excess cases of cancer, related to hazardous air pollutant (HAP) exposure, per 1 million people over a 70-year lifespan.

Figure 3.

Select ancestral clusters in the US

Figure 3 Note: Clusters were defined based on a k-means cluster analysis. Two categories (1=tract is in a high cluster, 0=tract is not in a high cluster) were output and mapped for tract-level proportion variables of each selected ancestry variable.

Table 1.

Categories of ancestry examined within each racial/ethnic group

Group	Specific Origins Included	Source ^a
Asian		Census
Chinese	Chinese	Census
Filipino	Filipino	Census
Asian Indian	Asian Indian	Census
South Asian	Bangladeshi, Bhutanese, Nepalese, Pakistani, Sri Lankan	Census
Southeast Asian	Burmese, Cambodian, Hmong, Indonesian, Laotian, Malaysian, Thai, Vietnamese	Census
Northeast Asian	Japanese, Korean, Taiwanese	Census
Hispanic		Census
Dominican	Dominican	Census
Mexican	Mexican, Mexican Indian	Census
Puerto Rican	Puerto Rican	Census
Cuban	Cuban	Census
Central American	Central American Indian, Costa Rican, Guatemalan, Honduran, Panamanian, Salvadoran	Census
South American	South American Indian, Argentinean, Bolivian, Chilean, Colombian, Ecuadorian, Paraguayan, Peruvian, Uruguayan	Census
Pacific Islander		Census
Polynesian	Native Hawaiian, Samoan, Tongan	Census
Micronesian	Guamanian or Chamorro, Marshallese	Census
Melanesian	Fijian	Census
Native American		Census
Combined American Indian Tribes	Apache, Arapaho, Blackfeet, Cheyenne, Chickasaw, Choctaw, Colville, Comanche, Cree, Creek, Crow, Delaware, Hopi, Houma, Iroquois, Kiowa, Lumbee, Menominee, Osage, Ottawa, Paiute, Pima, Potawatomi, Pueblo, Puget Sound Salish, Seminole, Shoshone, Sioux, Tohono O'odham, Ute, Yakama, Yaqui, Yuman	Census
Combined Alaskan Tribes	Alaskan Athabaskan, Aleut, Inupiat, Tlingit Haida, Tsimshian	Census
Navajo	Navajo	Census
Cherokee	Cherokee	Census
Chippewa	Chippewa	Census
Black		Census
West Indian	Bahamian, Barbadian, Belizean, Bermudan, British West Indian, Dutch West Indian, Haitian, Jamaican, Trinidadian and Tobagonian, U.S. Virgin Islander, West Indian	ACS
Nigerian	Nigerian	ACS
Ethiopian	Ethiopian	ACS
Somalian	Somalian	ACS
White		Census
Middle Eastern	Assyrian Chaldean Syriac, Afghan, Iranian, Israeli, Turkish	ACS
Arabic	Egyptian, Iraqi, Jordanian, Lebanese, Moroccan, Palestinian, Syrian, Arabic	ACS

^aCensus=2010 US Census; ACS=2009–2013 American Community Survey 5-year estimates

Table 2.

Total US population in each racial/ethnic and ancestry group

Race/Ethnicity (shaded gray) or Ancestry Group (shaded white)	Total U.S. Population^I
Asian (non-Hispanic)	14,674,252
Chinese	3,137,061
Asian Indian	2,843,391
Southeast Asian	2,556,086
Filipino	2,555,923
Northeast Asian	2,383,800
South Asian	598,284
Hispanic (of all races)	46,494,505
Mexican	31,919,477
Puerto Rican	4,623,716
Central American	3,982,536
South American	2,768,526
Cuban	1,785,547
Dominican	1,414,703
Pacific Islander (non-Hispanic)	540,013
Polynesian	768,700
Micronesian	170,232
Melanesian	32,304
Native American (non-Hispanic)	2,932,248
Combined American Indian tribes	803,590
Navajo	286,731
Cherokee	284,247
Chippewa	112,757
Combined Alaskan tribes	98,892
Black (non-Hispanic)	38,929,319
West Indian	2,738,152
Nigerian	271,530
Ethiopian	213,204
Somalian	118,032
White (non-Hispanic)	223,553,265
Arabic	1,507,501
Middle Eastern	978,479
Multiracial (non-Hispanic)	9,009,073
Total Population	308,745,558

^I Includes the 50 states and the District of Columbia

Table 3.

Population-weighted mean lifetime cancer risk (LCR) for racial/ethnic and ancestry groups in the US

Group	Total LCR ^I	Point LCR ^I	On-Road LCR ^I
Asian (non-Hispanic)	44.365	0.751	9.626
Chinese ancestry	46.432	0.706	11.081
South Asian ancestry	46.274	0.904	10.769
Northeast Asian ancestry	44.805	0.652	9.666
Southeast Asian ancestry	44.063	0.829	9.024
Asian Indian ancestry	43.578	0.905	9.283
Filipino ancestry	42.246	0.621	8.580
Hispanic (all races)	43.376	0.876	8.869
Dominican ancestry	53.102	0.695	14.929
Mexican ancestry	42.555	0.930	7.988
Puerto Rican ancestry	44.635	0.863	10.519
Cuban ancestry	41.131	0.462	10.032
Central American ancestry	46.161	0.871	10.087
South American ancestry	44.897	0.628	10.672
Pacific Islander (non-Hispanic)	39.992	0.499	7.524
Melanesian ancestry	42.954	0.401	8.191
Micronesian ancestry	41.319	0.605	7.662
Polynesian ancestry	37.333	0.399	6.374
Native American (non-Hispanic)	36.816	0.603	5.790
Cherokee ancestry	42.080	0.799	5.086
Combined American Indian tribes	35.403	0.517	4.674
Combined Alaskan tribes	33.260	0.129	5.307
Chippewa ancestry	27.288	0.462	4.547
Navajo ancestry	26.932	0.275	3.386
Black (non-Hispanic)	45.638	1.464	8.798
Ethiopian ancestry	49.177	0.680	11.421
Somalian ancestry	48.257	1.142	12.997
Nigerian ancestry	45.369	0.936	9.627
West Indian ancestry	44.419	0.599	10.869
White (non-Hispanic)	38.300	0.918	6.600
Middle Eastern ancestry	44.189	0.737	9.429
Arabic ancestry	42.028	1.115	8.832
Multiracial (non-Hispanic)	41.704	0.858	8.149
Total Population	39.999	0.973	7.222

^I The units for these scores are the number of excess cases of cancer, related to hazardous air pollutant (HAP) exposure, per 1 million people over a 70-year lifespan.