**Title:**

Racial Residential Segregation and Airborne Fine Particulate Matter Components in the United States

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The authors declare they have no actual or potential competing financial interests.

**Abstract:**

*Background:* Both exposure to fine particulate matter ≤ 2.5 microns in diameter (PM2.5) and racial residential segregation, the separation of two or more groups into different neighborhoods by race, of African Americans in the United States (US) have been associated with common negative health outcomes including cardiovascular disease, respiratory disease, lung cancer, low birthweight, preterm birth, and death. Evidence is mounting that the toxicity of PM2.5 varies according to its chemical composition.

*Objectives:* We evaluated associations between African American racial residential segregation and PM2.5 total and component levels in the US

*Methods:* We calculated 2005-2015 average census tract concentrations of total PM2.5 (*n*=886) and aluminum (*n*=276), arsenic (As) (*n*=276), bromine (Br) (*n*=274), cadmium (*n*=276), calcium (*n*=276), chlorine (*n*=276), copper (Cu) (*n*=275), iron (Fe) (*n*=276), lead (Pb) (*n*=276), mercury (*n*=162), nickel (Ni) (*n*=276), silicon (*n*=276), sodium (*n*=264), titanium (*n*=276), vanadium (V) (*n*=276), zinc (Zn) (*n*=276), ammonium ion (NH4+) (*n*=213), sodium ion (*n*=213), nitrate ion (NO3–) (*n*=267), sulfate ion (SO42–) (*n*=277), and elemental carbon (EC) (*n*=201) using daily averages from the US Environmental Protection Agency. We used 2010 US Census data to calculate a spatial isolation (SI) index of RRS by census tract and 2008-2012 American Community Survey data to evaluate socioeconomic confounding. We used a one-way analysis of variance to evaluate differences in PM2.5 total and component concentrations by SI quintile and linear models to evaluate associations between PM2.5 concentrations and SI quintiles.

*Results:* Concentrations of As, Br, Cu, Fe, Pb, Ni, V, Zn, NH4+, NO3-, and SO42- were higher for those living in the highest SI quintile than for those in the lowest. Linear models showed a 0.38-μg/m3 increase (95% CI: 0.22, 0.54, *p* < 0.00001) in total PM2.5 per one-quintile increase in SI after controlling for region, poverty, racial/ethnic composition, unemployment, and age.

*Conclusions:* Results suggest that total PM2.5 concentrations are higher in more segregated areas and that associations appear to vary by PM2.5 composition in the US.

**Introduction**

Exposure to fine particulate matter ≤ 2.5 microns (µm) in diameter (PM2.5) has been associated with between 103,300 (Sun et al. 2015) and 200,000 (Dai et al. 2014) premature deaths per year in the United States (US) (Caiazzo et al. 2013; Dai et al. 2014; Fang et al. 2013; Sun et al. 2015), primarily from cardiovascular disease (CVD), respiratory disease, and lung cancer (Burnett et al. 2014; Franklin et al. 2006; Lelieveld et al. 2015; Pope and Dockery 2006), and with adverse birth outcomes including low birthweight (Bell et al. 2007b; Brauer et al. 2008; Gray et al. 2014; Hao et al. 2015; Parker et al. 2005; Sun et al. 2016) and preterm birth (Brauer et al. 2008). The chemical composition of PM2.5 varies by source (Zheng et al. 2002) and has been shown to be heterogeneous at the community level (Bell et al. 2011). Evidence is mounting that different chemical components of PM2.5 have different health impacts, with some more toxic than others (Atkinson et al. 2015; Beelen et al. 2015; Bell et al. 2007a; Chung et al. 2015; Eeftens et al. 2014; Franklin et al. 2008; Hampel et al. 2015; Kelly and Fussell 2012; Lelieveld et al. 2015; Ostro et al. 2015; Peng et al. 2009; Raaschou-Nielsen et al. 2016; Stanek et al. 2011; Thurston et al. 2015; US EPA 2009; Wang et al. 2017; Wolf et al. 2015).

Disparities in environmental exposures, including to PM2.5, have been suggested as one factor influencing racial/ethnic disparities in health outcomes in the US For example, compared to non-Hispanic whites, African Americans had higher age-adjusted adult mortality rates for total (all-cause) mortality in 2015 (Xu et al. 2016) as well as for CVD and lung cancer mortality in 2014 (the year of the latest data available) (Heron 2016), and higher incidences of low birth weight and preterm birth in 2015 (Martin et al. 2017), all of which also have been linked to PM2.5 exposure. Various national studies (Bell and Ebisu 2012; Miranda et al. 2011; Sexton et al. 1993) and at least one statewide study (Gray et al. 2013) found higher levels of total ambient PM2.5 (Bell and Ebisu 2012; Miranda et al. 2011; Sexton et al. 1993) and several PM2.5 components (Bell and Ebisu 2012) in African American residential areas compared to non-Hispanic white residential areas. Those studies are corroborated by the environmental justice literature, in which the disproportionate siting of some air pollution sources in communities of color, particularly African American communities, is well documented (Chavis and Lee 1987; Hipp and Lakon 2010; Hunter et al. 2003; Mohai et al. 2009b, 2009a; Mohai and Saha 2015; Perlin et al. 2001; Sexton et al. 1993).

Another factor that has been linked to racial/ethnic health disparities is residential segregation (Williams and Collins 2001), defined as “the degree to which two or more groups live separately from one another” (Massey and Denton 1988). Among African Americans, residence in areas more highly segregated by race and ethnicity has been associated, independently of the overall racial/ethnic composition of those areas, with negative health outcomes including increased rates of adult all-cause mortality (Jackson et al. 2000), CVD mortality (Kershaw et al. 2014; Kershaw and Albrecht 2015), lung cancer mortality (Hayanga AJ et al. 2013), low birthweight (Anthopolos et al. 2011; Grady 2006; Grady and Ramírez 2008; Mehra et al. 2017), and preterm birth (Anthopolos et al. 2011; Mehra et al. 2017; Osypuk and Acevedo-Garcia 2008), all of which have also been linked to PM2.5 exposure.

Despite shared negative health outcomes associated with PM2.5 exposure, racialization (particularly African American racialization), and residential segregation, few studies have directly investigated associations between residential segregation and PM2.5 levels.A few studies of hazardous air pollutants (HAPs) found that living in more highly segregated areas was associated with increased HAP exposure for both non-Hispanic African Americans and non-Hispanic whites (Ard 2016; Lopez 2002) and increased cancer risk from HAP exposure for non-Hispanic African Americans, non-Hispanic whites, Hispanics, Native Americans, and Asians and Pacific Islanders (Morello-Frosch and Jesdale 2006), but did not investigate PM2.5 specifically. One study investigated total PM2.5 exposure and segregation and found higher total PM2.5 levels in census tract clusters where Hispanics were overrepresented or whites were underrepresented, but the study was limited to six cities, excluded rural areas, only included four racial/ethnic categories, and used old US census data from 2000 (Jones et al. 2014). Another study found that racial isolation was associated with five-year total PM2.5 levels, but it used 2000 US Census data, relied on modeling instead of measured air pollution data, and did not investigate PM2.5 components (Bravo et al. 2016). No studies of PM2.5 and residential segregation to date have used current US Census data or evaluated PM2.5 components. To fill this gap in the literature, we used nationwide air pollution monitor data from the Environmental Protection Agency (EPA) and race/ethnicity data from the 2010 US Census to evaluate associations between racial/ethnic segregation and PM2.5 total and component levels.

**Methods**

*Air pollution data*

We obtained daily averages for total PM2.5, nitrate ion (NO3–), sulfate ion (SO42–), ammonium ion (NH4+), elemental carbon (EC), sodium ion (Na+), aluminum (Al), arsenic (As) maybe, bromine (Br), calcium (Ca), cadmium (Cd), chlorine (Cl), copper (Cu), iron (Fe), lead (Pb), mercury (Hg), nickel (Ni), silicon (Si), titanium (Ti), vanadium (V), and zinc (Zn) for the years 2005 to 2015 from the Environmental Protection Agency Chemical Speciation Network via the AirData database (US EPA 2016). We chose the years 2005 through 2015 to center the pollution data on 2010, the year of known race and ethnicity data from the US Census. We analyzed concentrations of NO3–, SO42–, NH4+, EC, Na+, and Si because they have been shown to comprise >1% of PM2.5 total mass in national PM2.5 component studies, and concentrations of NO3–, SO42–, EC, Al, As, Br, Ca, Cd, Cl, Cu, Fe, Hg, Ni, Pb, Ti, V, and Zn because of possible associations with adverse health outcomes (Basu et al. 2014; Beelen et al. 2015; Eeftens et al. 2014; Hampel et al. 2015; Kelly and Fussell 2012; Ostro et al. 2015; Peng et al. 2009; Raaschou-Nielsen et al. 2016; Stanek et al. 2011; Thurston et al. 2015; Wang et al. 2017; Wolf et al. 2015).

We included only census tracts with monitors that operated for ≥3 years within the study period and included ≥180 days of observations for total PM2.5 or at least one component of interest within the study period (Table 1, Figure 1). We examined detection rates among observations for total PM2.5 and each component using method detection limits (MDL) published by the EPA (Solomon et al. 2014) for each component and monitoring method (Table 1, Figure 2). For observations of zero, below zero, or below the MDL, we used the data as provided by the EPA. As some monitors measured EC according to the thermal/optical transmittance (TOT) method and others according to the thermal/optical reflectance (TOR) method, we multiplied TOT EC by 1.3 to approximate TOR EC values as recommended by Malm et al. 2011. We only included monitors for total PM2.5 that used the federal reference method (FRM) in the analysis. We matched pollutant monitors to their containing 2010 US Census tracts and calculated total PM2.5 and individual component levels for each tract using data from all available days for all monitors within that census tract.

*Sociodemographic data*

We obtained data on total population, race, ethnicity, and age from the 2010 US Census for each census tract (US Census Bureau 2011):

* Total population (DP0010001);
* Race (total population: DP0080001):
  + Population self-identified as Black or African American alone, not Hispanic or Latino (DP0110012);
  + Population self-identified as Asian alone, not Hispanic or Latino (DP0110014);
  + Population self-identified as American Indian or Alaska Native (DP0110013) or Native Hawaiian and Other Pacific Islander alone, not Hispanic or Latino (DP0110015);
  + Population self-identified as white alone, not Hispanic or Latino (DP0110011);
* Ethnicity (total population DP0100001)
  + Population self-identified as of Hispanic or Latinx ethnicity (regardless of race) (DP0100002)
* Age (total population: DP0010001)
  + Age in five-year increments (DP0010001–DP0010019) aggregated into the age categories 0-19 years old and 65 years old and older.

We also obtained five-year population characteristic estimates from the American Community Survey as 2008-2012 five-year estimates (US Census Bureau 2014), chosen to center the data on 2010, the year of known race, ethnicity, and age data from the US Census:

* Educational attainment: The percentage of the population with less than a high school education, a high school degree or some college, or a college degree (S1501).
* Poverty: The percentage of the population below the poverty level as classified by the 2010 US Census (S1701).
* Unemployment: The percentage of the population over 16 years who were unemployed (S2301).

We obtained rural-urban commuting area (RUCA) codes for 2010 from the US Department of Agriculture (US Department of Agriculture 2013) to determine the urbanicity of census tracts (Table A1). We obtained geographic region classifications of Northeast, Midwest, South, and West by state from the US Census (US Census Bureau 2015) (Table A1).

We estimated racial residential segregation by census tract using the spatial racial isolation index (RI) developed by Anthopolos et al. (Anthopolos et al. 2011). Isolation/exposure indices like the spatial isolation index measure the probability that a person will encounter, within their own neighborhood, someone of their own race/ethnicity (isolation) or someone of another race/ethnicity (exposure), whereas the more common dissimilarity indices measure evenness, or how similar the proportions of racial/ethnic groups in a neighborhood are to those of a larger containing region (Massey and Denton 1988). We chose an isolation/exposure index because such indices show more consistent associations with adverse health outcomes than dissimilarity indices (Mehra et al. 2017). We calculated the index using US Census data for the total population and the population identifying as Black or African American alone, not Hispanic or Latino (US Census Bureau 2011):

*b*: African American (Black) population.

*i,j*: Indices of census tracts *r* in a containing region *R*.

*rj*: Census tract *j*.

: Measure of the spatial isolation of Black population b in census tract *ri*.

: Total population of census tract *rj*.

: Total Black population *b* of census tract *rj*.

𝛾𝑖𝑗: Adjacency term (1 if census tracts *ri* and *rj* share a border, 0 otherwise).

See Figure 3. We then broke the RI into quintiles among all urban census tracts in the US for the analyses.

*Statistical analyses*

We included tracts in the analysis for a given pollutant if they were within an urbanized area or the surrounding commuting area as defined by 2010 RUCA codes (US Department of Agriculture 2013) (Table A1), contained at least 100 persons in the 2010 US Census, and had at least one monitor with data for total PM2.5 and/or at least one component of interest available for ≥ 3 years with ≥ 180 days of observations between 2005 and 2015 (Table 1). We calculated monthly means for total PM2.5 and individual component levels for each census tract, which we then averaged to generate a single estimate of the mean level of each pollutant for each census tract during the study period.

We then conducted analysis of variance (analysis of variance) to determine if levels of total PM2.5 and each individual component differed by RI quintile. We applied Welch’s correction in cases of non-homogenous variances found using Levene’s test. We then used linear regression models to evaluate associations between total PM2.5 and each component separately and RI, controlling for demographic variables including percentage with less than a high school education, percent in poverty, race/ethnicity (percent Black or African American; percent American Indian, Alaska Native, Native Hawaiian, or Pacific Islander; percent Asian; and percent Hispanic or Latino), percent age 0–19, percent age 65 and older, as well as geographic region. We then fit individual multivariable linear models by total PM2.5 and each PM2.5 component to estimate the associations of each with RI. All statistical analyses were run in R version 3.4.1 (R Core Team, 2017). All P-values are from two-sided 95% confidence intervals.

**Results**

In this study, PM2.5 concentrations showed a consistent increasing association with RI quintile (Figure 4). Tracts in the highest quintile of RI compared to those in the lowest (Tables 4 and 5, Figures 4 and 5) had higher mean concentrations of PM2.5 (mean difference (MD) 2.67 µg/m3, 95% CI: 2.04, 3.29) (Figure 4) as well as the components

* As (MD 0.000456 µg/m3, 95% CI: 0.000304, 0.000608)
* Br (MD 0.00117 µg/m3, 95% CI: 0.000556, 0.00179)
* Cu (MD 0.00220 µg/m3, 95% CI: 0.000654, 0.00375)
* Fe (MD 0.0415 µg/m3, 95% CI: 0.0121, 0.0709)
* Pb (MD 0.00129 µg/m3, 95% CI: 0.000173, 0.00240)
* Ni (MD 0.000856 µg/m3, 95% CI: 0.000423, 0.00129)
* V (MD 0.000728 µg/m3, 95% CI: 0.000297, 0.00116)
* Zn (MD 0.0074 µg/m3, 95% CI: 0.0024, 0.0125)
* NH4+ (MD 0.347 µg/m3, 95% CI: 0.085, 0.609)
* NO3- (MD 0.497 µg/m3, 95% CI: 0.179, 0.815)
* SO42- (MD 1.469 µg/m3, 95% CI: 1.096, 1.843)

(See Tables 4 and 5 and Figures 4 and 5 for results compared among all quintiles for all components.) We found lower mean concentrations of elemental carbon in 1st RI quintile compared to the 2nd, 3rd, and 4th quintiles, but not the 5th. We did not find any significant differences in mean concentrations of Al, Cd, Ca, Cl, Hg, Si, Na, Ti, Na+, or EC by RI quintile.

Preliminary regression results showed that a one-quintile increase in RI remained a significant predictor of total PM2.5 concentrations (*β* = 0.383 µg/m3, 95% CI: 0.223 – 0.543) in a census tract after controlling for region, racial and ethnic composition, poverty, education less than high school, unemployment, percent of tract population ages 19 or less, and percent of tract population ages 65 or older. We also found a one-quantile increase in RI positively associated with

* As ( = 0.0000735 µg/m3, 95% CI: 0.0000156, 0.0001314)
* Ni (*β* = 0.000190 µg/m3, 95% CI: 0.000061, 0.000318)
* V (*β* = 0.000158 µg/m3, 95% CI: 0.000035, 0.000281)
* NH4+ (*β* = 0.0770 µg/m3, 95% CI: 0.0172 – 0.1368)
* NO3- (*β* = 0.145 µg/m3, 95% CI: 0.043 – 0.247)
* SO42- (*β* = 0.170 µg/m3, 95% CI: 0.081 – 0.258)

and negatively associated with

* Al (*β* = -0.00542 µg/m3, 95% CI: -0.00923 – -0.00161)
* Ca (*β* = -0.0155 µg/m3, 95% CI: -0.0247 – -0.0062)
* Si (*β* = -0.0149 µg/m3, 95% CI: -0.0245, -0.0053)

after controlling for the same set of factors. The associations between Br, Cu, Fe, Pb, and Zn and RI quintile observed in the analysis of variance did not remain after controlling for sociodemographic factors, nor did we observe associations between Cd, Cl, Hg, Na, Ti, Na+, or EC in multivariable analyses.

**Discussion**

Preliminary analyses show that levels of African American RRS, as measured by a spatial index of racial isolation, may be associated with higher levels of total PM2.5 as well as seven PM2.5 components. These results reinforce prior findings of an association between total PM2.5 levels and RI (Bravo et al. 2016) and further show that different PM2.5 compositions appear to have different associations with RI. Moreover, these results use data from ten years later than the prior study and rely solely on observed data. Higher levels of some PM2.5 components in more racially isolated neighborhoods could indicate disparities in the siting of sources of PM2.5 that emit higher levels of those components. Prior work has already shown a higher burden of sources of total PM2.5 among Black or African American US residents compared to white US residents (Mikati et al. 2018), with a stronger effect for race than for poverty. Another study used modeling data to find that white residents in the United States produce more PM2.5 on average via their consumption habits than they breathe and that African American and Hispanic/Latino residents breathe more PM2.5 on average than their consumption activities generate (Tessum et al. 2019). Although the current study was not a study of exposure, these results also provide some evidence that ambient PM2.5 levels and differences in PM2.5 chemical composition in highly segregated neighborhoods could be a factor in the negative health outcomes associated with African American racial residential segregation in the United States.

This study has manifold limitations. First, this study assigns the data from each monitor to its containing census tract and no others, likely resulting in exposure misclassification. We will use a distance-based analysis to correct this limitation in future work to address this limitation.

Second, limiting this study to measured data eliminates most urban tracts in the country, which could result in bias if the sociodemographic variables of interest also predict monitor locations. We will conduct additional analyses to determine if sociodemographic variables predict monitor locations in future work.

Third, this study includes PM2.5 components with very low detection rates, which might bias the results for those components downward. For example, although this study found consistently positive associations between As, Ni, and V and RI, those components were below their method detection limit for 95.6%, 88.3%, and 84.9%, respectively, of the observations in the study period in the study tracts (Table 1, Figure 2). Thus any results for components with low detection rates should be interpreted with extreme caution.

Fourth, in this study we fail to account for the margins of error in the American Community Survey sample data. Although this practice is common in published epidemiologic research, it likely leads to underestimation of the confidence intervals and an overestimation of the significance of the effects in the analyses (Folch et al. 2016). Moreover, at least one study found systemic variation in the reliability of ACS estimates by spatial and demographic patterns, e.g., higher uncertainties in low-income areas (Folch et al. 2016). Methods for accounting for error in ACS estimates include geographic aggregation or regionalization, e.g., aggregating block groups with similar demographic characteristics into bigger areas (Spielman and Folch 2015); data aggregation, e.g., grouping variable values into fewer categories; or over-imputation methods derived from multiple imputation methodologies to account for missing data (Casey and Morello-Frosch, in preparation).

Fifth, as the EPA operates its monitor network in part for regulatory purposes and often discontinues monitoring in tracts where measured concentrations have consistently been in compliance with Clean Air Act standards, the EPA steadily discontinued monitoring during the ten-year study period, likely in tracts with lower PM2.5 concentrations than those where the EPA continued monitor operations. Thus this study likely overestimates mean concentrations of PM2.5 ­in tracts with fewer observations. We will conduct a sensitivity analysis to investigate whether measured PM2.5 concentrations are higher in tracts with longer monitoring periods and investigate modeling approaches to account for potential observation bias.

**Conclusions**

This study showed a consistent association between PM2.5 concentration and RI quintile, even after controlling for poverty and racial/ethnic composition, and suggests that PM2.5 composition differs by RI. Additional work is needed to investigate PM2.5 sources and broader societal forces contributing to these disparities.

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**Tables**

**Table 1. Monitor, tract, observation, and non-detection counts by PM2.5 species for urban tracts with populations > 100 and at least 3 years and 180 days of observations per component.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Species** | **Parameter code** | **Monitors (*n*)** | **Tracts (*n*)** | **Observations (*n*)** | **Non-detects *(n*)** | **Non-detects (%)** |
| **PM2.5** | 88101 | 1127 | 886 | 2500350 | 149447 | 6.0 |
| **Al** | 88104 | 401 | 276 | 367517 | 88948 | 24.2 |
| **As** | 88103 | 404 | 276 | 367914 | 351554 | 95.6 |
| **Br** | 88109 | 399 | 274 | 365196 | 170792 | 46.8 |
| **Cd** | 88110 | 229 | 206 | 155782 | 146261 | 93.9 |
| **Ca** | 88111 | 401 | 276 | 367516 | 13527 | 3.7 |
| **Cl** | 88115 | 401 | 276 | 367613 | 229504 | 62.4 |
| **Cu** | 88114 | 400 | 275 | 368536 | 251431 | 68.2 |
| **Fe** | 88126 | 401 | 276 | 368820 | 9562 | 2.6 |
| **Pb** | 88128 | 404 | 276 | 369222 | 300414 | 81.4 |
| **Hg** | 88142 | 176 | 162 | 60060 | 55195 | 91.9 |
| **Ni** | 88136 | 404 | 276 | 369220 | 325935 | 88.3 |
| **Si** | 88165 | 401 | 276 | 368822 | 17894 | 4.9 |
| **Na** | 88184 | 388 | 264 | 359412 | 164649 | 45.8 |
| **Ti** | 88161 | 401 | 276 | 368824 | 200973 | 54.5 |
| **V** | 88164 | 401 | 276 | 368823 | 313019 | 84.9 |
| **Zn** | 88167 | 401 | 276 | 368901 | 117888 | 32.0 |
| **NH4+** | 88301 | 237 | 213 | 161515 | 3649 | 2.3 |
| **Na+** | 88302 | 237 | 213 | 160155 | 30298 | 18.9 |
| **NO3-** | 88306 | 391 | 267 | 375890 | 2955 | 0.8 |
| **SO42-** | 88403 | 405 | 277 | 391428 | 3888 | 1.0 |
| **EC (all)** | (99321) | 318 | 201 | 275540 | 25559 | 9.3 |
| **EC** | 88307 | 136 | 122 | 58840 | 10171 | 17.3 |
| **EC** | 88316 | 2 | 2 | 1978 | 646 | 32.7 |
| **EC** | 88321 | 187 | 83 | 214722 | 14742 | 6.9 |
| **EC** | 88381 | 0 | 0 | 0 | 0 | 0 |

**Table 4. Mean, 95% confidence interval, and *n* for PM2.5 component levels by quintile of racial isolation among all urban tracts in the United States.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Racial isolation quintile  (border values) |  | < 20  (0.000–0.014) | 20 - < 40  (0.014–0.037) | 40 - < 60  (0.037–0.084) | 60 - < 80  (0.084–0.214) | ≥ 80  (0.214–1.000) |
| **PM2.5** | Mean (95% CI) | 8.57  (8.18–8.95) | 10.10  (9.64–10.57) | 10.48  (10.03–10.92) | 10.83  (10.58–11.09) | 11.23  (11.00–11.46) |
|  | *n* | 163 | 158 | 144 | 202 | 219 |
| **Al** | Mean (95% CI) | 0.052  (0.04–0.064) | 0.044  (0.035–0.052) | 0.047  (0.034–0.059) | 0.041  (0.033–0.050) | 0.039  (0.034–0.043) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **As** | Mean (95% CI) | 0.00031  (0.00023–0.00039) | 0.00067  (0.00047–0.00087) | 0.00063  (0.00050–0.00076) | 0.00078  (0.00065–0.00092) | 0.00076  (0.00069–0.00084) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **Br** | Mean (95% CI) | 0.0023  (0.0019–0.0027) | 0.0031  (0.0025–0.0036) | 0.0032  (0.0029–0.0035) | 0.0034  (0.0031–0.0036) | 0.0035  (0.0033–0.0036) |
|  | *n* | 72 | 47 | 37 | 48 | 70 |
| **Cd** | Mean (95% CI) | 0.0016  (0.0014–0.0017) | 0.0017  (0.0014–0.0019) | 0.0017  (0.0015–0.0018) | 0.0017  (0.0015–0.0018) | 0.0016  (0.0015–0.0017) |
|  | *n* | 26 | 35 | 32 | 45 | 68 |
| **Ca** | Mean (95% CI) | 0.067  (0.034–0.099) | 0.052  (0.043–0.060) | 0.063  (0.047–0.078) | 0.059  (0.045–0.072) | 0.049  (0.042–0.056) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **Cl** | Mean (95% CI) | 0.046  (0.014–0.077) | 0.056  (0.028–0.084) | 0.053  (0.020–0.086) | 0.049  (0.032–0.067) | 0.031  (0.018–0.044) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **Cu** | Mean (95% CI) | 0.002  (0.0011–0.0029) | 0.0042  (0.0031–0.0054) | 0.0045  (0.0032–0.0059) | 0.0048  (0.0036–0.0060) | 0.0042  (0.0036–0.0048) |
|  | *n* | 71 | 48 | 37 | 49 | 70 |
| **Fe** | Mean (95% CI) | 0.053  (0.040–0.066) | 0.082  (0.063–0.101) | 0.085  (0.068–0.103) | 0.109  (0.080–0.137) | 0.095  (0.078–0.111) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **Pb** | Mean (95% CI) | 0.0017  (0.0012–0.0022) | 0.0026  (0.0018–0.0034) | 0.0025  (0.0019–0.0031) | 0.0032  (0.0025–0.0038) | 0.0030  (0.0024–0.0037) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **Hg** | Mean (95% CI) | 0.00091  (0.00069–0.00113) | 0.00100  (0.00080–0.0012) | 0.00096  (0.0008–0.0011) | 0.00088  (0.00077–0.00100) | 0.00094  (0.00087–0.00102) |
|  | *n* | 20 | 28 | 24 | 33 | 57 |
| **Ni** | Mean (95% CI) | 0.00032  (0.00021–0.00043) | 0.00100  (0.00067–0.00133) | 0.00095  (0.00070–0.00119) | 0.00133  (0.00091–0.00175) | 0.00118  (0.00089–0.00147) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **Si** | Mean (95% CI) | 0.138  (0.107–0.169) | 0.119  (0.097–0.140) | 0.125  (0.094–0.156) | 0.103  (0.085–0.120) | 0.099  (0.088–0.109) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **Na** | Mean (95% CI) | 0.073  (0.042–0.104) | 0.083  (0.055–0.112) | 0.099  (0.060–0.138) | 0.097  (0.067–0.128) | 0.071  (0.054–0.089) |
|  | *n* | 67 | 43 | 36 | 48 | 70 |
| **Ti** | Mean (95% CI) | 0.0037  (0.0028–0.0045) | 0.0035  (0.0030–0.0041) | 0.0041  (0.0030–0.0052) | 0.0039  (0.0032–0.0047) | 0.0032  (0.0029–0.0035) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **V** | Mean (95% CI) | 0.00060  (0.00046–0.00074) | 0.00100  (0.00076–0.00124) | 0.00106  (0.00073–0.00139) | 0.00144  (0.00106–0.00182) | 0.00133  (0.00105–0.00160) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **Zn** | Mean (95% CI) | 0.0061  (0.0039–0.0084) | 0.0113  (0.0073–0.015) | 0.0102  (0.0079–0.0126) | 0.0167  (0.0112–0.0222) | 0.0136  (0.0107–0.0164) |
|  | *n* | 72 | 48 | 37 | 49 | 70 |
| **NH4+** | Mean (95% CI) | 0.78  (0.62–0.95) | 0.96  (0.78–1.14) | 0.99  (0.81–1.17) | 1.11  (0.98–1.24) | 1.13  (1.04–1.22) |
|  | *n* | 28 | 39 | 33 | 45 | 68 |
| **Na+** | Mean (95% CI) | 0.123  (0.059–0.186) | 0.143  (0.102–0.184) | 0.139  (0.099–0.180) | 0.129  (0.100–0.158) | 0.107  (0.092–0.123) |
|  | *n* | 28 | 39 | 33 | 45 | 68 |
| **NO3-** | Mean (95% CI) | 0.74  (0.57–0.91) | 1.37  (1.07–1.68) | 1.65  (1.23–2.06) | 1.36  (1.12–1.61) | 1.24  (1.08–1.39) |
|  | *n* | 69 | 47 | 35 | 47 | 69 |
| **SO42-** | Mean (95% CI) | 1.27  (1.05–1.49) | 1.82  (1.50–2.14) | 2.00  (1.68–2.32) | 2.52  (2.27–2.77) | 2.74  (2.59–2.89) |
|  | *n* | 72 | 48 | 37 | 49 | 71 |
| **EC** | Mean (95% CI) | 0.31  (0.22–0.39) | 0.6  (0.48–0.73) | 0.70  (0.54–0.86) | 0.85  (0.70–1.01) | 1.14  (0.47–1.81) |
|  | *n* | 59 | 33 | 24 | 38 | 47 |

**Table 5. Analysis of variance results.**

**5a. PM2.5.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 12.64 | 4, 881 | **5.3 x 10-10** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 36.16 | 4,403.73 | **7.8 x 10-10** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | -0.398 | -0.873 | 0.076 | 0.123 | 2.30 | 407.40 | 0.14 |
| 5:3 | -0.753 | -1.446 | -0.060 | 0.178 | 2.99 | 217.38 | **0.026** |
| 5:2 | -1.127 | -1.845 | -0.409 | 0.185 | 4.32 | 230.99 | **< 1.0 x 10-6** |
| 5:1 | -2.665 | -3.289 | -2.040 | 0.161 | 11.72 | 267.48 | **< 1.0 x 10-6** |
| 4:3 | -0.354 | -1.067 | 0.359 | 0.183 | 1.37 | 236.34 | 0.65 |
| 4:2 | -0.729 | -1.466 | 0.009 | 0.190 | 2.71 | 249.81 | 0.055 |
| 4:1 | -2.266 | -2.913 | -1.619 | 0.167 | 9.61 | 290.12 | **< 1.0 x 10-6** |
| 3:2 | -0.374 | -1.265 | 0.517 | 0.230 | 1.15 | 300 | 0.77 |
| 3:1 | -1.912 | -2.731 | -1.093 | 0.211 | 6.41 | 293.94 | **< 1.0 x 10-6** |
| 2:1 | -1.538 | -2.378 | -0.697 | 0.217 | 5.02 | 307.72 | **< 1.0 x 10-6** |

**5b. Aluminum.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 2.97 | 4, 271 | **0.020** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.28 | 4, 115.94 | 0.28 |

**5c. Arsenic.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** |  | ***p*** |
| 12.64 | 4, 881 | **5.3 x 10-10** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 36.16 | 4,403.737 | **7.77 x 10-26** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | -1.34 x 10-4 | -3.46 x 10-4 | 7.70 x 10-5 | 5.30 x 10-5 | 1.78 | 60.15 | 0.39 |
| 5:3 | 1.90 x 10-5 | -1.95 x 10-4 | 2.33 x 10-4 | 5.40 x 10-5 | 0.25 | 77.47 | 1.00 |
| 5:2 | -9.40 x 10-5 | -3.90 x 10-4 | 2.01 x 10-4 | 7.40 x 10-5 | 0.90 | 60.75 | 0.90 |
| 5:1 | -4.56 x 10-4 | -6.08 x 10-4 | -3.04 x 10-4 | 3.90 x 10-5 | 8.31 | 139.57 | **< 2.2 x 10-16** |
| 4:3 | -1.54 x 10-4 | -4.14 x 10-4 | 1.07 x 10-4 | 6.60 x 10-5 | 1.64 | 82.81 | 0.48 |
| 4:2 | -1.14 x 10-4 | -4.45 x 10-4 | 2.18 x 10-4 | 8.40 x 10-5 | 0.96 | 83.17 | 0.87 |
| 4:1 | -4.75 x 10-4 | -6.93 x 10-4 | -2.58 x 10-4 | 5.50 x 10-5 | 6.09 | 81.64 | **< 2.2 x 10-16** |
| 3:2 | 4.00 x 10-5 | -2.90 x 10-4 | 3.69 x 10-4 | 8.30 x 10-5 | 0.34 | 77.85 | 1.00 |
| 3:1 | -3.22 x 10-4 | -5.37 x 10-4 | -1.07 x 10-4 | 5.40 x 10-5 | 4.20 | 63.74 | **7.82 x 10-4** |
| 2:1 | -3.62 x 10-4 | -6.60 x 10-4 | -6.40 x 10-5 | 7.50 x 10-5 | 3.41 | 62.84 | **0.0098** |

**5d. Bromine.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 2.73 | 4, 269 | **0.029** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 7.27 | 4, 116.77 | **2.92 x 10-5** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:3 | -2.74 x 10-4 | -7.85 x 10-4 | 2.38 x 10-4 | 1.28 x 10-4 | 1.51 | 55.27 | 0.56 |
| 5:4 | -7.70 x 10-5 | -4.79 x 10-4 | 3.24 x 10-4 | 1.02 x 10-4 | 0.54 | 89.46 | 0.98 |
| 5:2 | -3.65 x 10-4 | -0.00117 | 4.38 x 10-4 | 2.01 x 10-4 | 1.28 | 54.51 | 0.70 |
| 5:1 | -0.00117 | -0.00179 | -5.56 x 10-4 | 1.57 x 10-4 | 5.29 | 93.24 | **8.0 x 10-6** |
| 4:3 | -1.96 x 10-4 | -7.57 x 10-4 | 3.65 x 10-4 | 1.42 x 10-4 | 0.98 | 69.60 | 0.86 |
| 4:2 | -2.88 x 10-4 | -0.00112 | 5.47 x 10-4 | 2.10 x 10-4 | 0.97 | 62.77 | 0.87 |
| 4:1 | -0.00110 | -0.00175 | -4.37 x 10-4 | 1.68 x 10-4 | 4.62 | 107.93 | **1.04 x 10-4** |
| 3:2 | -9.20 x 10-5 | -9.78 x 10-4 | 7.95 x 10-4 | 2.24 x 10-4 | 0.29 | 72.56 | 1.00 |
| 3:1 | -8.99 x 10-4 | -0.00162 | -1.73 x 10-4 | 1.85 x 10-4 | 3.44 | 106.02 | **0.0073** |
| 2:1 | -8.07 x 10-4 | -0.00176 | 1.42 x 10-4 | 2.41 x 10-4 | 2.36 | 93.58 | 0.13 |

**5e. Cadmium.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.83 | 4, 201 | 0.12 |
| ***One-way analysis of variance assuming equal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.28 | 4, 201 | 0.89 |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.36 | 4, 79.64 | 0.84 |

**5f. Calcium.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.47 | 4, 271 | 0.21 |
| ***One-way analysis of variance assuming equal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.54 | 4, 271 | 0.71 |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.02 | 4, 119.50 | 0.40 |

**5g. Chlorine.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.85 | 4, 271 | 0.50 |
| ***One-way analysis of variance assuming equal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.63 | 4, 271 | 0.64 |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.22 | 4, 118.04 | 0.31 |

**5h. Copper.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 2.29 | 4, 270 | **0.060** |
| ***One-way analysis of variance assuming equal variance*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 5.91 | 4, 270 | **0.00014** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 5.12 | 4, 116.65 | **0.00077** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | 3.50 x 10-4 | -0.00166 | 0.00236 | 5.03 x 10-4 | 0.49 | 51.44 | 0.99 |
| 5:3 | 6.16 x 10-4 | -0.00124 | 0.00248 | 4.70 x 10-4 | 0.93 | 71.60 | 0.89 |
| 5:2 | 2.30 x 10-5 | -0.00179 | 0.00183 | 4.58 x 10-4 | 0.036 | 71.70 | 1.00 |
| 5:1 | -0.00220 | -0.00375 | -6.54 x 10-4 | 3.95 x 10-4 | 3.94 | 117.18 | **0.0013** |
| 4:3 | -2.66 x 10-4 | -0.00272 | 0.00219 | 6.22 x 10-4 | 0.30 | 79.82 | 1.00 |
| 4:2 | -5.93 x 10-4 | -0.0029 | 0.00171 | 5.86 x 10-4 | 0.72 | 94.95 | 0.95 |
| 4:1 | -0.00282 | -0.00493 | -7.05 x 10-4 | 5.38 x 10-4 | 3.70 | 100.41 | **0.0031** |
| 3:2 | -3.27 x 10-4 | -0.00275 | 0.00209 | 6.12 x 10-4 | 0.38 | 78.06 | 1.00 |
| 3:1 | -0.00255 | -0.00479 | -3.09 x 10-4 | 5.67 x 10-4 | 3.18 | 73.96 | **0.018** |
| 2:1 | -0.00223 | -0.00430 | -1.54 x 10-4 | 5.27 x 10-4 | 2.98 | 101.08 | **0.029** |

**5i. Iron.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 0.99 | 4, 271 | 0.41 |
| ***One-way analysis of variance assuming equal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 5.41 | 4, 271 | **0.00033** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 5.87 | 4, 122.47 | **0.00023** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | 0.0140 | -0.0319 | 0.0599 | 0.0116 | 0.85 | 80.40 | 0.91 |
| 5:3 | -0.0094 | -0.0426 | 0.0237 | 0.0084 | 0.79 | 93.52 | 0.93 |
| 5:2 | -0.0125 | -0.0477 | 0.0226 | 0.0090 | 0.99 | 104.94 | 0.86 |
| 5:1 | -0.0415 | -0.0709 | -0.0121 | 0.0075 | 3.91 | 131.77 | **0.0014** |
| 4:3 | -0.0235 | 0.0227 | -0.0696 | 0.0117 | 1.42 | 75.72 | 0.62 |
| 4:2 | -0.0265 | -0.0741 | 0.0210 | 0.0121 | 1.56 | 83.65 | 0.53 |
| 4:1 | -0.0555 | -0.0993 | -0.0118 | 0.0110 | 3.56 | 68.71 | **0.0060** |
| 3:2 | -0.0031 | -0.0387 | 0.0325 | 0.0090 | 0.24 | 82.96 | 1.00 |
| 3:1 | -0.0321 | -0.0621 | -0.0021 | 0.0076 | 2.98 | 77.72 | **0.030** |
| 2:1 | -0.0290 | -0.0612 | 0.0032 | 0.0082 | 2.51 | 89.12 | 0.098 |

**5j. Lead.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 0.70 | 4, 271 | 0.59 |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 3.93 | 4, 124.52 | **0.0048** |
| ***One-way analysis of variance assuming equal variance*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 3.66 | 4, 271 | **0.0064** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | 1.39 x 10-4 | -0.00112 | 0.001395 | 3.20 x 10-4 | 0.31 | 110.95 | 1.00 |
| 5:3 | -5.57 x 10-4 | -0.00177 | 6.55 x 10-4 | 3.08 x 10-4 | 1.28 | 96.23 | 0.71 |
| 5:2 | -4.24 x 10-4 | -0.00181 | 9.61 x 10-4 | 3.52 x 10-4 | 0.85 | 99.17 | 0.91 |
| 5:1 | -0.00129 | -0.0024 | -1.73 x 10-4 | 2.85 x 10-4 | 3.20 | 133.57 | **0.015** |
| 4:3 | -6.95 x 10-4 | -0.00194 | 5.52 x 10-4 | 3.16 x 10-4 | 1.55 | 83.64 | 0.53 |
| 4:2 | -5.63 x 10-4 | -0.00198 | 8.53 x 10-4 | 3.60 x 10-4 | 1.11 | 92.12 | 0.80 |
| 4:1 | -0.00143 | -0.00258 | -2.71 x 10-4 | 2.93 x 10-4 | 3.43 | 98.63 | **0.0076** |
| 3:2 | 1.33 x 10-4 | -0.00124 | 0.001509 | 3.49 x 10-4 | 0.27 | 82.02 | 1.00 |
| 3:1 | -7.29 x 10-4 | -0.00183 | 3.75 x 10-4 | 2.80 x 10-4 | 1.84 | 83.19 | 0.36 |
| 2:1 | -8.62 x 10-4 | -0.00216 | 4.31 x 10-4 | 3.28 x 10-4 | 1.86 | 85.35 | 0.35 |

**5k. Mercury.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.88 | 4, 157 | 0.11 |
| ***One-way analysis of variance assuming equal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.42 | 4, 157 | 0.80 |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.34 | 4, 58.89 | 0.84 |

**5l. Nickel.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 2.41 | 4, 271 | **0.049** |
| ***One-way analysis of variance assuming equal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 8.81 | 4, 271 | **1.1 x 10-6** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  |  |  |  |  | ***F*** | ***df*** | ***P*** |
|  |  |  |  |  | 16.88 | 4, 111.13 | **7.7 x 10-11** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Upper 95% CI** | **Lower 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | -2.28 x 10-4 | -7.54 x 10-4 | 2.98 x 10-4 | 1.34 x 10-4 | 1.20 | 103.01 | 0.75 |
| 5:3 | 1.54 x 10-4 | -5.54 x 10-4 | 8.62 x 10-4 | 1.80 x 10-4 | 0.61 | 91.15 | 0.97 |
| 5:2 | -1.76 x 10-4 | -7.88 x 10-4 | 4.35 x 10-4 | 1.56 x 10-4 | 0.80 | 105.16 | 0.93 |
| 5:1 | -8.56 x 10-4 | -0.00129 | -4.23 x 10-4 | 1.10 x 10-4 | 5.51 | 87.50 | **3.0 x 10-6** |
| 4:3 | -3.82 x 10-4 | -0.00106 | 2.92 x 10-4 | 1.71 x 10-4 | 1.58 | 74.53 | 0.51 |
| 4:2 | -3.30 x 10-4 | -0.00107 | 4.10 x 10-4 | 1.88 x 10-4 | 1.24 | 90.68 | 0.73 |
| 4:1 | -0.00101 | -0.00162 | -4.03 x 10-4 | 1.52 x 10-4 | 4.69 | 54.43 | **1.8 x 10-4** |
| 3:2 | 5.10 x 10-5 | -5.20 x 10-4 | 6.23 x 10-4 | 1.45 x 10-4 | 0.25 | 80.67 | 1.00 |
| 3:1 | -6.28 x 10-4 | -0.00100 | -2.53 x 10-4 | 9.40 x 10-5 | 4.74 | 50.59 | **1.7 x 10-4** |
| 2:1 | -6.80 x 10-4 | -0.00117 | -1.90 x 10-4 | 1.23 x 10-4 | 3.91 | 57.05 | **0.0022** |

**5m. Silicon.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 4.55 | 4, 271 | **0.0014** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 2.3 | 4, 115.49 | 0.062 |

**5n. Sodium.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.08 | 4, 259 | 0.37 |
| ***One-way analysis of variance assuming equal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.81 | 4, 259 | 0.52 |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.87 | 4, 112.82 | 0.49 |

**5o. Titanium.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 2.66 | 4, 271 | **0.033** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.27 | 4, 114.23 | 0.28 |

**5p. Vanadium.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 1.51 | 4, 271 | 0.20 |
| ***One-way analysis of variance assuming equal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 6.94 | 4, 271 | **2.5 x 10-5** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 9.18 | 4, 115.92 | **1.8 x 10-6** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | -2.68 x 10-4 | -8.59 x 10-4 | 3.24 x 10-4 | 1.50 x 10-4 | 1.26 | 84.66 | 0.72 |
| 5:3 | 1.13 x 10-4 | -5.40 x 10-4 | 7.65 x 10-4 | 1.66 x 10-4 | 0.48 | 94.25 | 0.99 |
| 5:2 | -3.26 x 10-4 | -8.33 x 10-4 | 1.80 x 10-4 | 1.29 x 10-4 | 1.79 | 115.78 | 0.39 |
| 5:1 | -7.28 x 10-4 | -0.00116 | -2.97 x 10-4 | 1.10 x 10-4 | 4.69 | 102.71 | **8.2 x 10-5** |
| 4:3 | -3.80 x 10-4 | -0.00107 | 3.13 x 10-4 | 1.76 x 10-4 | 1.53 | 83.97 | 0.55 |
| 4:2 | -4.39 x 10-4 | -0.00106 | 1.86 x 10-4 | 1.58 x 10-4 | 1.96 | 80.72 | 0.29 |
| 4:1 | -8.41 x 10-4 | -0.00141 | -2.73 x 10-4 | 1.43 x 10-4 | 4.16 | 61.41 | **9.22 x 10-4** |
| 3:2 | -5.90 x 10-5 | -6.20 x 10-4 | 5.03 x 10-4 | 1.42 x 10-4 | 0.29 | 70.18 | 1.00 |
| 3:1 | -4.60 x 10-4 | -9.58 x 10-4 | 3.70 x 10-5 | 1.24 x 10-4 | 2.62 | 50.15 | 0.082 |
| 2:1 | -4.02 x 10-4 | -7.89 x 10-4 | -1.50 x 10-5 | 9.80 x 10-5 | 2.90 | 79.09 | **0.038** |

**5q. Zinc.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 1.93 | 4, 271 | 0.11 |
| ***One-way analysis of variance assuming equal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 5.67 | 4, 271 | **0.00022** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 5.94 | 4, 124.16 | **0.00021** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | -0.0034 | -0.0085 | 0.0017 | 0.0013 | 1.83 | 103.33 | 0.36 |
| 5:3 | 0.0031 | -0.0055 | 0.0117 | 0.0022 | 1.01 | 73.77 | 0.85 |
| 5:2 | -0.0023 | -0.0091 | 0.0045 | 0.0017 | 0.95 | 91.25 | 0.88 |
| 5:1 | -0.0074 | -0.0125 | -0.0024 | 0.0013 | 4.08 | 132.96 | **7.37 x 10-4** |
| 4:3 | -0.0065 | -0.0148 | 0.0019 | 0.0021 | 2.17 | 64.30 | 0.20 |
| 4:2 | -0.0054 | -0.0148 | 0.0040 | 0.0024 | 1.60 | 87.23 | 0.50 |
| 4:1 | -0.0105 | -0.0188 | -0.0022 | 0.0021 | 3.56 | 64.90 | **0.0061** |
| 3:2 | 0.00105 | -0.0054 | 0.0075 | 0.0016 | 0.46 | 73.67 | 0.99 |
| 3:1 | -0.0041 | -0.0086 | 4.7 x 10-4 | 0.0012 | 2.49 | 94.08 | 0.10 |
| 2:1 | -0.0051 | -0.0115 | 0.0013 | 0.0016 | 2.24 | 77.63 | 0.18 |

**5r. Ammonium.**

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| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 1.61 | 4, 208 | **0.017** |
| ***One-way analysis of variance assuming equal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***P*** |
| 0.0083 | 4, 208 | **0.0083** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 3.99 | 4, 87.66 | **0.0050** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | -0.0227 | -0.2479 | 0.2026 | 0.0571 | 0.28 | 85.75 | 1.00 |
| 5:3 | -0.1397 | -0.4176 | 0.1382 | 0.0695 | 1.42 | 51.60 | 0.62 |
| 5:2 | -0.1698 | -0.4509 | 0.1111 | 0.0707 | 1.70 | 59.92 | 0.44 |
| 5:1 | -0.3472 | -0.6089 | -0.0854 | 0.0652 | 3.76 | 46.91 | **0.0041** |
| 4:3 | -0.1171 | -0.4217 | 0.1876 | 0.0767 | 1.08 | 64.17 | 0.82 |
| 4:2 | -0.1472 | -0.4549 | 0.1605 | 0.0778 | 1.34 | 72.62 | 0.67 |
| 4:1 | -0.3245 | -0.6145 | -0.0345 | 0.0729 | 3.15 | 59.54 | **0.021** |
| 3:2 | -0.0301 | -0.3758 | 0.3155 | 0.0873 | 0.24 | 69.70 | 1.00 |
| 3:1 | -0.2075 | -0.5376 | 0.1226 | 0.0829 | 1.77 | 59.00 | 0.40 |
| 2:1 | -0.1773 | -0.5103 | 0.1556 | 0.0839 | 1.49 | 64.72 | 0.57 |

**5s. Sodium ion.**

|  |  |  |  |
| --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.75 | 4, 208 | 0.14 |
| ***One-way analysis of variance assuming equal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 0.887 | 4, 208 | 0.47 |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | |
|  | ***F*** | ***df*** | ***p*** |
| 1.24 | 4, 80.51 | 0.30 |

**5t. Nitrate ion.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 1.89 | 4, 262 | 0.11 |
| ***One-way analysis of variance assuming equal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 8.31 | 4, 262 | **2.5 x 10-6** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***P*** |
| 8.87 | 4, 111.05 | **3.0 x 10-6** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | 0.4124 | -0.2080 | 1.0328 | 0.1543 | 1.89 | 44.32 | 0.34 |
| 5:3 | 0.1260 | -0.2752 | 0.5271 | 0.1017 | 0.88 | 82.98 | 0.91 |
| 5:2 | 0.1340 | -0.3417 | 0.6096 | 0.1201 | 0.79 | 70.70 | 0.93 |
| 5:1 | -0.4970 | -0.8149 | -0.1792 | 0.0813 | 4.32 | 135.31 | **2.8 x 10-4** |
| 4:3 | 0.2864 | -0.3805 | 0.9533 | 0.1674 | 1.21 | 56.88 | 0.75 |
| 4:2 | 0.0080 | -0.5299 | 0.5458 | 0.1365 | 0.04 | 87.78 | 1.00 |
| 4:1 | -0.6230 | -1.0327 | -0.2133 | 0.1040 | 4.24 | 87.60 | **5.28 x 10-4** |
| 3:2 | -0.2785 | -0.9889 | 0.4320 | 0.1792 | 1.10 | 66.68 | 0.81 |
| 3:1 | -0.9094 | -1.5350 | -0.2839 | 0.1558 | 4.13 | 45.93 | **0.0014** |
| 2:1 | -0.6310 | -1.1137 | -0.1483 | 0.1221 | 3.65 | 74.24 | **0.0042** |

**5u. Sulfate ion.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 4.78 | 4, 272 | **9.7 x 10-4** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 32.86 | 4, 117.84 | **2.2 x 10-18** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | -0.7416 | -1.2376 | -0.2456 | 0.1242 | 4.22 | 52.89 | **8.8 x 10-4** |
| 5:3 | -0.2153 | -0.6220 | 0.1914 | 0.1031 | 1.48 | 82.30 | 0.58 |
| 5:2 | -0.9215 | -1.4120 | -0.4309 | 0.1238 | 5.26 | 68.67 | **1.5 x 10-5** |
| 5:1 | -1.4693 | -1.8426 | -1.0959 | 0.0954 | 10.89 | 124.61 | **< 1.0 x 10-6** |
| 4:3 | -0.5263 | -1.0901 | 0.03754 | 0.1426 | 2.61 | 73.27 | 0.079 |
| 4:2 | -0.7061 | -1.2661 | -0.1462 | 0.1422 | 3.51 | 89.71 | **0.0062** |
| 4:1 | -1.2540 | -1.7180 | -0.7899 | 0.1183 | 7.50 | 108.65 | **< 1.0 x 10-6** |
| 3:2 | -0.1799 | -0.8039 | 0.4442 | 0.1581 | 0.80 | 81.46 | 0.93 |
| 3:1 | -0.7277 | -1.2701 | -0.1852 | 0.1371 | 3.75 | 71.63 | **0.0031** |
| 2:1 | -0.5478 | -1.0860 | -0.0097 | 0.1367 | 2.83 | 90.72 | **0.044** |

**5v. Elemental carbon.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Levene’s test for homogeneity of variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 0.62 | 4, 196 | 0.64 |
| ***One-way analysis of variance assuming equal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 3.60 | 4, 196 | **0.0074** |
| ***One-way analysis of variance with Welch correction for unequal variances*** | | | | | | | |
|  | | | | | ***F*** | ***df*** | ***p*** |
| 13.03 | 4, 83.13 | **2.8 x 10-8** |
| ***Games-Howell post-hoc tests for group differences*** | | | | | | | |
| **Quantiles** | **Mean difference** | **Lower 95% CI** | **Upper 95% CI** | **Standard error** | ***t*** | ***df*** | ***p*** |
| 5:4 | -0.4382 | -1.4065 | 0.5301 | 0.2421 | 1.28 | 51.01 | 0.70 |
| 5:3 | -0.2858 | -1.2520 | 0.6804 | 0.2416 | 0.84 | 50.68 | 0.92 |
| 5:2 | -0.5338 | -1.4936 | 0.4261 | 0.2397 | 1.57 | 49.22 | 0.52 |
| 5:1 | -0.8299 | -1.7825 | 0.1227 | 0.2376 | 2.47 | 47.58 | 0.11 |
| 4:3 | -0.1524 | -0.4608 | 0.1559 | 0.0773 | 1.39 | 55.41 | 0.63 |
| 4:2 | -0.2480 | -0.5229 | 0.0268 | 0.0694 | 2.53 | 68.13 | 0.096 |
| 4:1 | -0.5441 | -0.7892 | -0.2991 | 0.0617 | 6.24 | 61.42 | **< 1.0 x 10-6** |
| 3:2 | -0.0956 | -0.3816 | 0.1905 | 0.0713 | 0.95 | 47.45 | 0.88 |
| 3:1 | -0.3917 | -0.6504 | -0.1323 | 0.0639 | 4.34 | 37.71 | **9.4 x 10-4** |
| 2:1 | -0.2961 | -0.5104 | -0.0818 | 0.0539 | 3.88 | 62.46 | **0.0023** |

**Table 6. Linear regression results.**

**6a. PM2.5.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **PM2.5** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -7.656 | -16.804 – 1.492 | 0.101 |
| Racial isolation quintile | 0.395 | 0.233 – 0.557 | **< 0.001** |
| Black or African American (%) | 17.108 | 7.947 – 26.269 | **< 0.001** |
| Hispanic or Latino (%) | 17.886 | 8.807 – 26.965 | **< 0.001** |
| Asian (%) | 18.963 | 8.533 – 29.392 | **< 0.001** |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 11.572 | 1.310 – 21.835 | **0.027** |
| White (%) | 17.567 | 8.316 – 26.817 | **< 0.001** |
| Education less than high school (%) | 0.000 | -0.000 – 0.001 | 0.170 |
| Poverty (%) | 0.098 | -1.220 – 1.415 | 0.884 |
| Unemployed (%) | 5.298 | 0.398 – 10.199 | **0.034** |
| Age 0 to 19 (%) | -0.000 | -0.000 – 0.000 | 0.793 |
| Age 65 or over (%) | -0.000 | -0.001 – 0.000 | 0.461 |
| Northeast | -0.968 | -1.456 – -0.480 | **< 0.001** |
| RegionOther | -5.303 | -7.041 – -3.566 | **< 0.001** |
| South | -0.619 | -1.030 – -0.208 | **0.003** |
| West | -1.526 | -2.017 – -1.034 | **< 0.001** |
| Observations | 885 | | |
| Nagelkerke's R2 | 0.763 | | |

**6b. Aluminum.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | **Aluminum** | | |
| *Predictors* | | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.19601 | | -0.34073 – -0.05130 | **0.008** |
| Racial isolation quintile | -0.00542 | | -0.00923 – -0.00161 | **0.006** |
| Black or African American (%) | 0.25124 | | 0.10508 – 0.39741 | **0.001** |
| Hispanic or Latino (%) | 0.31038 | | 0.16614 – 0.45463 | **<0.001** |
| Asian (%) | 0.23135 | | 0.06469 – 0.39802 | **0.007** |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.27069 | | 0.10058 – 0.44080 | **0.002** |
| White (%) | 0.23585 | | 0.08976 – 0.38193 | **0.002** |
| Education less than high school (%) | -0.00001 | | -0.00001 – 0.00000 | 0.169 |
| Poverty (%) | 0.02417 | | -0.00615 – 0.05449 | 0.119 |
| Unemployed (%) | -0.08530 | | -0.19103 – 0.02043 | 0.115 |
| Age 0 to 19 (%) | 0.00000 | | -0.00000 – 0.00001 | 0.746 |
| Age 65 or over (%) | 0.00000 | | -0.00001 – 0.00002 | 0.520 |
| Northeast | -0.01094 | | -0.02177 – -0.00011 | **0.049** |
| South | 0.02859 | | 0.01883 – 0.03836 | **<0.001** |
| West | 0.01548 | | 0.00482 – 0.02613 | **0.005** |
| Observations | | 274 | | |
| Nagelkerke's R2 | | 0.408 | | |

**6c. Arsenic.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Arsenic** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | 0.0003873 | -0.0018105 – 0.0025851 | 0.730 |
| Racial isolation quintile | 0.0000735 | 0.0000156 – 0.0001314 | **0.014** |
| Black or African American (%) | -0.0000393 | -0.0022590 – 0.0021804 | 0.972 |
| Hispanic or Latino (%) | -0.0000353 | -0.0022259 – 0.0021554 | 0.975 |
| Asian (%) | 0.0000621 | -0.0024690 – 0.0025933 | 0.962 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -0.0011378 | -0.0037212 – 0.0014456 | 0.389 |
| White (%) | 0.0002264 | -0.0019922 – 0.0024450 | 0.842 |
| Education less than high school (%) | 0.0000000 | -0.0000001 – 0.0000002 | 0.746 |
| Poverty (%) | 0.0000966 | -0.0003638 – 0.0005570 | 0.681 |
| Unemployed (%) | 0.0022054 | 0.0005997 – 0.0038110 | **0.008** |
| Age 0 to 19 (%) | -0.0000001 | -0.0000002 – 0.0000000 | 0.136 |
| Age 65 or over (%) | -0.0000001 | -0.0000003 – 0.0000001 | 0.412 |
| Northeast | -0.0000314 | -0.0001960 – 0.0001331 | 0.708 |
| South | -0.0001954 | -0.0003437 – -0.0000471 | **0.010** |
| West | -0.0003254 | -0.0004872 – -0.0001636 | **<0.001** |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.258 | | |

**6d. Bromine.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Bromine** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.003702 | -0.010309 – 0.002906 | 0.273 |
| Racial isolation quintile | 0.000085 | -0.000089 – 0.000260 | 0.338 |
| Black or African American (%) | 0.007053 | 0.000382 – 0.013724 | **0.039** |
| Hispanic or Latino (%) | 0.008609 | 0.002013 – 0.015204 | **0.011** |
| Asian (%) | 0.008038 | 0.000411 – 0.015665 | **0.040** |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.004316 | -0.003443 – 0.012075 | 0.277 |
| White (%) | 0.006713 | 0.000045 – 0.013380 | **0.050** |
| Education less than high school (%) | -0.000000 | -0.000001 – 0.000000 | 0.293 |
| Poverty (%) | 0.000063 | -0.001323 – 0.001449 | 0.929 |
| Unemployed (%) | 0.001799 | -0.003046 – 0.006644 | 0.467 |
| Age 0 to 19 (%) | -0.000000 | -0.000000 – 0.000000 | 0.937 |
| Age 65 or over (%) | -0.000000 | -0.000001 – 0.000001 | 0.859 |
| Northeast | -0.000277 | -0.000770 – 0.000216 | 0.272 |
| South | -0.000259 | -0.000703 – 0.000185 | 0.254 |
| West | -0.000989 | -0.001475 – -0.000503 | **< 0.001** |
| Observations | 272 | | |
| Nagelkerke's R2 | 0.227 | | |

**6e. Cadmium.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Cadmium** | | | |
| *Predictors* | *Estimates* | *CI* | | *p* |
| Intercept (Midwest) | -0.00090 | | -0.00493 – 0.00313 | 0.663 |
| Racial isolation quintile | 0.00004 | | -0.00003 – 0.00012 | 0.239 |
| Black or African American (%) | 0.00244 | | -0.00160 – 0.00649 | 0.238 |
| Hispanic or Latino (%) | 0.00229 | | -0.00172 – 0.00630 | 0.265 |
| Asian (%) | 0.00290 | | -0.00151 – 0.00731 | 0.199 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.00299 | | -0.00396 – 0.00994 | 0.400 |
| White (%) | 0.00247 | | -0.00161 – 0.00654 | 0.237 |
| Education less than high school (%) | 0.00000 | | -0.00000 – 0.00000 | 0.572 |
| Poverty (%) | -0.00037 | | -0.00090 – 0.00017 | 0.180 |
| Unemployed (%) | 0.00085 | | -0.00109 – 0.00279 | 0.390 |
| Age 0 to 19 (%) | 0.00000 | | -0.00000 – 0.00000 | 0.801 |
| Age 65 or over (%) | -0.00000 | | -0.00000 – 0.00000 | 0.948 |
| Northeast | 0.00004 | | -0.00016 – 0.00023 | 0.696 |
| South | -0.00019 | | -0.00036 – -0.00002 | **0.030** |
| West | 0.00013 | | -0.00008 – 0.00034 | 0.230 |
| Observations | 205 | | | |
| Nagelkerke's R2 | 0.086 | | | |

**6f. Calcium.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Calcium** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.0533 | -0.4048 – 0.2981 | 0.766 |
| Racial isolation quintile | -0.0155 | -0.0247 – -0.0062 | **0.001** |
| Black or African American (%) | 0.1779 | -0.1770 – 0.5329 | 0.327 |
| Hispanic or Latino (%) | 0.3436 | -0.0067 – 0.6939 | 0.056 |
| Asian (%) | 0.1934 | -0.2113 – 0.5982 | 0.350 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.1544 | -0.2587 – 0.5675 | 0.465 |
| White (%) | 0.1437 | -0.2111 – 0.4984 | 0.428 |
| Education less than high school (%) | -0.0000 | -0.0000 – -0.0000 | **0.006** |
| Poverty (%) | 0.1342 | 0.0606 – 0.2079 | **<0.001** |
| Unemployed (%) | -0.3077 | -0.5645 – -0.0510 | **0.020** |
| Age 0 to 19 (%) | -0.0000 | -0.0000 – 0.0000 | 0.338 |
| Age 65 or over (%) | 0.0000 | -0.0000 – 0.0000 | 0.414 |
| Northeast | -0.0420 | -0.0683 – -0.0157 | **0.002** |
| South | 0.0056 | -0.0181 – 0.0294 | 0.641 |
| West | -0.0410 | -0.0669 – -0.0151 | **0.002** |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.293 | | |

**6g. Chlorine.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Chlorine** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | 1.1502 | 0.7009 – 1.5995 | **<0.001** |
| Racial isolation quintile | -0.0111 | -0.0230 – 0.0007 | 0.066 |
| Black or African American (%) | -1.0767 | -1.5305 – -0.6229 | **<0.001** |
| Hispanic or Latino (%) | -0.9824 | -1.4303 – -0.5346 | **<0.001** |
| Asian (%) | -0.9190 | -1.4364 – -0.4016 | **0.001** |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -1.1477 | -1.6758 – -0.6196 | **<0.001** |
| White (%) | -1.1185 | -1.5721 – -0.6650 | **<0.001** |
| Education less than high school (%) | -0.0000 | -0.0000 – 0.0000 | 0.848 |
| Poverty (%) | 0.0085 | -0.0856 – 0.1026 | 0.860 |
| Unemployed (%) | -0.1465 | -0.4747 – 0.1817 | 0.383 |
| Age 0 to 19 (%) | -0.0000 | -0.0000 – -0.0000 | **0.029** |
| Age 65 or over (%) | 0.0000 | -0.0000 – 0.0001 | 0.522 |
| Northeast | -0.0011 | -0.0347 – 0.0326 | 0.950 |
| South | 0.0260 | -0.0043 – 0.0563 | 0.094 |
| West | 0.0010 | -0.0321 – 0.0341 | 0.952 |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.209 | | |

**6h. Copper.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Copper** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.0054 | -0.0225 – 0.0118 | 0.542 |
| Racial isolation quintile | 0.0002 | -0.0003 – 0.0006 | 0.487 |
| Black or African American (%) | 0.0065 | -0.0108 – 0.0238 | 0.463 |
| Hispanic or Latino (%) | 0.0153 | -0.0018 – 0.0324 | 0.082 |
| Asian (%) | 0.0185 | -0.0013 – 0.0382 | 0.069 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.0008 | -0.0194 – 0.0210 | 0.940 |
| White (%) | 0.0068 | -0.0106 – 0.0241 | 0.445 |
| Education less than high school (%) | -0.0000 | -0.0000 – -0.0000 | **0.030** |
| Poverty (%) | 0.0028 | -0.0008 – 0.0064 | 0.126 |
| Unemployed (%) | 0.0130 | 0.0005 – 0.0256 | **0.043** |
| Age 0 to 19 (%) | -0.0000 | -0.0000 – 0.0000 | 0.482 |
| Age 65 or over (%) | 0.0000 | -0.0000 – 0.0000 | 0.719 |
| Northeast | -0.0005 | -0.0018 – 0.0007 | 0.414 |
| South | -0.0002 | -0.0013 – 0.0010 | 0.792 |
| West | -0.0010 | -0.0023 – 0.0002 | 0.115 |
| Observations | 273 | | |
| Nagelkerke's R2 | 0.292 | | |

**6i. Iron.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Iron** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.1956 | -0.5398 – 0.1485 | 0.266 |
| Racial isolation quintile | 0.0047 | -0.0044 – 0.0138 | 0.311 |
| Black or African American (%) | 0.2596 | -0.0880 – 0.6072 | 0.145 |
| Hispanic or Latino (%) | 0.3361 | -0.0069 – 0.6792 | 0.056 |
| Asian (%) | 0.3337 | -0.0627 – 0.7301 | 0.100 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.1689 | -0.2357 – 0.5734 | 0.414 |
| White (%) | 0.2703 | -0.0771 – 0.6177 | 0.129 |
| Education less than high school (%) | -0.0000 | -0.0000 – 0.0000 | 0.431 |
| Poverty (%) | 0.1080 | 0.0359 – 0.1801 | **0.004** |
| Unemployed (%) | 0.0905 | -0.1610 – 0.3419 | 0.481 |
| Age 0 to 19 (%) | -0.0000 | -0.0000 – 0.0000 | 0.406 |
| Age 65 or over (%) | -0.0000 | -0.0000 – 0.0000 | 0.271 |
| Northeast | -0.0329 | -0.0587 – -0.0071 | **0.013** |
| South | -0.0257 | -0.0490 – -0.0025 | **0.031** |
| West | -0.0200 | -0.0453 – 0.0054 | 0.123 |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.207 | | |

**6j. Lead.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Lead** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.0035 | -0.0151 – 0.0082 | 0.558 |
| Racial isolation quintile | -0.0000 | -0.0003 – 0.0003 | 0.991 |
| Black or African American (%) | 0.0078 | -0.0039 – 0.0196 | 0.192 |
| Hispanic or Latino (%) | 0.0088 | -0.0028 – 0.0204 | 0.137 |
| Asian (%) | 0.0082 | -0.0052 – 0.0216 | 0.232 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.0035 | -0.0102 – 0.0171 | 0.621 |
| White (%) | 0.0068 | -0.0049 – 0.0186 | 0.255 |
| Education less than high school (%) | -0.0000 | -0.0000 – 0.0000 | 0.905 |
| Poverty (%) | -0.0010 | -0.0035 – 0.0014 | 0.414 |
| Unemployed (%) | 0.0100 | 0.0015 – 0.0185 | **0.022** |
| Age 0 to 19 (%) | -0.0000 | -0.0000 – 0.0000 | 0.191 |
| Age 65 or over (%) | -0.0000 | -0.0000 – 0.0000 | 0.897 |
| Northeast | -0.0006 | -0.0015 – 0.0002 | 0.147 |
| South | -0.0015 | -0.0022 – -0.0007 | **<0.001** |
| West | -0.0020 | -0.0028 – -0.0011 | **<0.001** |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.183 | | |

**6k. Mercury.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Mercury** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | 0.00097 | -0.00365 – 0.00560 | 0.681 |
| Racial isolation quintile | 0.00003 | -0.00004 – 0.00010 | 0.445 |
| Black or African American (%) | -0.00022 | -0.00488 – 0.00443 | 0.925 |
| Hispanic or Latino (%) | -0.00064 | -0.00526 – 0.00397 | 0.785 |
| Asian (%) | -0.00117 | -0.00651 – 0.00417 | 0.669 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -0.00369 | -0.01085 – 0.00347 | 0.314 |
| White (%) | -0.00016 | -0.00484 – 0.00453 | 0.948 |
| Education less than high school (%) | 0.00000 | -0.00000 – 0.00000 | 0.188 |
| Poverty (%) | -0.00001 | -0.00050 – 0.00048 | 0.966 |
| Unemployed (%) | 0.00058 | -0.00117 – 0.00233 | 0.516 |
| Age 0 to 19 (%) | 0.00000 | -0.00000 – 0.00000 | 0.823 |
| Age 65 or over (%) | -0.00000 | -0.00000 – 0.00000 | 0.931 |
| Northeast | 0.00011 | -0.00006 – 0.00029 | 0.213 |
| South | -0.00002 | -0.00018 – 0.00014 | 0.803 |
| West | 0.00036 | 0.00015 – 0.00057 | **0.001** |
| Observations | 162 | | |
| Nagelkerke's R2 | 0.134 | | |

**6l. Nickel.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Nickel** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | 0.000215 | -0.004669 – 0.005099 | 0.931 |
| Racial isolation quintile | 0.000190 | 0.000061 – 0.000318 | **0.004** |
| Black or African American (%) | -0.000549 | -0.005482 – 0.004384 | 0.827 |
| Hispanic or Latino (%) | 0.000457 | -0.004411 – 0.005325 | 0.854 |
| Asian (%) | 0.003453 | -0.002172 – 0.009077 | 0.230 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -0.001508 | -0.007249 – 0.004233 | 0.607 |
| White (%) | -0.000508 | -0.005438 – 0.004422 | 0.840 |
| Education less than high school (%) | -0.000000 | -0.000000 – 0.000000 | 0.662 |
| Poverty (%) | 0.000373 | -0.000650 – 0.001396 | 0.476 |
| Unemployed (%) | 0.003255 | -0.000313 – 0.006823 | 0.075 |
| Age 0 to 19 (%) | 0.000000 | -0.000000 – 0.000000 | 0.729 |
| Age 65 or over (%) | -0.000000 | -0.000001 – 0.000000 | 0.552 |
| Northeast | 0.000777 | 0.000411 – 0.001142 | **<0.001** |
| South | -0.000195 | -0.000525 – 0.000134 | 0.247 |
| West | 0.000164 | -0.000196 – 0.000523 | 0.373 |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.323 | | |

**6m. Silicon.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Silicon** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.5233 | -0.8874 – -0.1591 | **0.005** |
| Racial isolation quintile | -0.0149 | -0.0245 – -0.0053 | **0.003** |
| Black or African American (%) | 0.6793 | 0.3115 – 1.0470 | **<0.001** |
| Hispanic or Latino (%) | 0.8230 | 0.4600 – 1.1859 | **<0.001** |
| Asian (%) | 0.5919 | 0.1726 – 1.0112 | **0.006** |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.7346 | 0.3066 – 1.1626 | **0.001** |
| White (%) | 0.6395 | 0.2720 – 1.0071 | **0.001** |
| Education less than high school (%) | -0.0000 | -0.0000 – 0.0000 | 0.094 |
| Poverty (%) | 0.0833 | 0.0071 – 0.1596 | **0.033** |
| Unemployed (%) | -0.2505 | -0.5165 – 0.0155 | 0.066 |
| Age 0 to 19 (%) | 0.0000 | -0.0000 – 0.0000 | 0.352 |
| Age 65 or over (%) | 0.0000 | -0.0000 – 0.0000 | 0.795 |
| Northeast | -0.0336 | -0.0609 – -0.0064 | **0.016** |
| South | 0.0528 | 0.0282 – 0.0774 | **<0.001** |
| West | 0.0363 | 0.0095 – 0.0631 | **0.008** |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.403 | | |

**6n. Sodium.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Sodium** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | 0.53937 | 0.04680 – 1.03194 | **0.033** |
| Racial isolation quintile | -0.00327 | -0.01642 – 0.00988 | 0.626 |
| Black or African American (%) | -0.48985 | -0.98736 – 0.00765 | 0.055 |
| Hispanic or Latino (%) | -0.34998 | -0.84308 – 0.14312 | 0.165 |
| Asian (%) | -0.22688 | -0.79523 – 0.34147 | 0.435 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -0.48456 | -1.06320 – 0.09409 | 0.102 |
| White (%) | -0.50048 | -0.99745 – -0.00351 | **0.050** |
| Education less than high school (%) | 0.00001 | -0.00002 – 0.00004 | 0.649 |
| Poverty (%) | -0.03326 | -0.14202 – 0.07550 | 0.549 |
| Unemployed (%) | -0.07318 | -0.44470 – 0.29833 | 0.700 |
| Age 0 to 19 (%) | -0.00002 | -0.00004 – 0.00000 | 0.100 |
| Age 65 or over (%) | 0.00001 | -0.00004 – 0.00005 | 0.781 |
| Northeast | 0.00627 | -0.03044 – 0.04298 | 0.738 |
| South | 0.06648 | 0.03337 – 0.09959 | **<0.001** |
| West | 0.03515 | -0.00172 – 0.07201 | 0.063 |
| Observations | 262 | | |
| Nagelkerke's R2 | 0.219 | | |

**6o. Titanium.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Titanium** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.015197 | -0.025868 – -0.004525 | **0.006** |
| Racial isolation quintile | -0.000171 | -0.000452 – 0.000110 | 0.234 |
| Black or African American (%) | 0.017068 | 0.006290 – 0.027846 | **0.002** |
| Hispanic or Latino (%) | 0.023239 | 0.012603 – 0.033876 | **<0.001** |
| Asian (%) | 0.019496 | 0.007206 – 0.031786 | **0.002** |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.018077 | 0.005534 – 0.030621 | **0.005** |
| White (%) | 0.017374 | 0.006602 – 0.028147 | **0.002** |
| Education less than high school (%) | -0.000001 | -0.000001 – 0.000000 | 0.052 |
| Poverty (%) | 0.003002 | 0.000766 – 0.005238 | **0.009** |
| Unemployed (%) | -0.001134 | -0.008930 – 0.006662 | 0.776 |
| Age 0 to 19 (%) | 0.000000 | -0.000000 – 0.000001 | 0.394 |
| Age 65 or over (%) | 0.000000 | -0.000001 – 0.000001 | 0.914 |
| Northeast | -0.000666 | -0.001464 – 0.000133 | 0.104 |
| South | 0.001992 | 0.001272 – 0.002712 | **<0.001** |
| West | 0.001288 | 0.000502 – 0.002073 | **0.001** |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.425 | | |

**6p. Vanadium.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Vanadium** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.003653 | -0.008322 – 0.001016 | 0.126 |
| Racial isolation quintile | 0.000158 | 0.000035 – 0.000281 | **0.013** |
| Black or African American (%) | 0.003966 | -0.000750 – 0.008681 | 0.100 |
| Hispanic or Latino (%) | 0.004938 | 0.000285 – 0.009592 | **0.039** |
| Asian (%) | 0.007790 | 0.002414 – 0.013167 | **0.005** |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 0.003605 | -0.001883 – 0.009093 | 0.199 |
| White (%) | 0.003772 | -0.000941 – 0.008485 | 0.118 |
| Education less than high school (%) | 0.000000 | -0.000000 – 0.000000 | 0.831 |
| Poverty (%) | -0.000159 | -0.001137 – 0.000819 | 0.751 |
| Unemployed (%) | 0.000866 | -0.002545 – 0.004277 | 0.619 |
| Age 0 to 19 (%) | 0.000000 | -0.000000 – 0.000000 | 0.210 |
| Age 65 or over (%) | -0.000000 | -0.000001 – 0.000000 | 0.265 |
| Northeast | 0.000556 | 0.000207 – 0.000906 | **0.002** |
| South | 0.000082 | -0.000233 – 0.000397 | 0.610 |
| West | 0.000185 | -0.000159 – 0.000529 | 0.292 |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.291 | | |

**6q. Zinc.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Zinc** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.00654 | -0.07050 – 0.05743 | 0.841 |
| Racial isolation quintile | 0.00127 | -0.00041 – 0.00296 | 0.141 |
| Black or African American (%) | 0.01200 | -0.05260 – 0.07660 | 0.716 |
| Hispanic or Latino (%) | 0.02282 | -0.04094 – 0.08657 | 0.484 |
| Asian (%) | 0.02176 | -0.05190 – 0.09543 | 0.563 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -0.00201 | -0.07720 – 0.07318 | 0.958 |
| White (%) | 0.01741 | -0.04716 – 0.08198 | 0.598 |
| Education less than high school (%) | 0.00000 | -0.00000 – 0.00000 | 0.643 |
| Poverty (%) | 0.00402 | -0.00938 – 0.01742 | 0.557 |
| Unemployed (%) | 0.05900 | 0.01227 – 0.10573 | **0.014** |
| Age 0 to 19 (%) | -0.00000 | -0.00000 – 0.00000 | 0.515 |
| Age 65 or over (%) | -0.00000 | -0.00001 – 0.00000 | 0.598 |
| Northeast | -0.00527 | -0.01005 – -0.00048 | **0.032** |
| South | -0.00834 | -0.01266 – -0.00403 | **<0.001** |
| West | -0.00948 | -0.01419 – -0.00477 | **<0.001** |
| Observations | 274 | | |
| Nagelkerke's R2 | 0.184 | | |

**6r. Ammonium ion.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Ammonium ion** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -0.5348 | -3.9202 – 2.8506 | 0.757 |
| Racial isolation quintile | 0.0770 | 0.0172 – 0.1368 | **0.012** |
| Black or African American (%) | 1.5691 | -1.8340 – 4.9722 | 0.367 |
| Hispanic or Latino (%) | 1.7235 | -1.6483 – 5.0952 | 0.318 |
| Asian (%) | 1.5760 | -2.1330 – 5.2851 | 0.406 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -1.6139 | -7.4365 – 4.2086 | 0.588 |
| White (%) | 1.7194 | -1.7030 – 5.1418 | 0.326 |
| Education less than high school (%) | 0.0001 | -0.0001 – 0.0003 | 0.209 |
| Poverty (%) | -0.2150 | -0.6628 – 0.2328 | 0.348 |
| Unemployed (%) | 0.2511 | -1.3514 – 1.8536 | 0.759 |
| Age 0 to 19 (%) | -0.0000 | -0.0001 – 0.0001 | 0.637 |
| Age 65 or over (%) | -0.0000 | -0.0003 – 0.0002 | 0.790 |
| Northeast | -0.1592 | -0.3227 – 0.0042 | 0.058 |
| South | -0.4038 | -0.5490 – -0.2585 | **<0.001** |
| West | -0.5443 | -0.7175 – -0.3711 | **<0.001** |
| Observations | 212 | | |
| Nagelkerke's R2 | 0.394 | | |

**6s. Sodium ion.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Sodium ion** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | 1.47181 | 0.66828 – 2.27534 | **<0.001** |
| Racial isolation quintile | -0.00860 | -0.02280 – 0.00560 | 0.237 |
| Black or African American (%) | -1.35758 | -2.16530 – -0.54986 | **0.001** |
| Hispanic or Latino (%) | -1.17419 | -1.97447 – -0.37390 | **0.004** |
| Asian (%) | -1.06123 | -1.94158 – -0.18089 | **0.019** |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -1.88326 | -3.26523 – -0.50128 | **0.008** |
| White (%) | -1.43027 | -2.24257 – -0.61797 | **0.001** |
| Education less than high school (%) | -0.00005 | -0.00009 – -0.00000 | **0.043** |
| Poverty (%) | -0.05319 | -0.15948 – 0.05310 | 0.328 |
| Unemployed (%) | -0.02777 | -0.40812 – 0.35258 | 0.886 |
| Age 0 to 19 (%) | -0.00001 | -0.00003 – 0.00001 | 0.431 |
| Age 65 or over (%) | 0.00006 | 0.00000 – 0.00011 | **0.044** |
| Northeast | -0.00649 | -0.04528 – 0.03230 | 0.743 |
| South | 0.04842 | 0.01394 – 0.08290 | **0.006** |
| West | 0.03605 | -0.00506 – 0.07716 | 0.087 |
| Observations | 212 | | |
| Nagelkerke's R2 | 0.349 | | |

**6t. Nitrate ion.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Nitrate ion** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | -3.480 | -7.224 – 0.264 | 0.070 |
| Racial isolation quintile | 0.145 | 0.043 – 0.247 | **0.006** |
| Black or African American (%) | 4.604 | 0.824 – 8.384 | **0.018** |
| Hispanic or Latino (%) | 6.084 | 2.350 – 9.818 | **0.002** |
| Asian (%) | 6.711 | 2.395 – 11.026 | **0.003** |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | 3.909 | -0.490 – 8.309 | 0.083 |
| White (%) | 4.870 | 1.092 – 8.648 | **0.012** |
| Education less than high school (%) | -0.000 | -0.000 – 0.000 | 0.549 |
| Poverty (%) | -0.321 | -1.125 – 0.483 | 0.435 |
| Unemployed (%) | 2.048 | -0.706 – 4.802 | 0.146 |
| Age 0 to 19 (%) | 0.000 | -0.000 – 0.000 | 0.461 |
| Age 65 or over (%) | -0.000 | -0.001 – 0.000 | 0.294 |
| Northeast | -0.744 | -1.024 – -0.464 | **<0.001** |
| South | -1.175 | -1.438 – -0.911 | **<0.001** |
| West | -0.750 | -1.034 – -0.467 | **<0.001** |
| Observations | 265 | | |
| Nagelkerke's R2 | 0.496 | | |

**6u. Sulfate ion.**

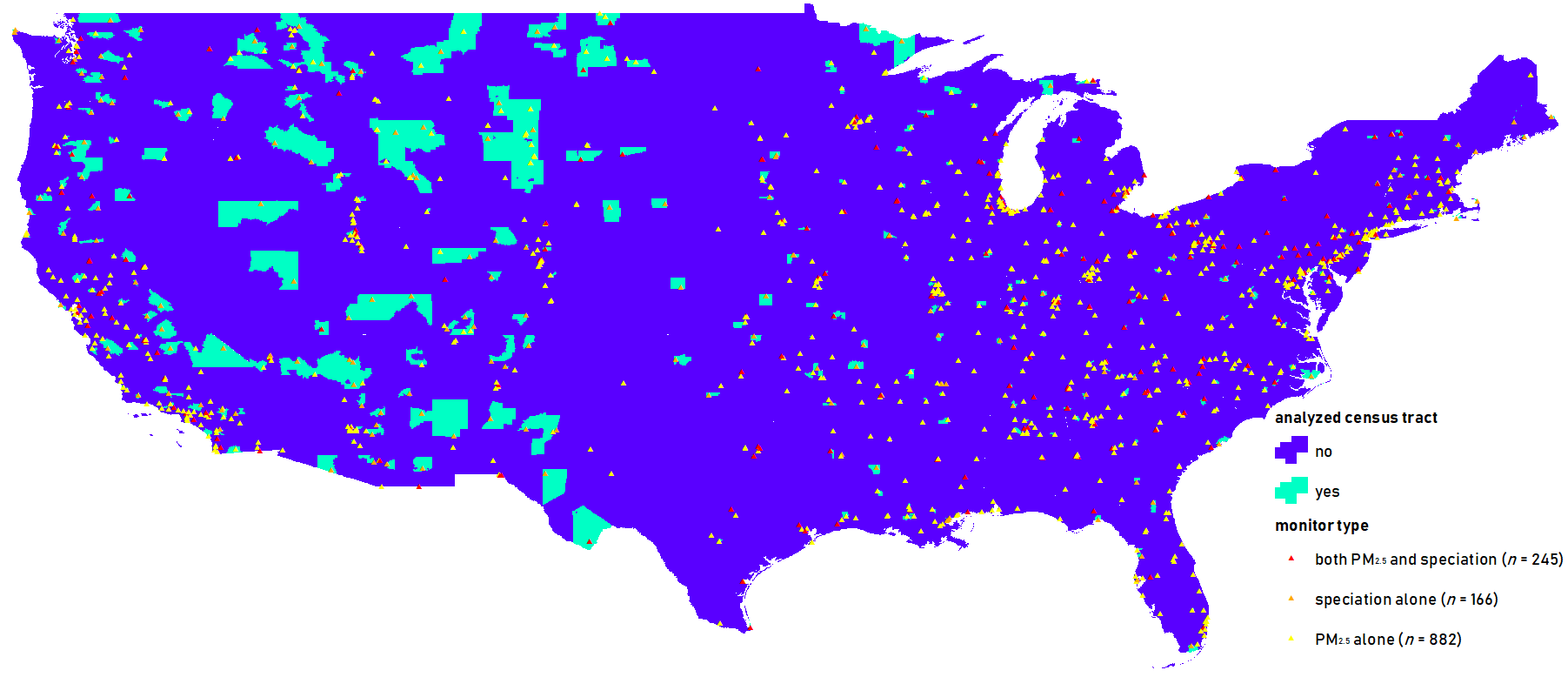
|  |  |  |  |
| --- | --- | --- | --- |
|  | **Sulfate ion** | | |
| *Predictors* | *Estimates* | *CI* | *p* |
| Intercept (Midwest) | 1.5180 | -1.8521 – 4.8881 | 0.378 |
| Racial isolation quintile | 0.1697 | 0.0811 – 0.2584 | **<0.001** |
| Black or African American (%) | 0.1584 | -3.2455 – 3.5623 | 0.927 |
| Hispanic or Latino (%) | 0.2915 | -3.0678 – 3.6508 | 0.865 |
| Asian (%) | 0.9291 | -2.9524 – 4.8106 | 0.639 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -1.2048 | -5.1662 – 2.7567 | 0.552 |
| White (%) | 0.5468 | -2.8552 – 3.9488 | 0.753 |
| Education less than high school (%) | 0.0000 | -0.0002 – 0.0002 | 0.990 |
| Poverty (%) | -0.2835 | -0.9896 – 0.4226 | 0.432 |
| Unemployed (%) | 2.2514 | -0.2106 – 4.7134 | 0.074 |
| Age 0 to 19 (%) | -0.0000 | -0.0002 – 0.0001 | 0.650 |
| Age 65 or over (%) | -0.0000 | -0.0003 – 0.0003 | 0.801 |
| Northeast | -0.0480 | -0.3003 – 0.2043 | 0.710 |
| South | 0.1713 | -0.0557 – 0.3983 | 0.140 |
| West | -1.4552 | -1.7032 – -1.2071 | **<0.001** |
| Observations | 275 | | |
| Nagelkerke's R2 | 0.763 | | |

**6v. Elemental carbon.**

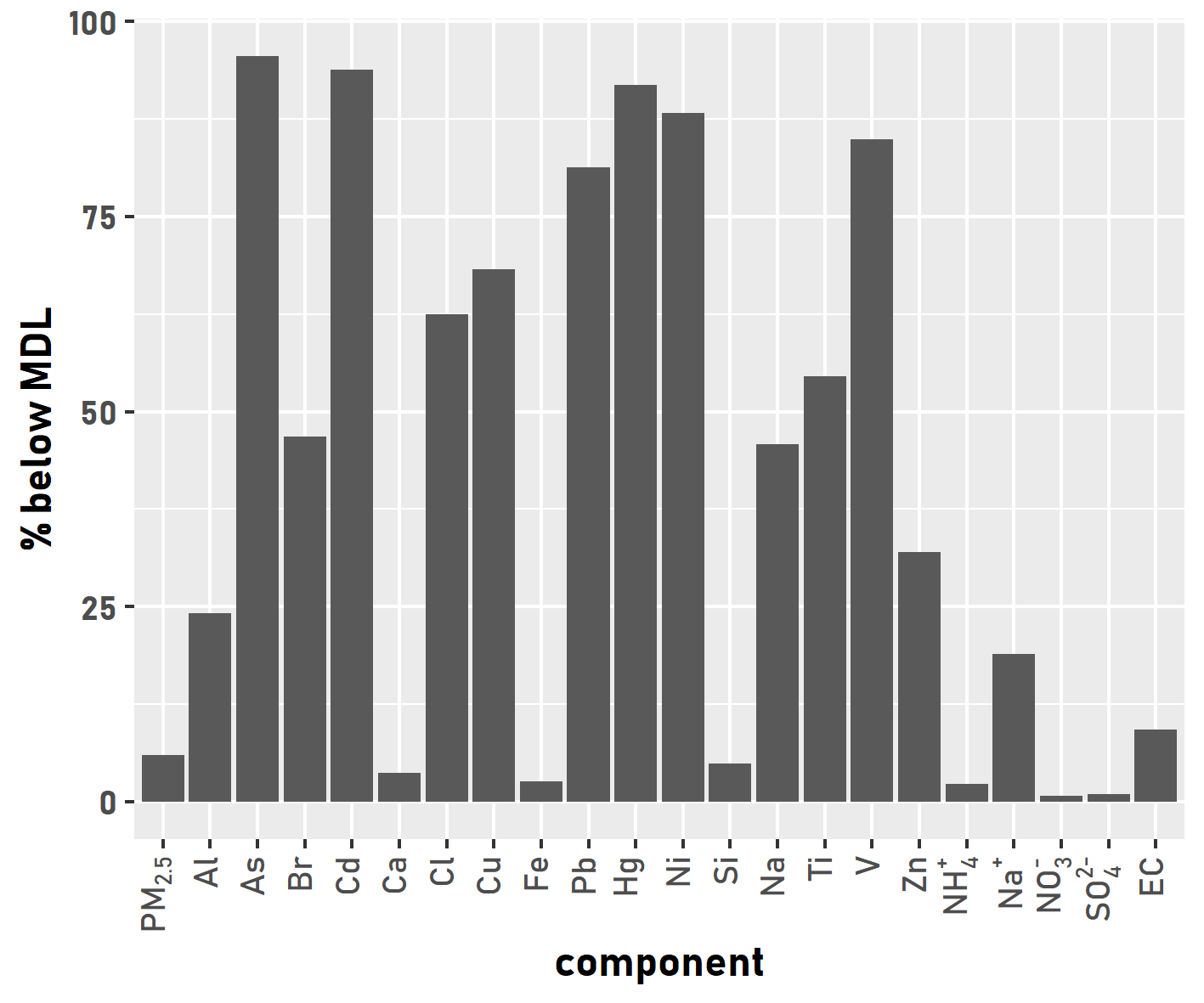
|  |  |  |  |
| --- | --- | --- | --- |
|  | **Elemental carbon** | | |
| *Predictors* | *Estimates* | *Confidence interval* | *p* |
| Intercept (Midwest) | 0.7619 | -6.5337 – 8.0575 | 0.838 |
| Racial isolation quintile | 0.0340 | -0.1530 – 0.2210 | 0.722 |
| Black or African American (%) | 0.5515 | -6.8273 – 7.9303 | 0.884 |
| Hispanic or Latino (%) | 0.1316 | -7.1085 – 7.3718 | 0.972 |
| Asian (%) | 0.1407 | -8.9166 – 9.1979 | 0.976 |
| American Indian, Alaska Native, Native Hawaiian, or Pacific Islander (%) | -0.7444 | -8.9370 – 7.4482 | 0.859 |
| White (%) | -0.5565 | -7.9137 – 6.8006 | 0.882 |
| Education less than high school (%) | -0.0001 | -0.0005 – 0.0002 | 0.440 |
| Poverty (%) | -0.3680 | -1.8006 – 1.0647 | 0.615 |
| Unemployed (%) | 0.0225 | -5.1398 – 5.1848 | 0.993 |
| Age 0 to 19 (%) | 0.0003 | 0.0000 – 0.0005 | **0.043** |
| Age 65 or over (%) | -0.0004 | -0.0010 – 0.0001 | 0.145 |
| Northeast | 0.1473 | -0.3915 – 0.6860 | 0.593 |
| South | 0.2439 | -0.2508 – 0.7385 | 0.335 |
| West | 0.1108 | -0.4168 – 0.6384 | 0.681 |
| Observations | 200 | | |
| Nagelkerke's R2 | 0.207 | | |

**Figures**

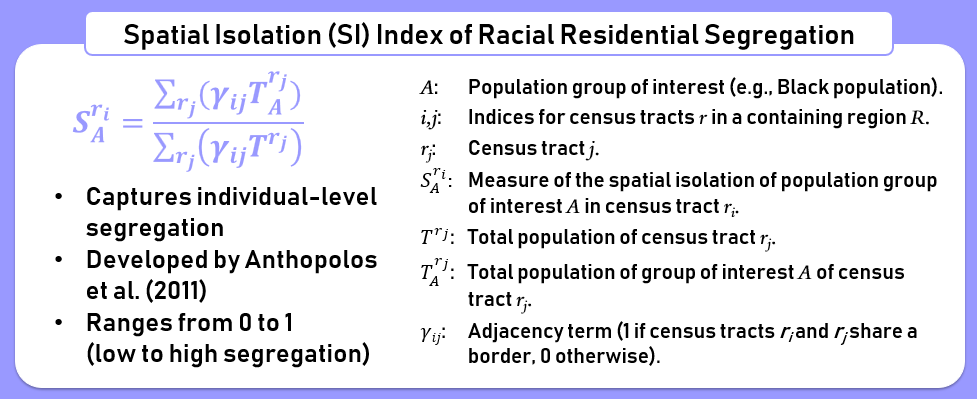
**Figure 1. Map of PM­2.5 total and component monitors (for urban tracts with < 100 people .**

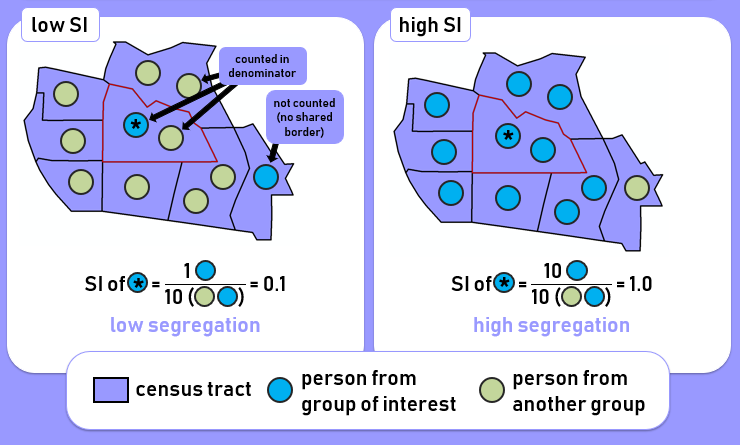


**Figure 2. Percent of observations below the method detection limit (MDL) by PM2.5 component.**

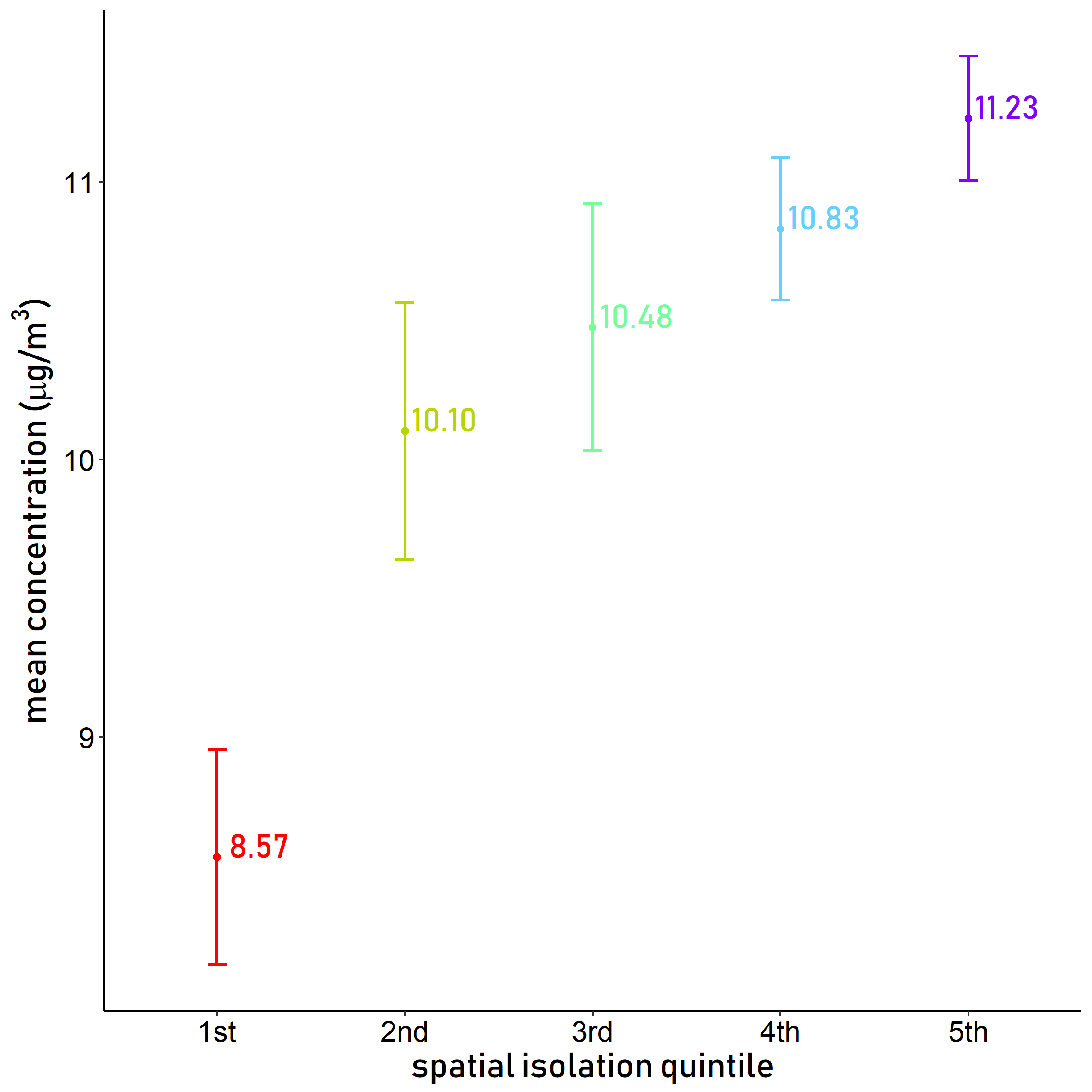


**Figure 3. Racial isolation index.**

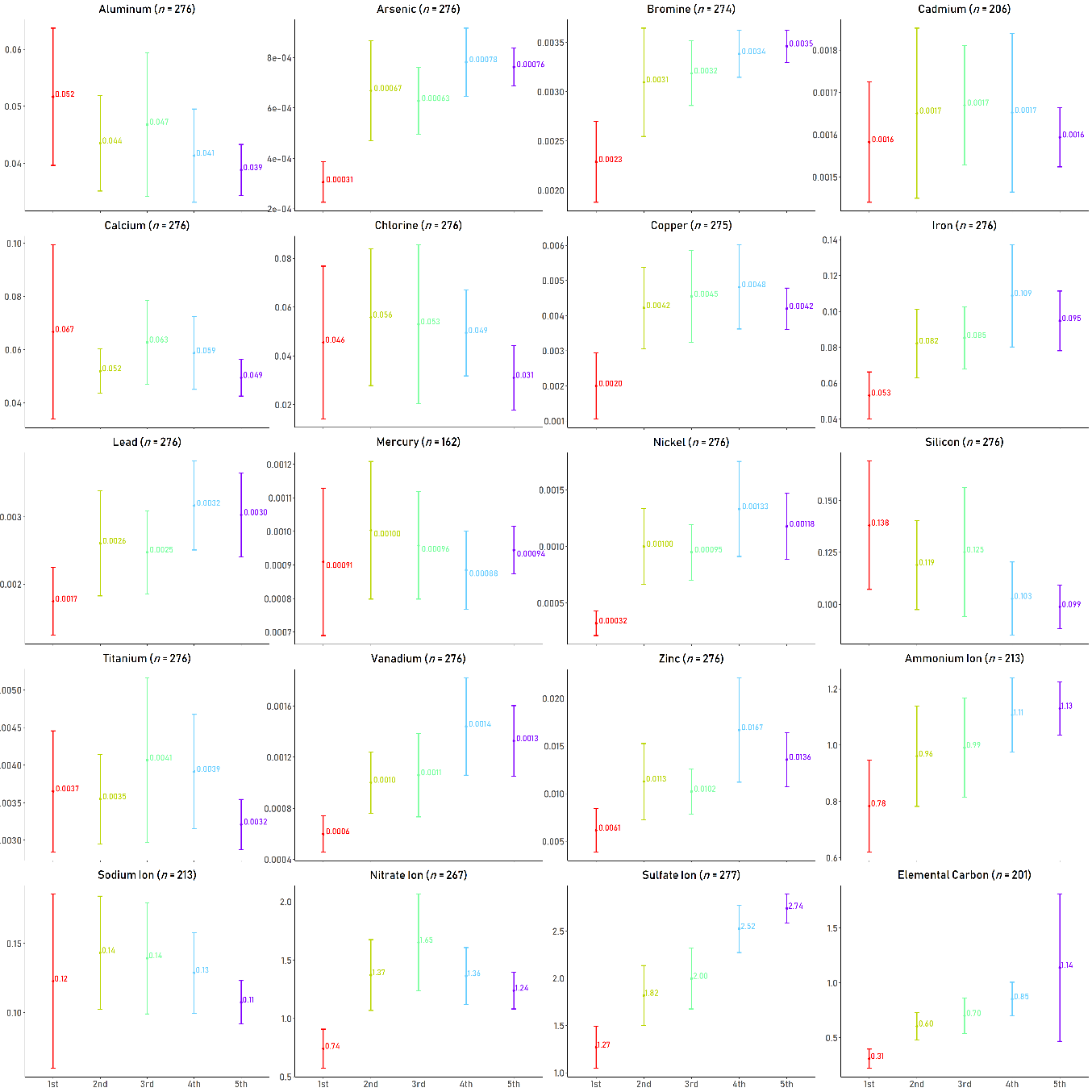
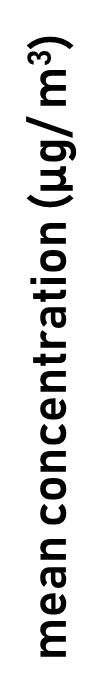


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**Figure 4. Means and 95% confidence intervals for PM2.5 by quintile of racial isolation.**



**Figure 5. Means and 95% confidence intervals for PM2.5 components by quintile of racial isolation.**

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**Appendices**

**Table A1. Primary and secondary RUCA codes, 2010. Tracts were considered urban if they had a primary code of 1, 2, or 3 or a secondary code of 1.**

|  |  |  |
| --- | --- | --- |
| **Primary code** | **Secondary code** | **Classification description** |
| 1 | | Metropolitan area core: primary flow within an urbanized area (UA) |
|  | 1.0 | No additional code |
|  | 1.1 | Secondary flow 30% to 50% to a larger UA |
| 2 | | Metropolitan area high commuting: primary flow 30% or more to a UA |
|  | 2.0 | No additional code |
|  | 2.1 | Secondary flow 30% to 50% to a larger UA |
| 3 | | Metropolitan area low commuting: primary flow 10% to 30% to a UA |
|  | 3.0 | No additional code |
| 4 | | Micropolitan area core: primary flow within an urban cluster of 10,000 to 49,999 (large UC) |
|  | 3.0 | No additional code |
|  | 3.1 | Secondary flow 30% to 50% to a UA |
| 5 | | Micropolitan high commuting: primary flow 30% or more to a large UC |
|  | 5.0 | No additional code |
|  | 5.1 | Secondary flow 30% to 50% to a UA |
| 6 | | Micropolitan low commuting: primary flow 10% to 30% to a large UC |
|  | 6.0 | No additional code |
| 7 | | Small town core: primary flow within an urban cluster of 2,500 to 9,999 (small UC) |
|  | 7.0 | No additional code |
|  | 7.1 | Secondary flow 30% to 50% to a UA |
|  | 7.2 | Secondary flow 30% to 50% to a large UC |
| 8 | | Small town high commuting: primary flow 30% or more to a small UC |
|  | 8.0 | No additional code |
|  | 8.1 | Secondary flow 30% to 50% to a UA |
|  | 8.2 | Secondary flow 30% to 50% to a large UC |
| 9 | | Small town low commuting: primary flow 10% to 30% to a small UC |
|  | 9.0 | No additional code |
| 10 | | Rural areas: primary flow to a tract outside a UA or UC |
|  | 10.0 | No additional code |
|  | 10.1 | Secondary flow 30% to 50% to a UA |
|  | 10.2 | Secondary flow 30% to 50% to a large UC |
|  | 10.3 | Secondary flow 30% to 50% to a small UC |
| 99 | | Not coded: Census tract has zero population and no rural-urban identifier information |

CBSA code

# onlyruca <- within(onlyruca, urban[ruca\_second == 1.0 | ruca\_second == 1.1 | ruca\_second == 2.0 | ruca\_second == 2.1 | ruca\_second == 3.0 | ruca\_second == 3.1 | ruca\_second == 4.1 | ruca\_second == 5.1 | ruca\_second == 6.1 | ruca\_second == 7.1 | ruca\_second == 8.1 | ruca\_second == 9.1 | ruca\_second == 10.1] <- 'urban')