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Linkage of the Third National Health and Nutrition Examination Survey to Air Quality Data



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Health Statistics

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Data Evaluation and Methods Research
Survey

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Health Statistics

Hyattsville, Maryland
November 2008
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Abstract

Objectives

This report describes the linked data file obtained as a result of combining air pollution data and National Health and Nutrition Examination Survey (NHANES) III data.

Methods

Average annual air pollution exposures to particulate matter consisting of particles smaller than 10 micrometers in diameter (PM₁₀), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), and carbon monoxide (CO) were created for NHANES III examined persons by averaging values from monitors within a 5-, 10-, 15-, and 20-mile radius from the block-group centroid of their residence and in the county of their residence. Percentage records geocoded to block-group level, percentage records linked to air pollution, and distributions of exposure values were estimated for the total sample and various demographic groups.

Results

The percentages of respondents who were assigned countywide air pollution values ranges from a low of 43 percent in the case of NO₂ data to a high of 68 percent in the case of PM₁₀ data. Among the pollutants considered, PM₁₀ data provides the best coverage. Of all the metrics created, the highest coverage is achieved by averaging readings of monitors located within a 20-mile distance from the centroid of respondents' block groups. Among the demographic variables analyzed, differences in air pollution coverage and exposure levels occur most often among groups defined by race and Hispanic origin, region, and county level of urbanization. However, differences among groups depend on the pollutant and geographic linkage method. The linked dataset provides researchers with opportunities to investigate the relationship between air pollution and various health outcomes.

Keywords: NHANES III • air pollution • data linkage

Linkage of the Third National Health and Nutrition Examination Survey to Air Quality Data

by Nataliya Kravets, M.A., NOVA Research Company, Northrop Grumman CITS II Contract, and Jennifer D. Parker, Ph.D., Office of Analysis and Epidemiology

Introduction

The effect of air pollution on health has been the subject of numerous epidemiologic studies (1–9). Some of these studies were based on data from the National Health and Nutrition Examination Survey (NHANES) (7–9). Chestnut et al. (7) used NHANES I data to examine the effect of total suspended particulates on lung functions in adults, and Schwartz (8) used NHANES II data to investigate the effect of total suspended particulates, nitrogen dioxide, sulfur dioxide, and ozone on lung function in children. More recently, Schwartz (9) linked particulate matter, sulfur dioxide, and nitrogen dioxide to NHANES III respondents to examine blood markers of cardiovascular risk; the results provided supporting biological plausibility for studies of air pollution and mortality. However, these studies did not systematically address coverage issues resulting from the absence of air pollution monitors near respondents' places of residence and the potential effect of these issues on resulting exposure estimates.

The objective of this report is to describe the linked data file obtained as a result of combining air pollution data and NHANES III data. To create the linked data file, several air pollution exposure variables were created from annual pollution data from the U.S. Environmental Protection Agency (EPA) for years 1988–1994. These variables were linked to NHANES III respondents using a confidential data file that contains respondents' 1990 census block-group codes. This report describes which demographic groups are more likely to be assigned air pollution values, how differences in air pollution exposure levels depend on the method of creating air pollution exposures, and which demographic groups are more likely to have higher exposure estimates. The report outlines the benefits and limitations of the resulting linked dataset.

A previous report describes the linkage of the National Health Interview Survey (NHIS) to air pollution data and provides more details about the air monitor selection and the evaluation of geographic references for these linkages (10).

Nataliya Kravets's work on this project was funded by the Office of the Assistant Secretary for Planning and Evaluation, ASPE SP 05–039 Data Linkage for Environmental Health Policy. This report was edited by Megan M. Cox and Demarius V. Miller, CDC/CCHIS/NCHM/Division of Creative Services, Writer-Editor Services Branch, and typeset by Annette F. Holman, CDC/CCHIS/NCHM/Division of Creative Services; graphics were produced by Zorica Tomic-Whalen, CDC/CCHIS/NCHM/Division of Creative Services.

Linkage of NHANES III to Air Quality Data

Data Files Used for Linkage

Third National Health and Nutrition Examination Survey

NHANES III provides health information for a nationally representative sample of the civilian noninstitutionalized U.S. population aged 2 months and over (11). The data were collected from 1988–1994, using a complex multistage probability sample. Non-Hispanic black persons, Mexican Americans, children ages 2 months through 5 years of age, and adults 60 years of age and over were oversampled. The survey included an interview and an examination.

All examined NHANES III respondents (that is, respondents who underwent the examination in the mobile examination center (MEC) or in their homes) were eligible to be included in the linkage. The National Center for Health Statistics retains confidential files that include the residential addresses of NHANES III respondents and their 1990 census block groups. The file containing 1990 census block-group codes is available under restricted conditions to analysts through the Research Data Center (12). County identifiers from the 1990 census and the coordinates of the centroids of the block groups were used to identify respondents' spatial location.

Census block groups are geographic subdivisions of census tracts; their primary purpose is to provide a geographic summary unit for census block data. A block group comprises a reasonably compact and contiguous cluster of census blocks. Each census tract contains a minimum of one block group and may have a maximum of nine block groups. Although the number of people in census block groups averages about 1,500, the minimum is about 600 and the maximum is about 3,000 (13).

EPA annual air pollution monitoring data

Monitor-level annual air pollution data for 1988–1994, the NHANES III survey years, came from the EPA Air Quality System database (14). Pollutants described in this report are carbon monoxide (CO), nitrogen dioxide (NO₂), particulate matter consisting of particles smaller than 10 micrometers in diameter (PM₁₀), and sulfur dioxide (SO₂). These pollutants are among those monitored for regulatory purposes.

Several data quality criteria were applied to select records for air pollution monitors from the database (10).

- Only nonexperimental monitors located in the 50 states were selected.
- When pollution measurements were recorded during exceptional events (e.g., fires), separate annual averages were calculated at the monitor, including and excluding the measurements for exceptional events. The annual average calculated from all measurements was selected.
- All records with missing arithmetic mean (yearly weighted arithmetic mean for PM₁₀) were removed.
- For each pollutant, only certain sampling intervals were selected: 1-hour sampling interval for CO, NO₂, and SO₂ and 24-hour and 24-hour block average for PM₁₀. 24-hour block averaged estimates at each monitor are recorded by averaging 24 1-hour samples each day.
- For CO, NO₂ and SO₂, two data quality criteria were applied: for a record to be kept, 75 percent of the possible observations during the year needed to be included in the annual calculation, and the number of observations recorded by a monitor had to be no less than 6,570. For PM₁₀, these criteria were 75 percent and 45 observations. For each pollutant, if more than one monitor was found at a monitoring site, only one monitor was selected by applying the following rules: a

monitor with the highest percentage observations was selected first; if two monitors had the same percentage observations, the one with the highest number of observations was selected.

- If more than one monitor was left after the quality criteria were applied, the monitor with the lowest parameter occurrence code (POC) was selected. The POC code uniquely identifies separate monitors for a particular pollutant (or parameter) at a location.

A more detailed description of the monitor selection process is available elsewhere (10). As with the NHANES III respondents who were assigned locations by county of residence and by coordinates of block-group centroids as described above, spatial locations of monitors were identified in two ways: by 1990 census county codes in which monitors were located and by coordinates of monitoring sites.

Linkage Methods

Monitors measure pollution at locations of monitoring sites, not where NHANES III respondents live. There are several methods to determine air pollution at unobserved locations (15). For this report, NHANES III respondents were assigned exposure measures in two ways: first, by averaging monitor values over 1990 census counties in which the monitors were located; and second, by averaging air pollution values from all monitors located within a certain distance from NHANES III block-group centroids, weighted by the inverse squared distance between monitors and block-group centroids. Distances for 5-, 10-, 15-, and 20-mile radiuses were used. As a result, five exposure variables were created for each pollutant: 5-, 10-, 15-, and 20-mile radius metrics and a countywide exposure variable.

Description of the Linked Data Files

Methods

The results of the linkage are described for the NHANES III sample as a whole and for subgroups. NHANES III respondents were grouped by their poverty status (below poverty threshold and at or above poverty threshold), race and Hispanic origin (non-Hispanic white, non-Hispanic black, or Mexican American), respondent-assessed health status (excellent, very good, good, fair, or poor), and age (under 25 years, 25–64 years, or 65 years and over). These age categories, although not the standard categories for NHANES III publications (16), correspond to those used in the report describing the linkage between the NHIS and air monitoring data (10). Two geographic variables were tabulated: region (Northeast, Midwest, South, or West) and county level of urbanization. County level of urbanization, based on the U.S. Department of Agriculture rural-urban code (17), was divided into “large metropolitan” and “all other counties,” where large metropolitan counties included central and fringe counties of metro areas of 1 million population or more, and all other counties included smaller metropolitan and nonmetropolitan counties.

To evaluate differences in coverage across these demographic groups, two statistics were calculated. The first statistic considered was weighted percentage of records geocoded to block-group level. Then, for each pollutant, the weighted percentage of respondents who were assigned air pollution values was calculated.

Across demographic subgroups, statements about differences in coverage for a particular geographic linkage method (for example, 5-mile by race and ethnicity) were tested using the following formula:

$$Z = \frac{|X_a - X_b|}{\sqrt{S_a^2 + S_b^2}},$$

where X_a and S_a are the percentage and

its standard error for one subgroup, and X_b and S_b are the percentage and its standard error in the second subgroup. No adjustments were made for multiple comparisons. The critical value used for two-sided tests at the level 0.05 was 1.96. Comparisons between any two groups that are not mentioned in the text are not necessarily insignificant. Terms such as “less likely,” “more likely,” and “lower coverage” indicate that the difference between the two groups was tested and found significant.

Because estimates comparing types of exposure metrics (for example, 5-mile compared with 15-mile for respondents in the Northeast) are not statistically independent, no statistical significance tests were performed to compare differences between these percentages.

To inform users about variability of air pollution data linked to NHANES III respondents, several statistics were calculated. To examine distributions of exposure values over the total sample and among groups of respondents, the central tendency statistics (medians) and the spread of air pollution exposure metrics (upper and lower quartiles) were calculated. Statistical methods to compare these percentiles that appropriately consider the sampling design, the linkage constraints, and the clustering of exposure estimates obtained from these restricted samples have not been developed; thus no statistical significance tests were performed to compare the groups.

With the exception of unweighted counts, all statistics in the tables were weighted by the final MEC and home examination weight. SUDAAN software (18) was used to calculate percentages and their standard errors. SAS software (19) was used to obtain percentiles.

Results

Percentage geocoded to block-group level

Although the county of residence is known for each respondent, out of a total of 31,311 respondents, 27,099 were geocoded to the block-group level (see Table 1).

The percentage of records geocoded

to block-group level differ among some demographic groups. Groups defined by age, poverty status, and self-reported health status did not differ with regard to the percentage of records geocoded to block-group level. The percentage geocoded differed among race and ethnicity groups, regions, and level of urbanization (Figure 1). Records for non-Hispanic white persons were less likely to be geocoded than those for non-Hispanic black persons and Mexican Americans. Among U.S. Census Bureau regions, persons living in the South were less likely to be geocoded to the block-group level (77 percent) than persons living in any other region. Persons residing in the West were more likely to be geocoded (97 percent) than residents of any other region. Persons living in large metropolitan counties with a population of more than 1 million were more likely to be assigned block-group geocodes than persons living in other counties (97 percent compared with 74 percent).

Coverage

Even though the county of residence is known for all respondents, not all counties have air pollution monitors. During the NHANES III survey years, counties may have had monitors that collected information on some pollutants but not others. As a result, PM₁₀ countywide air pollution data were available for 68 percent of persons (Table 2). SO₂ and CO data were available for 52 percent of persons (Table 3 and Table 5). NO₂ countywide data were available for only 43 percent of persons (Table 4). Regardless of the pollutant, countywide exposure values were more likely to be available for persons residing in large metropolitan counties with a population of more than 1 million than for persons residing in other areas (Tables 2–5). Some differences in coverage exist between groups formed by race and ethnicity and region. However, these differences depend on a pollutant.

To assess overall air pollution exposure availability of distance-based metrics, percentages of respondents with exposure values were calculated using the whole NHANES III examined

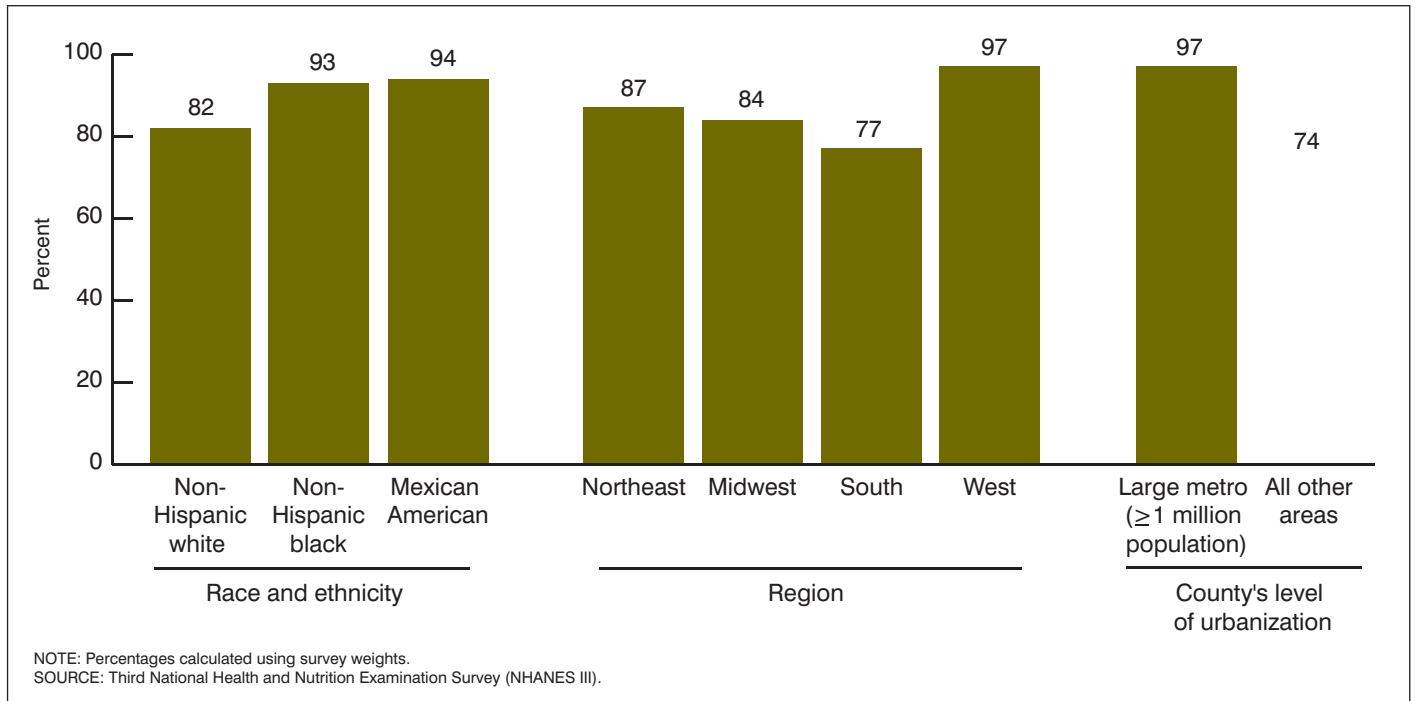


Figure 1. Percentage of NHANES III persons with block-group level geocodes by race and ethnicity, region, and county's level of urbanization: 1998–1994

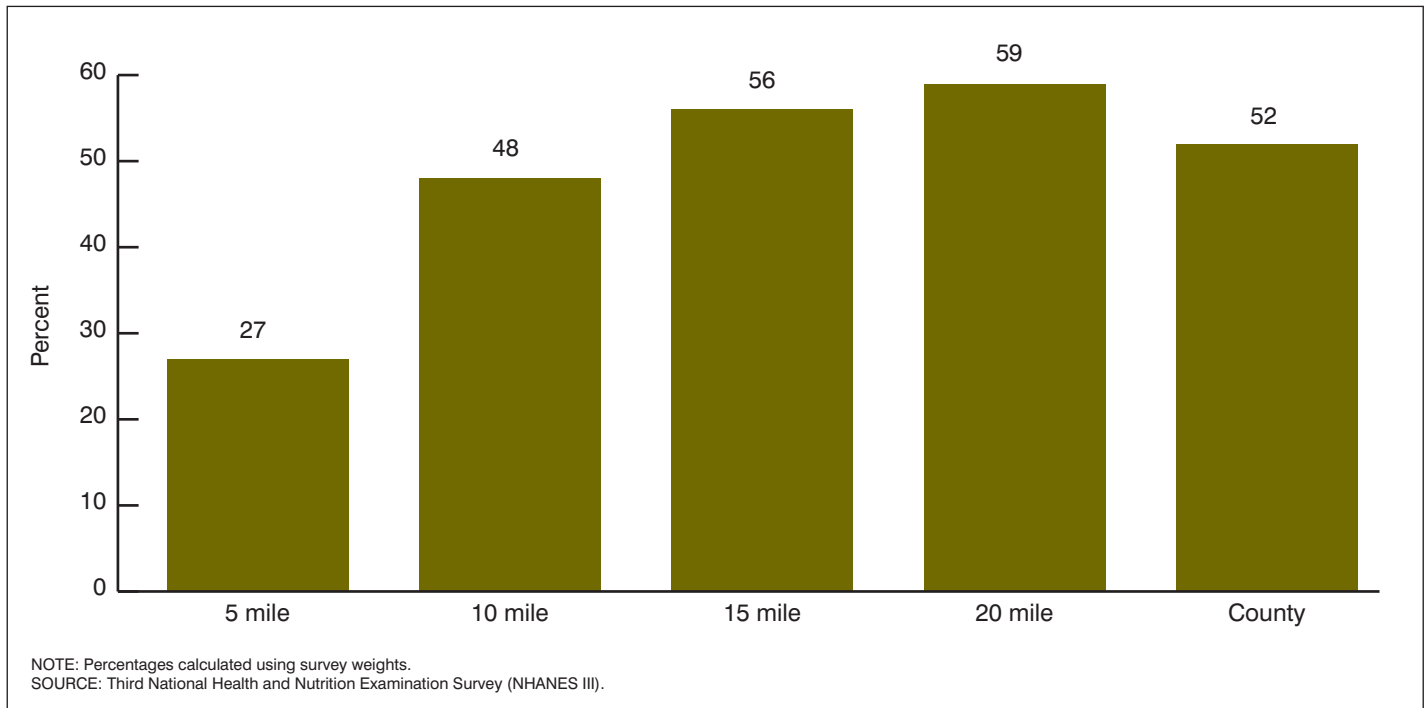


Figure 2. Percentage of NHANES III persons linked to carbon monoxide (CO) data by geographic linkage method: 1988–1994

sample, not just those who were geocoded to block-group level (Tables 2–5). Using a larger radius to calculate air pollution exposure leads to a larger number of records available for analysis for all pollutants and subgroups

(Tables 2–5). Although the coverage for all pollutants and demographic groups improved with each 5-mile expansion of the radius, most often the largest increase occurred when a 5-mile radius expanded to 10 miles, as seen in

Figure 2. (For some pollutants and types of analysis, air pollution within smaller distances may be more appropriate. However, the percentage of persons linked to air pollution for areas smaller than a 5-mile radius is extremely low.

For example, only 2 percent of persons have a CO air pollution monitor within 1 mile of the place of their residence.)

Of the four pollutants considered, PM₁₀ exposure data were most often available; for example, 20-mile radius exposure data for PM₁₀ are available for 73 percent of persons (Table 2). Similar to the result of geocoding, although there were no systematic differences among age, poverty status, and health status groups in air pollution coverage, there were significant differences among race and ethnicity groups and regions and by county level of urbanization. Overall, non-Hispanic white persons had lower coverage than the other two groups. With the exception of SO₂, persons living in the Midwest and South were less likely to have 10-, 15-, and 20-mile radius exposure data than those in the Northeast and West. Persons living in large metropolitan counties had significantly higher coverage than persons living in other counties.

Exposure

To assess whether different linkage methods influence resulting exposure distributions, the median and the 25th and 75th percentiles of air pollution values are presented in Tables 6–9.

These distributions show some variability of air pollution data over the NHANES III sample. Among the geographic linkage metrics, distributions for 10-, 15-, and 20-mile radius exposure values were quite similar. This similarity was apparent for all of the pollutants (Tables 6–9 and Figure 3).

Although not specifically tested, PM₁₀, NO₂, and CO exposure values appeared similar across age, poverty status, and health status groups (Tables 6, 8, and 9). Persons at or above the poverty threshold appeared to have somewhat higher SO₂ exposure values than those below the poverty threshold (Table 7). Regional differences in pollution exposure vary by pollutant. Mexican Americans had greater variability of exposure values than the other two race and ethnicity groups (Tables 6–9); for example, this difference for Mexican Americans is evident for NO₂ exposure (Figure 4).

Average exposure value and its variability depend on the county's level of urbanization. Although not tested, persons living in large metropolitan counties with a population of more than 1 million appeared to have higher exposure values than those in other areas (Tables 6–9).

Discussion

Using annual averages (rather than metrics derived from shorter time intervals) to measure air pollution limits the variability of exposure data. However, annual average data are easily available to the public and have been shown to be useful for estimating the possible effects of air pollution on health (20).

Collection of NHANES III data spanned several years, with different geographic locations included in the survey at different points in time. Overall levels of pollution declined during the years of data collection. As a result, respondents in earlier years of the survey may have higher assigned exposure values than respondents in later years of the survey.

NHANES III has a stratified multistage probability sample design. Individual counties or small adjacent counties were sampled at the first stage, and area segments (aggregates of U.S. Census bureau blocks) were sampled at the second. As a result, NHANES III respondents are clustered in a limited number of geographic locations. Implications of using this clustered

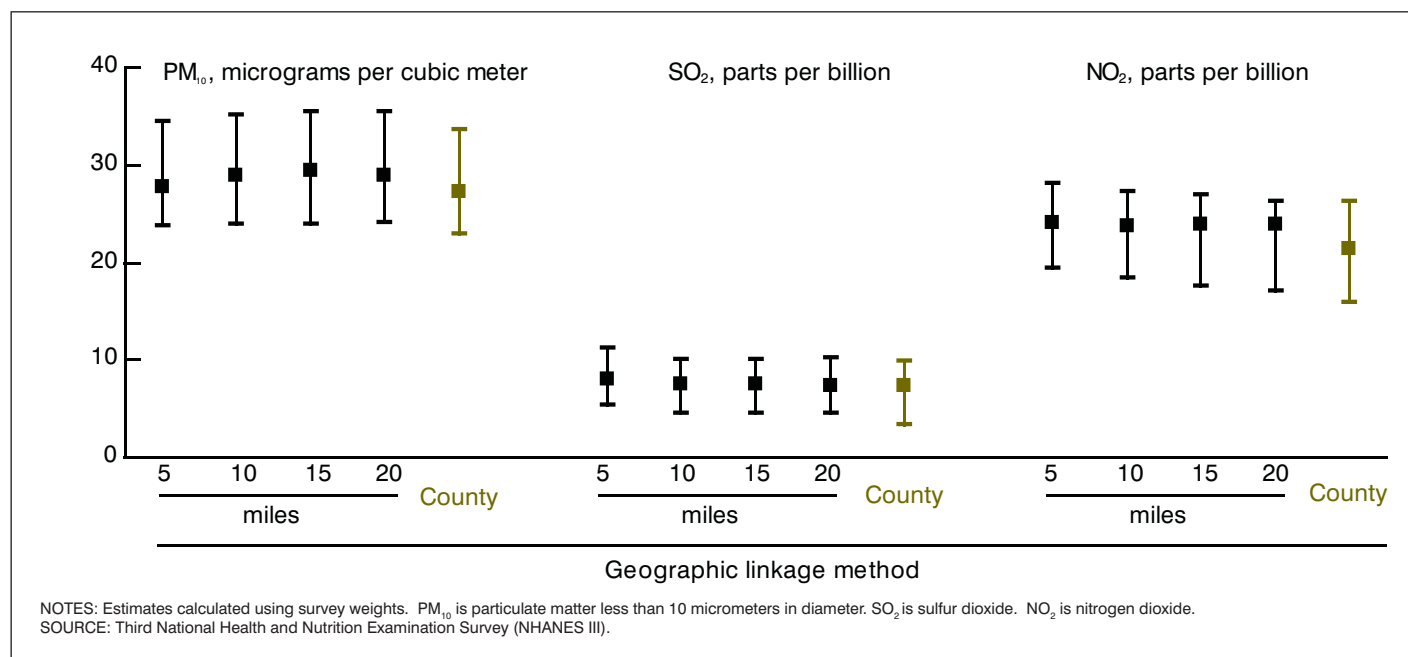


Figure 3. PM₁₀, SO₂, and NO₂ exposure values by 25th percentile, median, and 75th percentile, by geographic linkage: 1988–1994

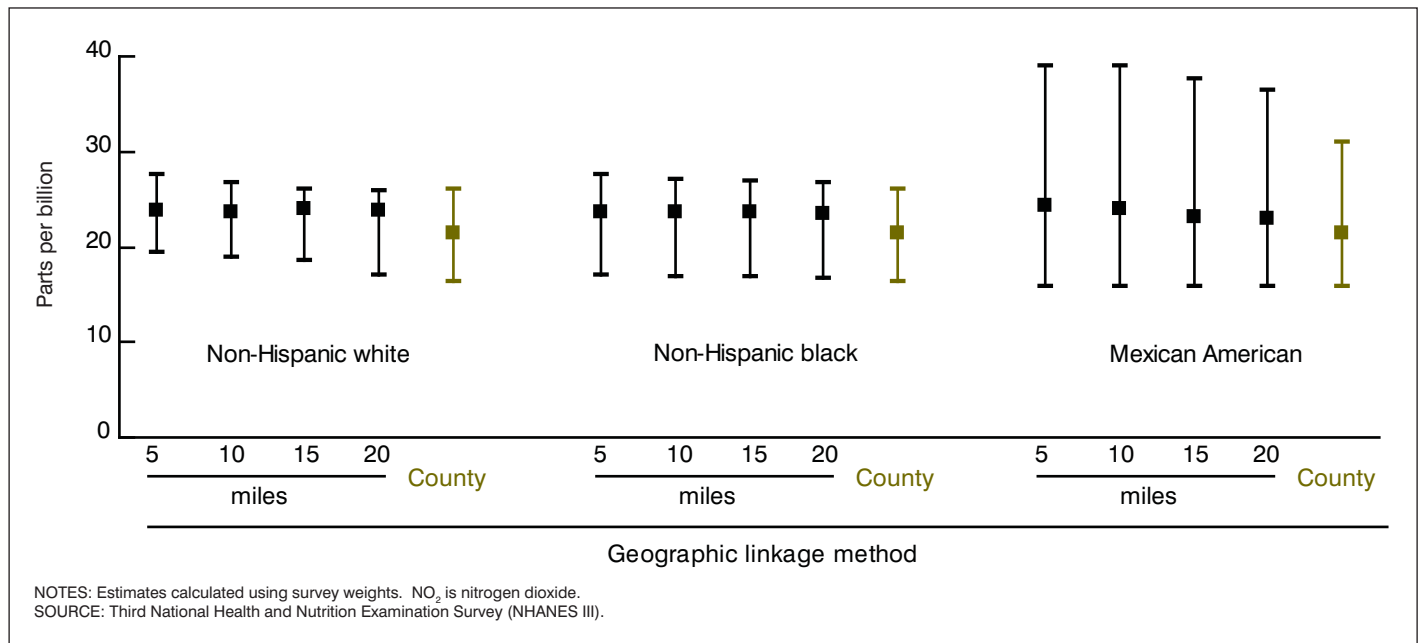


Figure 4. NO₂ exposure values by 25th percentile, median, and 75th percentile, by geographic linkage method and race and ethnicity: 1988–1994

sample, (which reduces the variability of pollution exposures) for inferences are unknown.

The use of coordinates of block-group centroids instead of exact locations of households introduces an additional geographic clustering of respondents. Respondents who lived in the same block group were assigned the same air pollution value, no matter how far they lived from the block-group centroid and from the pollution monitors. If the nearest monitor was located outside a certain radius from the block-group centroid, exposure data are missing for all respondents in the block group. In addition, data from the same monitor were often used to assign air pollution to several NHANES III block groups. If the same monitor was located within 20 miles from centroids of two block groups, the value reported by this monitor was used when calculating exposure metrics for each of the two block groups. Countywide metrics are more clustered than distance-based metrics because there are fewer counties than block groups represented in the sample. However, county of residence is known for every respondent, so the eligible sample is not limited to

respondents with available block-group geocodes.

Using the same methods, NHIS data files from 1987–2005 have been assigned air pollution exposure values (10). For the years that overlap the linked NHIS and NHANES III files, the percentages of respondents with exposures and the corresponding percentiles of air pollution exposure values are similar but not identical. The standard errors of the percentages are considerably higher in the NHANES III linked files compared with the NHIS linked files. This moderate correspondence is expected given the different sampling designs, the sizes of the two surveys, and the changing pollution exposure measures over the time period. Over the 6 years of data collection, NHANES III, for example, included approximately 30,000 participants from 83 counties. In contrast, during that time period, the NHIS included approximately 100,000 participants each year from approximately 600 counties. Also, given the inability to assign spatially averaged exposure estimates to all survey participants, comparisons for particular groups are based on different numbers

of locations. For example, the overall 20-mile exposure for CO was limited to NHANES III persons in 56 counties from 18 states and, in the 1990 NHIS, to persons from slightly under 300 counties in 43 states.

Conclusion

This report describes the dataset resulting from linking air pollution exposure data from the EPA to NHANES III respondents. Differences in air pollution coverage and exposure levels depend on the pollutant and most often occur among groups defined by geographic indicators, such as region and level of urbanization. Using a larger radius to calculate air pollution metrics resulted in greater sample coverage. In the majority of comparisons, 20-mile radius exposure variables provide greater coverage compared with county-based exposure variables. Distributions of countywide and 5-mile radius exposure variables are somewhat different from the other three distance-based metrics.

To take into account the additional clustering in the dataset, further

methodological research is needed to evaluate and perhaps develop appropriate statistical methods of analysis for complex surveys linked to environmental exposures.

Unlike the majority of previous studies, air pollution data in the linked dataset is not limited to a small geographic area but covers areas around the entire United States. Levels of air pollution have been declining, so this historic dataset allows researchers to investigate relationships between air pollution and health outcomes at a time when air pollution levels were higher. NHANES III is also linked to the National Death Index (NDI) (21). At the time of this publication, NDI mortality data are available through 2000, providing researchers with 6–12 years of mortality follow-up, and continued follow-up is planned. Despite its limitations, the created dataset combines a wealth of health data available in NHANES III with air pollution exposure data.

References

1. Pope CA, Dockery DW, Schwartz J. Review of epidemiological evidence of health effects of particulate air pollution. *Inhal Toxicol* 7(1):1–18. 1995.
2. Pope CA, Dockery DW. Health effects of fine particulate air pollution: Lines that connect. *J Air Waste Manag Assoc* 56(6):709–42. 2006.
3. Krewski D, et al. Mortality and long-term exposure to ambient air pollution: Ongoing analyses based on the American Cancer Society cohort. *J Toxicol Environ Health A* 68(13–14):1093–109. 2005.
4. Dockery DW, et al. An association between air pollution and mortality in six U.S. cities. *N Engl J Med* 329(24):1753–59. 1993.
5. Schwartz J, et al. Acute effects of summer air pollution on respiratory symptom reporting in children. *Am J Respir Crit Care Med* 150(5):1234–42. 1994.
6. Dominici F, et al. National maps of the effects of particulate matter on mortality: Exploring geographical variation. *Environ Health Perspect* 111(1):39–43. 2003.
7. Chestnut LG, et al. Pulmonary function and ambient particulate matter: Epidemiologic evidence from NHANES I. *Arch Environ Health* 46(3):135–44. 1991.
8. Schwartz J. Lung function and chronic exposure to air pollution: A cross-sectional analysis of NHANES II. *Environmental Research*. 50(2): 309–21. 1989.
9. Schwartz J. Air pollution and blood markers of cardiovascular risk. *Environ Health Perspect* 109(supplement 3):405–9. 2001.
10. Parker JD, Kravets N, Woodruff TJ. Linkage of the National Health Interview Survey to air quality data. *National Center for Health Statistics. Vital Health Stat* 2(145). 2008.
11. National Center for Health Statistics. Plan and operation of the Third National Health and Nutrition Examination Survey, 1988–94. *Vital Health Stat* 1(32). 1994.
12. National Center for Health Statistics. Research Data Center. Available from: <http://www.cdc.gov/nchs/r&d/rdc.htm>.
13. United States Census Bureau. Appendix A: Census 2000 geographic terms and concepts [online]. Available from: <http://www.census.gov/geo/www/tiger/glossry2.pdf>. 2000.
14. Environmental Protection Agency. Technology Transfer Network (TTN) Air Quality System (AQS). Available from: <http://www.epa.gov/ttn/airs/airsaqs/index.htm>. January 23, 2007.
15. Wong DW, Yuan L, Perlin SA. Comparison of spatial interpolation methods for the estimation of air quality data. *J Expo Analysis Environ Epidemiol* 14(5):404–15. 2004.
16. National Center for Health Statistics. Analytic and reporting guidelines: The Third National Health and Nutrition Examination Survey, NHANES III (1988–94). Available from: <http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf>. 1996.
17. Butler MA, Beale CL. Rural-urban continuum codes for metro and nonmetro counties, 1993. Staff Report No. AGES–9425. Agriculture and Rural Economy Division, Economic Research Services, U.S. Department of Agriculture: Washington, DC. 1993.
18. RTI International. SUDAAN, version 9.01 [computer software]. Research Triangle Institute: Research Triangle Park, NC. Available from: <http://www.rti.org/sudaan/index.cfm>. 2006.
19. SAS Release 9.1 [computer software]. SAS Institute Inc: Cary, NC. Available from: <http://www.sas.com/technologies/analytics/statistics/stat/index.html>. 2003.
20. Miller KA, et al. Long-term exposure to air pollution and incidence of cardiovascular events in women. *N Engl J Med* 356(5):447–58. 2007.
21. National Center for Health Statistics. NHANES III Linked Mortality File. Available from: http://www.cdc.gov/nchs/r&d/nchs_data/nhanes3_data_linkage_mortality_activities.htm.

Table 1. Number and percentage (standard error) of NHANES III respondents geocoded to block-group level, by respondent characteristics: United States 1988–1994

Characteristic	Total number of records	Records geocoded to block-group level	
		Number	Percent (SE)
Total	31,311	27,099	85 (2)
Poverty status			
Below poverty threshold	8,758	7,694	87 (3)
At or above poverty threshold	19,651	16,833	85 (2)
Race and Hispanic origin			
Non-Hispanic white	11,652	9,129	82 (3)
Non-Hispanic black	9,074	8,144	93 (2)
Mexican American	9,138	8,398	94 (1)
Age			
Under 25 years	16,091	14,087	86 (2)
25–64 years	10,725	9,309	85 (2)
65 years and over	4,495	3,703	83 (3)
Health status			
Excellent	7,834	6,786	86 (2)
Very good	7,765	6,718	86 (2)
Good	10,118	8,806	85 (3)
Fair	4,608	3,991	83 (3)
Poor	975	788	82 (4)
Region			
Northeast	4,052	3,713	87 (2)
Midwest	5,975	5,294	84 (3)
South	13,386	10,350	77 (6)
West	7,898	7,742	97 (1)
County's level of urbanization			
Large metropolitan (1 million population or more)	15,624	15,198	97 (1)
All other areas	15,687	11,901	74 (4)

NOTES: Percentages and standard errors (SE) were calculated using survey weights. NHANES is National Health and Nutrition Examination Survey.

Table 2. Number and percentage (standard error) of NHANES III respondents linked to annual EPA air monitoring data for PM₁₀, by geographic linkage method and respondent characteristics: United States 1988–1994

Characteristics	Total number	Geographic linkage method									
		5 mile		10 mile		15 mile		20 mile		County	
		Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)
Total	31,311	12,339	37 (4)	19,181	59 (4)	21,227	68 (3)	22,474	73 (3)	21,318	68 (5)
Poverty status											
Below poverty threshold	8,758	3,891	42 (4)	5,525	60 (4)	5,943	66 (4)	6,257	71 (4)	6,109	68 (5)
At or above poverty threshold	19,651	7,237	35 (4)	11,877	59 (4)	13,300	68 (3)	14,115	73 (3)	13,164	67 (5)
Race and Hispanic origin											
Non-Hispanic white	11,652	3,467	33 (5)	5,692	53 (4)	6,677	63 (4)	7,175	68 (4)	6,579	63 (6)
Non-Hispanic black	9,074	4,319	50 (5)	6,153	72 (5)	6,585	77 (5)	6,885	81 (4)	6,384	74 (6)
Mexican American	9,138	3,767	42 (4)	6,122	69 (5)	6,629	76 (4)	7,026	83 (4)	7,063	81 (5)
Age											
Under 25 years	16,091	6,400	36 (4)	9,986	59 (4)	11,041	68 (3)	11,751	73 (4)	11,127	68 (5)
25–64 years	10,725	4,324	37 (4)	6,762	60 (4)	7,494	69 (3)	7,908	74 (3)	7,500	68 (5)
65 years and over	4,495	1,615	35 (4)	2,433	54 (4)	2,692	62 (4)	2,815	67 (4)	2,691	64 (5)
Health status											
Excellent	7,834	3,015	37 (4)	4,834	61 (3)	5,433	70 (3)	5,758	75 (3)	5,431	71 (5)
Very good	7,765	3,028	37 (5)	4,764	60 (4)	5,280	69 (3)	5,619	74 (3)	5,223	68 (5)
Good	10,118	4,046	36 (4)	6,224	57 (4)	6,842	66 (4)	7,229	71 (4)	6,884	65 (5)
Fair	4,608	1,888	39 (4)	2,830	56 (4)	3,087	64 (4)	3,255	69 (4)	3,175	66 (5)
Poor	975	358	35 (4)	523	51 (4)	577	61 (4)	605	64 (5)	598	61 (5)
Region											
Northeast	4,052	2,445	52 (9)	3,388	77 (7)	3,572	83 (6)	3,575	83 (6)	3,453	84 (12)
Midwest	5,975	2,157	29 (9)	3,190	44 (9)	3,690	54 (6)	4,034	61 (5)	3,321	47 (11)
South	13,386	4,058	26 (6)	6,110	45 (7)	6,896	54 (7)	7,459	61 (8)	7,005	53 (9)
West	7,898	3,679	48 (8)	6,493	81 (6)	7,069	90 (4)	7,406	95 (2)	7,539	98 (2)
County's level of urbanization											
Large metropolitan (1 million population or more)	15,624	7,422	39 (5)	12,763	75 (5)	14,004	86 (3)	14,998	95 (1)	13,516	81 (6)
All other areas	15,687	4,917	34 (6)	6,418	44 (7)	7,223	50 (7)	7,476	52 (7)	7,802	55 (8)

NOTES: Percentages and standard errors (SE) were calculated using survey weights. NHANES is National Health and Nutrition Examination Survey. EPA is the U.S. Environmental Protection Agency. PM₁₀ is particulate matter less than 10 microns in diameter.

Table 3. Number and percentage (standard error) of NHANES III respondents linked to annual EPA air monitoring data for SO₂, by geographic linkage method and respondent characteristics: United States 1988–1994

Characteristics	Total number	Geographic linkage method									
		5 mile		10 mile		15 mile		20 mile		County	
		Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)
Total	31,311	8,595	24 (3)	13,746	42 (3)	16,116	52 (4)	17,699	58 (4)	16,161	52 (5)
Poverty status											
Below poverty threshold	8,758	2,691	30 (3)	3,934	43 (3)	4,410	51 (4)	4,793	57 (4)	4,503	53 (5)
At or above poverty threshold	19,651	4,977	22 (3)	8,393	41 (4)	10,136	52 (5)	11,198	57 (5)	10,010	52 (6)
Race and Hispanic origin											
Non-Hispanic white	11,652	2,266	20 (3)	4,056	37 (4)	5,236	49 (5)	5,942	54 (5)	5,193	49 (6)
Non-Hispanic black	9,074	3,530	40 (4)	4,858	56 (4)	5,385	62 (5)	5,774	66 (5)	5,071	59 (5)
Mexican American	9,138	2,170	22 (4)	3,882	40 (6)	4,446	47 (7)	4,840	53 (7)	4,789	52 (9)
Age											
Under 25 years	16,091	4,468	24 (3)	7,172	41 (3)	8,371	51 (4)	9,168	57 (5)	8,397	52 (5)
25–64 years	10,725	2,969	24 (3)	4,809	43 (4)	5,673	53 (4)	6,206	59 (5)	5,681	53 (5)
65 years and over	4,495	1,158	26 (3)	1,765	40 (4)	2,072	48 (4)	2,325	55 (4)	2,083	48 (5)
Health status											
Excellent	7,834	2,087	23 (3)	3,434	43 (4)	4,158	54 (4)	4,582	59 (4)	4,124	53 (6)
Very good	7,765	2,066	23 (3)	3,361	42 (4)	4,033	52 (5)	4,463	58 (5)	3,984	52 (6)
Good	10,118	2,858	24 (2)	4,540	42 (3)	5,186	51 (4)	5,676	58 (5)	5,243	52 (5)
Fair	4,608	1,339	28 (3)	2,033	42 (4)	2,303	49 (4)	2,489	54 (4)	2,363	51 (5)
Poor	975	242	26 (3)	374	39 (4)	430	46 (4)	483	54 (4)	441	47 (5)
Region											
Northeast	4,052	2,665	55 (9)	3,313	74 (7)	3,535	82 (6)	3,557	82 (6)	3,490	83 (13)
Midwest	5,975	2,199	22 (4)	3,144	40 (7)	3,707	52 (11)	4,217	61 (11)	3,311	46 (11)
South	13,386	1,730	12 (4)	3,221	25 (5)	4,221	36 (6)	4,821	42 (7)	4,418	37 (8)
West	7,898	2,001	18 (4)	4,068	41 (9)	4,653	48 (10)	5,104	56 (11)	4,942	55 (11)
County's level of urbanization											
Large metropolitan (1 million population or more)	15,624	6,237	33 (5)	10,472	61 (5)	12,177	76 (4)	12,979	82 (4)	11,747	72 (7)
All other areas	15,687	2,358	16 (4)	3,274	24 (5)	3,939	29 (6)	4,720	34 (6)	4,414	33 (8)

NOTES: Percentages and standard errors (SE) were calculated using survey weights. NHANES is National Health and Nutrition Examination Survey. EPA is the U.S. Environmental Protection Agency. SO₂ is sulfur dioxide.

Table 4. Number and percentage (standard error) of NHANES III respondents linked to annual EPA air monitoring data for NO₂, by geographic linkage method and respondent characteristics: United States 1988–1994

Characteristics	Total number	Geographic linkage method									
		5 mile		10 mile		15 mile		20 mile		County	
		Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)
Total	31,311	8,512	22 (3)	13,812	39 (4)	15,767	47 (4)	16,833	52 (5)	14,927	43 (4)
Poverty status											
Below poverty threshold	8,758	2,734	27 (3)	4,055	42 (3)	4,425	47 (4)	4,676	52 (4)	4,439	47 (4)
At or above poverty threshold	19,651	4,827	20 (3)	8,302	38 (4)	9,745	47 (4)	10,474	51 (5)	8,956	42 (5)
Race and Hispanic origin											
Non-Hispanic white	11,652	1,802	17 (2)	3,387	32 (4)	4,274	41 (5)	4,859	46 (5)	3,741	36 (4)
Non-Hispanic black	9,074	2,886	33 (4)	4,729	56 (4)	5,256	62 (4)	5,406	64 (4)	4,650	54 (5)
Mexican American	9,138	3,259	38 (4)	4,725	56 (5)	5,138	61 (5)	5,398	64 (6)	5,536	66 (6)
Age											
Under 25 years	16,091	4,600	23 (3)	7,343	39 (4)	8,368	48 (4)	8,881	53 (5)	7,906	43 (4)
25–64 years	10,725	2,912	21 (3)	4,832	39 (4)	5,536	48 (4)	5,923	52 (5)	5,251	43 (4)
65 years and over	4,495	1,000	20 (3)	1,637	36 (3)	1,863	42 (4)	2,029	47 (4)	1,770	40 (5)
Health status											
Excellent	7,834	1,958	21 (3)	3,362	39 (4)	3,991	49 (5)	4,297	54 (5)	3,708	44 (5)
Very good	7,765	1,990	21 (3)	3,305	38 (4)	3,839	47 (5)	4,138	51 (5)	3,525	41 (5)
Good	10,118	2,878	21 (2)	4,601	39 (3)	5,134	47 (4)	5,442	52 (5)	4,925	42 (4)
Fair	4,608	1,448	28 (3)	2,168	42 (3)	2,378	48 (4)	2,501	52 (4)	2,344	46 (4)
Poor	975	235	22 (3)	373	37 (3)	419	41 (4)	449	46 (4)	420	41 (4)
Region											
Northeast	4,052	1,583	31 (6)	2,559	52 (6)	2,881	60 (6)	3,064	66 (5)	2,012	45 (8)
Midwest	5,975	1,581	15 (4)	2,339	27 (5)	2,670	36 (9)	2,797	39 (10)	2,335	27 (4)
South	13,386	1,821	13 (4)	3,634	30 (5)	4,536	40 (6)	5,118	47 (7)	4,576	38 (7)
West	7,898	3,527	35 (7)	5,280	55 (12)	5,680	59 (13)	5,854	62 (13)	6,004	65 (14)
County's level of urbanization											
Large metropolitan (1 million population or more)	15,624	6,338	32 (5)	10,581	59 (5)	12,066	73 (5)	12,727	80 (5)	10,847	61 (8)
All other areas	15,687	2,174	12 (2)	3,231	19 (3)	3,701	23 (4)	4,106	26 (5)	4,080	25 (5)

NOTES: Percentages and standard errors (SE) were calculated using survey weights. NHANES is National Health and Nutrition Examination Survey. EPA is the U.S. Environmental Protection Agency. NO₂ is nitrogen dioxide.

Table 5. Number and percentage (standard error) of NHANES III respondents linked to annual EPA air monitoring data for CO, by geographic linkage method and respondent characteristics: United States 1988–1994

Characteristics	Total number	Geographic linkage method									
		5 mile		10 mile		15 mile		20 mile		County	
		Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)	Number	Percent (SE)
Total	31,311	10,810	27 (3)	16,508	48 (3)	18,472	56 (4)	19,317	59 (4)	17,686	52 (4)
Poverty status											
Below poverty threshold	8,758	3,495	34 (4)	4,753	50 (3)	5,175	56 (3)	5,361	58 (4)	5,086	54 (5)
At or above poverty threshold	19,651	6,120	25 (2)	10,111	47 (3)	11,478	56 (4)	12,078	59 (4)	10,845	51 (5)
Race and Hispanic origin											
Non-Hispanic white	11,652	2,398	21 (2)	4,533	41 (3)	5,387	50 (4)	5,812	53 (5)	5,018	46 (4)
Non-Hispanic black	9,074	3,685	42 (4)	5,247	62 (5)	5,827	69 (4)	5,997	71 (4)	5,111	60 (6)
Mexican American	9,138	4,033	43 (4)	5,622	63 (4)	6,033	68 (4)	6,253	72 (5)	6,398	73 (5)
Age											
Under 25 years	16,091	5,737	27 (3)	8,609	47 (3)	9,679	56 (4)	10,131	60 (4)	9,309	52 (4)
25–64 years	10,725	3,750	26 (3)	5,829	48 (3)	6,503	57 (4)	6,778	60 (4)	6,195	52 (5)
65 years and over	4,495	1,323	27 (3)	2,070	46 (3)	2,290	52 (4)	2,408	56 (4)	2,182	51 (4)
Health status											
Excellent	7,834	2,479	26 (3)	4,115	49 (4)	4,718	58 (4)	4,961	62 (4)	4,498	54 (5)
Very good	7,765	2,539	25 (3)	4,010	47 (4)	4,528	56 (4)	4,788	59 (5)	4,323	51 (5)
Good	10,118	3,669	27 (2)	5,415	47 (3)	5,999	55 (4)	6,236	58 (4)	5,727	50 (4)
Fair	4,608	1,807	33 (3)	2,515	49 (3)	2,727	56 (4)	2,815	58 (4)	2,657	54 (4)
Poor	975	311	29 (3)	448	43 (3)	492	48 (4)	509	51 (4)	474	46 (4)
Region											
Northeast	4,052	1,796	32 (6)	2,865	60 (4)	3,269	71 (3)	3,364	74 (3)	2,627	59 (10)
Midwest	5,975	1,929	20 (3)	2,843	34 (4)	3,150	43 (9)	3,262	45 (11)	2,991	37 (6)
South	13,386	2,921	18 (4)	4,793	38 (5)	5,682	46 (5)	6,083	50 (6)	5,296	41 (8)
West	7,898	4,164	42 (8)	6,007	66 (12)	6,371	73 (13)	6,608	76 (13)	6,772	79 (13)
County's level of urbanization											
Large metropolitan (1 million population or more)	15,624	7,858	39 (5)	12,071	71 (4)	13,610	85 (3)	14,245	90 (3)	12,931	77 (8)
All other areas	15,687	2,952	15 (3)	4,437	25 (5)	4,862	29 (5)	5,072	30 (5)	4,755	28 (5)

NOTES: Percentages and standard errors (SE) were calculated using survey weights. NHANES is National Health and Nutrition Examination Survey. EPA is the U.S. Environmental Protection Agency. CO is carbon monoxide.

Table 6. Median (25th and 75th percentiles) of PM₁₀ exposure (µg/m³) for NHANES III respondents linked to annual EPA air monitoring data, by geographic linkage method and respondent characteristics: United States 1988–1994

Characteristics	Geographic linkage method				
	5 mile	10 mile	15 mile	20 mile	County
Total	27.8 (23.8, 34.5)	29.0 (24.0,35.1)	29.4 (24.0,35.5)	29.0 (24.1,35.5)	27.3 (23.0,33.6)
Poverty status					
Below poverty threshold	28.3 (24.2,37.8)	29.0 (24.8,37.2)	29.3 (24.8,36.4)	28.6 (24.9,35.9)	28.2 (24.0,35.5)
At or above poverty threshold	27.7 (23.4,34.4)	28.9 (24.0,34.8)	29.2 (24.0,35.0)	29.0 (24.0,35.1)	27.3 (23.0,33.6)
Race and Hispanic origin					
Non-Hispanic white	27.0 (23.1,34.0)	27.8 (23.4,33.9)	28.0 (23.9,34.2)	28.4 (24.0,34.4)	26.7 (23.0,32.9)
Non-Hispanic black	28.2 (24.3,34.2)	29.3 (26.3,34.7)	29.7 (26.4,34.8)	29.6 (26.3,34.5)	27.7 (24.4,33.7)
Mexican American	32.8 (26.1,45.5)	34.1 (26.2,45.0)	33.6 (25.9,45.4)	32.4 (25.0,44.7)	32.9 (25.7,45.5)
Age					
Under 25 years	28.0 (23.8,34.8)	29.2 (24.0,35.4)	29.5 (24.2,35.8)	29.4 (24.2,35.8)	27.3 (23.0,33.7)
25–64 years	28.0 (23.9,34.5)	29.0 (24.0,35.0)	29.4 (24.0,35.5)	29.3 (24.2,35.6)	27.3 (23.0,33.6)
65 years and over	27.5 (23.8,34.2)	27.8 (24.0,34.2)	27.7 (24.0,33.8)	27.6 (24.0,33.4)	26.7 (23.0,33.6)
Health status					
Excellent	28.0 (23.7,34.5)	28.8 (24.0,34.8)	28.9 (24.0,34.8)	28.6 (24.0,34.5)	27.3 (23.0,33.3)
Very good	27.5 (23.1,34.4)	28.4 (23.9,34.8)	28.9 (24.0,35.6)	28.8 (24.0,35.7)	26.9 (23.0,33.6)
Good	28.0 (24.0,34.5)	29.0 (24.0,34.9)	29.5 (24.3,35.5)	29.4 (24.5,35.7)	27.5 (23.9,34.1)
Fair	28.9 (24.6,37.7)	29.6 (24.8,37.4)	29.6 (24.7,37.2)	29.3 (24.6,36.4)	27.7 (23.9,35.5)
Poor	29.5 (24.0,38.3)	29.6 (24.0,37.4)	30.4 (24.7,37.5)	29.6 (25.0,37.4)	29.2 (24.0,37.0)
Region					
Northeast	26.4 (24.0,32.9)	26.3 (23.1,31.0)	26.4 (23.9,31.7)	26.5 (24.0,31.8)	24.0 (23.0,33.6)
Midwest	26.3 (22.9,34.1)	29.4 (23.9,35.5)	29.6 (24.6,36.9)	30.4 (24.7,38.8)	29.5 (22.4,33.7)
South	26.5 (23.0,28.7)	26.7 (23.0,30.2)	26.7 (23.0,30.9)	26.8 (23.0,31.6)	26.8 (22.5,29.2)
West	37.0 (28.0,45.3)	36.1 (29.0,45.0)	34.7 (28.4,44.9)	33.9 (28.0,44.7)	32.9 (24.7,45.5)
County's level of urbanization					
Large metropolitan (1 million population or more)	28.7 (25.6,35.8)	29.9 (25.9,36.4)	30.3 (26.1,36.4)	30.2 (26.0,36.4)	29.3 (24.4,37.0)
All other areas	26.4 (22.8,34.1)	26.7 (22.9,32.4)	26.5 (22.9,32.3)	26.6 (22.9,32.2)	24.7 (23.0,31.9)

NOTES: Percentiles calculated using survey weights. PM₁₀ is particulate matter consisting of particles smaller than 10 micrometers. NHANES is National Health and Nutrition Examination Survey. EPA is the U.S. Environmental Protection Agency.

Table 7. Median (25th and 75th percentiles) of SO₂ exposure (ppb) for NHANES III respondents linked to annual EPA air monitoring data, by geographic linkage method and respondent characteristics: United States 1988–1994

Characteristics	Geographic linkage method				
	5 mile	10 mile	15 mile	20 mile	County
Total	8.1 (5.4,11.2)	7.6 (4.5,10.1)	7.5 (4.5,10.1)	7.4 (4.5,10.2)	7.3 (3.3, 9.9)
Poverty status					
Below poverty threshold	8.1 (5.1,11.6)	6.9 (3.7,10.8)	6.7 (2.9,10.4)	6.5 (2.9,10.4)	6.1 (2.9, 9.9)
At or above poverty threshold	8.1 (5.4,10.9)	7.6 (4.7,10.1)	7.6 (4.6,10.0)	7.7 (4.5,10.1)	7.3 (3.3, 9.9)
Race and Hispanic origin					
Non-Hispanic white	8.1 (5.4,10.9)	7.7 (5.4,10.1)	7.7 (5.2,10.1)	7.7 (5.1,10.4)	7.7 (4.5,10.1)
Non-Hispanic black	8.2 (5.6,11.5)	7.7 (5.5,10.8)	7.7 (5.1,10.4)	7.7 (5.0,10.3)	7.8 (3.6,10.5)
Mexican American	2.9 (2.3, 5.6)	2.9 (1.8, 4.8)	2.9 (2.0, 4.7)	2.9 (2.0, 4.8)	2.9 (2.5, 4.5)
Age					
Under 25 years	8.1 (5.3,10.7)	7.5 (4.5,10.1)	7.7 (4.5,10.1)	7.5 (4.4,10.1)	7.3 (3.0, 9.9)
25–64 years	8.1 (5.4,11.4)	7.6 (4.5,10.1)	7.4 (4.5,10.1)	7.4 (4.5,10.2)	7.3 (3.3, 9.9)
65 years and over	8.1 (5.4,11.4)	7.7 (5.2,10.4)	7.7 (5.2,10.3)	7.5 (4.5,10.5)	7.3 (3.4, 9.9)
Health status					
Excellent	8.3 (5.9,11.2)	7.7 (5.1,10.1)	7.7 (5.2,10.1)	7.7 (5.1,10.2)	7.7 (3.4, 9.9)
Very good	8.1 (5.4,11.0)	7.7 (5.0,10.1)	7.5 (4.7,10.1)	7.7 (4.5,10.3)	7.7 (3.4,10.1)
Good	8.0 (5.2,11.4)	7.1 (4.5,10.2)	6.9 (4.2,10.1)	6.9 (3.9,10.2)	7.3 (3.0, 9.9)
Fair	7.2 (4.5,10.9)	6.7 (3.0,10.2)	6.4 (2.9,10.1)	6.1 (2.9, 9.9)	6.1 (2.9, 9.7)
Poor	8.1 (5.2,11.5)	7.5 (2.9,10.6)	6.9 (3.9,10.3)	6.8 (2.9,10.2)	7.3 (3.3,10.1)
Region					
Northeast	10.3 (8.1,12.5)	9.9 (7.9,12.5)	9.9 (7.8,12.4)	9.9 (8.0,12.3)	9.0 (7.3,11.6)
Midwest	8.9 (5.6,11.0)	9.0 (6.2,10.8)	9.7 (6.4,11.0)	9.9 (6.3,11.0)	10.1 (6.9,10.5)
South	7.1 (5.1, 7.7)	5.9 (2.8, 7.7)	6.0 (2.8, 7.7)	6.0 (2.6, 7.7)	4.1 (2.4, 7.7)
West	2.6 (1.9, 4.0)	2.6 (2.0, 4.9)	2.8 (2.0, 5.1)	2.7 (1.9, 5.1)	3.0 (2.5, 5.1)
County's level of urbanization					
Large metropolitan (1 million population or more)	9.1 (6.3,12.0)	8.2 (4.6,10.8)	8.1 (4.2,10.6)	7.9 (3.9,10.5)	8.3 (3.3,10.1)
All other areas	5.9 (5.4, 8.1)	6.0 (4.5, 7.7)	6.0 (4.5, 7.7)	6.1 (4.5, 8.0)	5.9 (2.9, 7.7)

NOTES: Percentiles calculated using survey weights. SO₂ is sulfur dioxide. NHANES is National Health and Nutrition Examination Survey. EPA is the U.S. Environmental Protection Agency.

Table 8. Median (25th and 75th percentiles) of NO₂ exposure (ppb) for NHANES III respondents linked to annual EPA air monitoring data, by geographic linkage method and respondent characteristics: United States 1988–1994

Characteristics	Geographic linkage method				
	5 mile	10 mile	15 mile	20 mile	County
Total	24.1 (19.4,28.2)	23.8 (18.4,27.2)	24.0 (17.6,26.9)	23.9 (17.1,26.3)	21.5 (15.9,26.2)
Poverty status					
Below poverty threshold	23.9 (19.0,28.1)	24.0 (16.8,28.3)	24.0 (16.8,27.4)	23.3 (16.4,27.0)	21.4 (15.6,25.1)
At or above poverty threshold	24.0 (19.4,28.1)	23.7 (18.1,27.1)	24.0 (17.2,26.6)	23.9 (17.2,26.1)	21.5 (16.4,26.2)
Race and Hispanic origin					
Non-Hispanic white	23.9 (19.4,27.6)	23.7 (18.9,26.7)	24.0 (18.5,26.1)	23.9 (17.1,25.9)	21.4 (16.4,26.0)
Non-Hispanic black	23.7 (17.1,27.5)	23.7 (16.8,27.0)	23.7 (16.8,26.9)	23.5 (16.7,26.8)	21.5 (16.4,26.0)
Mexican American	24.3 (15.9,39.0)	24.0 (15.9,39.0)	23.2 (15.9,37.7)	22.9 (15.9,36.5)	21.4 (15.9,31.0)
Age					
Under 25 years	23.9 (19.0,27.8)	23.7 (16.8,27.1)	24.0 (16.8,26.6)	23.7 (16.8,26.1)	21.4 (15.9,26.1)
25–64 years	24.1 (19.6,28.6)	23.9 (19.1,27.3)	24.0 (18.7,26.9)	23.9 (17.8,26.2)	21.6 (16.4,26.2)
65 years and over	23.9 (19.5,29.1)	24.0 (19.4,28.6)	24.0 (19.6,27.5)	23.9 (16.8,27.0)	21.5 (15.9,26.2)
Health status					
Excellent	23.7 (19.4,27.5)	23.7 (18.5,26.9)	24.0 (18.7,26.2)	23.9 (17.9,26.0)	21.6 (16.4,26.1)
Very good	24.1 (19.4,29.3)	23.7 (18.5,27.2)	24.0 (17.2,26.7)	23.9 (17.2,26.2)	21.6 (16.4,26.4)
Good	24.1 (19.6,28.1)	24.0 (18.5,27.5)	24.0 (17.6,27.0)	23.8 (17.1,26.5)	21.5 (15.9,26.1)
Fair	24.0 (17.5,28.2)	24.0 (16.8,29.4)	24.0 (16.8,28.3)	23.6 (15.9,27.2)	21.4 (15.9,26.4)
Poor	24.1 (19.8,28.8)	24.1 (20.3,29.4)	24.1 (19.3,28.1)	24.0 (18.2,27.8)	21.5 (16.4,26.4)
Region					
Northeast	24.1 (21.0,28.6)	24.8 (21.8,30.1)	24.8 (23.3,29.6)	24.5 (22.8,29.6)	24.1 (21.0,26.4)
Midwest	23.5 (19.8,26.6)	24.2 (21.1,27.1)	25.0 (23.8,26.6)	25.4 (24.0,26.1)	25.1 (21.5,26.6)
South	17.2 (16.0,23.7)	16.4 (14.1,22.4)	16.8 (13.5,23.7)	16.7 (13.5,23.5)	15.9 (12.6,21.2)
West	25.1 (18.8,41.0)	25.1 (19.6,39.3)	25.1 (19.1,39.1)	24.2 (18.0,38.8)	25.1 (15.9,35.8)
County's level of urbanization					
Large metropolitan (1 million population or more)	25.4 (20.3,32.8)	25.2 (20.3,29.8)	25.1 (20.7,28.7)	24.7 (20.5,27.8)	24.0 (18.2,28.7)
All other areas	20.7 (16.8,24.1)	20.3 (13.5,23.7)	20.3 (13.5,23.7)	19.6 (13.5,23.7)	19.9 (13.5,23.7)

NOTES: Percentiles calculated using survey weights. NO₂ is nitrogen dioxide. NHANES is National Health and Nutrition Examination Survey. EPA is the U.S. Environmental Protection Agency.

Table 9. Median (25th and 75th percentiles) of CO exposure (ppm) for NHANES III respondents linked to annual EPA air monitoring data, by geographic linkage method and respondent characteristics: United States 1988–1994

Characteristics	Geographic linkage method				
	5 mile	10 mile	15 mile	20 mile	County
Total	0.99 (0.82,1.34)	0.99 (0.79,1.32)	0.99 (0.82,1.30)	0.99 (0.82,1.29)	0.95 (0.81,1.27)
Poverty status					
Below poverty threshold	0.97 (0.82,1.32)	0.97 (0.80,1.31)	0.99 (0.81,1.29)	0.98 (0.81,1.29)	0.91 (0.84,1.23)
At or above poverty threshold	0.99 (0.81,1.34)	0.99 (0.79,1.32)	0.99 (0.81,1.30)	0.99 (0.82,1.29)	0.95 (0.81,1.27)
Race and Hispanic origin					
Non-Hispanic white	0.96 (0.79,1.34)	0.98 (0.79,1.28)	0.99 (0.82,1.26)	0.99 (0.82,1.26)	0.91 (0.80,1.27)
Non-Hispanic black	0.95 (0.79,1.24)	0.94 (0.76,1.24)	0.95 (0.78,1.24)	0.94 (0.79,1.23)	0.90 (0.80,1.23)
Mexican American	1.02 (0.79,1.63)	0.99 (0.75,1.56)	0.99 (0.79,1.55)	0.97 (0.77,1.54)	0.91 (0.84,1.41)
Age					
Under 25 years	0.96 (0.79,1.34)	0.97 (0.80,1.31)	0.99 (0.81,1.29)	0.99 (0.81,1.28)	0.95 (0.81,1.27)
25–64 years	1.04 (0.82,1.36)	0.99 (0.79,1.33)	1.00 (0.81,1.31)	1.00 (0.82,1.30)	1.02 (0.81,1.27)
65 years and over	0.95 (0.84,1.31)	0.95 (0.82,1.33)	0.99 (0.84,1.31)	0.99 (0.82,1.28)	0.90 (0.81,1.27)
Health status					
Excellent	0.94 (0.76,1.31)	0.95 (0.79,1.30)	0.99 (0.82,1.30)	0.99 (0.82,1.26)	0.95 (0.81,1.27)
Very good	1.04 (0.84,1.52)	0.99 (0.80,1.36)	1.01 (0.82,1.32)	1.01 (0.82,1.30)	1.02 (0.81,1.29)
Good	1.05 (0.82,1.34)	0.99 (0.79,1.32)	1.01 (0.81,1.30)	1.01 (0.82,1.29)	0.95 (0.81,1.27)
Fair	0.96 (0.84,1.30)	0.96 (0.79,1.32)	0.96 (0.81,1.30)	0.96 (0.80,1.27)	0.90 (0.81,1.24)
Poor	1.04 (0.78,1.46)	0.96 (0.77,1.44)	1.04 (0.79,1.31)	1.00 (0.80,1.31)	0.95 (0.84,1.24)
Region					
Northeast	1.09 (0.85,1.42)	1.12 (0.85,1.43)	1.07 (0.85,1.44)	1.12 (0.86,1.45)	1.02 (0.85,1.27)
Midwest	0.85 (0.71,0.95)	0.86 (0.70,1.09)	0.89 (0.72,1.15)	0.89 (0.72,1.16)	0.89 (0.76,1.15)
South	0.87 (0.72,0.99)	0.88 (0.69,0.99)	0.88 (0.72,0.99)	0.88 (0.73,0.99)	0.88 (0.80,0.95)
West	1.30 (0.95,1.79)	1.31 (0.96,1.75)	1.31 (0.98,1.74)	1.31 (0.97,1.72)	1.24 (0.90,1.67)
County's level of urbanization					
Large metropolitan (1 million population or more)	1.18 (0.87,1.61)	1.12 (0.86,1.51)	1.13 (0.87,1.49)	1.15 (0.88,1.46)	1.15 (0.86,1.41)
All other areas	0.88 (0.74,0.97)	0.79 (0.70,0.95)	0.82 (0.72,0.96)	0.80 (0.72,0.96)	0.84 (0.71,1.02)

NOTES: Percentiles calculated using survey weights. CO is carbon monoxide. EPA is the U.S. Environmental Protection Agency. NHANES is National Health and Nutrition Examination Survey.

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