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Linkage of the 1999–2008 National Health and Nutrition Examination Surveys to Traffic Indicators From the National Highway Planning Network

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Abstract

Objectives—Growing evidence has shown the harmful effects of traffic-related pollution on human health, including adverse respiratory, cardiovascular, and pregnancy outcomes. This report describes the linkage of data from the 1999–2008 National Health and Nutrition Examination Surveys (NHANES) and traffic indicators from the 2005 National Highway Planning Network.

Methods—The residential addresses of NHANES participants were used to assign the distance to the nearest road, the number of roads within concentric buffers of specific radii, and the average annual daily traffic. Summaries of these traffic indicators by participant characteristics, including urbanization of their county of residence, race and ethnicity, poverty status, and health status, were tabulated.

Results—Using the traffic indicators, these data show differences in traffic exposure by several participant characteristics including poverty status. Further, reporting of fair or poor health was more common among NHANES respondents nearer to, compared with farther from, roads; this relationship was observed overall and for subgroups defined by urban county of residence, poverty status, and self-reported cigarette smoking.

Conclusions—These data may be a resource for understanding relationships between traffic exposure and adverse health, and for identifying subgroups that may be at increased risk. The NHANES-traffic data are restricted use and available to data users in the Research Data Center at the Centers for Disease Control and Prevention's National Center for Health Statistics.

Keywords: air pollution

Introduction

More than 250 million motor vehicles including passenger cars, motorcycles, buses, and trucks were registered in the United States in 2008 (1). Exhaust from these vehicles contains numerous air pollutants, including volatile organic compounds, polycyclic aromatic hydrocarbons, particulate matter, and carbon monoxide (2). Numerous studies have shown that the concentration of traffic-related air pollutants decreases sharply as the distance from the curbside increases, reaching background level within 300–500 meters (3–6). Therefore, persons living in close proximity to the roadways—characteristics of inner-city urban environments—are potentially exposed to high levels of traffic-related air pollutants.

Exposure assessment methods used to quantify traffic exposure can be broadly classified into four groups: (a) personal or area monitoring of specific pollutants; (b) modeled concentration (including land-use regression); (c) distance from primary residence to the roadways, referred to in this report as distance-based traffic exposure; and (d) traffic density [such as vehicle miles traveled, average annual daily traffic (AADT), and number of roadways] within a specified radius of primary residence, referred to in this report as density-based traffic exposure. Using these approaches, increasing numbers of epidemiological studies in the United States and elsewhere have examined the

effects of traffic exposure with a host of adverse health outcomes, including pregnancy (7–9), respiratory (10–15), and cardiovascular outcomes (16–21), and cancer (22–24) and mortality (21,25,26), although not all studies find associations. Fewer studies of the potential impact of traffic on other diseases, such as diabetes (27) and arthritis (28), have been reported. A recent meta-analysis showed an increased risk of wheezing and hospital visits for treatment of asthma-related symptoms associated with both distance- and density-based measures of traffic exposure (10).

In 2009, a panel convened by the Health Effects Institute (HEI) systematically reviewed the scientific literature from the United States and other countries on many aspects of traffic-related air pollution, including its measurement and relationship with health outcomes (2). The HEI panel concluded that the evidence for causal effects of traffic-related air pollution on health outcomes was suggestive but not sufficient for several outcomes, including all-cause and cardiovascular mortality, cardiovascular morbidity, adult respiratory symptoms and pulmonary function, childhood asthma incidence and prevalence, and childhood respiratory-related health care utilization. The panel determined that existing evidence supports a causal association between traffic and asthma exacerbation among children. This broad assessment by HEI was based on several surrogates of exposure, including direct and modeled estimates of air pollutants (for example, nitrogen dioxide or fine particulate matter), distance-based metrics between roads and residences, and traffic density indicators based both on the distance to roads and traffic volume on the road.

This report describes the geographic linkage of data from the 1999–2008 National Health and Nutrition Examination Surveys (NHANES), a large nationally representative health survey, to traffic data from the National Highway Planning Network (NHPN), to provide information for examining the relationship between proximity to traffic and health indicators in the United States. This report focuses on traffic-derived measures of exposure rather than measured levels of air pollution. While directly monitoring air quality can capture exposure to many components of traffic emissions, direct measures of traffic exposure based on proximity and volume remain important because of the complex mixture of pollutants from vehicular emissions. Traffic indicators are tabulated by selected factors known to be related to health in the United States. The NHANES-traffic data are restricted use and available to data users in the Research Data Center (RDC) at the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS) (29).

Linkage of NHANES to Traffic Data

Data files used for linkage

NHANES

NHANES is a large program of studies designed to assess the health and nutritional status of adults and children in the United States (30). The survey is unique in that it combines interviews and physical examinations. The survey examines a nationally representative sample of about 5,000 participants each year. The sample consists of 15 randomly selected locations—typically counties (referred to as primary sampling units or PSUs)—and the participants are randomly selected from within these PSUs. The NHANES interview includes demographic, socioeconomic, dietary, and health-related questions. The examination component, conducted in the mobile examination center (MEC), consists of medical, dental, and physiological measurements as well as laboratory tests administered by highly trained medical personnel. Respondent characteristics considered in this report include urbanization level of the county of residence, race and ethnicity, age, education (for adults aged 25 and over), family poverty status, self-reported smoking status (for adults aged 18 and over), and self-reported health status. Although not exhaustive, these factors were chosen because of their possible relationship with traffic exposure or their potential effect on the relationship between traffic exposure and health outcomes.

Data from the 1999–2008 NHANES were used, which include approximately 50,000 sampled persons from 75 locations. All interviewed and MEC-examined NHANES respondents were eligible to be included in the linkage. Restricted-use files, available to users in the NCHS RDC (29) have been geocoded to participants' residential addresses and to census administrative units such as residential block group (31).

Traffic data

The primary traffic data used for this linkage are from NHPN (32), maintained by the Federal Highway Administration as a component of the Highway Performance Monitoring System (HPMS) (33). These traffic data (NHPN version 2005.08) are the most comprehensive GIS-based network database available, containing information about the location and features of the major roadways in the United States. NHPN contains information on more than 450,000 miles of roadways in the 48 contiguous states and the District of Columbia, Alaska, Hawaii, and Puerto Rico, consisting of rural principal arterials, urban principal arterials, and all National Highway System routes (see "Technical Notes" for definitions). Smaller roadways are not in this system and could not be used in the assessment of traffic exposure.

Linkage methods

Geocoded NHANES residential addresses were linked with the traffic information using ArcInfo (34). Concentric traffic buffers of radius 100, 300, and 500 meters (m) were drawn around each respondent's residence to create traffic exposure estimates based on the roadways located within the buffers and identify the nearest road to each residence.

Exposure estimates

Traffic exposure variables were assigned to each NHANES participant using NHPN traffic data and geocoded residential addresses. These variables included (a) distance from respondent's residence to the nearest road; (b) number of roads within concentric traffic buffers of specific radii from respondent's residence; (c) aggregated length of all roads within concentric traffic buffers of specific radii from respondent's residence; and (d) sum of AADT values for all roads within concentric traffic buffers of specific radii from respondent's residence. AADT values are the average number of motor vehicles on the road each day for each segment of the road; for roads with multiple segments, each with a separate AADT value within the traffic buffer, the highest AADT was used to represent the road for the traffic buffer.

Additional variables were created for the aggregated length of all roads and the sum of AADT values by weighting the road-specific values by the distance from the respondent's residence to each road within the traffic buffer. These additional variables are available but not described in this report.

The functional classification (FCLASS) system groups roads, streets, and highways into different classes based on the character of service they provide. The underlying principle of this classification is that individual roads and streets do not serve as separate entities, but rather as a network of roads through which traffic moves. FCLASS designations can differ among states; consequently, although FCLASS variables are available, they are not described in this report.

Description of the Linked Data Files

Methods

The number of NHANES respondents geocoded to a residential address was calculated. Of these, the numbers and percentages of respondents who could be linked to any road and any road within three specified traffic buffers (100 m, 300 m, and 500 m) were calculated. In addition, among those linked to one or more roads, the percentages linked to only one road within the same three traffic buffers were calculated.

Medians and interquartile ranges (IQR, 25th and 75th percentiles) were calculated for the following traffic measures: the distance from residence to the nearest road overall and within three specified buffers, the length of all roads within three specified buffers, and the AADT within three specified buffers. All numbers and summary statistics were tabulated overall and for subgroups defined by selected respondent characteristics.

The overall medians and IQRs for each traffic variable were used to identify quartiles and form categorical traffic exposure variables. Associations between selected respondent characteristics and the categorical traffic exposure variables were assessed using chi-square statistics. Relationships among reporting fair or poor health status and quartiles of traffic exposure measures were examined overall and for potentially vulnerable subgroups, including those living in the most urban areas, non-Hispanic black and Mexican-American persons, adults with less than a high school education, persons below the poverty level, and adult current smokers; tests for trend by quartile were used to assess statistical significance. A thorough examination of the relationships among health outcomes including reporting of fair or poor health status and traffic exposure indicators overall and for subgroups was not performed. A lack of comment on any characteristic or subgroup should not be interpreted that a statistical test was performed and the results found to be not statistically significant. No adjustments for multiple comparisons were considered.

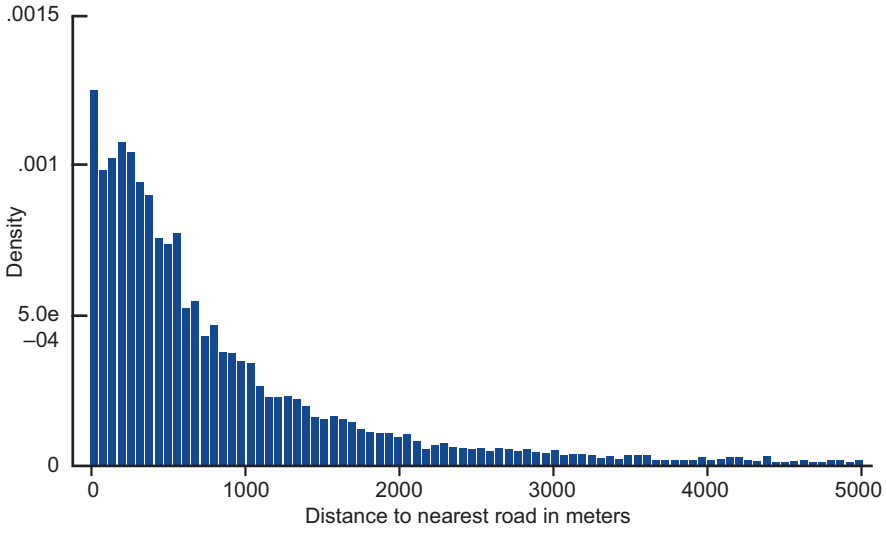
SUDAAN software (35), which incorporates survey design information including survey weights, strata identifiers, and PSU identifiers, was used to account for the complex stratified cluster design. Sample size numbers are unweighted. All percentages and percentiles including medians were weighted using NHANES interview weights. Unstable estimates are not shown; stability was determined by assessment of the relative standard error (RSE = 100 * standard error / estimate) and the design degrees of freedom; estimates for subgroups with RSE less than 30% or with fewer than 12 degrees of freedom are not shown (36).

Results

Table 1 describes the geocoding and the linkage between the NHANES respondents based on residential address and the traffic buffers. Addresses of about 90% of NHANES respondents were geocoded. The percentage geocoded differed significantly by all of the characteristics shown in the table. Of the respondents with address geocoded, 10% resided within 100 m of one or more roads, almost 30% were within 300 m, and more than 40% were within 500 m of one or more roads in NHPN. Living within a specific distance to one or more roads differed by several respondent characteristics; for example, poverty status, urbanization, race/ethnicity, self-reported smoking status among adults, and health status were associated with living within a specific distance to one or more roads for each of the three traffic buffers, 100 m, 300 m, and 500 m.

Table 2 shows the percentage living near only one road within specified traffic buffers. Of those respondents who live within 100 m of the nearest road, most (about 95%) lived within 100 m of only one road. Of those who lived within 500 m from one or more roads, only two-thirds (about 66%) lived within 500 m of only one road. Among those within 500 m from one or more roads, living near only one road was significantly related to urbanization, race/ethnicity, poverty status, education among adults aged 25 and over, self-reported smoking status among adults aged 18 and over, and self-reported health status.

Figure 1 shows the weighted distribution of the distance from residence to the nearest road for NHANES participants within 5,000 m



SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

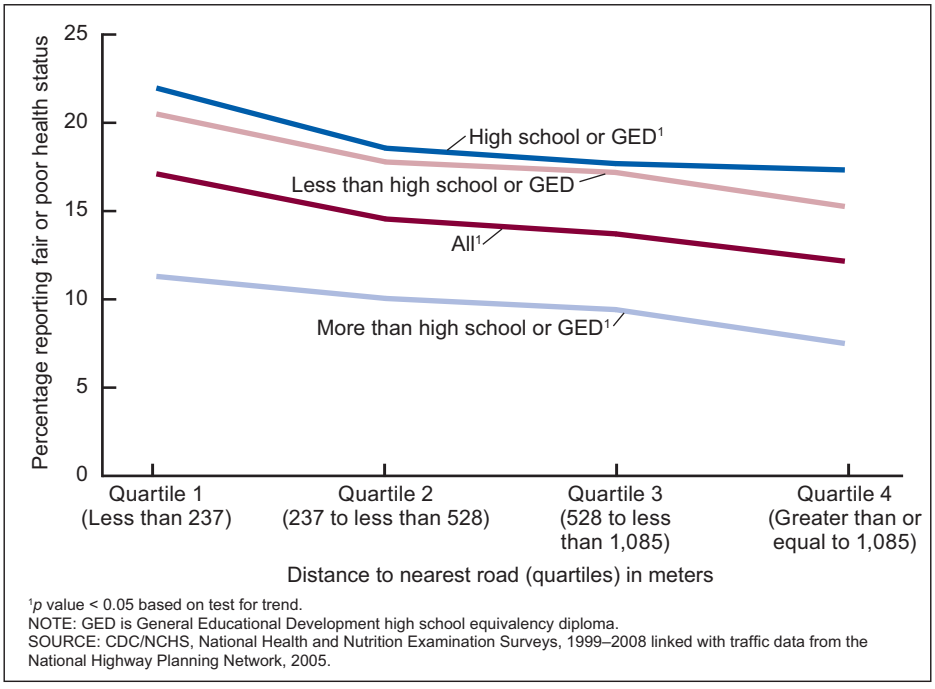
Figure 1. Weighted distribution of distance from residence to nearest road for NHANES participants within 5,000 meters of nearest road

of the nearest road (over 98% of participants). The distribution is skewed to the left with nearly 6% living within 50 m of the nearest road; about one-fourth live at least 1,000 m from the nearest road.

Table 3 compares the percent distribution among quartiles of distance from residence to the nearest road by selected respondent characteristics, with quartiles defined by overall distance distributions (see Table I for overall values of the 25th, 50th, and 75th percentiles used here and by subgroup). For distance not restricted by traffic buffer size, the distribution of the distance from residence to the nearest road varied by urbanization, race and ethnicity, poverty status, education among adults aged 25 and over, self-reported smoking status among adults, and self-reported health status, but not by age category. These relationships differed for respondents within a specified distance to one or more roads. For example, among those within 100 m, the distribution of distance to the nearest road varied by urbanization and race/ethnicity, whereas among those within 500 m, the distribution was associated with poverty status, education level among adults aged 25 and over, smoking status among adults aged 18 and over, and health status, but not with urbanization, age, or race/ethnicity.

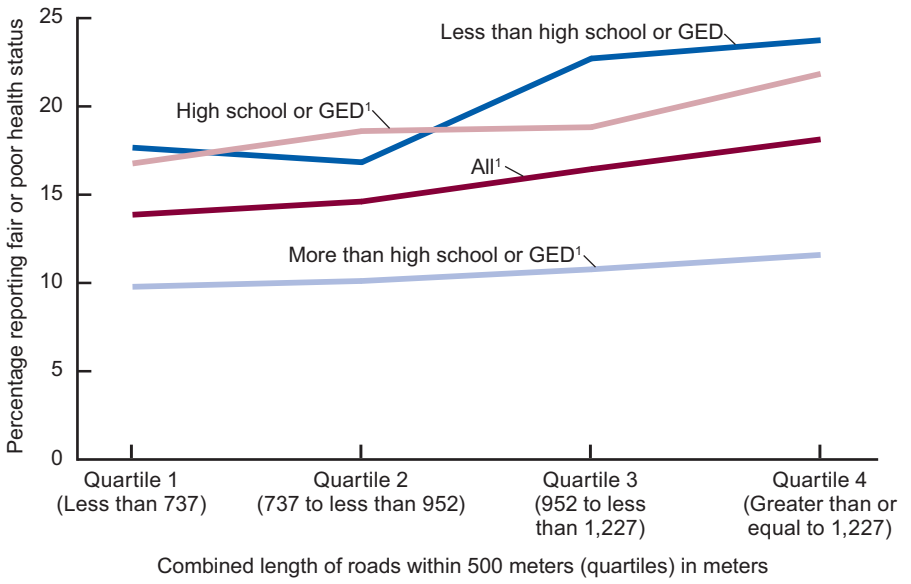
Figure 2 shows the proportion reporting fair or poor health status by quartiles of the distance to the nearest road and education among adults. Overall and among those with a high school education or more, reporting of fair or poor health status was significantly related to the quartile of distance to the nearest road based on tests for trend. Those in the highest quartile of distance, that is, those living farthest from the nearest road, were the least likely to report fair or poor health status. In addition, this relationship was significant for other subgroups, including those living in large central metropolitan counties, non-Hispanic black and non-Hispanic white persons, those with family incomes below the poverty threshold, and among adults who were former and never smokers, but not for current adult smokers or for Mexican-American persons (not shown).

Table 4 shows the percent distribution of the length of roads among quartiles of the overall distribution. See Table II for the overall values of the 25th, 50th, and 75th percentiles used here and by subgroup. The percent distribution of the length of the roads within 500 m differed statistically among respondents characterized by urbanization, race/ethnicity, poverty status, education (adults aged 25 and over), self-reported smoking (adults aged 18 and over), and self-reported health status, but not by age; the length of roads within 100 m was associated with race/ethnicity and urbanization but not by other factors.



[1]*p* value < 0.05 based on test for trend.
NOTE: GED is General Educational Development high school equivalency diploma.
SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

Figure 2. Percentage reporting fair or poor health status, by quartiles of distance to nearest road and education among adults



[1]*p* value < 0.05 based on test for trend.
NOTE: GED is General Educational Development high school equivalency diploma.
SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

Figure 3. Percentage reporting fair or poor health among respondents, by quartiles of length of roads within 500 meters, overall, and by educational attainment among adults

Figure 3 shows the percentage reporting fair or poor health among respondents by quartiles of the length of roads within 500 m, overall, and by educational attainment among adults. The percentage reporting fair or poor health generally increased with the increasing length of roads; this association was significant based on a test for trend overall and among those with a high school or General Educational Development education. The percentage reporting fair or poor health was also significantly related to the quartiles of length of road within 500 m for those below poverty level, Mexican-American persons, and for adults who were former and never smokers (not shown).

Table 5 shows the percent distribution among the overall quartiles of AADT. See Table III for the overall 25th, 50th, and 75th percentiles used here and by subgroup. These estimates are based on a subset of NHANES respondents who were linked to roads containing AADT values. Of the 5,763 NHANES respondents within 100 m of a road, only 1,519 (about one-fourth) had AADT information; however, of the 24,826 within 500 m of a road, nearly one-half had AADT information. AADT within 500 m was significantly associated with urbanization, education (adults aged 25 and over), age category, and race/ethnicity.

Discussion

The potential for exposure to automobile exhaust is most pronounced in urban locations where heavily commuted roadways transect densely populated communities. Human exposure to these mobile source emissions can be substantial due to increasing traffic volume and congestion; vehicle-miles driven; and numbers of heavier, less efficient sport utility vehicles (37). Epidemiological studies have linked exposure to automobile exhaust with elevated risks of cancers, heart disease, asthma exacerbation, preterm birth, low birthweight, and mortality. Despite this growing literature, there is a critical gap in literature regarding how traffic-related exposure and the associated health outcomes may vary across different geographical areas and population groups.

This report describes the linkage process and the availability of the linked data to the wider scientific community. This report does not provide a detailed analysis of traffic exposure and specific health outcomes; however, preliminary examination of these linked data shows possible associations between measures of traffic exposure and reported health status, albeit an imprecise measure. Further, although the strength of associations differed among metrics and distances, those with incomes below poverty lived closer to the nearest road and closer to a larger number of roads. These initial comparisons suggest that analytic studies of specific morbidities, considering other factors available from NHANES, may improve our understanding of the relationships among poverty, health, and traffic exposure.

Numerous analytic challenges exist that should be considered when using these data. Not all roads are included in the NHPN network. Information about smaller roads that are not part of the national network is not available through the linked NHANES-traffic file. This lack of detail results in exposure misclassification for those who live near a small road. It is possible but unknown whether living near smaller rather than larger roads varies by respondent characteristics, and in turn, indirectly or directly, by health measures. Furthermore, not all the roads in NHPN have AADT values from the HPMS. In addition to reduced sample size and statistical power, other impacts of missing AADT information on results using that variable are unknown. As in prior linkages of air monitoring data, the impact and appropriate uses of survey weights and other design information for summary measures and variance estimation are also unknown (38,39). Further understanding missing values for the AADT may provide insight into analyses; for example, the fact that traffic density is less likely to be measured on less traveled roads may be able to be incorporated into analyses.

Importantly, even with multiple years of NHANES, the degrees of freedom can be relatively small for some analyses, leading to unstable estimates. Decreased degrees of freedom may be of particular concern for

analyses restricted to participants living within a specific distance to one or more roads, for analyses restricted to participants living close to a road with AADT information, and for analyses restricted to specific population subgroups.

Additional information not fully described in this report is available from this linkage. The traffic measures reported were calculated based on the respondent's latitude and longitude of residence. Additional measures were calculated using the latitude and longitude of the respondent's block group of residence; these measures were created to allow for comparison among these linkage approaches because some health data sources cannot be geocoded to the exact residence. In addition, as mentioned above, some roadways also have an assigned FCLASS value.

The linkage of existing NHANES respondents with traffic data provides the scientific community with the capability to investigate associations between traffic exposure and health using a large, nationally representative sample of the U.S. population. Individual-level biomarker data as well as health outcome data are available that will enable investigators to explore traffic-related health outcomes, controlling for individual-level confounders. In addition, ambient air quality indicators have been geographically linked to NHANES data, which can be used to further explore these relationships.

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Table 1. Number and percentage of respondents with address of residence geocoded and linked to traffic data within buffers of specific radii, by selected respondent characteristics

		Geocoded		Linked to one or more roads within 100 meters		Linked to one or more roads within 300 meters		Linked to one or more roads within 500 meters	
	Number of respondents	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	51,623	47,202	90	5,763	10	16,452	28	24,826	43
Urbanization									
Large central metropolitan	19,709	19,237	98	2,703	12	7,584	34	11,209	52
Other counties	31,914	27,965	86	3,060	9	8,868	26	13,617	39
Race and ethnicity									
Mexican American	13,692	12,518	90	1,834	13	4,963	34	7,551	53
Non-Hispanic white	20,149	17,719	88	1,863	9	5,299	25	8,138	39
Non-Hispanic black	12,493	11,968	96	1,332	11	4,142	33	6,221	49
Poverty status									
Below poverty level	12,591	11,303	87	1,651	12	4,634	35	6,690	51
100%–199%	12,668	11,391	86	1,585	12	4,336	31	6,274	45
200%–399%	12,200	11,264	91	1,313	10	3,589	27	5,527	40
400% or higher	9,872	9,272	93	723	7	2,450	23	4,090	39
Age in years									
Under 25	28,286	26,065	90	3,176	10	9,265	29	13,911	44
25–64	16,243	14,776	90	1,781	10	4,990	28	7,557	42
Over 65	7,094	6,361	89	806	10	2,197	28	3,358	43
Education (over age 24)									
Less than high school	7,587	6,749	87	937	11	2,632	32	3,828	46
High school or GED[1]	5,588	4,995	88	677	11	1,712	28	2,587	42
More than high school	10,548	9,757	91	1,026	9	2,985	26	4,697	41
Self-reported smoking status (adults)									
Never smoker	13,657	12,532	91	1,535	10	4,288	28	6,459	43
Past smoker	6,830	6,111	88	707	9	1,966	26	3,092	41
Current smoker	5,709	5,102	89	717	12	1,914	31	2,795	45
Self-reported health status									
Excellent	15,936	14,689	91	1,587	9	4,853	27	7,507	42
Very good	13,061	11,945	90	1,381	9	4,015	27	6,069	42
Good	14,655	13,420	89	1,746	10	4,815	29	7,172	44
Fair	6,439	5,832	89	855	12	2,250	32	3,307	46
Poor	1,505	1,296	82	189	11	512	31	760	46

[1]GED is General Educational Development high school equivalency diploma.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

Table 2. Percentage of respondents with only one road within buffers of specific radii among those with one or more roads within buffers of specific radii, by selected respondent characteristics

	Within 100 meters	Within 300 meters	Within 500 meters
		Percent	
Total	95	79	66
Urbanization[1,2,3]			
Large central metropolitan	91	72	58
Other counties	96	82	70
Race and ethnicity[2,3]			
Mexican American	93	74	60
Non-Hispanic white	96	82	69
Non-Hispanic black	93	74	61
Poverty status[2,3]			
Below poverty level	93	74	59
100%–199%	94	76	64
200%–399%	96	81	68
400% or higher	96	83	71
Age in years			
Under 25	95	79	66
25–64	94	78	65
Over 65	95	79	69
Education (over age 24)[1,2,3]			
Less than high school	91	73	60
High school or GED[4]	96	79	66
More than high school	96	81	68
Self-reported smoking status (adults)[2,3]			
Never smoker	94	78	65
Past smoker	95	82	69
Current smoker	95	77	63
Self-reported health status[3]			
Excellent	94	80	68
Very good	96	80	67
Good	93	78	64
Fair	96	77	62
Poor	96	74	64

[1] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and number of roads (1 compared with 2 or more) for "within 100 meters."
[2] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and number of roads (1 compared with 2 or more) for "within 300 meters."
[3] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and number of roads (1 compared with 2 or more) for "within 500 meters."
[4] GED is General Educational Development high school equivalency diploma.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

Table 3. Number of records and percent distribution by quartiles of distance to the nearest road, overall, and within buffers of specific radii, by selected respondent characteristics

	Total sample					Within 100 meters					Within 300 meters					Within 500 meters				
	n	0–25	25–50	50–75	75–100	*n*	0–25	25–50	50–75	75–100	*n*	0–25	25–50	50–75	75–100	n	0–25	25–50	50–75	75–100
Total	47,202	25	25	25	25	5,763	25	25	25	25	16,452	25	25	25	25	24,826	25	25	25	25
Urbanization[1,2]										Percent distribution										
Large central metropolitan	19,237	28	28	27	17	2,703	18	19	29	34	7,584	22	27	26	25	11,209	26	25	25	24
Other counties	27,965	24	24	24	29	3,060	29	28	23	20	8,868	27	24	24	25	13,617	25	25	25	25
Race and ethnicity[1,2]																				
Mexican American	12,518	31	29	24	16	1,834	21	19	32	28	4,963	26	26	25	23	7,551	26	25	24	25
Non-Hispanic white	17,719	23	24	25	28	1,863	27	27	24	22	5,299	26	24	25	26	8,138	25	25	26	25
Non-Hispanic black	11,968	27	26	27	20	1,332	21	27	23	29	4,142	23	26	26	25	6,221	25	26	25	24
Poverty status[1,3,4]																				
Below poverty level	11,303	32	28	21	19	1,651	23	32	21	25	4,634	25	24	25	27	6,690	26	26	26	22
100%–199%	11,391	30	24	24	22	1,585	25	26	27	23	4,336	29	27	23	21	6,274	29	26	23	22
200%–399%	11,264	24	22	27	26	1,313	27	24	23	25	3,589	26	26	24	23	5,527	27	26	23	24
400% or higher	9,272	19	25	26	29	723	25	21	27	27	2,450	21	24	27	27	4,090	20	23	27	30
Age in years																				
Under 25	26,065	26	26	25	24	3,176	25	26	24	26	9,265	24	25	26	26	13,911	24	25	25	25
25–64	14,776	25	25	25	26	1,781	25	24	26	25	4,990	25	25	25	25	7,557	25	25	25	25
Over 65	6,361	25	25	25	25	806	26	27	26	21	2,197	28	25	24	23	3,358	26	24	24	25
Education (over age 24)[1,3,4]																				
Less than high school	21,324	26	26	24	24	2,630	25	24	25	27	7,774	24	25	25	26	11,585	25	26	26	24
High school or GED[5]	6,448	27	24	24	25	869	27	26	23	25	2,271	28	25	25	22	3,398	28	25	22	25
More than high school	11,227	23	25	26	26	1,235	25	26	26	23	3,490	25	25	25	25	5,440	24	24	26	26
Self-reported smoking status (adults)[1,3,4]																				
Never smoker	12,532	24	25	26	25	1,535	24	24	26	27	4,288	24	25	25	26	6,459	25	24	26	25
Past smoker	6,111	23	25	26	26	707	27	25	28	20	1,966	27	24	24	26	3,092	25	23	25	27
Current smoker	5,102	29	24	23	24	717	27	29	21	23	1,914	28	26	25	21	2,795	29	27	23	22
Self-reported health status[1,4]																				
Excellent	14,689	23	25	26	26	1,587	24	25	26	25	4,853	24	24	26	26	7,507	23	25	25	27
Very good	11,945	23	25	25	26	1,381	23	26	24	26	4,015	24	25	25	25	6,069	25	24	26	25
Good	13,420	26	25	25	24	1,746	27	25	24	24	4,815	26	25	24	25	7,172	25	25	25	25
Fair	5,832	30	24	25	21	855	25	23	25	26	2,250	27	26	24	23	3,307	28	27	24	21
Poor	1,296	29	30	21	21	189	26	26	28	20	512	28	22	22	27	760	27	23	26	24

[1] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and quartile of distance measure for "total sample."
[2] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and quartile of distance measure for "within 100 meters."
[3] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and quartile of distance measure for "within 300 meters."
[4] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and quartile of distance measure for "within 500 meters."
[5] GED is General Educational Development high school equivalency diploma.

NOTES: Row totals within subgroups sum to 100%. Quartiles of distance from residence to the nearest road within buffers of specific radii are defined by the median and interquarile ranges in Table I.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

Table 4. Percent distribution by quartiles of length of roads within buffers of specific radii, by selected respondent characteristics

	Radii														
	Within 100 meters					Within 300 meters					Within 500 meters				
	Percentiles					Percentiles					Percentiles				
	n	0–25	25–50	50–75	75–100	*n*	0–25	25–50	50–75	75–100	*n*	0–25	25–50	50–75	75–100
	Percent distribution														
Total	5,763	25	25	25	25	16,450	25	25	25	25	24,826	25	25	25	25
Urbanization[1,2]															
Large central metropolitan	2,703	31	31	17	21	7,584	24	24	24	27	11,209	24	24	20	31
Other counties	3,060	22	22	29	27	8,866	26	25	25	24	13,617	25	26	28	22
Race and ethnicity[1,2]															
Mexican American	1,834	28	31	17	24	4,962	22	24	26	27	7,551	24	24	22	30
Non-Hispanic white	1,863	23	23	28	26	5,298	26	25	26	23	8,138	25	25	27	22
Non-Hispanic black	1,332	28	25	23	24	4,142	25	25	22	28	6,221	24	26	21	29
Poverty status[2,3]															
Below poverty level	1,651	24	22	28	26	4,634	25	23	23	29	6,690	21	24	23	31
100%–199%	1,585	23	27	25	24	4,334	22	23	28	28	6,274	23	22	27	28
200%–399%	1,313	25	23	27	25	3,589	23	25	27	24	5,527	24	25	28	23
400% or higher	723	28	26	22	24	2,450	28	29	23	20	4,090	30	27	23	20
Age in years															
Under 25	3,176	27	23	25	25	9,264	26	25	24	24	13,911	25	25	25	25
25–64	1,781	25	26	25	24	4,990	25	25	25	26	7,557	25	25	25	26
Over 65	806	22	27	24	27	2,196	21	25	30	25	3,358	25	25	28	22
Education (over age 24)[2,3]															
Less than high school	2,630	26	25	23	26	7,774	26	24	23	27	11,585	24	25	24	27
High school or GED[4]	869	25	23	26	26	2,271	22	24	29	25	3,398	25	23	28	24
More than high school	1,235	24	26	27	23	3,489	25	26	25	24	5,440	26	25	24	24
Self-reported smoking status (adults)[2,3]															
Never smoker	1,535	27	25	23	25	4,287	26	24	25	25	6,459	25	25	24	26
Past smoker	707	20	28	26	26	1,966	26	25	27	22	3,092	27	25	26	21
Current smoker	717	23	23	28	26	1,914	22	25	25	28	2,795	22	24	27	28
Self-reported health status[2]															
Excellent	1,587	25	26	25	24	4,851	26	25	24	25	7,507	27	26	25	22
Very good	1,381	27	24	27	22	4,015	26	25	25	23	6,069	26	25	25	24
Good	1,746	23	24	25	28	4,815	24	25	25	25	7,172	24	25	24	26
Fair	855	25	27	21	26	2,250	22	24	26	28	3,307	21	23	27	29
Poor	189	22	28	24	27	512	27	20	26	26	760	25	23	24	28

[1] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and quartile of distance measure for "within 100 meters."
[2] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and quartile of distance measure for "within 500 meters."
[3] p value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and quartile of distance measure for "within 300 meters."
[4] GED is General Educational Development high school equivalency diploma.

NOTES: Row totals within subgroups sum to 100%. Quartiles of distance from residence to the nearest road within buffers of specific radii are defined by the median and interquartile ranges shown in Table II.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

Table 5. Number of records and percent distribution by quartiles of average annual traffic density within buffers of specific radii, by selected respondent characteristics

	Within 100 meters					Within 300 meters					Within 500 meters				
	n	0–25	25–50	50–75	75–100	*n*	0–25	25–50	50–75	75–100	*n*	0–25	25–50	50–75	75–100
Total	1,519	25	25	25	25	6,418	25	25	25	25	11,279	25	25	25	25
Urbanization[1,2]															
Large central metropolitan	†	†	†	†	†	3,038	6	20	29	45	5,483	8	20	28	44
Other counties	821	36	28	20	†15	3,380	36	28	22	13	5,796	36	28	24	13
Race and ethnicity[1,2,3]															
Mexican American	484	†17	13	†29	42	1,946	20	18	24	38	3,464	19	21	25	34
Non-Hispanic white	503	31	28	21	20	2,003	32	27	22	19	3,474	31	27	23	18
Non-Hispanic black	381	14a	30	31	25	1,672	16	23	32	29	3,036	15	25	30	31
Poverty status															
Below poverty level	454	23	20	31	26	1,840	27	25	23	25	3,096	25	26	22	27
100%–199%	435	23	34	20	23	1,743	29	26	24	22	2,936	28	25	25	22
200%–399%	312	34	23	20	23	1,366	27	23	25	25	2,481	29	22	25	23
400% or higher	178	20a	18a	32	30	903	20	27	28	26	1,707	21	27	28	23
Age in years[2]															
Under 25	853	25	24	26	25	3,675	25	25	25	26	6,382	24	25	25	26
25–64	459	28	23	25	25	1,948	25	24	25	26	3,420	25	24	25	25
Over 65	207	19	36	22	22	795	28	30	25	17	1,477	29	27	26	18
Education (over age 24)[1,2]															
Less than high school	683	26	24	23	26	2,997	23	25	25	27	5,302	25	25	25	25
High school or GED[4]	238	23	31	25	21	915	31	27	21	21	1,542	31	28	19	22
More than high school	315	28	21	27	25	1,330	24	23	28	25	2,388	23	23	29	25
Self-reported smoking status (adults)[3]															
Never smoker	412	23	24	28	25	1,674	23	25	26	27	2,941	24	23	27	26
Past smoker	167	25	22	21	32	721	26	24	27	23	1,376	25	25	27	23
Current smoker	200	30	29	24	17	735	29	28	20	23	1,240	28	28	23	22
Self-reported health status															
Excellent	414	28	20	26	26	1,877	23	25	25	27	3,395	24	23	27	26
Very good	370	21	27	26	26	1,581	25	24	27	24	2,722	25	25	25	26
Good	465	27	30	23	20	1,911	27	26	24	23	3,296	26	26	24	24
Fair or poor	269	27	19	24	30	1,048	27	25	23	26	1,864	27	25	25	23

† Estimate may be unreliable; estimates preceded by a dagger have a relative standard error (RSE) greater than 30%; estimates not shown have RSE greater than 50% or fewer than 12 degrees of freedom.
[1]*p* value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and quartile of distance measure for "within 300 meters."
[2]*p* value < 0.05 based on chi-square statistic for the association between categories of respondent characteristic and quartile of distance measure for "within 500 meters."
[3]*p* value < 0.05 based on chi-square statistic for association between categories of respondent characteristic and quartile of distance measure for "within 100 meters."
[4]GED is General Educational Development high school equivalency diploma.

NOTE: Quartiles of distance from residence to the nearest road within buffers of specific radii are defined by the median and interquartile ranges shown in Table III.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

Technical Notes

Selected definitions

Average annual daily traffic (AADT)—The AADT value is the average number of motor vehicles on the road each day. Separate AADT values can be estimated for different segments of the road. For this linkage, the highest AADT value was used for roads with multiple segments within a traffic buffer. The 2005.05 National Highway Planning Network (NHPN) includes AADT for selected roads from the 2002 Highway Performance Monitoring System (HPMS).

Functional classification (FCLASS)—The FCLASS system groups roads, streets, and highways into different classes based on the character of service they provide. The underlying principle of this classification is that individual roads and streets do not serve as separate entities, but rather as a network of roads through which traffic moves. FCLASS designations can differ among states, so an overall description of this variable is not presented in this report. The 2005.05 NHPN includes FCLASS for selected roads from the 2002 HPMS.

National Highway Planning Network (NHPN)—Maintained by the Federal Highway Administration (FHWA), NHPN is the most comprehensive GIS-based network database available, containing information about the location and features of the major roadways in the United States. NHPN contains information on over 450,000 miles of roadways in the 48 contiguous states and the District of Columbia, Alaska, Hawaii, and Puerto Rico, consisting of rural principal arterials, urban principal arterials, and all National Highway System routes. Smaller roadways are not in this system. The NHPN's primary purpose is to help FHWA in highway planning, policy analysis, network modeling, and visualization of the Highway Performance Monitoring System database (HPMS).

National Highway System—Approximately 160,000 miles (256,000 kilometers) of roadway important to the U.S. economy, defense, and mobility. Further information is available from http://www.fhwa.dot.gov/planning/nhs/.

Highway Performance Monitoring System (HPMS)—This database provides data that reflect the extent, condition, performance, use, and operating characteristics of U.S. highways. It was developed in 1978 as a national highway transportation system database. The database includes limited data on all public roads, more detailed data for a sample of the arterial and collector functional systems, and certain statewide summary information. Some highway characteristics from the 2002 HPMS (for example, AADT and FCLASS) are in the 2005.08 NHPM database.

Rural principal arterials—The rural principal arterial system consists of a connected rural network of continuous routes with the specific characteristics: (a) serve corridor movements having trip length and travel density characteristics indicative of substantial statewide or interstate travel; (b) serve all or virtually all urban areas of 50,000 and over population and a large majority of those with population of 25,000 and over; and (c) provide an integrated network without stub connections except where unusual geographic or traffic flow conditions dictate otherwise (for example, international boundary connections and connections to coastal cities) (40).

Traffic buffer—For this linkage a traffic buffer was defined as the area included within a specified radius from a respondent's household address. Traffic buffers of 100 m, 300 m, and 500 m were used in the calculations.

Urban principal arterials—Every urban environment has a system of streets and highways that can be identified as unusually significant to the area in which it lies in terms of the nature and composition of travel it serves. In smaller urban areas (under population 50,000) these facilities may be very limited in number and extent and their importance may be primarily derived from the service provided to travel passing through the area. In larger urban areas their importance also derives from service to rural-oriented traffic, but equally or even more important, from service for major movements within these urbanized areas. This system of streets and highways is the urban principal arterial system and should serve the major centers of activity of a metropolitan area, the highest traffic volume corridors, and the longest trip desired, and should carry a high proportion of the total urban area travel on a minimum of mileage. The system should be integrated both internally and between major rural connections.

Table I. Median and interquartile range of distance from residence to nearest road within buffers of specific radii, by selected respondent characteristics

	Radii											
	Total			Within 100 meters			Within 300 meters			Within 500 meters		
	Median (25th, 75th percentile)											
	Median	p25	p75	Median	p25	p75	Median	p25	p75	Median	p25	p75
	Distance in meters											
Total	528	237	1,085	36	15	70	145	66	223	227	111	349
Urbanization												
Large central metropolitan	454	207	869	51	19	78	148	75	222	224	107	346
Other counties	565	254	1,229	28	12	63	144	60	224	230	112	350
Race and ethnicity												
Mexican American	423	189	811	49	17	74	142	64	216	224	103	347
Non-Hispanic white	578	258	1,226	32	13	64	147	62	224	231	112	349
Non-Hispanic black	483	216	944	38	17	76	148	76	222	223	112	342
Poverty status												
Below poverty level	389	186	842	32	16	69	150	65	227	218	104	331
100%–199%	461	188	963	36	15	65	131	56	211	202	94	336
200%–399%	567	245	1,151	35	13	71	138	61	217	216	101	343
400% or higher	602	298	1,239	39	15	74	158	82	231	258	134	371
Age in years												
Under 25	514	234	1,049	36	15	73	150	73	225	230	113	350
25–64	540	241	1,099	38	15	70	144	64	222	226	109	347
Over 65	524	234	1,083	33	14	65	138	56	219	224	105	351
Education (over age 24)												
Less than high school	498	225	1,045	38	15	73	149	73	227	226	111	341
High school or GED[1]	520	220	1,083	33	14	70	138	57	213	213	98	347
Greater than high school	555	257	1,112	36	15	67	146	65	224	236	115	354
Self-reported smoking status (adults)												
Never smoker	534	244	1,076	38	15	74	149	70	226	231	112	349
Past smoker	553	260	1,114	33	13	64	143	58	224	240	111	359
Current smoker	487	204	1,045	31	14	66	138	52	212	207	95	333
Self-reported health status												
Excellent	551	254	1,119	38	15	71	150	73	224	235	118	358
Very good	554	254	1,139	36	16	73	147	68	224	233	111	349
Good	514	229	1,060	33	14	68	143	63	223	225	107	349
Fair	465	197	956	38	14	74	138	61	215	206	97	335
Poor	418	206	915	35	13	63	145	60	228	226	100	343

[1]GED is General Educational Development high school equivalency diploma.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

Table II. Median and interquartile range of length of roads within buffers of specific radii, by selected respondent characteristics

	Within 100 meters			Within 300 meters			Within 500 meters		
	Median (25th, 75th percentile)								
	Median	p25	p75	Median	p25	p75	Median	p25	p75
Total	187	145	198	544	409	600	952	737	1,227
Urbanization									
Large central metropolitan	178	129	197	551	415	606	963	746	1,492
Other counties	192	154	199	541	406	600	946	731	1,074
Race and ethnicity									
Mexican American	177	137	198	555	427	600	964	747	1,393
Non-Hispanic white	190	151	199	540	405	599	948	734	1,091
Non-Hispanic black	184	132	198	545	411	602	955	752	1,425
Poverty status									
Below poverty level	190	150	199	554	405	602	982	795	1,429
100%–199%	186	152	198	559	441	601	971	766	1,336
200%–399%	189	145	199	550	420	600	956	751	1,141
400% or higher	184	135	198	516	386	597	915	676	1,025
Age in years									
Under 25	188	138	198	538	398	600	948	734	1,221
25–64	187	145	198	546	409	600	953	741	1,267
Over 65	188	151	199	557	432	600	950	733	1,117
Education (over age 24)									
Less than high school	186	140	199	541	398	600	956	752	1,316
High school or GED[1]	188	143	199	561	436	600	964	739	1,173
More than high school	188	147	198	540	405	600	941	721	1,172
Self-reported smoking status (adults)									
Never smoker	185	140	198	546	403	600	950	734	1,275
Past smoker	190	156	199	542	408	599	932	705	1,072
Current smoker	192	152	199	559	431	601	976	774	1,349
Self-reported health status									
Excellent	187	145	198	539	403	600	932	716	1,111
Very good	186	136	198	540	400	599	949	731	1,173
Good	190	150	199	546	412	600	952	746	1,283
Fair	185	140	199	559	423	601	981	779	1,406
Poor	188	156	199	556	397	600	963	737	1,341

[1]GED is General Educational Development high school equivalency diploma.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

Table III. Median, 25th, and 75th percentiles of average annual traffic density within buffers of specific radii, by selected respondent characteristics

	Within 100 meters				Within 300 meters				Within 500 meters			
		Median (25th, 75th percentile)				Median (25th, 75th percentile)				Median (25th, 75th percentile)		
	n	Median	p25	p75	*n*	Median	p25	p75	*n*	Median	p25	p75
Total	1,519	21,586	13,844	43,451	6,418	31,953	17,508	76,531	11,279	38,049	19,667	101,416
Urbanization												
Large central metropolitan	†	†	†	†	3,038	61,770	31,348	141,434	5,483	81,634	35,728	160,018
Other counties	821	18,020	9,701	27,625	3,380	23,317	13,856	45,333	5,796	27,302	15,501	51,811
Race and ethnicity												
Mexican American	484	35,539	17,419	†83,359	1,946	42,242	21,851	129,891	3,464	51,731	24,710	141,276
Non-Hispanic white	503	19,648	11,651	31,096	2,003	26,352	15,530	55,740	3,474	29,928	16,399	71,980
Non-Hispanic black	381	25,295	15,973	44,386	1,672	38,744	22,902	90,817	3,036	48,858	25,948	120,228
Poverty status												
Below poverty level	454	25,449	13,901	44,807	1,840	30,370	16,726	75,863	3,096	37,291	19,660	109,327
100%–199%	435	19,729	14,310	40,065	1,743	29,335	16,149	63,074	2,936	36,652	18,100	81,119
200%–399%	312	19,390	†9,280	41,198	1,366	31,914	16,430	73,008	2,481	35,871	17,388	93,974
400% or higher	178	27,139	15,271	44,557	903	36,077	19,993	79,357	1,707	38,948	21,544	98,375
Age in years												
Under 25	853	21,717	13,849	44,825	3,675	32,852	18,089	79,322	6,382	38,990	19,929	105,863
25–64	459	21,617	12,652	44,384	1,948	34,402	17,693	79,774	3,420	38,970	19,724	105,123
Over 65	207	20,937	17,657	37,550	795	27,834	16,348	55,489	1,477	33,127	18,562	71,987
Education (over age 24)												
Less than high school	683	21,532	13,357	45,431	2,997	34,428	18,670	81,558	5,302	38,176	19,700	104,136
High school or GED[1]	238	20,377	13,904	35,274	915	27,298	15,632	61,409	1,542	30,036	16,935	82,448
More than high school	315	21,777	13,026	41,980	1,330	35,732	18,112	75,833	2,388	41,138	20,769	101,829
Self-reported smoking status (adults)												
Never smoker	412	22,652	15,115	42,022	1,674	35,755	19,115	80,763	2,941	41,027	20,331	106,875
Past smoker	167	22,430	13,895	50,215	721	32,160	16,940	68,878	1,376	37,460	19,650	87,595
Current smoker	200	19,665	12,488	37,383	735	27,809	16,402	63,108	1,240	32,201	17,565	90,375
Self-reported health status												
Excellent	414	21,872	12,981	45,498	1,877	36,638	19,473	84,724	3,395	40,640	19,912	105,748
Very good	370	22,320	15,116	45,115	1,581	33,435	17,843	70,897	2,722	38,419	19,882	105,599
Good	465	19,606	12,903	39,642	1,911	30,050	16,733	71,374	3,296	36,676	19,661	96,751
Fair or poor	269	25,210	12,684	46,981	1,048	30,041	16,688	79,186	1,864	36,665	17,958	90,772

† Estimate may be unreliable; estimates preceded by a dagger have a relative standard error (RSE) greater than 30%; estimates not shown have RSE greater than 50% or fewer than 12 degrees of freedom.

[1]GED is General Educational Development high school equivalency diploma.

SOURCE: CDC/NCHS, National Health and Nutrition Examination Surveys, 1999–2008 linked with traffic data from the National Highway Planning Network, 2005.

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