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Secondhand Smoke Exposure in Cars Among Middle and High School Students—United States, 2000–2009

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Abstract

OBJECTIVE—Exposure to secondhand smoke (SHS) from cigarettes poses a significant health risk to nonsmokers. Among youth, the home is the primary source of SHS. However, little is known about youth exposure to SHS in other nonpublic areas, particularly motor vehicles.

METHODS—Data were obtained from the 2000, 2002, 2004, 2006, and 2009 waves of the National Youth Tobacco Survey, a nationally representative survey of US students in grades 6 to 12. Trends in SHS exposure in a car were assessed across survey years by school level, gender, and race/ethnicity by using binary logistic regression.

RESULTS—From 2000 to 2009, the prevalence of SHS exposure in cars declined significantly among both nonsmokers (39.0%–22.8%; trend $P < .001$) and smokers (82.3%–75.3%; trend $P < .001$). Among nonsmokers, this decline occurred across all school level, gender, and race/ethnicity subgroups.

CONCLUSIONS—SHS exposure in cars decreased significantly among US middle and high school students from 2000 to 2009. Nevertheless, in 2009, over one-fifth of nonsmoking students were exposed to SHS in cars. Jurisdictions should expand comprehensive smoke-free policies that prohibit smoking in worksites and public places to also prohibit smoking in motor vehicles occupied by youth.

Keywords

smoking; tobacco smoke pollution; motor vehicles; adolescent

Exposure to secondhand smoke (SHS) from burning tobacco products causes disease and premature death in nonsmokers.[1] Among youth, SHS exposure is associated with acute respiratory infections, middle ear disease, delayed lung growth, and more severe asthma.[2]

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Nonsmoking youth are more heavily exposed to SHS than nonsmoking adults and are particularly vulnerable to SHS due to their limited ability to avoid smoke-permitted environments, higher breathing rates, and the developing nature of their respiratory, immune, and nervous systems.[2,3] Accordingly, the American Academy of Pediatrics has concluded that there is no safe level or duration of SHS exposure and has advocated for the implementation of smoke-free environments, including homes, cars, schools, workplaces, and play areas.[4] Nonetheless, during 2007–2008, ~88 million nonsmokers aged ≥3 years in the United States were exposed to SHS, 32 million (36%) of whom were between the ages of 3 and 19.[5]

The home represents the primary source of SHS exposure among youth.[2,6] However, the extent to which youth are exposed to SHS in other nonpublic areas, particularly motor vehicles, is uncertain. Environmental studies have revealed that smoking in a motor vehicle can lead to elevated levels of fine particle air pollution and airborne nicotine within the vehicle.[7–12] Moreover, additional studies reveal that youth exposed to SHS in motor vehicles may be at an increased risk for adverse respiratory health effects when compared with unexposed youth, including current and persistent wheeze, hay fever symptoms, and decreased lung function.[13,14] There is also some evidence to suggest that smoking in motor vehicles occurs at higher rates among socioeconomically disadvantaged populations and thus may contribute to inequalities in SHS-attributable health outcomes.[15]

As of January 2011, multiple jurisdictions throughout the world, including 4 US states (Arkansas, California, Louisiana, Maine) and the territory of Puerto Rico, have enacted legislation that prohibits smoking inside motor vehicles occupied by persons younger than a specified age.[16] Studies indicate strong support for the implementation of such laws, irrespective of smoking status.[17–25] However, despite this support for policies prohibiting smoking in motor vehicles occupied by youth, few authors have assessed the extent of SHS exposure in this environment.[26,27] In the United States, no authors have documented the prevalence, trends, or correlates of SHS exposure in motor vehicles among youth at the national level; the limited number of studies in which the issue at the state level was assessed reveal that, though exposure in this environment has decreased, it remains a considerable public health problem.[28–30] Given the scarcity of data, we sought to assess the prevalence, trends, and correlates of SHS exposure in cars among a nationally representative sample of US middle and high school students during 2000–2009 by using data from the National Youth Tobacco Survey (NYTS).

METHODS

Data Source

The NYTS is an ongoing school-based survey that collected information on key tobacco-related measures[31] from middle school (grades 6–8) and high school (grades 9–12) students in 2000, 2002, 2004, 2006, and 2009. In all years, students were asked to complete a self-administered, pencil and paper questionnaire in a classroom setting. Parental permission was obtained for each student, and participation was voluntary at both the school and student level. At the student level, participation was anonymous. Overall response rates for each

survey year were as follows: 2000 (84.1%), 2002 (74.2%), 2004 (82.0%), 2006 (80.2%), and 2009 (84.8%).

Sample

The NYTS utilizes a 3-stage cluster sampling procedure to generate cross-sectional, nationally representative samples of US middle and high school students. The sampling frame consists of all public school, Catholic school, and other private school students enrolled in regular middle and high schools in grades 6 to 12 in the 50 states and the District of Columbia. Alternative schools, special education schools, Department of Defense-operated schools, vocational schools, and students enrolled in regular schools unable to complete the questionnaire without special assistance are excluded.

Sampling procedures for NYTS are probabilistic and conducted without replacement at 3 stages: (1) primary sampling unit (PSU), such as a county, group of small counties, or portion of a large county; (2) schools within each selected PSU; and (3) classes within each selected school. The 3-stage cluster sample is stratified by non-Hispanic black or Hispanic composition and urban versus rural status at the first stage. PSUs are classified as “urban” if they are in 1 of the 54 largest metropolitan statistical areas in the United States. In subsequent sampling stages, a probabilistic selection of schools and students is made from the sample PSUs. African American and Hispanic students are oversampled by using a modified weighted measure of size that increases the probability of selection of PSUs and schools with disproportionately high minority student enrollments.

The present analysis includes NYTS participants for whom complete data were available on the measures described herein; the proportion of respondents excluded due to missing data for the dependent variable (ie, SHS exposure in a car) ranged from 1.2% in 2006% to 4.2% in 2002. Analyzed overall sample sizes were as follows: 2000 (n = 34 937), 2002 (n = 25 044), 2004 (n = 27 479), 2006 (n = 26 710), and 2009 (n = 22 219).

Measures

SHS Exposure in a Car—Exposure to SHS in a car was determined by using the question, “During the past 7 days, on how many days did you ride in a car with someone who was smoking cigarettes?” Categorical response options included: “0 days,” “1 or 2 days,” “3 or 4 days,” “5 or 6 days,” and “7 days.” Respondents who indicated a response other than “0 days” were classified as being exposed to SHS in a car within the past 7 days.

Smoking Status—Smoking status was determined by using the question, “During the past 30 days, on how many days did you smoke cigarettes?” Categorical response options included the following: “0 days,” “1 or 2 days,” “3 to 5 days,” “6 to 9 days,” “10 to 19 days,” “20 to 29 days,” and “all 30 days.” Respondents who indicated a response of “0 days,” which included both never and former smokers, were classified as nonsmokers; those who indicated any option other than “0 days” were classified as current smokers.

Sociodemographic Characteristics—Sociodemographic characteristics assessed included gender (boy or girl), race/ethnicity (Hispanic, non-Hispanic white, non-Hispanic

black, non-Hispanic Asian, non-Hispanic American Indian or Alaska Native, and non-Hispanic Native Hawaiian or other Pacific Islander), and school level (middle or high). Middle school was defined as grades 6 to 8 and high school was defined as grades 9 to 12.

Data Analysis

Data were analyzed by using SAS-callable SUDAAN, version 9.2 (SAS Institute, Inc, Research Triangle Park, NC). The final student level response data were weighted to reflect the initial probabilities of selection and nonresponse patterns, to mitigate large variations in sampling weights, and to poststratify the data to known sampling frame characteristics.

The primary outcome of interest was SHS exposure in a car within the past 7 days. After stratification by smoking status, differences in point estimates for this outcome were assessed within and across survey years for each school level, gender, and racial/ethnic group by using 95% confidence limits. In addition, trends during 2000–2009 were assessed by using estimates of relative percent change, as well as a linear coefficient in a binary logistic regression model with a significance level of $P < .05$. For the regression analysis, orthogonal polynomials were developed to account for variations in time between survey years, and results were adjusted for school level, gender, and race/ethnicity.

RESULTS

Overall

The percentage of all respondents who reported riding in a car with someone who was smoking decreased (trend $P < .001$) from 48.1% to 29.8% during 2000–2009. This decrease occurred irrespective of the number of days exposed during the past 7 days: 1 to 2 days (18.1% to 12.7%; trend $P < .001$), 3 to 4 days (9.8% to 6.2%; trend $P < .001$), 5 to 6 days (5.9% to 3.1%, trend $P < .001$), and 7 days (14.3% to 7.8%, trend $P < .001$) (data not shown).

During 2000–2009, the percentage of overall respondents who rode in a car with someone who was smoking declined (trend $P < .001$) among both middle (43.9% to 25.3%) and high (51.7% to 33.2%) school students. By gender, a decline was observed (trend $P < .001$) among both girls (49.8% to 31.8%) and boys (46.4% to 27.8%). A decline (trend $P < .01$) was also observed among all racial/ethnic groups, including non-Hispanic white participants (50.2% to 32.5%), non-Hispanic black participants (46.9% to 24.8%), Hispanic participants (41.1% to 27.3%), non-Hispanic Asian participants (34.6% to 18.7%), non-Hispanic American Indian or Alaska Native participants (50.5% to 39.3%), and non-Hispanic Native Hawaiian or other Pacific Islander participants (51.6% to 44.8%; data not shown).

Nonsmokers

The proportion of nonsmokers in the study sample was 80.4% in 2000, 84.3% in 2002, 86.0% in 2004, 87.4% in 2006, and 87.5% in 2009. The percentage of nonsmokers who reported riding in a car with someone who was smoking decreased (trend $P < .001$) from 39.0% to 22.8% during 2000–2009 (Table 1). This decrease occurred irrespective of the number of days exposed during the past 7 days: 1 to 2 days (17.8% to 11.5%; trend $P <$.

001), 3 to 4 days (8.2% to 4.6%; trend $P < .001$), 5 to 6 days (4.3% to 2.2%, trend $P < .001$), and 7 days (8.6% to 4.5%, trend $P < .001$).

During 2000–2009, the percentage of nonsmokers who rode in a car with someone who was smoking declined (trend $P < .001$) among both middle (38.7% to 21.7%) and high (39.2% to 23.8%) school students. By gender, a decline was observed (trend $P < .001$) among both girls (40.9% to 25.4%) and boys (37.0% to 20.2%). A decline (trend $P < .01$) was also observed among all racial/ethnic groups, including non-Hispanic white participants (40.1% to 24.8%), non-Hispanic black participants (41.0% to 20.7%), Hispanic participants (33.2% to 20.1%), non-Hispanic Asian participants (26.7% to 14.1%), non-Hispanic American Indian or Alaska Native participants (40.7% to 32.5%), and non-Hispanic Native Hawaiian or other Pacific Islander participants (39.2% to 29.6%).

Current Smokers

The percentage of current smokers who reported riding in a car with someone who was smoking declined (trend $P < .001$) from 82.3% to 75.3% during 2000–2009 (Table 2). During 2000–2009, a significant (trend $P < .001$) decline was observed in the prevalence of current smokers who rode in a car with someone who was smoking during all 7 of the past 7 days (36.0% to 27.9%, trend $P < .001$); in contrast, no significant decline was observed in the prevalence of exposure during 1 to 2 (19.0% to 20.9%, trend $P = .23$), 3 to 4 (15.8% to 17.5%, trend $P = .50$), or 5 to 6 (11.4% to 9.0%, trend $P = .06$) of the previous 7 days.

During 2000–2009, the percentage of current smokers who reported riding in a car with someone who was smoking declined (trend $P < .05$) among students in both middle (80.6% to 75.5%) and high (82.9% to 75.4%) school. By gender, a decline (trend $P < .001$) was observed among both girls (85.4% to 81.2%) and boys (79.4% to 70.7%). By race/ethnicity, declines (trend $P < .05$) were observed only among non-Hispanic white participants (84.5% to 79.2%), non-Hispanic black participants (76.5% to 70.2%), and Hispanic participants (74.9% to 66.2%).

DISCUSSION

This study used nationally representative samples of US middle and high school students to assess the prevalence and trends of SHS exposure in cars. The findings indicate that SHS exposure in cars decreased among both nonsmoking and smoking students across all demographic groups examined between 2000 and 2009. Nonetheless, in 2009, 22.8% of nonsmoking students and 75.3% of smoking students still reported SHS exposure in a car within the past 7 days. The implications of these findings are twofold: (1) considerable progress has been made over the past decade in uniformly reducing SHS exposure in cars among US middle and high school students; however, (2) enhanced and sustained efforts are needed to further reduce SHS exposure in this environment.

The decline in SHS exposure in cars observed in the current study is likely attributable to a number of factors, one of which is the proliferation of comprehensive smoke-free laws prohibiting smoking inside all workplaces, restaurants, and bars. During the time period when the data included in this analysis were collected (2000–2009), the number of states

with comprehensive smoke-free laws increased from 0 to 21; as of June 2011, 25 states had currently enacted such laws.[32] Comprehensive smoke-free laws have been shown to greatly reduce the probability and amount of SHS exposure and to stimulate the adoption of voluntary policies in nonpublic places such as homes.[33,34] Additional factors that likely contributed to this decline in exposure include decreases in the prevalence of smoking in the United States and changes in public attitudes regarding the social acceptability of smoking near nonsmokers and children.[5,35]

Although the decline in SHS exposure in cars was uniform across school level, gender, and race/ethnicity, disparities remain. Specifically, the prevalence of SHS exposure was higher among girls than boys. This finding may be due to higher smoking rates among male students,[36] which could lead to increased SHS exposure among female peers. Future research, including survey questions addressing the respondent's relationship to the individual smoking inside the motor vehicle, could provide insight into this disparity. Similarly, the prevalence of SHS exposure in cars was lowest among nonsmoking Hispanic youth and non-Hispanic Asian youth. This disparity is consistent with existing racial/ethnic variations in overall smoking rates and SHS exposure among both adults and youth.[35–37]

The implementation of a smoke-free motor vehicle policy represents the most effective way to protect youth from SHS exposure in this environment.[2] The innovation and diffusion of smoke-free policies typically follows a continuum from voluntary to legislative, during which public acceptance and social normalization are enhanced.[38] Although some state-specific data are available,[30,39] the national prevalence of voluntary smoke-free motor vehicle policies is unknown. Findings from the 2007–2008 International Tobacco Control Survey reveal that 56% of US adult smokers never smoke in a car when nonsmokers are present.[26] With regard to legislation, multiple local jurisdictions, 4 US states, and 1 US territory have enacted laws that prohibit smoking in a motor vehicle when occupied by youth less than a specified age, ranging from 13 years old in Louisiana to 18 years old in California.[40] In addition, 8 states have enacted laws prohibiting smoking in motor vehicles while transporting foster children.[40] It is important to note that, given the greater population-level protection afforded by smoke-free laws in worksites and public places,[41] smoke-free motor vehicle policies are best suited for consideration after the successful implementation of comprehensive laws prohibiting smoking in all worksites, restaurants, and bars.

Strengths of this study include the use of a large, nationally representative sample and the ability to assess 10-year time trends. However, some study limitations should be noted. First, these data were collected from youth enrolled in traditional middle or high schools and may not be representative of all youth, particularly infants, young children, and those who are home-schooled or enrolled in alternative, vocational, or special education schools. Nonetheless, data from the Current Population Survey indicate that 98.7% of US youth aged 7 to 13 years and 96.8% of those 14 to 17 years were enrolled in a traditional school in 2008.[42] Second, the self-reported nature of the data could have introduced recall or response bias. However, the recall period of 7 days was relatively short, and self-reported survey questions of tobacco-related behaviors have previously demonstrated good test-retest reliability among youth.[43] Finally, both the limited recall period and the use of a self-

reported exposure assessment could have resulted in an underestimation of true SHS exposure.[37]

CONCLUSIONS

This study revealed that exposure to SHS in cars decreased significantly among nonsmoking US middle and high school students during 2000–2009, irrespective of school level, gender, and race/ethnicity. Nevertheless, in 2009, over one-fifth of nonsmoking students reported SHS exposure in a car in the previous 7 days. Because the implementation of 100% smoke-free policies is the only effective way to fully eliminate SHS, states and communities should expand comprehensive smoke-free policies that prohibit smoking in worksites and public places to also prohibit smoking in motor vehicles occupied by youth. Future research, including the evaluation of both voluntary policies and legislative initiatives, could help identify the most effective approaches to promote, implement, and sustain smoke-free motor vehicles.

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ABBREVIATIONS

NYTS	National Youth Tobacco Survey
PSU	primary sampling unit
SHS	secondhand smoke

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WHAT'S KNOWN ON THIS SUBJECT

Secondhand smoke exposure poses a significant health risk to nonsmokers. With the proliferation of comprehensive smoke-free laws prohibiting smoking in worksites and public areas, private areas have become the primary source of secondhand smoke exposure for many individuals, particularly youth.

WHAT THIS STUDY ADDS

Secondhand smoke exposure in cars has steadily declined among middle and high school students. However, many remain exposed to secondhand smoke in this environment. Jurisdictions should expand existing comprehensive smoke-free policies to prohibit smoking in vehicles occupied by youth.

TABLE 1

Percentage of Middle and High School Nonsmokers Who Reported Riding in a Car With Someone Who Was Smoking During the Past 7 Days, by Year, School Level, Gender, and Race/Ethnicity—NYTS, United States, 2000–2009

Characteristic[a]	2000		2002		2004		2006		2009		2000–2009	
	n = 27 214		*n* = 20 552		*n* = 22 783		*n* = 22 585		*n* = 18 854			
	%	(95% CI)[b]	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	% Change	(95% CI)
Overall	39.0	(37.0–41.0)	38.5	(36.5–40.5)	30.7	(29.0–32.6)	28.6	(26.7–30.6)	22.8	(21.0–24.8)	−71.1[c]	(−65.4 to −76.8)
School level												
Middle (grades 6–8)	38.7	(36.4–41.1)	38.0	(35.5–40.6)	29.6	(27.3–31.9)	27.5	(24.9–30.2)	21.7	(19.2–24.5)	−78.3[c]	(−70.8 to −85.8)
High (grades 9–12)	39.2	(36.9–41.5)	38.9	(36.5–41.3)	31.9	(29.8–34.2)	29.6	(27.3–32.1)	23.8	(21.5–26.2)	−64.7[c]	(−57.9 to −71.5)
Gender												
Girl	40.9	(38.7–43.2)	40.6	(38.4–42.8)	32.8	(30.6–35.0)	30.9	(28.6–33.3)	25.4	(23.4–27.6)	−61.0[c]	(−54.9 to −67.1)
Boy	37.0	(34.9–39.0)	36.3	(34.2–38.5)	28.7	(26.9–30.5)	26.0	(24.2–28.0)	20.2	(18.2–22.3)	−83.2[c]	(−77.0 to −89.4)
Race/ethnicity												
White, non-Hispanic	40.1	(37.6–42.6)	40.4	(37.7–43.1)	33.3	(30.9–35.8)	31.0	(28.4–33.7)	24.8	(22.7–26.9)	−61.7[c]	(−55.3 to −68.1)
Black, non-Hispanic	41.0	(38.5–43.7)	39.3	(36.7–41.9)	28.2	(26.1–30.4)	26.4	(24.2–28.8)	20.7	(17.1–24.9)	−98.1[c]	(−88.3 to −107.9)
Hispanic	33.2	(30.0–36.6)	32.0	(29.6–34.5)	25.8	(23.4–28.3)	23.4	(21.2–25.8)	20.1	(17.1–23.4)	−65.2[c]	(−54.0 to −76.4)
Asian, non-Hispanic	26.7	(23.1–30.7)	24.8	(21.3–28.7)	14.8	(12.2–17.9)	15.1	(12.4–18.1)	14.1	(10.6–18.4)	−89.4[c]	(−73.4 to −105.4)
AI/AN,[d] non-Hispanic	40.7	(32.7–49.3)	42.0	(34.7–49.6)	29.4	(23.0–36.7)	30.0	(23.9–36.8)	32.5	(23.5–43.0)	−25.2[c]	(+3.6 to −54.0)
NH/PI,[e] non-Hispanic	39.2	(31.7–47.3)	37.9	(29.0–47.7)	32.1	(23.2–42.4)	29.8	(23.5–37.0)	29.6	(20.2–41.1)	−32.4[c]	(−2.0 to −62.8)

All data presented are weighted to adjust for differential nonresponse and selection.

[a] A “nonsmoker” was defined as any student who responded “0 days” to the question, “During the past 7 days, on how many days did you ride in a car with someone who was smoking cigarettes?”

[b] CI, confidence interval.

[c] Significant linear trend between 2000 and 2009 (binary logistic regression, $P < .05$); adjusted for all other covariates listed in table.

[d] American Indian or Alaska Native.

[e] Native Hawaiian or other Pacific Islander.

TABLE 2

Percentage of Middle and High School Current Smokers Who Reported Riding in a Car With Someone Who Was Smoking During the Past 7 Days, by Year, School Level, Gender, and Race/Ethnicity—NYTS, United States, 2000–2009

Characteristic[a]	2000		2002		2004		2006		2009		2000–2009	
	n = 6648		*n* = 3834		*n* = 3716		*n* = 3253		*n* = 2685			
	%	(95% CI)[b]	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	% Change	(95% CI)
Overall	82.3	(80.7–83.8)	82.9	(81.1–84.6)	80.6	(78.6–82.5)	79.3	(76.9–81.6)	75.3	(70.4–79.7)	−9.3[c]	(−3.5 to −15.1)
School level												
Middle (grades 6–8)	80.6	(78.1–82.8)	82.1	(79.1–84.8)	76.5	(72.8–79.9)	77.6	(73.0–81.6)	75.5	(70.5–79.9)	−6.8[c]	(−1.2 to −12.4)
High (grades 9–12)	82.9	(81.3–84.5)	83.4	(81.2–85.4)	81.9	(79.6–84.0)	79.8	(76.9–82.4)	75.4	(69.3–80.7)	−9.9[c]	(−0.6 to −19.2)
Gender												
Girl	85.4	(83.6–87.0)	86.1	(84.0–87.9)	82.4	(79.7–84.8)	83.2	(80.3–85.8)	81.2	(76.5–85.2)	−5.2[c]	(+0.8 to −11.2)
Boy	79.4	(77.4–81.3)	80.2	(77.6–82.5)	78.7	(76.1–81.1)	75.6	(72.3–78.6)	70.7	(62.5–77.7)	−12.3[c]	(−5.0 to −19.6)
Race/ethnicity												
White, non-Hispanic	84.5	(83.0–86.0)	85.4	(83.0–87.5)	83.9	(81.8–85.8)	81.2	(78.3–83.8)	79.2	(73.8–83.6)	−6.7[c]	(−0.8 to −12.6)
Black, non-Hispanic	76.5	(73.1–79.6)	72.0	(67.1–76.5)	70.3	(63.4–76.4)	69.4	(63.5–74.7)	70.2	(63.2–76.3)	−9.0[c]	(+0.3 to −18.3)
Hispanic	74.9	(70.1–79.2)	78.2	(74.3–81.6)	70.0	(66.0–73.6)	75.6	(71.6–79.2)	66.2	(61.0–71.1)	−13.1[c]	(−4.6 to −21.6)
Asian, non-Hispanic	75.8	(69.3–81.3)	84.1	(75.1–90.2)	75.6	(64.1–84.3)	78.9	(67.0–87.4)	73.5	(58.3–84.7)	−3.1	(+15.8 to −22.0)
AI/AN,[d] non-Hispanic	79.9	(69.8–87.2)	83.0	(67.6–92.0)	77.2	(61.2–88.0)	84.4	(64.2–94.2)	67.5	(46.9–83.0)	−18.4	(+ 6.4 to −43.2)
NH/PI,[e] non-Hispanic	81.1	(72.0–87.7)	68.5	(47.2–84.1)	88.6	(70.8–96.1)	73.7	(60.7–83.6)	72.2	(36.7–92.1)	−12.3	(+25.1 to −49.7)

All data presented are weighted to adjust for differential nonresponse and selection.

[a] A “current smoker” was defined as any student who responded “1 to 2 days,” “3 to 4 days,” “5 to 6 days,” or “7 days” to the question, “During the past 7 days, on how many days did you ride in a car with someone who was smoking cigarettes?”

[b] CI, confidence interval.

[c] Significant linear trend between 2000 and 2009 (binary logistic regression, $P < .05$); adjusted for all other covariates listed in table.

[d] American Indian or Alaska Native.

[e] Native Hawaiian or other Pacific Islander.