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Association of blood cotinine level with cognitive and physical performance in non-smoking older adults

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Abstract

Background—Studies show that active smoking may be associated with cognitive decline. However, the consequence of secondhand smoke on cognitive and physical performance remains unclear. The purpose of this study was to assess the association of secondhand smoke with cognitive performance and physical function using a population-based sample.

Methods—Data of 2,542 non-smoking participants from the 1999–2002 National Health and Nutrition Examination Survey were analyzed. Secondhand smoke exposure level was estimated using blood cotinine concentrations. Cognitive performance was assessed with the Digit Symbol Substitution Test and self-reported confusion/memory problems. Physical performance was analyzed using visual gait speed (m/s) and self-reported physical function. Multivariate linear and logistic regression models were used to assess the association.

Results—In never smokers, cognitive performance score decreased by 2.03 points (95% confidence interval (CI): –3.00, –1.05) per one unit increase in log-transformed blood cotinine level. After adjusting for potential confounders, including diabetes, hypertension, body mass index, alcohol, and blood lead level, change in cognitive performance score was still statistically significant (–1.17 95% CI: –2.32, –0.02). Similar trends were observed in former smokers. Gait speed decreased by 0.02 m/s for one unit increase in log-transformed blood cotinine level. This was evident in both never and former smokers. The relationship remained significant after adjusting for potential confounders in former smokers.

Conclusions—Our study suggests that secondhand smoke may contribute to cognitive decline in never and former smokers. Considering the cross-sectional design and the limitations of this study, the relationship warrants further assessment.

Keywords

Environmental tobacco smoke; Secondhand smoke; Aging; Cognition; Older adults

1. Introduction

Compared to non-smokers, active smokers have shown to have an increased risk for cognitive decline and dementia (Juan et al., 2004; Launer et al., 1999; Laurin et al., 2004; Ott et al., 2004). Studies have also shown that high levels of environmental tobacco smoke, or secondhand smoke, can have close to the same health effects as active smokers (Barnoya

and Glantz, 2005; Llewellyn et al., 2009). Only a few studies have assessed the effects of secondhand smoke on cognitive performance in older adults (Llewellyn et al., 2009; Barnes et al., 2010).

Poor physical function is related to risk of disability, hospitalization, and mortality (Cesari et al., 2005; Guralnik et al., 2000; Perera et al., 2005). Studies have shown that the survival rate in older adults significantly increases by an increment of 0.1 m/s in gait speed (Studenski et al., 2011). Using an objective measure, such as gait speed, we can characterize the relationship of secondhand smoke and physical function.

As secondhand smoke exposure increases so does the risk for cardiovascular disease, which is a known risk factor for cognitive decline (Barnes et al., 2010). Although there is some debate as to the exact causal pathway between secondhand smoke and cognitive decline, identification of preventive measures and policies that limit secondhand smoke exposure have already become a top public health priority. For example, *Healthy People 2020* includes no less than five separate objectives pertaining to reduction of secondhand smoke (US Department of Health and Human Services, 2011).

In the present study, we examined the association of secondhand smoke via a biomarker (serum cotinine) with cognitive performance and physical performance using a population-based sample.

2. Methods

2.1. Study population

The National Health and Nutrition Examination Study (NHANES) is a cross-sectional, population-based survey of non-institutionalized persons in the United States (Centers for Disease Control a, 2011). Conducted by the National Center of Health Statistics, the NHANES uses a stratified, clustered representative sample of the US population. The survey became continuous in 1999 and releases data every 2 years (Centers for Disease Control a, 2011). Informed consent from all participants was obtained and approved by the NCHS institutional review board (Centers for Disease Control b, c, 2011). Data from the 1999–2002 NHANES were used for this analysis. Among the 21,004 participants, we limited our investigation to older adults aged 60 and over as cognitive testing was done only for that age group. Details of the weighting methods and sampling in NHANES are reported elsewhere (Centers for Disease Control d, 2011). Figs 1 and 2.

2.2. Assessment of environmental tobacco smoke

The NHANES collected blood cotinine (ng/mL) as a measure of an environmental toxin to measure the prevalence of tobacco use, as well to estimate the exposure to tobacco smoke (Centers for Disease Control e, 2011). Cotinine was measured with isotopic dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry (Centers for Disease Control f, 2011). Serum cotinine below the detection limit were imputed by dividing the limit of detection by 2. Percentages of participants below the limit of detection are shown in Table 1.

To ensure that blood cotinine concentration was a result from environmental tobacco smoke, active smokers were excluded from our analysis. Two questions were used to determine the smoking status of respondents. When asked, “Have you smoked at least 100 cigarettes in your entire life?” respondents who answered “no” were categorized as never smokers. Respondents who answered “yes” and answered “no” to, “Do you now smoke cigarettes?” were labeled as former smokers. Those that answered “yes” to both were classified as

current smokers. A total of 7 respondents had missing values, and were removed from the analysis.

Because participants with serum cotinine concentrations greater than 10 ng/mL are considered current smokers, respondents who were classified as former and never smokers and had a blood cotinine level over 10 ng/ml were removed from the analysis (Environmental Protection Agency, 2010; Jeemon et al., 2010). As the distribution of serum cotinine was not normally distributed (Table 1), we analyzed it as a log-transformed continuous variable. We first assessed how different log-transformed cotinine linear regression compared to log-transformed b-spline. To do this we used proc transreg on SAS. Shown in Figure 1, the relationship was very similar the smoothed bspline's (in black) slope was very similar to the log-transformed linear regression we used in our study. We then tried using the b-spline expansion using untransformed blood cotinine. The fit was not similar and showed a positive association as the levels of cotinine increased.

2.3. Cognitive performance

Two measures of cognitive performance were used in this study: self-reported functional limitation due to confusion and memory problems and scores from the Digit Symbol Substitution Test (DSST). Participants were asked the following question: “{Are you/Is SP} limited in any way because of difficulty remembering or because {you/s/he} experience{s} periods of confusion?” Responses included “yes,” “no,” “refused,” and “don’t know.” Nine participants responded “don’t know,” and were excluded from the study. None of the participants responded with “refused.” Concern for memory loss and confusion is the first step in identifying cognitive decline in older adults (Feldman et al., 2008).

The DSST is a component of the Wechsler Adult Intelligence Test and examines measures of dementia that include response speed, attention, visual spatial skills, associative learning, and memory (Centers for Disease Control g, 2011). Within 2 min, participants were asked to draw symbols under a corresponding number, using a key that was provided on the top of the exercise form. A score of 1 is given for each symbol correctly drawn within the time limit. A score of 133 is the maximum. The distribution of this cognitive test ranged from 0 to 117, and was normally distributed (Table 1).

2.4. Physical function

A standardized 20-ft walk timed-test was used to assess gait speed in the Medical Examination Center of the NHANES. Using a hand-held stopwatch, participants were asked to walk at their usual pace, using a walker or cane if needed. Gait speed was then calculated as meters per second (20 ft=6.096 m). Three participants were removed in the original sample because their gait speed was unlikely as a valid measurement and was classified as greater than 3.0 m/s.

The NHANES also asked a series of questions to measure participants’ functional status, activities of daily living and instrumental activities of daily living. Two of these questions were used to assess physical function. Participants who reported “much difficulty” and “unable to do” to the two questions below were labeled as poor physical function: “By {yourself/himself/herself} and without using any special equipment, how much difficulty {do you/does SP} have walking for a quarter of a mile [that is about 2 or 3 blocks]?” or to “By {yourself/himself/herself} and without using any special equipment, how much difficulty {do you/does SP} have walking up 10 steps without resting?”

2.5. Covariates

Potential confounders were included for analyzing the associations between levels of cotinine and cognitive performance as well as gait speed. Covariates were chosen on the basis of their observed associations with cognitive impairment or physical function and/or findings from previous studies (Llewellyn et al., 2009; Barnes et al., 2010; Xu et al., 2010). Demographic factors such as age, gender, race/ethnicity, and education were included in the analysis. Race/ethnicity included the categories of non-Hispanic white, non-Hispanic black, Mexican American, and other groups. Education was divided into three groups; high school diploma or less, some college, and college graduate or more. In addition, diabetes, hypertension, body mass index (BMI), stroke, and heart attack were used to adjust for confounding in the model. Alcohol use was measured using a question that asked respondents on the average number of alcoholic drinks they consumed a day.

2.6. Statistical analysis

All statistical analysis were conducted on SAS 9.2 (SAS Institute, Cary, NC) accounting for the complex sampling characteristics of NHANES. NHANES complex sampling weights, stratification, and clustered design were used for the purpose of correct estimation of sampling error. Four-year sampling weights were used for to combine 1999–2000 and 2001–2002 NHANES datasets.

Linear regression models were used to estimate the association of the linear outcomes—cognitive performance score, and gait speed. Logistic regression models were used for self-reported confusion/memory problems, and self-reported physical function. In the first model, multivariate linear and logistic regression was performed adjusting for age, gender, education, and race/ethnicity for never and former smokers separately. The second model adjusted for the variables above along with diabetes, hypertension, BMI, and alcohol use. The final model adjusted for the above variables as well as history of stroke and heart attack.

Former and never smokers were analyzed separately. We also evaluated the models by checking the resultant coefficient of determination (adjusted R^2) for linear regression and the Akaike information criterion (AIC) for logistic regression as a fit statistics. The higher R^2 value indicates a better fit for linear regression while the smaller AIC indicates a better fit for logistic regression. Mean differences, odds ratios and 95% confidence intervals (CIs) for the multivariable linear and logistic regression were subsequently reported.

3. Results

Among the 21,004 participants in 1999–2002, 3706 participants were aged 60 and over and 2957 had available serum cotinine samples. After removing current smokers ($n=365$) from the sample, with cotinine levels over 10 ng/mL ($n=133$), and missing self-reported smoking status ($n=7$), our final analysis had a total of 2452 participants ($n=1317$ for never smokers and $n=1135$ for former smokers).

Table 2 depicts the characteristics of the sample used in the analysis. With a range of 0.01–9.53 ng/mL, the average cotinine level in our total sample was 0.17 ng/mL (95% CI: 0.14–0.20). Mean gait speed was 0.95 m/s (95% CI: 0.92–0.97), and the mean cognitive performance score was 47.2 (95% CI: 45.8–48.5). Former smokers had a higher proportion of males and comorbidities such as diabetes, coronary heart disease, heart attack, and cancer compared to never smokers. Compared to former smokers, uncontrolled hypertension was higher among the never smokers group. Differences in cognitive performance and gait speed were not statistically significant between smoking statuses. Participants who reported confusion/memory problems scored 13.86 points lower on the cognitive test than those that did not report confusion/memory problems. Similarly, participants reporting difficulty

walking for a quarter mile and walking up ten steps had a lower gait speed (0.27 and 0.28 m/s lower, respectively).

Shown in Table 3, after adjusting for age, gender, education, and race/ethnicity, never smokers' cognitive performance score decreased by an average of 2.03 (95% CI: -3.00, -1.05) for one unit increase of log-transformed blood cotinine. In our sequentially more complex models, the association remained statistically significant (-1.17 95% CI: -2.32, -0.02). Similarly, former smokers' cognitive performance decreased by an average of 0.93 (95% CI: -1.60, -0.27) and remained statistically significant after further adjustment of potential confounders. Cotinine level was not associated with self-reported confusion and memory problems in never and former smokers. In addition, blood cotinine level was significantly associated with slower gait speed in former smokers. After adjusting for age, gender, education, and race/ethnicity, gait speed decreased by an average of 0.02 m/s (95% CI: -0.03, -0.00) for one unit increase of log-transformed blood cotinine. After further adjustment for diabetes, hypertension, BMI, alcohol, stroke, heart attack and blood lead level, the association remained significant for former smokers. In never smokers, similar associations were observed although they did not remain statistically significant after further adjusting for the covariates of health status. Similarly, blood cotinine level was associated with difficulty walking for a quarter mile in former smokers. The odds of having difficulty in walking a quarter mile was 1.18 (95% CI 1.02, 1.47). The association remained significant after further adjustment. Cotinine level was not associated with difficulty walking up 10 steps in never nor former smokers.

4. Discussion

Our study suggests that secondhand smoke is significantly associated with decline in cognitive performance among never smokers and former smokers. The association was independent of potential confounders such as BMI, diabetes, hypertension, and cardiovascular disease. The cognitive performance test used is a test of psychomotor performance which involves multi-functions including incidental memory, perceptual organization, visuo-motor coordination, and selective attention (Rosano C et al., 2008). This test has been widely used in epidemiological studies of cognitive function. Although a variety of conditions are associated with low cognitive performance score, the test is sensitive and reliable to measure cognitive function (Proust-Lima et al., 2006). Studies have found that low cognitive performance score was associated with a greater risk of mortality and incident disability in community dwelling older adults (Rosano et al., 2008; Swan et al., 1995). Therefore, the observed associations in the study have important public health implications.

Cotinine level was also associated with gait speed and physical function in both never smokers and former smokers. Our study found that gait speed reduced 0.02 m/s per unit increase in log-transformed serum cotinine in both groups. Gait speed is a very important measure of community ambulation. For example, speeds of 1.2 m/s have been reported to be needed to cross a four lane urbane street during the time a typically timed traffic light remains green (Lerner-Frankiel MB et al., 1986). Studies have shown that the extension in survival was significant for each 0.1 m/s increase in speed in older adults (Studenski et al., 2011). Therefore, the implications of the observed associations in this study are quite profound given safety issues with the elderly.

4.1. Previous studies

To our knowledge, this is the first study that has assessed the association of secondhand smoke on objective physical performance. Two other studies have observed the association of secondhand smoke and cognitive decline (Llewellyn et al., 2009; Barnes et al., 2010).

Llewellyn et al. assessed salivary cotinine level with a dichotomized measure of cognitive impairment. Our study assessed this measure using a continuous variable as our test does not have a set cut-off point. Barnes et al. examined lifetime exposure of secondhand smoke using self-report and incidence of dementia. Future studies could use such model to determine lifetime exposure as well as incorporating a biological marker such as blood cotinine.

4.2. Possible mechanisms

Secondhand smoke activates mediators such as fibrinogen and thromboxane which are responsible for platelet activation and increases the risk of thrombus formation (Barnoya and Glantz, 2005; Ambrose and Barua, 2004; Burghuber et al., 1986; Glantz and Parmley, 1995; Iso et al., 1996; Law et al., 1997; Schmid et al., 1996). Platelets activated by secondhand smoke have also been seen to damage the endothelium layer of the arterial wall (Barnoya and Glantz, 2005). This in effect contributes to athero-sclerotic plaque formation and progression, plaque rupture, and decreased blood flow because of thrombosis (Barnoya and Glantz, 2005; Widlansky et al., 2003). This will inevitably lead to cardiovascular disease.

Studies have shown that an increased risk of cardiovascular disease is associated with an increased risk of cognitive decline (Llewellyn et al., 2009; Newman et al., 2005; Otsuka et al., 2001). Although cotinine level may interact with subclinical cardiovascular disease and cognitive decline in older adults (Llewellyn et al., 2009), future studies investigating this are warranted.

4.3. Strengths and limitations

Our study offers several strengths. First, our study utilizes a large population-based sample of the United States and not only assessed the effects of passive smoking on cognitive decline but also on physical performance. The findings from this study can be generalized to the U.S older adult population. Second, this study relied on an objective measure of serum cotinine to estimate environmental tobacco use. This method could provide a more accurate measurement of passive smoking from all sources compared with the method of questionnaires. For example, more than 60% participants had serum cotinine concentrations above the limit of detections in this study while only a small number of participants reported that there were smokers at home. If information on number of smokers at home is used to estimate passive smoking, it could increase misclassification errors in this study. A log transform was used to improve linearity in the regression model. Residual plots provided a visual comparison for linearity between untransformed and log-transformed cotinine. Akaike information criterion (AIC) was then used to compare untransformed and log-transformed cotinine for the logistic models used in the study. Models using log-transformed cotinine had a lower AIC for each outcome variable. As shown in Figure 1, the log-transformed cotinine closely resembled the smoothed b-spline. Third, a wide range of potential confounders including demographic factors and health conditions such as cardiovascular diseases and diabetes were included in the models. Moreover, to test the reliability of our estimation, we computed several models with different covariates and found consistent results. It suggested that the observed associations in this study are very unlikely explained by unselected confounders.

However, our study has several limitations that should be considered when interpreting our results. First, the cross-sectional nature of this study limited its value for causal inference between passive smoking and cognitive as well as physical functions in older adults. Future studies with prospective study design could better address the need. Second, although cotinine concentrations are objective measurements, they may only be able to assess recent exposure of secondhand smoke but not reflect long term exposure that is needed to assess

long term developments such as cognitive impairment and decline in physical performance. Moreover, smoking status was categorized using self-reported smoking status, which may increase biases. However, to reduce the potential misclassification of smoking status, participants with cotinine concentrations greater than 10.0 ng/mL were removed from the analysis ($n=133$). Third, our multivariate regression models included different sets of potential confounders. Although our modeling strategy is conservative, it is possible that including variables that did not confound the associations may lead to inflated standard errors. However, we checked the resultant coefficient of determination (adjusted R^2) for linear regressions and the Akaike Information Criterion (AIC) for logistic regressions as a fit statistics. The final models tended to have a higher R^2 or smaller AIC value, which suggests a better fit. Fourth, survival bias may also play a role in this study. Exposure to secondhand smoke has been associated with increased morbidity. Older adults in the present study may be secondhand smoke exposed participants who have survived and have had better cognitive and physical performance than those who died. Survival bias may in fact, underestimate the associations in our study. Finally, studies have shown that the cognitive performance test used in this study is very sensitive in detecting change at higher levels of cognition and less sensitive in lower levels of cognition (Proust-Lima et al., 2006). This may be an issue as our population consisted of normal and cognitively declined participants.

Our analysis showed that high levels of blood cotinine concentrations are associated with an increased risk of cognitive and physical decline in older adults. Future longitudinal studies assessing lifetime blood cotinine levels may be warranted to further elucidate these relationships.

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Fig. 1. Scatterplot of log-transformed cotinine with regression line and smoothed B-spline.

Fig. 2.
Predicted and original values of cognitive performance score and cotinine.

Table 1

Blood cotinine, cognitive performance score and gait speed distributions by smoking status, NHANES 1999–2002.

	Below limit of detection (%)	Minimum	25th Percentile	Median	75th Percentile	Maximum
Blood cotinine level						
Never Smoker	538 (39.85)	0.011 ng/mL	0.027 ng/mL	0.035 ng/mL	0.076 ng/mL	6.67 ng/mL
Former Smoker	425 (38.57)	0.011 ng/mL	0.030 ng/mL	0.035 ng/mL	0.110 ng/mL	9.53 ng/mL
Cognitive performance score						
Never Smoker	–	0	28	41	54	96
Former Smoker	–	0	30	43	56	117
Gait speed						
Never Smoker	–	0.12 m/s	0.73 m/s	0.90 m/s	1.07 m/s	1.72 m/s
Former Smoker	–	0.10 m/s	0.77 m/s	0.94 m/s	1.10 m/s	1.77 m/s

Table 2

Population characteristics, NHANES 1999–2002 self-reported non-smokers aged 60 and older.

Characteristic	Never smokers		Former smokers		Total non-smokers	
	n	Weighted %, or mean (95% CI)	n	Weighted %, or mean (95% CI)	n	Weighted %, or mean (95% CI)
Gender						
Male	450	27.6 (24.5–30.6)	712	58.4 (54.4–62.4)	1162	41.5 (39.4–43.5)
Female	900	72.4 (69.4–75.5)	390	41.6 (37.6–45.5)	1290	58.5 (56.5–60.6)
Age						
60–64	293	20.2 (16.7–23.7)	263	25.5 (21.9–29.1)	556	22.6 (19.5–25.7)
65–69	272	21.3 (17.8–24.8)	219	22.5 (18.7–26.3)	491	21.8 (19.0–24.7)
70–74	250	19.6 (16.4–22.7)	213	19.6 (16.7–22.5)	463	19.6 (17.5–21.7)
75–79	190	17.3 (14.1–20.4)	173	17.3 (14.9–19.8)	363	17.3 (15.2–19.4)
80–84	201	13.1 (10.9–15.2)	150	9.3 (7.4–11.1)	351	11.4 (9.8–12.9)
85 and over	144	8.6 (6.9–10.4)	84	5.8 (4.5–7.0)	228	7.3 (6.1–8.5)
Race/ethnicity						
White, non-Hispanic	739	79.7 (74.8–85.6)	677	86.0 (82.4–89.6)	1416	82.5 (78.7–86.4)
Black, non-Hispanic	213	7.9 (5.6–10.2)	152	6.1 (3.5–8.8)	365	7.1 (4.9–9.3)
Mexican American	305	3.3 (1.9–4.7)	226	2.9 (1.8–4.1)	531	3.1 (1.9–4.4)
Other	93	9.1 (5.3–13.4)	47	3.8 (1.9–8.3)	140	7.3 (3.8–10.7)
Education						
High school diploma or less	890	59.8 (56.5–63.1)	702	57.2 (52.7–61.8)	1592	58.6 (56.1–61.2)
Some college	249	20.5 (18.4–22.7)	230	23.9 (20.8–27.0)	479	22.0 (20.1–24.0)
College graduate or more	209	19.7 (15.6–23.7)	166	18.9 (15.6–22.1)	375	19.3 (16.8–21.8)
Marital status						
Married/live with partner	745	61.3 (56.6–67.0)	726	69.4 (65.3–73.4)	1471	64.9 (61.6–68.3)
Divorced/separated/widowed	504	35.6 (30.6–40.6)	305	28.6 (24.9–32.2)	809	32.4 (29.1–35.8)
Never married	43	3.1 (1.7–4.5)	28	2.1 (0.5–3.6)	71	2.7 (1.5–3.9)
Poverty income ratio ^d						
0–0.9	180	12.7 (9.3–16.1)	124	8.1 (5.0–11.1)	304	10.6 (8.0–13.2)
1–1.9	381	28.9 (24.9–32.8)	290	26.5 (22.4–30.6)	671	27.8 (24.4–31.2)
2–2.9	203	18.6 (14.6–22.7)	183	19.6 (15.2–23.9)	386	19.1 (15.7–22.4)

Characteristic	Never smokers			Former smokers			Total non-smokers		
	n	Weighted %	or mean (95% CI)	n	Weighted %	or mean (95% CI)	n	Weighted %	or mean (95% CI)
3–3.9	132	12.3	(10.0–14.7)	112	13.1	(9.6–16.6)	244	12.7	(10.4–14.9)
4–4.9	86	8.4	(6.0–10.7)	71	8.4	(6.5–10.2)	157	8.4	(6.8–9.9)
Greater than 5	183	19.1	(15.1–23.0)	187	24.4	(18.3–30.5)	370	21.5	(17.0–26.0)
Body mass index									
Normal (<25 kg/m ²)	355	28.8	(25.1–32.6)	252	25.3	(21.5–29.1)	607	27.2	(24.5–29.9)
Overweight (25–30 kg/m ²)	525	39.0	(34.9–43.1)	434	40.0	(35.6–44.4)	959	39.4	(36.4–42.5)
Obese (≥ 30 kg/m ²)	393	32.2	(29.3–35.1)	355	34.7	(30.7–38.8)	748	33.3	(30.6–36.0)
Diabetes*	264	13.9	(11.9–15.9)	214	16.1	(12.8–19.5)	460	14.9	(13.4–16.4)
Arthritis*	620	48.9	(45.3–52.4)	509	49.6	(45.1–54.0)	1129	49.2	(46.4–51.9)
Congestive heart Failure*	84	6.1	(4.2–7.9)	82	6.6	(4.9–8.3)	166	6.3	(4.9–7.7)
Coronary heart Disease*	108	8.8	(6.1–11.4)	137	13.5	(10.9–16.1)	245	10.9	(8.7–13.1)
Angina/angina Pectoris*	94	8.4	(5.8–11.0)	111	9.6	(7.2–11.9)	205	8.9	(6.9–10.9)
Heart attack*	105	7.8	(5.8–9.9)	127	11.7	(8.9–14.5)	232	9.6	(8.1–11.1)
Stroke*	106	7.7	(5.6–9.8)	75	5.8	(4.0–7.5)	181	6.8	(5.5–8.1)
Cancer or Malignancy*	200	17.6	(14.8–20.4)	244	24.9	(22.1–27.7)	444	20.9	(18.9–22.9)
Hypertension									
Normotensive	385	31.1	(28.8–33.3)	362	34.9	(30.3–39.5)	747	32.8	(30.4–35.1)
Hypertension, controlled	275	21.3	(18.7–23.8)	255	25.2	(22.3–28.1)	530	23.0	(20.8–25.2)
Hypertensive, not controlled	640	47.7	(44.3–51.1)	441	39.9	(35.3–44.5)	1081	44.2	(41.3–47.0)
Average alcoholic drinks per day									
1 drink	511	40.6	(34.8–46.4)	582	54.8	(51.3–58.3)	1093	47.0	(43.3–50.8)
2 drinks	697	55.7	(49.0–62.3)	371	36.2	(31.7–40.7)	1068	46.8	(41.9–51.8)
3 or more drinks	68	3.7	(2.3–5.1)	108	9.0	(6.8–11.3)	176	6.1	(4.6–7.7)
Total number of smokers in home									
None	1270	95.8	(94.4–97.2)	1020	93.8	(92.3–95.1)	2290	94.9	(93.8–95.9)
1	56	3.8	(2.4–5.1)	58	5.2	(3.8–6.6)	114	4.4	(3.4–5.4)
2	6	0.3	(0.0–0.6)	12	0.7	(0.2–1.2)	18	0.5	(0.2–0.7)
3 or more	1	0.1	(0.0–0.3)	3	0.4	(0.0–0.9)	4	0.2	(0.0–0.5)
Experience confusion/memory Problems	174	11.7	(9.2–14.2)	144	11.1	(8.8–13.5)	318	11.4	(9.7–13.2)

Characteristic	Never smokers			Former smokers			Total non-smokers		
	n	Weighted %	or mean (95% CI)	n	Weighted %	or mean (95% CI)	n	Weighted %	or mean (95% CI)
Cognitive Performance Score ^b	1141	46.6	(45.0–48.2)	968	47.9	(46.1–49.7)	2109	47.8	(46.4–49.1)
Difficulty walking for a quarter mile	171	13.7	(10.9–16.5)	116	11.1	(8.3–13.9)	287	12.5	(10.3–14.8)
Difficulty walking up 10 steps	96	7.8	(5.4–10.2)	91	7.9	(6.1–9.8)	187	7.9	(6.0–9.7)
gait speed (m/s)	1208	0.93	(0.91–0.95)	1007	0.97	(0.94–0.99)	2215	0.95	(0.93–0.97)
Lead (ug/dL)	1350	0.45	(0.43–0.48)	1100	0.56	(0.53–0.58)	2450	2.6	(2.4–2.7)
Cotinine (ng/mL)	1350	0.15	(0.11–0.18)	1100	0.20	(0.15–0.24)	2450	0.17	(0.14–0.20)

^a Poverty income ratio—a ratio of family income to poverty threshold.

^{*} Self-reported doctor's diagnosis.

^b Digit symbol substitution test (0–133).

Table 3

Logistic and linear regression models for cognitive performance score and gait speed by cotinine, NHANES 1999–2002.

	Never smokers		Former smokers			
	Model one ^a	Model two ^b	Model three ^c	Model one ^a	Model two ^b	Model three ^c
Logistic regression						
Self-reported confusion and memory problems	1.16 (0.98,1.37)	1.14 (0.92,1.41)	1.12 (0.90,1.40)	1.01 (0.82,1.24)	1.04 (0.83,1.29)	1.03 (0.83,1.28)
Difficulty walking for a quarter mile	1.04 (0.85,1.27)	1.03 (0.83,1.28)	1.01 (0.80,1.28)	1.18 (1.02,1.38)	1.21 (1.00,1.47)	1.22 (1.00,1.48)
Difficulty walking up 10 steps	1.14 (0.89,1.46)	1.17 (0.88,1.56)	1.15 (0.84,1.58)	1.01 (0.85,1.20)	1.07 (0.86,1.34)	1.09 (0.87,1.37)
Linear regression						
Gait speed (m/s)	−0.02 (−0.04,−0.00)	−0.02 (−0.04,0.00)	−0.02 (−0.04,0.00)	−0.02 (−0.03,−0.00)	−0.02 (−0.03,−0.00)	−0.02 (−0.03,−0.00)
Cognitive performance score	−2.03 (−3.00,−1.05)	−1.93 (−3.01,−0.84)	−1.17 (−2.32,−0.02)	−0.93 (−1.60,−0.27)	−0.92 (−1.60,−0.25)	−0.91 (−1.62,−0.20)

^a Adjusted for age, gender, education, race/ethnicity.

^b Adjusted for age, gender, education, race/ethnicity, diabetes, hypertension, body mass index (BMI), and alcohol.

^c Adjusted for age, gender, education, race/ethnicity, diabetes, hypertension, BMI, alcohol, stroke, and heart attack.