

- Even low levels of secondhand smoke may harm memory and thinking in older adults who never smoked.
- Creating smoke-free spaces can help protect brain health in aging populations.

Secondhand Smoke Exposure and Cognitive Function in U.S. Never-Smoking Older Adults

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Background

Secondhand smoke (SHS) is a pervasive environmental neurotoxin, yet evidence linking biomarker-measured SHS exposure to domain-specific cognitive decline in older never-smokers remains limited. This study investigates how serum cotinine-based SHS exposure associates with cognitive performance and explores sociodemographic/lifestyle modifiers.

Objective

This study addresses these gaps to test two hypotheses:

- 1.Higher SHS exposure is associated with poorer performance in domain-specific cognitive tasks among never-smoking older adults.
- 2.Sociodemographic and lifestyle factors attenuate or exacerbate these associations.

Methods

We analyzed 2011–2014 NHANES data from 1,211 never-smokers aged ≥60 years. SHS exposure was categorized into four groups (unexposed to high) using serum cotinine. Cognitive function was assessed via CERAD (immediate/delayed recall), Animal Fluency, and Digit Symbol Substitution. Survey-weighted linear regression models evaluated associations across three adjustment levels: demographics (age, sex, race), socioeconomic factors (education, income), and lifestyle (BMI, physical activity). Subgroup and sensitivity analyses tested effect modification and robustness to unmeasured confounding.

Findings

Moderate SHS exposure (0.02–0.04 ng/mL) was associated with deficits in delayed recall (β = -0.49, 95% CI: -0.99, -0.04) and executive function (β = -2.33, -4.45, -0.21) after full adjustment, whereas high exposure (>0.04 ng/mL) showed no consistency dose-response. Vulnerable subgroups included adults aged ≥80 (β = -1.10, -2.11, -0.09), married individuals (β = -0.58, -1.16, -0.002), and those with high school education (β = -0.96, -1.89, -0.04). Physical activity moderated SHS effects on delayed recall (interaction p = 0.033).

	Overall N = 1,211	Unexposed N = 596	Low N = 182	Moderate N = 181	High N = 252	p-Value ^b
Unweighted NHANES sample	N = 22,978,3404	N = 13,150,9591	N = 3,423,7421	N = 2,631,0571	N = 3,772,5821	
Age (years)	69.54 (6.87)	70.38 (7.01)	69.29 (6.81)	68.99 (6.63)	68.11 (6.47)	0.219
Gender						0.770
Male	437 (36)	192 (32)	69 (38)	73 (40)	103 (41)	
Female	774 (64)	404 (68)	113 (62)	108 (60)	149 (59)	
Race/ethnicity						P < 0.001
Mexican American	104 (8)	62 (10)	13 (7)	14 (7)	15 (5.50)	
Other Hispanic	128 (11)	71 (12)	17 (9)	25 (14)	15 (5.50)	
Non-Hispanic White	589 (49)	349 (59)	83 (46)	72 (40)	85 (34)	
Non-Hispanic Black	253 (21)	67 (11)	42 (23)	36 (20)	108 (43)	
Other race (including Multi-Racial Individuals)	137 (11)	47 (7.90)	27 (15)	34 (19)	29 (12)	
Education level						P < 0.001
Less than high school	261 (22)	107 (18)	40 (22)	43 (24)	71 (28)	
High school graduate	269 (22)	115 (19)	35 (19)	48 (27)	71 (28)	
Some college or above	681 (56)	374 (63)	107 (59)	90 (50)	110 (44)	
Marital status						0.042
Married	693 (57)	372 (62)	105 (58)	91 (50)	125 (50)	
Otherwise	518 (43)	224 (38)	77 (42)	90 (50)	127 (50)	
Employment status						0.956
Employed	369 (30)	172 (29)	56 (31)	58 (32)	83 (33)	
Unemployed	842 (70)	424 (71)	126 (69)	123 (68)	169 (67)	
Ratio of family income to poverty						P < 0.001
Low	186 (15)	61 (10)	24 (13)	35 (19)	66 (26)	
Middle	673 (56)	329 (55)	98 (54)	104 (57)	142 (56)	
High	352 (29)	206 (35)	60 (33)	42 (23)	44 (17)	
Health insurance						0.049
Yes	1,108 (91)	554 (93)	168 (92)	165 (91)	221 (88)	
No	103 (9)	42 (7)	14 (8)	16 (9)	31 (12)	
BMI (kg/m^2)						0.144
Underweight (<18.5)	16 (2)	7 (1)	3 (2)	2 (1)	4 (2)	
Normal weight (18.5–24.9)	306 (25)	166 (28)	37 (20)	50 (28)	53 (21)	
Overweight (25–29.9)	423 (35)	209 (35)	74 (41)	66 (36)	74 (29)	
Obese (≥ 30)	466 (38)	214 (36)	68 (37)	63 (35)	121 (48)	
PA recommendation ^c						0.438
Yes	610 (50)	307 (52)	88 (48)	100 (55)	115 (46)	
No	601 (50)	289 (48)	94 (52)	81 (45)	137 (54)	
CERAD-immediate recall score	19.17 (4.85)	19.46 (4.81)	19.07 (4.86)	18.78 (5.10)	18.85 (4.71)	0.051
CERAD-delay recall score	6.05 (2.42)	6.18 (2.43)	5.83 (2.62)	5.89 (2.38)	6.03 (2.27)	0.038
Animal fluency test score	16.74 (5.52)	17.33 (5.48)	16.77 (6.17)	16.20 (5.33)	15.69 (5.08)	0.005
Digit symbol substitution test score	47.52 (17.26)	49.44 (17.04)	47.75 (17.24)	45.38 (17.31)	44.34 (17.22)	0.040

Abbreviation: SD, standard deviation; BMI, Body mass index.
*Descriptive statistics are presented as mean (SD) or N (%) for the unweighted NHANES sample (N=1,211). p-Values were derived from weighted analyses to account for NHANES' complex survey design and provide nationally representative inferences.
^bp-Values were derived from Chi-square test and F-test using the survey-weighted regression model.
^cParticipants were classified as either meeting or not meeting the Physical Activity recommendation (≥150 minutes of moderate-intensity or ≥75 minutes of vigorous-intensity activity per week), based on their responses to the Global Physical Activity Questionnaire (GPAQ).

Conclusions

Moderate SHS exposure is associated with domain-specific cognitive impairment in older never-smokers, independent of socioeconomic confounders. The lack of a monotonic dose-response may indicate threshold effects Clinicians should prioritize cotinine screening for cognitively impaired older adults in high-exposure settings. Policy interventions enforcing smoke-free environments, paired with longitudinal studies using biomarker studies, are critical to mitigate dementia risk.

Findings

	Low			Moderate			High			p for interaction ^b
	β	95% CI	p-Values	β	95% CI	p-Values	β	95% CI	p-Values	
Age Group										
60-69	-0.65	(-1.64, 0.34)	0.179	-0.16	(-0.86, 0.53)	0.614	0.47	(-1.11, 0.18)	0.143	0.135
70-79	-0.06	(-0.99, 0.88)	0.898	-0.73	(-1.72, 0.25)	0.131	0.32	(-0.30, 0.95)	0.284	
>= 80	-0.28	(-1.24, 0.68)	0.515	-1.10	(-2.11, -0.09)	0.037	0.27	(-1.09, 1.63)	0.653	
Gender Group										
Male	-0.65	(-1.75, 0.46)	-0.647	-0.61	(-1.52, 0.30)	0.170	0.56	(-1.48, 0.35)	0.208	0.403
Female	-0.43	(-1.19, 0.33)	0.244	-0.39	(-1.03, 0.25)	0.211	0.03	(-0.48, 0.42)	0.897	
Education Group										
Less than high school	0.52	(-0.31, 1.34)	0.199	0.52	(-0.41, 1.45)	0.245	0.30	(-1.01, 0.42)	0.386	0.489
High school	-0.76	(-2.11, 0.60)	0.241	-0.96	(-1.89, -0.04)	0.043	0.10	(-1.14, 0.95)	0.839	
Some college or above	-0.57	(-1.34, 0.19)	0.130	-0.48	(-1.03, 0.07)	0.081	0.21	(-0.87, 0.45)	0.508	
Marital status										
Married	-0.61	(-1.56, 0.33)	0.183	-0.58	(-1.16, -0.002)	0.049	0.63	(-1.16, -0.10)	0.023	0.118
Otherwise	-0.23	(-0.96, 0.51)	0.519	-0.15	(-0.84, 0.53)	0.639	0.37	(-0.17, 0.92)	0.162	
Employment status										
Employed	-0.17	(-1.19, 0.85)	0.719	-0.66	(-1.65, 0.33)	0.174	0.53	(-1.47, 0.41)	0.242	0.255
Unemployed	-0.69	(-1.45, 0.07)	0.072	-0.38	(-1.13, 0.36)	0.288	0.13	(-0.69, 0.42)	0.606	
PA recommendation										
Yes	0.30	(-0.51, 1.11)	0.436	-0.60	(-1.16, -0.03)	0.04	0.05	(-0.55, 0.66)	0.86	0.033
No	-1.38	(-2.15, -0.62)	0.002	-0.26	(-1.07, 0.55)	0.50	0.59	(-1.30, 0.11)	0.09	

Abbreviation: CI: Confidence interval; Ref: Reference.
*All models adjusted for covariates from Model 3 (age, sex, race, education, poverty ratio, marital status, employment, BMI, and PA), except for the stratification variables. The unexposed SHS group was used as the reference group in the analysis.
^bp-Values for interaction derived from Wald test from weighted regression analyses.

	Low			Moderate			High			P for interaction ^b
	β	95% CI	p-Values	β	95% CI	p-Values	β	95% CI	p-Values	
Age Group										
60-69	-0.47	(-5.29, 4.34)	0.834	-1.68	(-5.06, 1.70)	0.300	0.02	(-4.17, 4.20)	0.99	0.230
70-79	1.58	(-2.90, 6.07)	0.457	-3.13	(-8.02, 1.75)	0.188	2.22	(-2.62, 7.05)	0.34	
>= 80	-2.95	(-10.35, 4.45)	0.378	-0.81	(-5.45, 3.83)	0.692	-4.04	(-12.95, 4.87)	0.319	
Gender Group										
Male	0.22	(-2.69, 3.13)	0.873	-2.58	(-5.64, 0.48)	0.092	-1.83	(-6.87, 3.21)	0.446	
Female	-0.90	(-4.19, 2.40)	0.567	-2.14	(-5.86, 1.58)	0.236	0.51	(-2.35, 3.37)	0.708	0.557
Education Group										
Less than high school	4.51	(-0.26, 9.28)	0.062	-2.37	(-6.45, 1.72)	0.230	-3.89	(-7.85, 0.06)	0.053	
High school	-1.44	(-5.85, 2.97)	0.483	0.41	(-4.22, 5.04)	0.848	4.73	(-3.82, 13.28)	0.246	
Some college or above	-1.04	(-4.33, 2.25)	0.509	-3.23	(-6.05, -0.41)	0.028	-1.40	(-4.71, 1.91)	0.379	0.169
Marital status										
Married	-0.82	(-3.68, 2.04)	0.546	-2.09	(-4.71, 0.52)	0.108	-0.79	(-5.11, 3.52)	0.698	
Otherwise	-0.66	(-4.84, 3.51)	0.736	-1.42	(-5.58, 2.74)	0.475	0.20	(-4.24, 4.64)	0.924	0.982
Employment status										
Employed	2.08	(-3.15, 7.30)	0.404	-3.44	(-7.78, 0.91)	0.111	1.06	(-3.77, 5.89)	0.641	
Unemployed	-1.48	(-4.93, 1.97)	0.371	-1.96	(-5.79, 1.88)	0.290	-1.50	(-5.61, 2.60)	0.443	0.544
PA recommendation										
Yes	0.20	(-3.25, 3.64)	0.904	-3.20	(-5.71, -0.70)	0.016	0.10	(-2.57, 2.77)	0.937	
No	-1.40	(-5.32, 2.520)	0.455	-1.13	(-5.36, 3.10)	0.574	-0.94	(-6.38, 4.51)	0.716	0.732

Abbreviation: CI: Confidence interval; Ref: Reference.
*All models adjusted for covariates from Model 3 (age, sex, race, education, poverty ratio, marital status, employment, BMI, and PA), except for the stratification variables. The unexposed SHS group was used as the reference group in the analysis.
^bp-Values for interaction derived from Wald test from weighted regression analyses.