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RESEARCH ARTICLE

Tobacco Smoke Exposure, School Engagement, School Success, and Afterschool Activity Participation Among US Children

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ABSTRACT

BACKGROUND: Tobacco smoke exposure (TSE), defined as secondhand smoke (SHS) and thirdhand smoke (THS), is associated with negative health consequences. This study's objective was to assess the associations between home TSE status and school engagement, school success, and afterschool activity participation among school-aged children.

METHODS: We conducted a secondary analysis of 2018-2019 National Survey of Children's Health cross-sectional data. Children ages 6-11 years (N = 17,466) were categorized into home TSE groups: no home TSE; THS exposure only; and SHS and THS exposure. Weighted logistic and Poisson regression models were built.

RESULTS: Compared to children with no home TSE, children with home THS exposure only and SHS and THS exposure were at decreased odds of being engaged in school (AOR = 0.69, 95%CI = 0.57, 0.83; AOR = 0.63, 95%CI = 0.41, 0.97, respectively), and at increased odds of having ≥1 school-to-home contact about child problems in school (AOR = 1.83, 95%CI = 1.50, 2.23; AOR = 1.58, 95%CI = 1.05, 2.37, respectively). Children with THS exposure only were at increased odds of missing ≥1 school day (AOR = 1.43, 95%CI = 1.13, 1.81). Children with THS exposure only (ARR = 0.90, 95%CI = 0.83, 0.96) and SHS and THS exposure (ARR = 0.74, 95%CI = 0.61, 0.89) were at reduced likelihood of participating in a higher number of afterschool activities.

CONCLUSIONS: Children exposed to home tobacco smoke are at unique risk for poorer school engagement and success.

Keywords: alcohol; tobacco; and other drugs; environmental health; tobacco smoke pollution; child; school engagement; school success.

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Concerning US tobacco product use patterns, 15% of adults smoke combustible tobacco products including cigar products, pipes, and water pipes.[1] Concerning US rates of tobacco smoke exposure (TSE), approximately 1-in-3 children are exposed to tobacco smoke, and higher rates are observed among children who are younger, non-Hispanic black, and live below the poverty level.[2,3] When children are exposed to tobacco smoke, they may be exposed to secondhand smoke (SHS) and/or thirdhand smoke (THS).[4] SHS exposure can occur via inhalation if children are present during or shortly after combustible tobacco products are lit. THS exposure can occur via inhalation, dermal absorption, or ingestion of tobacco smoke pollutant residue that remains and forms a persistent reservoir in environments where tobacco products have been previously used days to years later.[4] TSE, defined as SHS and/or THS exposure, is associated with

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many known adverse pediatric health consequences such as asthma, otitis media, and viral illnesses.[5-7] Additionally, there is evidence that TSE is associated with a number of neurodevelopmental conditions such as attention-deficit hyperactivity disorder, behavioral problems, cognitive deficits, as well as decreased academic performance and declines in overall health and physical fitness.[8-14]

Given the myriad of illnesses and conditions that are associated with TSE, prior research indicates that school-aged children who live with tobacco smokers may have decreased school engagement and school activity participation because of frequent school absences and TSE-related symptoms, conditions, and other consequences.[9,11,14,15] School engagement is a multifaceted construct consisting of behavioral, cognitive, and emotional dimensions.[16-18] Briefly, behavioral engagement in school consists of the student's class attendance, paying attention in class, completing school tasks, following school rules, and participating in school activities.[19-21] Cognitive engagement includes the student's individual effort, self-regulation, and problem-solving activities.[18,21] Emotional engagement in school is exhibited by the student being connected and/or identifying to the school, and having positive feelings toward the school, personnel (eg, teachers), and fellow classmates.[20-22] Lower levels of school engagement may lead to declines in areas that are also associated with TSE among children, such as decreased academic performance, maladaptive behavior, and lower educational attainment due to school drop-out.[23-26] Further, prior research indicates that children who lived with tobacco smokers missed a higher number of school days compared to children who did not live with smokers, which totaled about $227 million per year of lost work for parental smokers while caring for their sick children.[27]

To date, there are limited studies about the associations between TSE, including assessment of exposure patterns of THS and/or SHS from combustible tobacco products in children's homes, and school engagement and success among US children. Additionally, to our knowledge, no studies examine the associations between TSE and participation in afterschool activities, which can contribute to overall school engagement and success. Several of the studies that have examined TSE and school engagement have focused on older children or on academic achievement such as grades or the results of cognitive tests.[8,9,11,14] In this study, we sought to address these gaps by assessing whether children's home TSE status was associated with school engagement and several factors indicative of challenges pertaining to school success including: missed school days; school-to-home contacts about any problems with school; and history of repeating a school grade. This study focused on TSE from combustible cigarettes, cigars, and pipe tobacco smoked in children's homes, which did not include the assessment of exposure to noncombustible tobacco products such as electronic cigarettes (e-cigarettes). We hypothesized that when compared to children with no home TSE (ie, did not live with a household tobacco smoker), children exposed to home THS exposure only (ie, lived with a household combustible tobacco smoker who did not smoke inside the home) and home SHS and THS exposure (ie, lived with a household combustible tobacco smoker who smoked inside the home) would be less engaged in school and have higher factors indicative of school success challenges (eg, miss $\geq$1 school day). Another study objective was to assess the associations between child home TSE status and participation in afterschool activities overall, and by activity type including sports teams or lessons, clubs or organizations, and other activities or lessons (eg, music, dance). We posited that when compared to children with no home TSE, children with home THS exposure only and children with home SHS and THS exposure would be less likely to participate in afterschool activities overall and by activity type.

METHODS

Participants and Procedure

We conducted a secondary analysis of the 2018-2019 National Survey of Children's Health (NSCH) data.[28] NSCH is national-level data that provides information about the physical health, emotional health, and overall well-being of noninstitutionalized children ages 0-17 years. Households were randomly sampled and initially reached by mail invitation asking a parent to complete a screener questionnaire identifying all children residing in the household. If more than 1 child was reported in the household, 1 child was randomly selected, and a detailed age-specific topical questionnaire was completed by the parent. Comprehensive information about the study methodology is compiled in NSCH documentation available for reference elsewhere.[29,30]

The current study included 17,466 US children who participated in the NSCH 2018-2019 topical questionnaire for the school-aged group of children ages 6-11 years. Children in the other NSCH topical questionnaire age groups (ie, 0-5 and 12-17 years old) and those missing data on child home TSE status were excluded from the current study. The University of Cincinnati's institutional review board approved this study with a ''not human subjects research'' determination.

Instrumentation

Home TSE status. The independent variable of interest of this study was home TSE status, which was calculated using the yes/no question: (1) ''Does

anyone living in your household use cigarettes, cigars, or pipe tobacco?'' and follow-up yes/no question: (2) ''If yes, does anyone smoke inside your home?'' Children were classified based on the responses to both TSE questions into 3 child home TSE status levels: (1) no one living in the child's household used tobacco (ie, no home TSE); (2) someone living in the child's home used combustible tobacco products, but did not smoke inside the child's home (ie, home THS exposure only proxy); and (3) someone living in the child's home used combustible tobacco products and smoked inside the child's home (ie, home THS and SHS exposure proxy).

School engagement. One of the dependent variables, school engagement, was measured using the following 2 questions: (1) ''Does this child care about doing well in school?'' and (2) ''Does this child do all required homework?'' Original response options were: ''always,'' ''usually,'' ''sometimes,'' and ''never.'' The NSCH provided a composite, dichotomized variable that measures the national indicator of school engagement, which defined children who ''always'' cared about doing well in school and ''always'' did all required homework as engaged in school. This NSCH-provided variable was used in the current study due to the positive skewedness of the original scale responses.

School success. One school success-related dependent variable, missed school days, was measured using the following question: ''During the past 12 months, about how many days did this child miss school because of illness or injury?'' Response options were: ''0 days,'' ''1-3 days,'' ''4-6 days,'' ''7-10 days,'' and ''11 or more days.'' Based on the ordinal scale distribution, response options were dichotomized for analysis into: 0 days versus ≥1 day.

The dependent variable, school-to-home contacts about any child problems with school, was measured using the following question: ''During the past 12 months, how many times has this child's school contacted you or another adult in your household about any problems he or she is having with school?'' Response options were: ''none,'' ''1 time,'' and ''2 or more times.'' Based on the ordinal scale distribution, response options were dichotomized for analysis into: none versus ≥1 time.

The dependent variable, child history of repeating a school grade, was measured using the following yes/no question: ''Since starting kindergarten, has this child repeated any grades?'' Child history of repeating a school grade was analyzed in the current study as a dichotomized variable using the original yes/no response options.

Afterschool activities participation. Several dependent variables were related to children's afterschool activity participation, which were measured using the following yes/no questions: ''During the past 12 months, did this child participate in: (1) A sports team or did he or she take sports lessons after school or on weekends?'' (2) ''Any clubs or organizations after school or on weekends?'' and (3) ''Any other organized activities or lessons, such as music, dance, language, or other arts?'' Each activity was assessed individually as well as combined. Specifically, the NSCH provided a composite yes/no variable on whether children participated in organized activities after school during the past 12 months (ie, no defined as the child did not participate in any afterschool activities and yes defined as the child participated in sports teams/lessons, clubs/organizations, and/or any other organized activities/lessons). In addition, the NSCH provided a composite count variable on the number of organized activities children participated in after school (range 0-3). Both of these composite variables, including the dichotomized variables using the original yes/no response options and the count variable using the original response scale ranging from 0 to 3, were included in the current study's analyses.

Sociodemographic characteristics. Respondents reported their child's age, sex, and race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic other/multiracial, and Hispanic). Respondents were also asked the yes/no question, ''Was this child born more than 3 weeks before his or her due date?'' Children born 3 weeks prior to their due date were considered as being born premature, which was important to consider in the current analysis since prematurity is a long-term risk factor for impaired behavioral and socioemotional functioning among children.[31] Parent respondents also reported on their highest education level, the child's family household structure (2 parents who were currently married, 2 parents who were not currently married, single parent, and other family structure), and household income level. To protect participants' confidentiality, NSCH did not publicly provide income level, but provided a calculated federal poverty level variable derived from State Children's Health Insurance Program groupings (0-199%, 200-299%, 300-399%, ≥400%).

Data Analysis

The NSCH was designed to provide generalizable estimates for US children and sampling weights were applied to the current study's analyses using SPSS Complex Samples (version 28.0) and Stata SE (version 16.1). Descriptive statistics were calculated for all variables of interest, and unweighted sample size counts and weighted percents are presented. To assess the associations between sociodemographic characteristics and child home TSE status, a weighted analysis of variance (ANOVA) test was computed for

the continuous variable of child age and a series of weighted chi-square tests were computed for the categorical variables such as child sex. Eight weighted unadjusted logistic regression models were initially fitted to assess the associations between child home TSE status and school engagement, child missed school days, school-to-home contacts about any child problems with school, history of repeating a school grade, and participates in afterschool activities overall and by activity type including sports teams/lessons, clubs/organizations, and/or other activities/lessons. Unadjusted odds ratios (ORs) and 95% confidence intervals (95%CIs) are presented. Then, 8 weighted multivariable logistic regression models were fitted to assess whether the covariates attenuated the crude associations between child home TSE status and the categorical outcome variables. Adjusted ORs (AORs) and 95% confidence intervals (95%CIs) are presented. Additionally, weighted unadjusted and adjusted Poisson regression models were fitted to assess the association between child home TSE status and the count outcome variable of the number of activities the child participates in after school. For the unadjusted Poisson model, the unadjusted relative risk ratio (RR) and 95%CI is presented, and for the adjusted Poisson model, the adjusted RR (ARR) ratios and 95%CIs are presented. All adjusted logistic and Poisson regression models included the covariates of child's age, sex, and race/ethnicity; parent education level; family household structure and federal poverty level. Statistical significance was indicated by $p < .05$ for analyses.

RESULTS

Table 1 presents sample characteristics of school-aged children by their home TSE status. Of the 17,466 6- to 11-year-olds, the mean (±SE) age was 8.56 (±0.03) and about half (49.2%) were girls and non-Hispanic white (50.8%). A total of 11.9% of children were born premature. Half (50.0%) of children's parents obtained a college degree or higher and the majority (63.9%) of children lived with 2 parents who were currently married. Federal poverty level varied with 40.0% of children in the lowest category of 0-199% and 31.8% of children in the highest category of ≥400%.

Sociodemographics by Child Home TSE Status

A total of 85.4% (n = 14,865) of children had no home TSE, 12.9% (n = 2304) had home THS exposure only, and 1.8% (n = 297) had home SHS and THS exposure. Child race/ethnicity, parent education level, family household structure, and federal poverty level significantly differed based on home TSE status (see Table 1).

Child Home TSE Status by School Engagement

A total of 52.3% (n = 8720) of children were engaged in school. By home TSE status, 54.0%, 42.9%, and 37.5% of children were engaged in school with no home TSE, home THS exposure only, and home SHS and THS exposure, respectively. Unadjusted logistic regression model results indicated that children with home THS exposure only and home SHS and THS exposure were at decreased odds of being engaged in school (Table 2). Similarly, adjusted model results indicated that compared to children with no home TSE, children with home THS exposure only (AOR = 0.69, 95%CI = 0.57, 0.83) and home SHS and THS exposure (AOR = 0.63, 95%CI = 0.41, 0.97) were at decreased odds of being engaged in school, while controlling for child age, sex, race/ethnicity, and parent education level, family household structure, and federal poverty level (Table 3).

Child Home TSE Status by School Success

Over the past 12 months, a total of 27.5% (n = 3973) of children missed 0 school days and 72.5% (n = 13,493) missed ≥1 school day. By home TSE status, 71.7%, 77.8%, and 71.5% of children missed ≥1 school day with no home TSE, home THS exposure only, and home SHS and THS exposure, respectively. Unadjusted and adjusted logistic regression model results indicated that children with home THS exposure only were at increased odds to miss ≥1 school day than children with no home TSE (see Tables 2 and 3).

Over the past 12 months, 70.4% (n = 12,253) of children's parents were not contacted about any child problems with school and 29.6% (n = 5213) of children's parents were contacted ≥1 time. By home TSE status, 27.6%, 41.7%, and 40.5% of children's parents were contacted ≥1 time with no home TSE, home THS exposure only, and home SHS and THS exposure, respectively. Unadjusted and adjusted logistic regression model results indicated that children with home THS exposure only and home SHS and THS exposure were at increased odds of having ≥1 school-to-home contact about child problems in school compared to children with no home TSE (see Tables 2 and 3).

Only 4.6% (n = 783) of children repeated a school grade. By home TSE status, 4.2%, 7.2%, and 8.9% of children repeated a school grade with no home TSE, home THS exposure only, and home SHS and THS exposure, respectively. Unadjusted logistic regression model results indicated that children with home THS exposure only (OR = 1.77, 95%CI = 1.24, 2.53) and home SHS and THS exposure (OR = 2.24, 95%CI = 1.32, 3.82) were at increased odds of repeating a school grade compared to children with no home TSE (see Table 2). Conversely, adjusted model

Table 1. **Sample Characteristics of US School-Aged Children by Home TSE Status, 2018-2019 NSCH**

Characteristics	Overall (N = 17,466) n (%)*	Home TSE Status			p-Value
		No Home TSE (n = 14,865) n (%)*	THS Exposure Only (n = 2304) n (%)*	SHS and THS Exposure (n = 297) n (%)*	
Child age, mean (SE)	8.56 (0.03)	8.55 (0.03)	8.58 (0.07)	8.61 (0.18)	.841
Child sex					.748
Boys	9063 (50.8)	7727 (51.0)	1171 (49.4)	165 (52.2)	
Girls	8403 (49.2)	7138 (49.0)	1133 (50.6)	132 (47.8)	
Child race/ethnicity					**<.001**
Non-Hispanic white	11, 947 (50.8)	10, 080 (49.5)	1656 (57.3)	221 (65.3)	
Non-Hispanic black	1144 (13.3)	989 (13.6)	113 (10.4)	42 (19.9)	
Hispanic	2137 (24.8)	1874 (25.6)	251 (22.3)	12 (6.1)	
Non-Hispanic other/multiracial	2238 (11.1)	1922 (11.3)	284 (10.0)	32 (8.7)	
Child premature birth					.079
No	15, 505 (88.1)	13, 255 (88.5)	1990 (85.5)	260 (90.3)	
Yes	1961 (11.9)	1610 (11.5)	314 (14.5)	37 (9.7)	
Parent education level					**<.001**
≤High school graduate/equivalent	2656 (27.3)	1926 (25.0)	591 (38.5)	139 (58.6)	
Some college	4264 (22.7)	3248 (21.0)	893 (33.0)	123 (35.2)	
≥College degree	10, 546 (50.0)	9691 (54.0)	820 (28.5)	35 (6.3)	
Family household structure					**<.001**
Two parents, currently married	11, 935 (63.9)	10, 616 (66.2)	1220 (53.3)	99 (26.5)	
Two parents, not currently married	1225 (8.2)	878 (7.6)	295 (11.4)	52 (13.9)	
Single parent	3317 (20.9)	2627 (19.7)	589 (27.6)	101 (34.1)	
Other family structure	989 (7.0)	744 (6.5)	200 (7.7)	45 (25.5)	
Federal poverty level					**<.001**
0-199%	5028 (40.0)	3841 (37.2)	984 (53.5)	203 (81.6)	
200%-299%	2914 (16.1)	2396 (15.9)	464 (18.0)	54 (11.8)	
300%-399%	2522 (12.1)	2225 (12.6)	279 (9.7)	18 (3.4)	
≥400%	7002 (31.8)	6403 (34.3)	577 (18.8)	22 (3.2)	

NSCH, National Survey of Children's Health; SHS, secondhand smoke exposure; THS, thirdhand smoke exposure; TSE, tobacco smoke exposure.
*n refers to unweighted sample size and % refers to weighted column percent, unless noted otherwise. Bold font indicates statistical significance $p < .05$.

Table 2. **Unadjusted Logistic Regression Model Results of Child Home TSE Status With School Engagement and Success Among US School-Aged Children, 2018-2019 NSCH**

	Child is Engaged in School			Child Missed School ≥1 Day			≥ 1 School-to-Home Contact About Any Child Problems With School			Child Repeated School Grade		
	OR*	95% CI	p-Value	OR†	95% CI	p-Value	OR‡	95% CI	p-Value	OR*	95% CI	p-Value
Child home TSE status												
No home TSE	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
THS exposure only	**0.64**	**0.53, 0.77**	**<.001**	**1.38**	**1.11, 1.73**	**.004**	**1.88**	**1.55, 2.27**	**<.001**	**1.77**	**1.24, 2.53**	**.002**
SHS and THS exposure	**0.51**	**0.34, 0.78**	**.002**	0.99	0.58, 1.70	.970	**1.78**	**1.20, 2.66**	**.004**	**2.24**	**1.32, 3.82**	**.003**

CI, confidence interval; NSCH, National Survey of Children's Health; OR, odds ratio; Ref, reference group; SHS, secondhand smoke exposure; THS, thirdhand smoke exposure; TSE, tobacco smoke exposure.
Bold font indicates statistical significance $p < .05$.
*Weighted unadjusted logistic regression models with reference category as "no."
†Weighted unadjusted logistic regression model with reference category as "0 days."
‡Weighted unadjusted logistic regression model with reference category as "none."

results indicated no differences between child home TSE status and child history of repeating a school grade (see Table 3).

Child Home TSE Status by Afterschool Activity Participation

A total of 79.1% (n = 14,717) of children participated in at least 1 afterschool activity, with 20.9% (n = 2749) participating in no activities, 27.7% (n = 4442) participating in 1 activity, 28.2% (n = 5413) participating in 2 activities, and 23.2% (n = 4862) participating in all 3 activities including sports teams/lessons, clubs/organizations, and other activities/lessons. By home TSE status, 81.1%, 68.9%, and 54.8% of children participated in at least 1 afterschool activity with no home TSE, home THS

Table 3. **Adjusted Logistic Regression Model Results of Child Home TSE Status With School Engagement and Success Among US School-Aged Children, 2018-2019 NSCH**

	Child is Engaged in School			Child Missed School ≥1 Day			≥ 1 School-to-Home Contact About Any Child Problems With School			Child Repeated School Grade		
	AOR*	95% CI	*p*-Value	AOR†	95% CI	*p*-Value	AOR‡	95% CI	*p*-Value	AOR*	95% CI	*p*-Value
Child home TSE status												
No home TSE	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
THS exposure only	**0.69**	**0.57, 0.83**	**<.001**	**1.43**	**1.13, 1.81**	**.003**	**1.83**	**1.50, 2.23**	**<.001**	1.39	0.96, 2.03	.084
SHS and THS exposure	**0.63**	**0.41, 0.97**	**.034**	1.21	0.71, 2.08	.489	**1.58**	**1.05, 2.37**	**.028**	1.33	0.75, 2.37	.329
Child age	**0.94**	**0.91, 0.98**	**<.001**	**0.95**	**0.91, 0.99**	**.012**	1.01	0.97, 1.05	.705	**1.25**	**1.16, 1.34**	**<.001**
Child sex												
Boys	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Girls	**1.96**	**1.73, 2.22**	**<.001**	1.04	0.90, 1.20	.630	**0.65**	**0.56, 0.75**	**<.001**	**0.61**	**0.45, 0.83**	**.002**
Child race/ethnicity												
Non-Hispanic white	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Non-Hispanic black	**1.66**	**1.35, 2.05**	**<.001**	**0.49**	**0.39, 0.61**	**<.001**	**1.39**	**1.13, 1.71**	**.002**	1.08	0.70, 1.66	.733
Hispanic	**1.29**	**1.06, 1.55**	**.009**	**0.66**	**0.54, 0.82**	**<.001**	**1.33**	**1.08, 1.64**	**.007**	0.93	0.63, 1.37	.718
Non-Hispanic other/multiracial	**1.21**	**1.01, 1.45**	**.043**	**0.65**	**0.53, 0.79**	**<.001**	0.90	0.75, 1.09	.295	0.94	0.61, 1.47	.794
Child premature birth												
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.93	0.77, 1.14	.493	0.94	0.73, 1.21	.613	1.17	0.94, 1.45	.157	**1.89**	**1.31, 2.74**	**<.001**
Parent education level												
≤High school graduate/equivalent	0.97	0.80, 1.17	.723	0.93	0.75, 1.16	.530	1.02	0.82, 1.25	.879	**2.46**	**1.73, 3.49**	**<.001**
Some college	0.96	0.82, 1.12	.573	1.03	0.85, 1.25	.751	1.01	0.86, 1.20	.880	**1.51**	**1.11, 2.05**	**.008**
≥College degree	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Family household structure												
Two parents, currently married	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Two parents, not currently married	0.83	0.65, 1.07	.159	1.07	0.80, 1.44	.647	**1.45**	**1.11, 1.88**	**.006**	1.02	0.59, 1.77	.944
Single parent	**0.72**	**0.60, 0.85**	**<.001**	1.08	0.89, 1.32	.417	**1.39**	**1.16, 1.68**	**<.001**	1.12	0.76, 1.66	.569
Other family structure	**0.64**	**0.48, 0.84**	**.002**	**0.61**	**0.45, 0.83**	**.002**	**1.33**	**1.01, 1.76**	**.042**	1.44	0.89, 2.36	.138
Federal poverty level												
0-199%	0.91	0.77, 1.08	.265	**0.68**	**0.56, 0.82**	**<.001**	1.08	0.89, 1.30	.438	**1.69**	**1.22, 2.35**	**.002**
200%-299%	0.84	0.70, 1.01	.051	0.83	0.67, 1.03	.083	1.10	0.89, 1.35	.375	1.34	0.88, 2.04	.172
300%-399%	1.08	0.89, 1.30	.437	0.87	0.68, 1.12	.276	0.91	0.73, 1.13	.384	1.47	0.95, 2.29	.088
≥400%	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref

AOR, adjusted odds ratio; CI, confidence interval; NSCH, National Survey of Children's Health; Ref, reference group; SHS, secondhand smoke exposure; THS, thirdhand smoke exposure; TSE, tobacco smoke exposure.

Bold font indicates statistical significance $p < 0.05$.

*Weighted adjusted logistic regression models with reference category as "no" and adjusting for child age, child sex, child race/ethnicity, parent education level, family household structure, and federal poverty level.

†Weighted adjusted logistic regression model with reference category as "0 days" and adjusting for child age, child sex, child race/ethnicity, parent education level, family household structure, and federal poverty level.

‡Weighted adjusted logistic regression model with reference category as "none" and adjusting for child age, child sex, child race/ethnicity, parent education level, family household structure, and federal poverty level.

exposure only, and home SHS and THS exposure, respectively.

Concerning number of afterschool activities, unadjusted and adjusted Poisson regression model results indicated that children with home THS exposure only and home SHS and THS exposure were at reduced likelihood of participating in a higher number of afterschool activities than children with no home TSE (Tables 4 and 5). Further, unadjusted and adjusted logistic regression model results indicated that children with home THS exposure only and home SHS and THS exposure were at decreased odds to participate in at least 1 afterschool activity.

By afterschool activity type, a total of 56.5% (n = 11,287) of children participated in sports teams/lessons, 48.6% (n = 9305) participated in clubs/organizations, and 49.9% (n = 9262) participated in other activities/lessons. Specifically, 58.8%, 45.4%, and 27.2% of school-aged children participated in sports teams/lessons with no home TSE,

Table 4. **Unadjusted Poisson and Logistic Regression Model Results of Child Home TSE Status With Afterschool Activities Participation Among US School-Aged Children, 2018-2019 NSCH**

	Number of Activities Child Participates in After School			Child Participates in Afterschool Activities			Child Participates in Sports Teams or Lessons			Child Participates in Clubs or Organizations			Child Participates in Other Activities or Lessons		
	RR*	95% CI	*p*-Value	OR†	95% CI	*p*-Value	OR†	95% CI	*p*-Value	OR†	95% CI	*p*-Value	OR†	95% CI	*p*-Value
Child home TSE status															
No home TSE	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
THS exposure only	**0.78**	**0.72, 0.84**	**<.001**	**0.52**	**0.41, 0.65**	**<.001**	**0.58**	**0.49, 0.70**	**<.001**	**0.70**	**0.58, 0.83**	**<.001**	**0.58**	**0.48, 0.70**	**<.001**
SHS and THS exposure	**0.53**	**0.44, 0.65**	**<.001**	**0.28**	**0.19, 0.43**	**<.001**	**0.26**	**0.18, 0.39**	**<.001**	**0.39**	**0.26, 0.59**	**<.001**	**0.38**	**0.24, 0.61**	**<.001**

CI, confidence interval; NSCH, National Survey of Children's Health; OR, adjusted odds ratio; Ref, reference group; RR, relative risk; SHS, secondhand smoke exposure; THS, thirdhand smoke exposure; TSE, tobacco smoke exposure.
Bold font indicates statistical significance $p < .05$.
*Weighted unadjusted Poisson regression model.
†Weighted unadjusted logistic regression models with reference category as "no".

home THS exposure only, and home SHS and THS exposure, respectively. Additionally, 50.2%, 41.2%, and 28.3% of school-aged children participated in clubs/organizations with no home TSE, home THS exposure only, and home SHS and THS exposure, respectively. Finally, 52.0%, 38.7%, and 29.3% of school-aged children participated in other activities/lessons with no home TSE, home THS exposure only, and home SHS and THS exposure, respectively. Unadjusted logistic regression model results indicated that children with home THS exposure only and home SHS and THS exposure were at decreased odds to participate in sports teams/lessons, clubs/organizations, and other activities/lessons (see Table 4). Adjusted logistic regression model results indicated that children with home THS exposure only and home SHS and THS exposure were at deceased odds to participate in sports teams/lessons (see Table 5). Adjusted model results indicated that children with home SHS and THS exposure were at decreased odds to participate in clubs/organizations, but children with home THS exposure only were at decreased odds to participate in other activities/lessons compared to children with no home TSE.

DISCUSSION

The current study assessed the associations of home TSE status with several in-school and afterschool factors among a US sample of school-aged children. Concerning home TSE prevalence, we report that 13% of school-aged children were exposed to home THS only, and about 2% were exposed to home SHS and THS. As posited, findings revealed that children exposed to home THS only and home SHS and THS exposure are at unique risk for poorer school engagement and success. Specifically, when compared to the no home TSE group, children in the home THS exposure only and home SHS and THS exposure groups were less likely to be engaged in school, and were more likely to have at least 1 school-to-home contact about any child problems with school. Other research using 2016-2017 NSCH data reported that children with home THS exposure only and home SHS and THS exposure were more likely to have mental health and neurodevelopmental conditions,[12] which may lead to lower school engagement and success over time. Additional studies indicate that parent-reported TSE from parental tobacco use is associated with the development of internalizing symptoms and externalizing behaviors (eg, problems with school) among their children.[32,33] Prior research also indicates that biochemically measured TSE, as assessed with the widely used nicotine biomarker of cotinine, is associated with lower cognitive abilities.[34] Consequently, the economic burden of parent-reported and cotinine-measured

Table 5. **Adjusted Poisson and Logistic Regression Model Results of Child Home TSE Status With Afterschool Activities Participation Among US School-Aged Children, 2018-2019 NSCH**

	Number of Activities Child Participates in After School			Child Participates in Afterschool Activities			Child Participates in Sports Teams or Lessons			Child Participates in Clubs or Organizations			Child Participates in Other Activities or Lessons		
	aRR*	95% CI	*p*-Value	AOR†	95% CI	*p*-Value	AOR†	95% CI	*p*-Value	AOR†	95% CI	*p*-Value	AOR†	95% CI	*p*-Value
Child Home TSE Status															
No home TSE	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
THS exposure only	**0.90**	**0.83, 0.96**	**.002**	**0.68**	**0.54, 0.87**	**.002**	**0.77**	**0.64, 0.93**	**.007**	0.87	0.73, 1.05	.144	**0.72**	**0.59, 0.87**	**.001**
SHS and THS exposure	**0.74**	**0.61, 0.89**	**.002**	**0.55**	**0.36, 0.84**	**.006**	**0.51**	**0.34, 0.76**	**.001**	**0.63**	**0.42, 0.95**	**.029**	0.68	0.41, 1.11	.123
Child age	**1.06**	**1.05, 1.07**	**<.001**	**1.22**	**1.16, 1.28**	**<.001**	**1.11**	**1.06, 1.15**	**<.001**	**1.23**	**1.18, 1.27**	**<.001**	**1.12**	**1.08, 1.16**	**<.001**
Child sex															
Boys	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Girls	**1.12**	**1.08, 1.16**	**<.001**	1.19	0.99, 1.42	.061	**0.60**	**0.53, 0.69**	**<.001**	**1.20**	**1.06, 1.37**	**.005**	**2.97**	**2.60, 3.39**	**<.001**
Child race/ethnicity															
Non-Hispanic white	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Non-Hispanic black	**0.91**	**0.84, 0.97**	**.006**	**0.74**	**0.56, 0.97**	**.027**	**0.53**	**0.42, 0.66**	**<.001**	0.90	0.72, 1.13	.359	1.07	0.86, 1.33	.557
Hispanic	0.95	0.89, 1.01	.075	**0.78**	**0.62, 0.99**	**.047**	**0.67**	**0.55, 0.82**	**<.001**	**0.81**	**0.67, 0.99**	**.035**	**1.25**	**1.03, 1.52**	**.028**
Non-Hispanic other/multiracial	**0.92**	**0.88, 0.97**	**.002**	**0.69**	**0.54, 0.87**	**.002**	**0.77**	**0.63, 0.93**	**.008**	**0.62**	**0.52, 0.74**	**<.001**	1.17	0.95, 1.43	.137
Child premature birth															
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.99	0.93, 1.06	.903	0.88	0.66, 1.19	.412	0.94	0.75, 1.18	.599	1.01	0.82, 1.24	.963	1.00	0.80, 1.24	.968
Parent education level															
≤High school graduate/equivalent	**0.64**	**0.60, 0.69**	**<.001**	**0.32**	**0.25, 0.41**	**<.001**	**0.39**	**0.32, 0.47**	**<.001**	**0.47**	**0.38, 0.57**	**<.001**	**0.41**	**0.34, 0.50**	**<.001**
Some college	**0.79**	**0.75, 0.83**	**<.001**	**0.45**	**0.36, 0.58**	**<.001**	**0.58**	**0.49, 0.68**	**<.001**	**0.60**	**0.51, 0.70**	**<.001**	**0.53**	**0.45, 0.62**	**<.001**
≥College degree	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Family household structure															
Two parents, currently married	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Two parents, not currently married	1.01	0.93, 1.09	.890	1.16	0.84, 1.60	.356	0.84	0.64, 1.10	.202	1.04	0.78, 1.40	.788	1.16	0.88, 1.52	.302
Single parent	0.97	0.92, 1.03	.371	0.90	0.72, 1.13	.352	0.90	0.75, 1.08	.261	1.00	0.83, 1.19	.955	0.93	0.78, 1.11	.406
Other family structure	0.97	0.88, 1.07	.503	0.88	0.63, 1.23	.454	0.89	0.66, 1.20	.432	1.09	0.83, 1.44	.525	0.87	0.65, 1.17	.359
Federal poverty level															
0-199%	**0.73**	**0.69, 0.77**	**<.001**	**0.30**	**0.23, 0.41**	**<.001**	**0.34**	**0.28, 0.40**	**<.001**	**0.50**	**0.42, 0.59**	**<.001**	**0.60**	**0.50, 0.71**	**<.001**
200-299%	**0.82**	**0.78, 0.87**	**<.001**	**0.43**	**0.32, 0.59**	**<.001**	**0.46**	**0.38, 0.56**	**<.001**	**0.60**	**0.50, 0.72**	**<.001**	**0.66**	**0.55, 0.79**	**<.001**
300-399%	**0.90**	**0.86, 0.95**	**<.001**	**0.60**	**0.41, 0.87**	**.007**	**0.60**	**0.48, 0.76**	**<.001**	**0.76**	**0.63, 0.93**	**.007**	**0.78**	**0.63, 0.96**	**.019**
≥400%	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref

AOR, adjusted odds ratio; ARR, adjusted relative risk; CI, confidence interval; NSCH, National Survey of Children's Health; Ref, reference group; SHS, secondhand smoke exposure; THS, thirdhand smoke exposure; TSE, tobacco smoke exposure.

Bold font indicates statistical significance $p < .05$.

*Weighted Poisson regression model adjusting for child age, child sex, child race/ethnicity, parent education level, family household structure, and federal poverty level.

†Weighted adjusted logistic regression models with reference category as "no" and adjusting for child age, child sex, child race/ethnicity, parent education level, family household structure, and federal poverty level.

TSE-attributable behavioral and cognitive effects alone (ie, attention-deficit hyperactivity disorder) on the education systems ranges from about $3-9 billion.[35]

Children in the home THS exposure only group were significantly more likely to miss at least 1 school day compared to children in the no home TSE group, but no difference was reported for children in the home SHS and THS exposure group. Concerning school absenteeism, other research reports results that are congruent to ours in that children living with 1 and 2 or more household smokers had a higher number of missed school days during the academic year than children that lived with no household smokers.[27] Similarly, other work has found that children with TSE were at increased risk of respiratory-related missed school days.[15] The current study supports and extends the literature by reporting that home THS exposure only, irrespective of SHS exposure, is linked with negative in-school outcomes of lower engagement and success.

Generally, afterschool program participation has been linked with positive child development such as having higher academic achievement and lower problem behaviors.[36,37] As posited, the current study reports that children exposed to home THS only and exposed to home SHS and THS were less likely to participate in at least 1 afterschool activity, and they engaged in fewer afterschool activities, relative to children with no home TSE. By afterschool activity type, both home TSE groups were at decreased odds of participating in sports teams/lessons when compared to the no home TSE group. Children exposed to home THS only and home SHS and THS exposure were less likely to participate in clubs/organizations and other activities/lessons in the unadjusted models. After covariate adjustment, however, children exposed to home THS only were less likely to participate in other activities/lessons while children exposed to home SHS and THS were less likely to participate in clubs/organizations. Much of the literature has focused on primary substance use and afterschool activities including sports and other organized activities (eg, music, dance), and reports that children's participation in afterschool activities plays a protective role against them engaging in primary cigarette smoking.[38-42] Therefore, findings from this study extend current, albeit limited knowledge about children's home SHS and THS exposure and its relationship with afterschool activity participation. It is also important to note that a higher percent of children in the home THS exposure only and home SHS and THS exposure groups had lower federal poverty levels, and that children in the lower federal poverty levels were at decreased odds to participate in organized activities overall, and by specific type compared to children in the highest level of ≥400%. The Afterschool Alliance report cites the top barriers of children's participation in afterschool activities as program availability, accessibility, and affordability, especially among low-income families.[43] For participation in organized activities, our findings suggest a dose-response association with children in the home SHS and THS exposure group having poorer participation, above and beyond sociodemographic covariates including socioeconomic status, followed by children in the home THS exposure only group and then the no home TSE group. Further, in addition to increasing access and public funding for these programs, future research should consider assessment of unorganized activities (eg, playing with other children at the playground). Overall, this study makes important contributions to the extant literature on the associations of children's exposure to THS and/or SHS and the extent to which they are engaged in school and extracurricular activities. Since child engagement in these activities plays a significant role in promoting the behavioral, emotional, and cognitive aspects of school engagement to preventing poor academic outcomes,[44] these findings should be examined further in longitudinal research.

Limitations

The 2018-2019 NSCH data have several associated strengths including a large, nationally-representative sample of US school-aged children. However, these data are cross-sectional and longitudinal or causal relationships cannot be determined. The NSCH relies on parent reports, which responses may have been impacted by recall or social desirability bias. The NSCH only asks 2 questions about household combustible tobacco product use and does not collect reports on other locations of TSE (eg, cars) or tobacco product type (eg, cigars). Although the US adult e-cigarette use prevalence is lower than combustible tobacco product use at nearly 4%,[1] the NSCH did not ask about whether children lived with household members who used noncombustible tobacco products such as e-cigarettes. Further, the NSCH only asks about participation in organized activities and did not include assessment of other leisure-time activities such as unstructured physical activities (eg, free active play) that are very popular and promote increased school engagement among children over time.[45] Further, biological samples for objective measures of TSE (eg, cotinine) were not collected and thus not provided for secondary analysis. However, parent reports of home TSE status parallel other national research that biochemically verified TSE,[3] indicative that the NSCH parent-reports of home TSE status are valid.

Conclusions

The current study's results report that children exposed to home THS only and home SHS and THS were at increased odds of having poorer

school engagement, school success, and overall afterschool activity participation. We also observed that children in homes with TSE participated in significantly fewer afterschool activities compared to children with no home TSE. Our results report important preliminary evidence on the need to investigate the associations between child TSE and afterschool activity participation. Further work is warranted to confirm these associations and to explain the possible mechanisms of these findings. Thus, promoting household tobacco cessation may lead to an improvement in school-aged children's engagement and success in school as well as their participation in afterschool activities.

IMPLICATIONS FOR SCHOOL HEALTH AND EQUITY

The current study has several implications for school health and equity. One major school health implication is the importance of promoting comprehensive, smoke-free school, home, and car rules, which can reduce child TSE.[46] There is a major emphasis on implementing clean air policies for primary and secondary school campuses to protect the health of children since they spend a great amount of time at school as well as in their homes.[47,48] Thus, maintaining smoke-free campuses could potentially decrease children's current and future risk of SHS and THS exposure in areas outside of their homes. Further, clean indoor air policies can also encourage the voluntary adoption of smoke-free home rules including the implementation of smoke-free policies in shared community spaces such as hallways, lobbies, and balconies.[49,50] While smoke-free home rules have increased over 2 decades, school-based programming should center on smoke-free rules as only about 60% of households with adult tobacco smoker and child occupants have implemented such voluntary rules.[51]

It is important to note that the current study's results indicated that home THS exposure only, without the presence of home SHS exposure, is associated with school-related consequences. Thus, smoke-free home rules do not fully mitigate THS exposure and its associated consequences including negative school outcomes among children. This indicates that promoting household tobacco cessation is needed to decrease THS pollutant reservoirs to which children may be exposed. School-based interventions and programs that provide anti-tobacco messages and emphasize the importance of tobacco cessation and smoke-free rules may encourage students to promote these efforts at home and may also decrease primary tobacco use in students.[52,53] Additionally, tobacco cessation and smoke-free home initiatives should focus on addressing identified health inequities. These efforts are especially needed in racially/ethnically diverse and low-income communities since households with black occupants and those of lower socioeconomic status (eg, households with lower education) are less likely to adopt these rules.[54]

Concerning health equity, children with high prevalence rates of home SHS and THS exposure were non-Hispanic white and black and had indicators of lower socioeconomic status (eg, lower parent education level, lower federal poverty level), which parallels other US national child findings.[3,55] While it has been previously thought that child SHS exposure is the sole cause of many negative health consequences,[5] emerging evidence indicates that child THS exposure is differentially linked to poor child health outcomes including clinical illnesses.[56-58] Thus, there is a need for further research on the characteristics of families, environmental contexts, and the impact of chronic THS exposure among children over time. Further, the study findings highlight the need for comprehensive programs targeted at educating parents and school personnel on both SHS and THS exposures, and the potential impact THS exposure alone has on children's school engagement and success. In summary, school- and community-level interventions and policies may increase children's engagement in school and afterschool activities.

Human Subjects Approval Statement

The current study was reviewed by the Institutional Review Board at the University of Cincinnati and was approved with a not human subjects research determination (#2021-0262) due to the use of publicly available, de-identified data.

Conflict of Interest

All authors of this article declare they have no conflicts of interest.

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