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POPULATION STUDY ARTICLE

The context of background TV exposure and children's executive functioning

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BACKGROUND: This study investigated relations between background TV exposure (BTV) and executive function (EF) when children were engaged in activities during exposure and how cumulative risk moderated these relations.
METHODS: A nationally-representative survey with US caregivers ($N = 1180$) of 2–8-years-old children participated in a telephone survey. Data included demographic information, the child's EF, and time use across a 24-h period. Total BTV exposure within various contexts was calculated from diaries.
RESULTS: In the direct effects regressions, BTV during sleep predicted poorer EF for all children. Playing by self with BTV predicted poorer EF for preschoolers while playing with others with BTV predicted stronger EF for school-age children. When cumulative risk was included, engaging in routines and chores with BTV predicted stronger EF for preschoolers while high-risk school-age children evidenced stronger EF when exposed to BTV while socializing with family or engaging in academic enrichment. Low-risk school-age children evidenced poorer EF in both contexts.
CONCLUSIONS: Reducing exposure can mitigate negative relations. This is an important goal as children are exposed to more of all forms of screen media during the COVID-19 pandemic. Results confirm the American Academy of Pediatrics' recommendation that TV be turned off in the background when a child is in the room.

IMPACT:

- Young children are exposed to significant hours of background television per day across multiple contexts: socializing with family, playing alone or with others, engaging in routines/chores, eating/drinking, and sleeping.
- Most exposure (46%) occurred while sleeping. Sleep exposure predicted poorer executive functioning (EF).
- During background TV exposure, as preschoolers' time spent playing alone increased, EF scores worsened. School-age children's time spent playing with others during exposure predicted stronger EF.
- EF scores for low-risk school-age children worsened when background TV was on while socializing with family or engaging in academic activities whereas the reverse was true for high-risk school-age children.

INTRODUCTION
Noise is defined as disturbing or excessive sound that produces both physiological and behavioral stress in humans. It has been linked to deficits in multiple domains of cognition, motor behavior, communication skills, and perceptual abilities in both adults and children.[1,2] At the moment, environmental noise impairs speech perception; reduces available attentional and working memory capacities; diminishes motivation for taking on new challenges; and increases stress reactivity.[3–6] Noise is also negatively associated with sleep disturbances often at decibel levels that are lower (i.e., beginning at 35 dB; bird calls, typical library environment) when compared with typical daytime conversations (50–65 dB) or actively watching TV (60–70 dB).[7] Young children may be especially vulnerable to noise-related deficits due to an inability to avoid or control their own exposure.[2] One especially noxious and pervasive form of indoor noise exposure is background TV. Background TV (BTV) exposure occurs when a TV is on in the background while a child is in the room.[8,9] The exposure is not the child's primary or even secondary activity; instead, a child is often engaged in another activity in the room (e.g., playing, eating, sleeping) while a parent views or does some activity in this room or while no other person is in the room. The average child under 8 years is exposed to about 3.9 h of background TV per day.[9]

Background TV exposure, task type, and executive function
Research investigating the consequences of exposure to BTV on child development is limited. It has been causally linked to reductions in both the length and quality of toddlers' play episodes[10] and fewer and lower-quality parent-child interactions when the TV was on.[11] In addition, correlational research indicates that preschoolers' increased exposure predicts poorer executive function concurrently[12] and across time.[13] The mechanisms for these negative effects have not been articulated; however, the

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nature of the activities in which children are engaged when exposure occurs offers an explanation for these relations. Previous studies of noise exposure (e.g., classroom, traffic, airplane) that occurred while children were engaged in cognitively-demanding tasks (e.g., school activities, play, learning, interacting with others) indicated such exposure was linked to poorer performance on these tasks including reductions in executive function, memory, attention, reading, and concentration.[1,2,5] Noise exposure that occurred during sleep (e.g., traffic) was linked to poor sleep quality and daytime sleepiness.[14] Finally, noise exposure can interfere with direct communication as it is both distracting and potentially difficult to hear others who are speaking. If BTV exposure functions similarly to noise, it would be expected that similar deficits would be observed.

Cumulative risk status

Beyond the direct effects of BTV exposure on EF, researchers recently argued that media effects models should apply a developmental approach wherein the effects of media on children are embedded within various contexts[15,16] including the family context. More complex models that consider these multiple sources and how each additively contribute to positive or negative developmental trajectories are needed to understand development.[17] One such multi-dimensional factor is cumulative sociodemographic risk. Cumulative risk reflects the number of sociodemographic risk factors that a particular family has (e.g., low maternal education, single parent, living below the poverty threshold, identifying as an under-represented minority, young maternal age at child's birth, and the number of children in the household).[17] As risks accumulate, children's EF skills worsen.[18]

Current study

The purpose of this paper is to investigate the relations among BTV exposure and EF when children are engaged in a variety of activities during that BTV exposure. Activity contexts were aligned with existing literature and derived from 24-h time diary data provided by parents. Specifically, activities included socializing with family, playing alone, playing with others, engaging in academic enrichment activities, eating/drinking, sleeping, and engaging in chores or personal care routines. First, the direct effects of BTV exposure on EF during these activities were tested. Then, cumulative risk was tested as a potential moderator.

METHOD
Participants

After receiving approval from the Institutional Review Board at the University of Pennsylvania, a private survey firm specializing in telephone surveys administered the survey. Participants were primary caregivers aged 18 years or older: 789 had a child 2- to 5-year-olds (preschoolers) and 391 had a child 6- to 8-years-old (school-aged). An additional 298 surveys were not included in the analysis because the target child was under 2 years of age and EF could not be collected for this age group.

Design

A disproportionate stratified random digit dialing cross-sectional was used to collect the sample between January and March 2009 by trained interviewers. The response rate (39.1%) was similar to other nationally-representative surveys that have assessed media use among young children.[12,13] See Lapierre et al.[9] for more detailed information about the survey design. Survey design weights were used to compensate for known biases from telephone interviewing and were post-stratified along several dimensions obtained from the 2009 national estimates of the Census' American Community Survey.

Procedure

After eligibility screening and informed consent were completed, parents were asked a series of questions ranging from household demographics, to a 24-h time diary, and their child's behavioral functioning. The survey took

~50 min to complete. All participants were compensated and provided with contact information for the study coordinator as well as for the Institutional Review Board.

Measures

Child and family characteristics. Parents were asked to describe their child and family along with a number of sociodemographic characteristics (see Table 1 for descriptive information) including race/ethnicity, family size, maternal age and education, single-parent status, income.

Cumulative risk. The following characteristics were used to construct a cumulative risk index based on criteria presented in Sameroff et al.[17] Risks were dichotomized into low risk (i.e., 0 to 1 risk) and high risk (≥2 risks).

Child's racial/ethnic background: At-risk was coded when parents identified their children as an under-represented minority (i.e., Latinx, African American, American Indian, or other).

Children in the household: At-risk was coded when there were 4 or more children living in the home.

Maternal age: At-risk was coded when a child's mother was younger than 18 years at the time of the child's birth.

Maternal education: At-risk was coded when a child's mother reported having less than a high school diploma.

Single parent status: At-risk was coded when the child was living in a home with only one adult caregiver.

Socioeconomic status: At-risk was coded when the family's income-to-needs ratio was less than 2.0 using 2009 federal poverty guidelines (Federal Register, 23 January 2009).

Background television exposure (BTV)

A 24-h time diary adapted from the Child Development Supplement to the Panel Study of Income Dynamics was administered to all respondents. Parents were asked to report all activities that occurred during the previous 24-h time period. For each primary activity reported by the parent (with the exception of watching television), parents were asked "was there a TV on in the background while CHILD [insert activity]?" The durations of time when the parent reported that there was a television on in the background were summed to create separate estimates by context/activity in which the exposure occurred. Contexts included socializing with family, playing alone; playing with others, engaging in academic enrichment activities; eating/drinking; sleeping, and engaging in chores or personal care routines.

Executive function measure

Executive function was measured via parent report using the Behavior Assessment System for Children (*BASC-2)* Executive Function Content Scale. The BASC-2 has sound psychometric properties (internal consistency = 0.90 to 0.91; test–retest = 0.84) and discriminates groups of children with preexisting clinical diagnoses.[19] Convergent validity has been established with The Achenbach System of Empirically Based Assessment (0.71–0.83); Conner's Rating Scales (0.51–0.78); and the Behavior Rating Inventory of Executive Function (0.83, global executive function composite). Validity correlations with direct assessments of children's sustained attention and inhibitory control are also adequate (−0.22 to −0.81).[20] Parents reported on the frequency with which their child regulated behavior and cognition (e.g., how often does your child interrupt conversations) on a 4-point Likert scale from never to almost always. Total raw scores were converted to T-scores (mean = 50, SD = 10). with higher scores indicating poorer EF; a T-score of 60 to 69 is considered clinically at-risk for EF problems and ≥70 is associated with clinical symptomology.

Analytic approach

Chi-squares, z-tests, and F-tests were computed to explore whether the sociodemographic risks, background TV exposure, and outcome variables were associated with differing levels of family risk by age (Table 1). Next, all BTV exposure categories were included in regressions split by age to predict EF (Table 2). Chi-square analyses were then computed to examine

Table 1. Demographics, key predictors, and outcome by age and cumulative risk.

Variable	Preschool children			Sig[a]	School-age children			Sig[a]
	All	Low risk	High risk		All	Low risk	High risk	
Sample size	789	487	302	–	391	266	125	–
Cumulative risk (%)								
Child minority (yes)	31.56	10.68	65.23	265.29***	27.88	10.53	64.80	132.02***
Mom age at birth (≤18)	1.15	0.21	2.68	10.00**	0.77	0.38	1.60	1.67
Single parent (yes)	17.36	2.05	42.05	207.85***	16.62	3.76	44.00	99.35***
Mom's education (<HS)	7.48	1.44	17.22	67.10***	7.16	1.13	20.00	45.56***
Income-to-needs (<1.85)	35.36	11.70	73.51	311.53***	27.88	6.77	72.80	184.42***
More than 3 siblings (yes)	14.70	12.32	18.54	5.76*	13.81	12.41	16.80	1.38
All background TV (h, SE)	3.85	3.01	5.20	116.79***	2.70	2.34	3.48	49.24***
Primary activity during background TV (min, SE)								
Socializing with family	6.09 (1.22)	6.37 (1.46)	5.70 (2.09)	−0.26	4.93 (2.29)	5.97 (3.42)	3.43 (2.67)	−0.57
Playing alone	53.71 (5.93)	51.88 (6.33)	56.35 (11.24)	0.35	21.21 (4.60)	22.31 (5.29)	19.63 (8.36)	−0.26
Playing with others	11.24 (2.73)	11.69 (3.32)	10.60 (4.64)	−0.19	4.38 (1.58)	5.93 (2.52)	2.15 (1.29)	−1.38
Academic or enrichment	5.88 (1.51)	8.01 (2.50)	2.81 (0.75)	−2.55*	6.54 (1.91)	7.72 (2.31)	4.85 (3.25)	−0.63
Routines/chores	27.97 (4.13)	20.35 (3.24)	38.96 (8.94)	2.33*	25.47 (4.88)	32.14 (7.79)	15.86 (3.95)	−2.03*
Eating/drinking	22.41 (2.49)	20.67 (3.48)	24.92 (3.44)	0.86	13.07 (2.16)	11.73 (2.58)	15.01 (3.73)	0.74
Sleeping	104.47 (11.68)	81.94 (13.64)	136.97 (20.66)	2.29*	74.37 (14.04)	55.38 (12.92)	101.77 (28.78)	1.66
Outcome								
Executive function (EF, SD)	49.99 (9.98)	48.84 (8.62)	51.86 (11.62)	17.44***	49.98 (10.00)	48.17 (8.34)	53.85 (11.99)	29.41***

[a]X^2 tests were computed to test for significant differences by risk status for all demographic variables included in the cumulative risk variable. Poisson regressions were computed in Stata 14.2 for all categories of background TV exposure due to substantially non-normal distributions. The margins command was used to calculate the means for each category. One-way ANOVAs were computed to test for EF differences by risk status.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

whether the percentage of children in each risk category who were exposed to any BTV in a particular context differed (Table 3). Finally, a series of hierarchical regression models, separated by age, were computed to test whether cumulative risk status moderated relations. First, cumulative risk status was added to the regressions computed in Table 2 to calculate the change in R2 associated with the inclusion of risk. Then, interactions between risk and each BTV category were included to examine whether risk moderated any of the relations between the BTV category and EF. The moderator analysis for preschoolers was not significant; that is, all interaction terms, as well as the change in R2, were not significant. Only the main effects model including risk and the BTV categories is presented for preschoolers. In contrast, risk status did significantly moderate the relations between BTV categories and EF for school-age children. BTV exposure estimates were centered to avoid multicollinearity problems; however, to ease interpretation, uncentered estimates are provided in the text and tables. The survey weight correction in STATA 14.2 was used to eliminate problems arising from incorrect standard error estimations.

RESULTS
Does BTV exposure during different activities predict EF?
Preschool children. The BTV main effects regression model for preschool children accounted for 8.85% of the variance in EF. Playing by self ($B = 0.93$, $p < 0.05$) and sleeping ($B = 0.50$, $p < 0.05$) predicted poorer EF scores (Table 2).

School-age children. The BTV main effects regression model for school-age children accounted for 7.56% of the variance in EF. Playing with others ($B = −1.58$, $p < 0.01$) predicted stronger EF scores while sleeping ($B = 0.89$, <0.01) predicted poorer EF scores (Table 2).

Does BTV exposure vary by cumulative risk status?
Preschool children. As presented in Table 1, high-risk preschoolers were exposed to more minutes of BTV while engaging in routines and chores and sleeping while low-risk preschoolers were exposed to more minutes of BTV while engaging in academic enrichment activities. Overall, a larger percentage of high-risk preschool children were exposed to BTV while eating (low risk: 32.24% | high risk: 47.68%); sleeping (low risk: 23.61% | high risk: 45.03%); and engaging in chores (low risk: 33.47% | high risk: 40.40%) (Table 3).

School-age children. As presented in Table 1, high-risk school-age children were exposed to less BTV while engaging in routines and chores compared with low-risk school-age children. Overall, a larger percentage of high-risk school-age children were exposed to BTV while sleeping (low risk: 19.55% | high risk: 35.20%) whereas a smaller percentage were exposed to BTV while socializing with family (low risk: 7.52% | high risk: 1.60%) (Table 3).

Does cumulative risk status moderate the relations between BTV exposure and EF?
Preschool children. Cumulative risk did not moderate the relations between BTV exposure categories and EF; therefore, only the main effects model with all BTV exposure categories and cumulative risk status is presented in Table 4. Adding cumulative risk status to the BTV exposure categories increased the amount of variance accounted for in EF scores by 2.8%. In this model, playing by self ($B = 0.94$, $p < 0.05$) predicted poorer EF for all preschoolers while engaging in routines and chores ($B = −1.05$, $p < 0.05$)

Table 2. BTV exposure categories predicting EF and exposure means overall and by only those with exposure, split by age.

BTV category	B	SE	β	95th% Low	95th% High	Mean (SE), all	Mean (SE), any exposure
Preschoolers ($N = 789$)							
Socializing with family	−0.76	0.70	−0.04	−2.13	0.61	0.16 (0.03)	1.69 (0.21)
Playing by self	0.93*	0.41	−0.05	0.12	1.75	0.97 (0.06)	2.34 (0.11)
Playing with others	0.66	1.47	0.15	−2.23	3.54	0.15 (0.02)	1.91 (0.14)
Academic/enrichment	−1.25	0.88	0.04	−2.97	0.47	0.11 (0.02)	0.82 (0.09)
Routines/chores	−0.76	0.47	−0.08	−1.68	0.16	0.39 (0.04)	1.08 (0.08)
Eating/drinking	1.45	0.86	0.10	−0.24	3.15	0.36 (0.03)	0.93 (0.05)
Sleeping	0.50*	0.24	0.16	0.03	0.97	1.71 (0.12)	5.36 (0.26)
Total R^2	0.089***						
School-age ($N = 391$)							
Socializing with family	0.16	0.92	0.01	−1.66	1.97	0.07 (0.02)	1.28 (0.24)
Playing by self	0.10	0.71	0.01	−1.29	1.49	0.42 (0.05)	1.72 (0.17)
Playing with others	−1.58**	0.57	−0.08	−2.69	−0.47	0.15 (0.04)	1.94 (0.31)
Academic/enrichment	−2.38	1.78	−0.11	−5.87	1.10	0.13 (0.02)	1.08 (0.14)
Routines/chores	−0.33	0.42	−0.04	−1.16	0.50	0.42 (0.06)	1.15 (0.14)
Eating/drinking	−0.25	1.53	−0.01	−3.25	2.74	0.26 (0.03)	0.80 (0.06)
Sleeping	0.89**	0.30	0.28	0.31	1.48	1.25 (0.14)	5.06 (0.35)
Total R^2	0.076*						

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 3. Chi-square analyses crossing any exposure to BTV in a particular category by cumulative risk status, split by age.

BTV category	Preschoolers ($N = 789$) Low risk	High risk	X^2	School-age ($N = 391$) Low risk	High risk	X^2
Socializing with family	9.45	9.27	0.01	7.52	1.60	5.61*
Playing by self	45.59	50.66	1.93	30.08	36.80	1.76
Playing with others	6.98	8.61	0.70	9.02	5.60	1.36
Academic/enrichment	12.73	10.93	0.57	12.41	10.40	0.33
Routines/chores	33.47	40.40	3.88*	33.83	41.60	2.22
Eating/drinking	32.24	47.68	18.84***	29.32	37.60	2.68
Sleeping	23.61	45.03	39.42***	19.55	35.20	11.25***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

predicted stronger EF. Cumulative risk ($B = 1.20$, **$p < 0.01$) also significantly predicted poorer EF.

School-age children. Cumulative risk did moderate the relations between BTV exposure categories and EF. Table 4 presents the main effects and interaction effects. Adding cumulative risk status to the BTV exposure categories increased the amount of variance accounted for in EF scores by 9.1%. Adding the interaction terms further increased the variance by 6.0%.

Two significant interactions were found: risk by socializing with family ($B = −1.87$, $p < 0.01$) and risk by academic enrichment ($B = −3.07$, $p < 0.001$). For both interactions, as the amount of BTV exposure increased, low-risk school-age children evidenced poorer EF while high-risk school-age children evidenced stronger EF (Fig. 1).

In addition to these two-way interactions, there were also significant main effects beyond those involved with the interactions. Time spent eating/drinking with BTV exposure predicted stronger EF ($B = −2.65$, $p < 0.05$) while time spent sleeping with BTV exposure predicted poorer EF ($B = 1.02$, $p < 0.001$).

DISCUSSION

In this study, BTV exposure was conceptualized as a form of chronic noise exposure in the home. Previous research established links between other environmental noise sources (e.g., traffic, airplane, classroom) and EF deficits[1,21] especially when noise exposure occurred during cognitively-demanding tasks[1] or when working to interpret speech.[5,22] In the direct effects regressions, exposure during sleep was the only activity to directly predict poorer EF for all children in this study. The immediate effects of noise on sleep have been well documented.[14,23] In other research, when young children used TV in the hour before bed[24] or when they had access to TVs in their bedrooms (that presumably led to more and later TV viewing), the quantity and quality of their sleep was negatively impacted.[25] In the current study, exposure while sleeping occurred most frequently, representing more than 46% of total BTV exposure. In addition to EF deficits associated with sleep, preschoolers evidenced poorer EF as they spent more time with BTV exposure while playing by themselves. This is consistent with previous research.[10] School-age children evidenced stronger EF

Table 4. Regressions predicting executive function from background TV exposure during different activities and cumulative risk status, split by age.

Variable	Preschoolers (N = 789)						School age (N = 391)					
	ΔR^2	B	SE	β	95th%		ΔR^2	B	SE	β	95th%	
					Low	High					Low	High
Primary task during background TV (h)	0.089***						0.076*					
Socializing with family (SOC)		−0.60	0.68	−0.03	−1.93	0.73		1.63*	0.77	0.08	0.12	3.13
Playing by self (SELF)		0.94*	0.40	0.15	0.16	1.72		−0.02	0.73	−0.02	−1.45	1.42
Playing with others (OTR)		0.63	1.39	0.04	−2.10	3.36		−1.11	0.63	−0.06	−2.35	0.13
Academic/enrichment (ACAD)		−0.96	0.90	−0.04	−2.73	0.80		2.47	1.31	0.11	−0.89	5.03
Routines/chores (ROUT)		−1.05*	0.48	−0.11	−2.00	−0.11		0.17	0.57	0.02	−0.96	1.30
Eating/drinking (EAT)		1.61	0.85	0.11	−0.06	3.29		−2.65*	1.15	−0.13	−4.90	−0.40
Sleeping (SLEEP)		0.43	0.24	0.13	−0.04	0.89		1.02***	0.32	0.32	0.41	1.64
Demographics	0.028**						0.091***					
Cumulative risk		1.20**	0.42	0.17	0.34	2.13		1.97**	0.64	0.32	0.72	3.23
Interactions							0.060***					
RISK × SOC		—						−1.87**	0.64	−0.10	−3.14	−0.61
RISK × SELF		—						0.002	0.26	0.001	−0.50	0.50
RISK × OTR		—						−0.39	0.82	−0.03	−1.99	1.20
RISK × ACAD		—						−3.07***	0.82	−0.27	−4.68	−1.45
RISK × ROUT		—						−0.39	0.45	−0.07	−1.27	0.49
RISK × EAT		—						1.52	1.01	0.18	−0.46	3.50
RISK × SLEEP		—						−0.07	0.16	−0.06	−0.39	0.25
Total R^2	0.117***						0.227***					

*p < 0.05; **p < 0.01; ***p < 0.001.

as BTV exposure increased when playing with others. One possibility is that a peer in the room can help school-age children modulate attention to the task at hand. Children with siblings, both older and younger, demonstrate stronger EF.[26,27] Researchers speculate that this positive association arises from the management of conflict (e.g., negotiation), engagement in interactions known to promote EF skills (e.g., cooperation), and modeling of appropriate and more mature social behavior.[28,29] Older siblings may engage in behavior or interactions with other siblings and caregivers in ways that alert younger children to more appropriate ways of interacting and behaving.[27] Analyzing who was present when playing with others and the kinds of interactions with which they engaged would be important next steps.

In recent years, media effects researchers have argued for the inclusion of multiple influences on young children's development in order to better understand which child is affected by what content under which circumstances.[15,16,30] The use of these contextually sensitive models is supported by the identification of larger effect sizes for children most susceptible, in both positive and negative ways, to these contexts.[12,30,31] Family provides the most immediate and influential context in which children grow and develop, particularly the family's sociodemographic profile.[18] Economic disadvantage predicts greater parental stress; less parental involvement; lower levels of warmth, structure, and control; and less access to cognitively stimulating experiences and materials.[18,32] Results in this study are consistent with the identification of larger effect sizes for more contextually sensitive models. Specifically, the direct media effects models accounted for less than 9% of the variance in EF. Adding in cumulative risk as a direct effect in the preschool model and as both direct effect and moderator in the school-age model increased the amount of variance explained in EF for preschoolers from 8.9% to 11.6% and for school-age children from 7.6% to 22.7%.

Cumulative risk
Controlling for cumulative risk in the preschool model did not impact the finding that playing by self with BTV exposure predicted poorer EF. In fact, each hour spent playing by self was associated with an EF score that was 1-point worse. Previous experimental research found a similar relation: play sessions were shorter and less focused.[10] Given that the average preschooler spent just under an hour playing alone with the TV on in the background and preschoolers who had any exposure to BTV while playing alone did so for an average of 2.3 h, finding ways to encourage parents and caregivers to turn off the TV when no one is watching is imperative.

While the significance of the relation between BTV exposure during sleep and EF fell below the threshold of traditional significance in the preschool model, the standardized coefficient actually increased from 0.10 to 0.13 when cumulative risk was added suggesting that BTV noise during sleep is problematic for preschoolers and should be reduced or removed altogether. In fact, preschoolers who do sleep with a TV on in the background spend about 5.4 h per day doing so, leading to a 2.3-point worsening in EF scores. The results for BTV during sleep for school-age children did not change when cumulative risk was added, indicating that these results occur regardless of family risk profiles.

EF was poorer for school-age children in higher-resourced homes when they spent more time socializing with family and more time engaging in academic enrichment activities with a TV on in the background. While children living in these homes have more resources available (as indexed by fewer cumulative risks), spending time competing with the TV when socializing with their parents and family members or when engaging in cognitively-demanding learning contexts likely overwhelmed their attentional capacities. In addition, as previous research indicates, when the TV is on in the background, parents talk less and engage in lower-quality interactions with their children.[10,33] Therefore, school-age
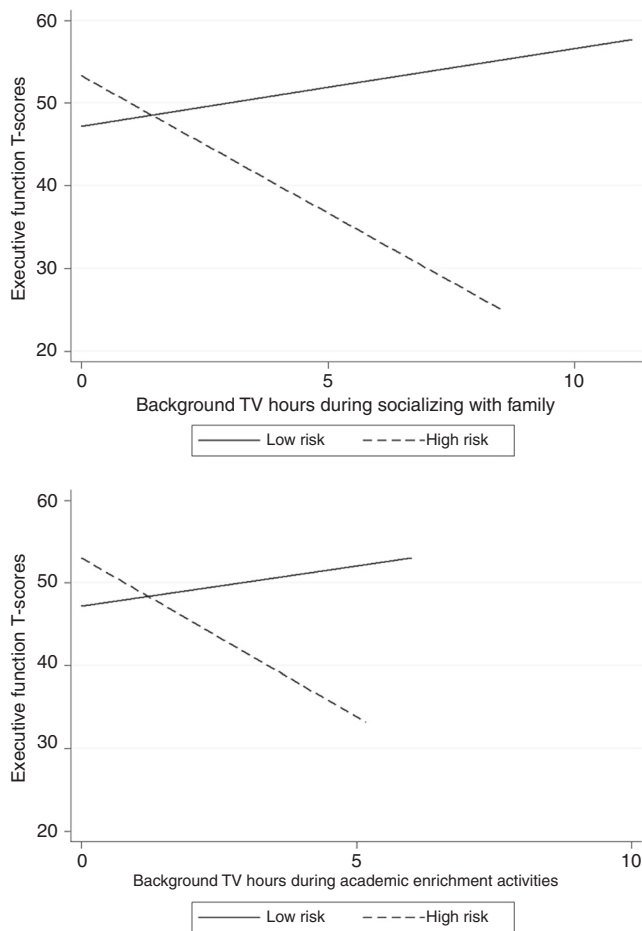
Fig. 1 Executive Function Scores and Different Exposure Contexts. BASC-2 executive function *T*-scores for low and high-risk school-age children by exposure to background TV when socializing with family or engaged in academic enrichment activities.

children in highly resourced homes are missing multiple opportunities to engage with parents and materials in ways that are beneficial to their developing EF skills. For school-age children living in higher-risk environments, the reverse was true. While children were exposed to significantly more BTV in these homes, the benefits of interacting with family and engaging in academic activities more frequently buffered the negative impacts of noise generated by BTV.

Including cumulative risk as a control in the school-age models also uncovered the main effect of eating and drinking with the TV on in the background. For each hour spent, school-age children evidenced a 2.65-point strengthening in EF scores. About one-third of school-age children were exposed to BTV while eating and drinking for an average of 48 min per day. It is unclear why this relationship occurred. Understanding the kinds of parents who choose to put the TV on in the background while eating including investigating their interactional style, whether they eat meals together, and other components of the home environment are warranted to investigate this finding more fully.

Strengths and limitations
One strength of this study is that it was designed to be a U.S. nationally-representative study. Over 1100 parents and caregivers reported on a comprehensive set of measures related to parenting, child language and literacy skills, and child executive functioning. Further, a detailed time diary comprising the previous 24 h, where media content and detailed descriptions of children's

activities were documented (including where activities took place and who was with the target child), were collected with a sizable sample compared to many smaller correlational and experimental studies. Conversely, survey research is limited in that it is correlational and based solely on parent report. While measures were selected for their predictive value and robust relations with other direct assessments and observational measures, no direct observations or child assessments were used. An additional limitation is that the data in this study were collected in 2009; however, levels of exposure to BTV have actually increased since 2009, suggesting the results presented here may underestimate the strength of the relations. Specifically, in 2009, 35% of children under eight lived in homes where the TV was on all or most of the day compared with 42% in 2017.[12,34] In the context of the current COVID-19 pandemic and the greater time spent at home, it is likely that exposure levels are even higher than in 2017.

The results do suggest that exposure to BTV is associated differentially with EF depending on the context in which that exposure occurs and the family's level of cumulative risk. Previous experimental studies suggest that when toddlers are exposed to BTV, they engage in shorter and less focused play episodes and parents engage in fewer and poorer-quality interactions during that exposure.[10,11] Preschoolers in the current study were exposed daily to 4.1 h of BTV while school-age children were exposed daily to 2.8 h of BTV. The chronic nature of such exposure may pose significant long-term consequences for EF. Early deficits in EF frequently translate into life-long physical and mental health problems, including internalizing and externalizing problems, substance use/abuse, delinquency, obesity, and other health-related issues.[35] These findings lend further support to the growing body of research that documents high levels of exposure to BTV, particularly during cognitively-demanding tasks or when sleeping, are associated with poorer EF. These results confirm the American Academy of Pediatrics' recommendation that TV be turned off in the background when a child is in the room.[36]

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D.L.N. conceptualized the study, collected the data, analyzed the data, and wrote the manuscript.

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The author declares no competing interests.

CONSENT STATEMENT

All protocols were approved by the University of Pennsylvania's Institutional Review Board. Participants gave verbal consent to participate in the study when contacted by phone.

ADDITIONAL INFORMATION

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