Adverse Childhood Experiences and Trajectories of Firearm Exposure in Childhood

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Objective To examine the longitudinal relationship between exposure to adverse childhood experiences (ACEs) in early life and trajectories of firearm exposure from early to middle childhood (ages 5-9 years old).

Study design Data from the Longitudinal Studies of Child Abuse and Neglect (LOGSCAN) study were used. The LONGSCAN study was a prospective study in the United States and contained data from 1354 children from age 4 to age 18 years old. Exposure to ACEs was measured through the wave 1 interview (age 5 years old) and trajectories of firearm exposure were created using data from waves 1 (age 5 years old) and two (age 9 years old).

Results Two trajectories of firearm exposure in childhood were identified: a low exposure group and a group with persistently-high firearm exposure from ages 5 to 9 years old. ACEs were associated with membership in the high exposure group and children with four or more ACEs had over twice the odds of membership in the high exposure group compared with children with zero ACEs.

Conclusion ACEs exposure in early childhood is associated with persistently-high exposure to firearms from early to middle childhood. This finding highlights the need for pediatricians to consider screening for both ACEs and firearm exposure in routine examinations, as well as the need for future research to identify and evaluate interventions intended to address exposure to adversity and firearms. *(J Pediatr 2024;270:114008)*.

Firearm violence has been highlighted as a critical public health issue in the US. From 1990 to 2021, there were 1 110 421 firearm fatalities in the US,[1] including over 48 000 firearm deaths in 2021 alone.[2] Firearms now rank as the leading cause of mortality among children aged 1-18 years old.[3,4] From 2018 to 2021, the relative increase in the rate of firearm-related deaths increased by nearly 41.6% among children and adolescents,[4] twice as high as the relative increase in the general US population.[3] One of the stronger correlates of firearm fatalities for children is firearm exposure (ie, being exposed to firearms in the home or the community) and children with more frequent firearm exposure both in the home and in the community are more likely to experience firearm fatality.[5,6]

Thousands of children are directly and indirectly exposed to firearms each year through witnessing or hearing about gunshots and firearm violence in their communities and seeing firearms in the home.[6,7] Children's exposure to firearms has significant short- and long-term repercussions for psychological well-being and development,[7-11] and is not experienced equally across children. Resulting from persistent, systemic, and intentionally-maintained systems of oppression, such as structural racism and concentrated disadvantage, and the confluence of political, economic, interpersonal, and historical biases held by those in positions of power, children's exposure to firearms is particularly elevated among children with low socioeconomic status and from marginalized communities.[5,12-18] However, extant research has overlooked the role of early life adversity as a potential risk factor for firearm exposure among children, despite efforts to conceptualize exposure to firearm violence as an adverse childhood experience (ACE).[7,19]

ACEs refer to potentially traumatic events that occur during childhood, encompassing various forms of abuse, neglect, and household dysfunction.[20] ACEs are a significant public health issue because they impact the lives of millions of children and adolescents annually[21] with long-lasting and profound effects on the physical, emotional, and mental well-being of individuals throughout their life course.[22-24] However, substantially less research has considered how ACEs may be a risk factor for firearm exposure. While there is evidence of a positive cross-sectional relationship between ACEs and firearm exposure in early adulthood,[25,26] it is not known how or if ACEs are associated with firearm exposure in younger children.

Using data from the Longitudinal Studies of Child Abuse and Neglect (LONGSCAN) consortium, the current study expands upon extant cross-sectional research on ACEs and firearm exposure among older adolescents and young

ACE	Adverse childhood experience
GBTM	Group-based trajectory model
LONGSCAN	Longitudinal Studies on Child Abuse and Neglect

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adults[25,26] by providing the first investigation of the longitudinal relationship between ACEs and trajectories of firearm exposure among children ages five to nine years old.

Methods

Sample

The current study used longitudinal data from the LONGSCAN consortium. The LONGSCAN consortium was founded with the goal of improving understanding of the risk factors and outcomes associated with child maltreatment.[27] The LONGSCAN data are derived from a set of prospective cohort studies of children ages 4 through 18 years old conducted at five sites across the country: Seattle, WA; Phoenix, AZ; Chicago, IL; Baltimore, MD; and Chapel Hill, NC. At each site, children were recruited if they were deemed to be at risk or had a history of child welfare system involvement; children and caregivers were recruited from medical and social services providers when the child was below school age (ages four to six years old). Follow-up interviews with caregivers, children, and teachers were conducted every 2 years through age 18 years old (approximately); caregiver reports of important life-events were conducted annually. A total of 1354 children were recruited for the initial sample and data collection for the consortium began in 1991. Data collection concluded in 2012. More information on the data and years of data collection is available in **Appendix B** (available online at www.jpeds.com).

Children who did not respond to questions assessing firearm exposure at either wave one or two were excluded from the sample (n = 143). Children who were excluded from the analytic sample were less likely to be Black and less likely to have come from the Midwestern site.

Measures

Firearm exposure was measured using child responses to questions assessing their exposure to firearms in the home and in the community at the wave one interview (when children were, on average, aged six years old) and wave two interview (when children were, on average, aged eight years old). At each interview, children were asked whether and how often they had (1) seen a firearm in their home; (2) heard firearms being shot, (3) seen someone be shot, or (4) seen someone pull a firearm on someone else. Responses were coded as follows: 0 = never, 1 = 1 time, 2 = 2 times, 3 = 3 times, 4 = 4 or more times, and were summed across the four questions to generate an index of exposure to firearms. Firearm exposure was operationalized in this manner for several reasons. First, due to the ages in the sample, incidents of violence exposure were low, and the broader measure that includes exposure to firearms both in the home and in the community allowed us to address concerns regarding rare events and trajectory models. Second, while the bulk of research on ACEs and firearms examines the impact of violence exposure on children, research suggests firearms in the home can have similarly problematic impacts on children,[4-6] particularly when the home is also experiencing other forms of violence like domestic violence and child abuse.[28] We therefore felt it was important to include guns in the home in the measure and opted for a broad measure of firearm exposure in the home and in the community. Additional analyses excluding exposure in the home are available in **Appendix D** and **E** (available online at www.jpeds.com). To provide measures of firearm exposure across childhood, the data were then organized according to the child's actual age at the interview (ranging from five to eight years old at wave one, and six to ten years old at wave two), generating measures of firearm exposure at ages five, six, seven, eight, nine, and ten years old. This age range was selected based on availability in the data and to reflect exposure in both early and middle childhood.[29,30] Because so few children (n = 3) were ten years old at the wave two interview, the measure of firearm exposure at age 10 years old was not used to model trajectories.

ACEs were measured using caregiver reports of exposure to caregiver divorce or separation, caregiver incarceration, caregiver substance abuse, caregiver mental health concerns, and intimate partner violence, as well as official records of allegations of physical, emotional, and sexual abuse and neglect at baseline interviews. The categorization of ACEs was based on items used in the Kaiser-CDC ACEs inventory and prior research using the LONGSCAN data.[20,31] Responses to each ACE item were dichotomized and summed to generate a baseline measure of ACEs exposure. This measure was then categorized to reflect children who reported zero ACE, 1 ACE, two ACEs, three ACEs, or four or more ACEs.[32] ACEs were measured in this way to ensure adequately powered cell sizes and because of evidence that four or more ACEs is a threshold above which there is an elevated risk for adverse outcomes.[32]

Race and ethnicity were measured using caregiver reports of the child's race and ethnicity obtained at baseline, with children identified as White serving as the reference category. Race and ethnicity categories included Black children, Latino/a children, and children who identified as another race/ethnicity. Among children in the "other" group, 89.81% identified as multiracial, 2.55% as Native American, 2.55% as Asian, and 5.10% as an unlisted race or ethnicity. Though race is a social construct, structural racism causes differential exposure to firearms and adverse experiences.[13,33] Measures of race and ethnicity were therefore included as proxies for exposure to structural racism and its associated impacts (see **Appendix B** for more detail; available online at www.jpeds.com). Gender was measured using caregiver responses to the child's gender at baseline. Neighborhood violence was measured using caregiver responses to seven questions assessing violence and disorder in the child's neighborhood at baseline. Responses were summed to create a composite measure of neighborhood violence exposure. Finally, due to the nature of the LONGSCAN data, dichotomous measures for each site were included to account for site-related fixed effects, with the southwestern site (San Diego) serving as the reference category because it

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had the largest number of participants. See **Appendix A** (available online at www.jpeds.com) for greater detail on all included measures.

Analytic Strategy

Prior to conducting analyses, missing data were examined. Missingness was identified in trajectory variables and risk factors associated with trajectory group membership and was addressed using multiple imputation and full-information maximum likelihood estimation. More information is available in **Appendix B** (available online at www.jpeds.com).

After addressing missing data, descriptive statistics and bivariate correlations were examined.[34] Next, trajectory models were estimated using the "traj" command in Stata, version 14.2. Group-based trajectory modeling (GBTM) is a data reduction strategy that identifies groups of individuals that follow similar patterns of a construct over time.[35,36] This approach overcomes limitations of examining frequencies at each age by identifying "trajectory groups" that represent broad trends in developmental patterns and assigning individuals to these trajectory groups according to which pattern the individual's development most closely resembles.[36-38] For the current study, the use of GBTM allows for both the identification of patterns of firearm exposure across childhood and an examination of factors that increase risk of persistent high exposure. Additional information on the GBTM methodology used in the current study is provided in **Appendix B** (available online at www.jpeds.com).

After estimating a trajectory model accounting for risk factors, a weighted logistic regression model was conducted to examine the relationship between risk factors and membership in the high exposure trajectory, using the probability of membership in the high-exposure trajectory as the weight. Estimates were weighted according to the posterior probability of group membership to account for uncertainty in group assignment.[39,40]

Results

Descriptive statistics are shown in **Table I**. As shown in **Figure 1**, there was little consistent pattern in firearm exposure by age and ACEs, with variation in mean firearm exposure by ACEs exposure at each age. The results of the trajectory group model are shown in **Figure 2**. In total, 57.4% of the sample was assigned to a trajectory group marked by consistently high exposure to firearms from ages 5 to 9 years old. Firearm exposure for this group peaked at ages 6 and 7 years old, and then declined slightly. Across ages, average firearm exposure for the high exposure group was 4.85. However, for the low firearm exposure group (42.6% of the sample), average firearm exposure across ages was 1.13. For this group, there was a steady increase in firearm violence exposure each year, with the lowest firearm violence exposure observed at age 5 years old and the highest levels at age 9 years old.

The results of the risk model are shown in **Table II**. Results showed a graded relationship between ACEs exposure and membership in the high exposure trajectory group (see **Figure 2**). Compared with children with no ACEs, children with 1 ACE did not differ significantly in odds of membership in the high exposure group (OR = 1.64, P = .086); children with two ACEs (OR = 1.87, P = .036) and three ACEs (OR = 1.86, P = .041) both experienced significant increases in odds of membership as opposed to children with zero ACE. Children with four or more ACEs experienced the greatest increase in odds of membership in the high-exposure group compared with children with no ACEs (OR = 2.36, P = .006). **Figure 3** shows marginal probabilities of membership in the high firearm exposure trajectory group by ACEs. As shown, the average probability of high exposure for children with zero ACEs (holding all other measures at their means) was 90%, and increased to a peak of 96% for children with four or more ACEs (holding all other measures at their means).

Table I. Descriptive statistics (n = 1211)

Variable	Mean (%)	SD	Range
Zero ACE	16.18%	-	-
1 ACE	24.44%	-	-
Two ACEs	21.39%	-	-
Three ACEs	17.34%	-	-
Four or more ACEs	20.64%	-	-
Neglect	51.69%	-	-
Physical abuse	23.04%	-	-
Emotional abuse	24.77%	-	-
Sexual abuse	10.65%	-	-
Caregiver incarceration	15.28%	-	-
Exposure to intimate partner violence	6.94%	-	-
Caregiver mental health problems	28.65%	-	-
Caregiver substance use problems	37.82%	-	-
Caregiver divorce/separation	16.76%	-	-
Black	55%	-	-
Latino/a	6.85%	-	-
Other race/ethnicity	12.96%	-	-
White	25.19%	-	-
Boy	48.47%	-	-
Girl	51.53%	-	-
Baltimore	21.47%	-	-
Chicago	16.68%	-	-
Seattle	19.08%	-	-
North Carolina	18.25%	-	-
San Diego	24.53%	-	-
Neighborhood disorder	7.60	6.83	0 – 28

Supplemental Analyses

A series of supplemental analyses were performed to assess the robustness of the study findings. **Appendix C** (available online at www.jpeds.com) provides results of a weighted logistic regression model predicting membership in the high exposure trajectory using individual ACEs items. According to results, no one particular ACE was associated with membership in the exposure group, indicating the accumulation of trauma exposure is a stronger predictor of group membership than individual exposures. **Appendix D** (available online at www.jpeds.com) provides a factor analysis of the firearm exposure measure and results indicated items included in the measure were appropriate from a measurement perspective. **Appendix E** (available

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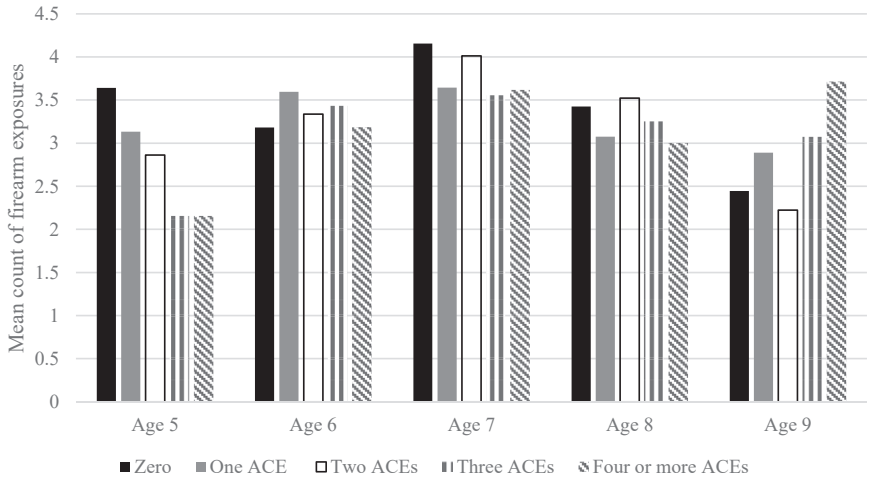

Figure 1. Firearm exposure by age and ACEs.

online at www.jpeds.com) provides a GBTM of firearm exposure without "seen a gun in the home" included and the results of a weighted logistic regression model excluding "seen a gun in the home". As show in **Appendix E** (available online at www.jpeds.com), excluding this measure did not significantly alter results. Finally, **Appendix F** (available online at www.jpeds.com) provides the results of a negative binomial regression assessing cumulative firearm exposure. According to results, youth with four or more ACEs were more likely to report greater cumulative firearm exposure. Due to space constraints, details explaining the findings of these supplementary analyses are provided in the Appendices.

Discussion

Children's exposure to firearms is associated with negative mental, physical, and behavioral health outcomes.[9,41-44] Thus, it is critical to better understand the risk factors that generate greater likelihood of firearm exposure among children, including adverse experiences in early childhood. In this study, we set out to analyze the relationship between ACEs and trajectories of firearm exposure in the home and community using 5 years of data from the LONGSCAN study. Our results generated two main findings. First, children in the sample had two unique trajectories of firearm exposure over the study period, designated as low exposure

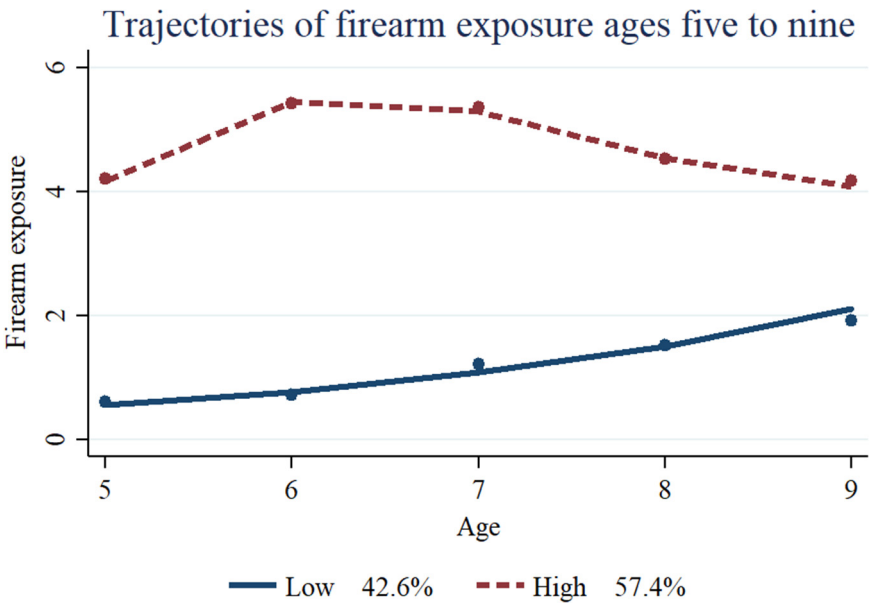

Figure 2. Trajectory model (n = 1211).

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Table II. Results of weighted logistic regression model predicting membership in the high exposure trajectory (n = 1211)

Variable	OR	SE	*P* value	95% CI LL	95% CI UL
1 ACE	1.64	.48	.086	.93	2.90
Two ACEs	1.87	.56	.036	1.05	3.35
Three ACEs	1.86	.56	.041	1.03	3.35
Four or more ACEs	2.36	.74	.006	1.28	4.36
Black	1.40	.35	.171	.86	2.28
Latino/a	.98	.38	.961	.46	2.08
Other race and ethnicity	1.22	.38	.517	.67	2.25
Boy	.90	.16	.550	.64	1.27
Neighborhood disorder	1.00	.01	.713	.98	1.03
Baltimore	2.05	.62	.017	1.13	3.70
Chicago	1.49	.44	.172	.84	2.66
Seattle	.82	.23	.486	.48	1.42
North Carolina	3.18	.99	.000	1.73	5.85

LL, lower level; *UL*, upper level.
All estimates are weighted according to posterior probability of membership in the high exposure group. San Diego serves as the reference site for site variables; White children serve as the reference group for race and ethnicity variables; zero ace serves as the reference group for ACEs; girls are the reference group for sex variables.

and high exposure. The majority (57%) of the sample was assigned to the high exposure group. Second, ACEs were associated in a graded, dose-response fashion with likelihood of membership in the high firearm exposure trajectory group.

Our findings corroborate a handful of studies on the link between ACEs and exposure to firearms while focusing on this relationship specifically among young children ages 5 through 9 years old, and suggesting firearm exposure may be an important construct to consider including as an ACE.[25,26] Although experiencing a single ACE was not linked to greater likelihood of membership in the high exposure group, every other level of cumulative ACEs was associated with increased likelihood of being in the high exposure trajectory.

Our findings highlight the urgent need to develop effective interventions that interrupt ACEs and their substantial long-term health effects. In clinical practice, screening for early childhood exposure to ACEs, when coupled with interventions that connect families to social support resources and trauma-informed behavioral health services, may reduce ongoing exposure to ACEs.[45-48] However, there remains a dearth of evidence-based interventions at the individual or community level that effectively reduce or prevent ACEs to improve long-term physical and mental health outcomes. As ongoing research to develop, test, and implement such interventions progresses, pediatricians who wish to screen for and intervene upon ACEs in early childhood should additionally consider how ACEs impact a child's future risk of firearm exposure and provide targeted anticipatory guidance. Our findings further suggest that, given the intricate association between ACEs in early childhood and future childhood firearm exposure, firearm violence reduction, and firearm safety interventions may be most effective when designed through a trauma-informed framework with a focus on promoting resilience and developing supportive social relationships.[49,50]

Specifically, pediatricians may wish to engage in firearm counseling and firearm safety interventions for children with ACEs. Though more research is needed that examines the effectiveness of firearm counseling and firearm safety interventions in this particular subgroup as well as the challenges in balancing privacy concerns with advocating for the safety of the child,[51,52] certain interventions can reduce

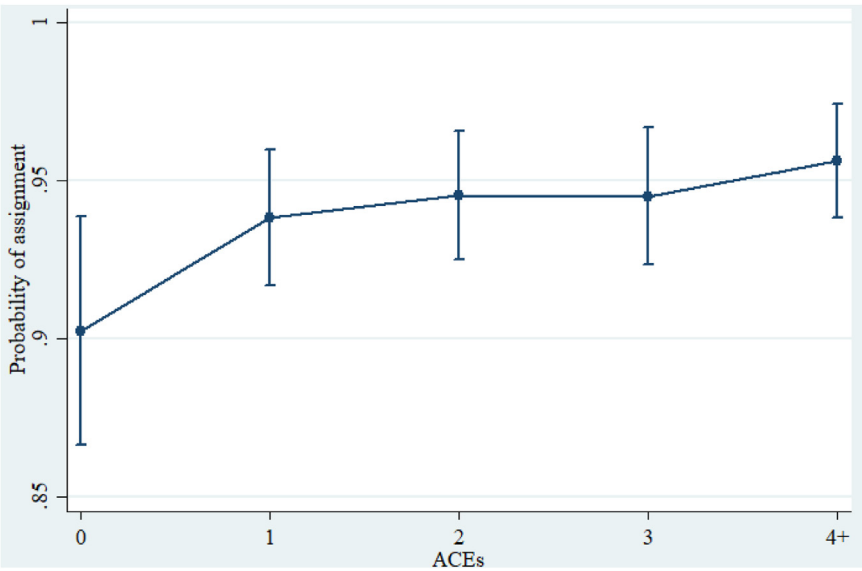

Figure 3. Marginal probability of high-exposure group membership by ACEs, holding all other risk factors at their means.

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or potentially prevent firearm exposure for children broadly. Lee et al.[53] calls for pediatricians to engage in firearm-specific anticipatory guidance and recommends pediatricians give firearm safety equipment to families to decrease suicide, homicide, and unintentional injury and death. Working altogether, trauma-informed pediatricians, clinical staff, and social workers could screen, counsel, and distribute firearm safety equipment to families, prioritizing children with ACEs. Although educating and assisting families with ACEs that have firearms to reduce exposure, injuries, and death is a critical step for individual/household or targeted firearm exposure, these steps may be insufficient in preventing community-level exposures (eg, seeing or hearing firearms and witnessing someone being shot or killed with a firearm). For community-level exposures, pediatricians may wish to become involved in efforts that prevent firearm exposure through violence reduction, firearm buyback, and firearm safety and storage programs which may occur in clinical settings or community settings.[53] Pediatricians can also support or engage in advocacy for the passage of firearm safety legislation, which would include appropriate licensing requirements, such as universal background checks and safety regulations, and the use of "smart" firearm technology (eg, built-in biometrics to gain access to firearm or trigger), which would help to reduce firearm exposure at both the individual- and community-levels.[53]

Additionally, the striking association between early childhood ACEs and subsequent frequent and persistent exposure to firearms before adolescence likely derives from a complex interplay of various factors. ACEs can create an environment of heightened vulnerability and risk for children, and often occur in households and neighborhoods that are already disproportionately marked by poverty, dysfunction, and violence.[26] Although neighborhood level safety and support may play a role in reducing the effect of ACEs,[54] it is notable that the children in this cohort lived in areas with overall low levels of neighborhood violence. This importantly highlights the widespread prevalence of ACEs and firearm exposure in childhood, and the need for pediatricians to be vigilant in identifying children with such exposures. Further, at the community-level, there is a clear need for future research to help identify those potentially modifiable environmental factors that are most amenable to intervention to reduce exposure to ACEs and firearms, simultaneously.

Finally, our findings highlight the need for preventative and intervening support from a wide range of community stakeholders, including policy makers, social support services, and others, to prevent both ACEs and firearm exposure among children. According to results, children exposed to firearms and firearm violence in and outside of the home may have a more extensive history of trauma exposure, indicating first responders should be prepared to contact appropriate social service providers (ie, child advocates and licensed mental health providers) and employ a developmentally-appropriate, trauma-informed approach to meet the needs of children on-scene.[55,56] Our findings also suggest community stakeholders and policy makers interested in preventing exposure to firearms and firearm violence in childhood should consider trauma exposure more broadly when making policy recommendations. Given observed relationships, it is possible that policies intended to improve child well-being more broadly may reduce both ACEs and firearm exposure and may therefore be more effective and efficient avenues for reducing undesired exposures in childhood.[57]

This study should be considered in the context of certain limitations. First, the LONGSCAN data were limited to five sites and respondents were purposefully selected based on their risk for maltreatment. The results here are not nationally generalizable and future studies should aim to replicate our findings using a broader representative sample. The LONGSCAN data also contain a larger number of children in foster care or adopted placements than more normative samples and the placement instability associated with child welfare system involvement may have impacted our measures. Due to sampling differences in each of the LONGSCAN sites, it is possible our model "over-controls" for ACEs related to child maltreatment, as all children from some of the LONGSCAN sites were exposed to some form of maltreatment. Second, our analysis was limited to the use of a two-group trajectory model as our outcome. Though some measures of model fit (likelihood ratio tests), suggested a three-group model fit the data significantly better than a two-group model, others (entropy statistics and posterior probability of group membership) decreased significantly with the introduction of a third group. This suggests the sample was not large enough to sufficiently differentiate a third trajectory of firearm exposure. Future research with larger samples should explore multigroup solutions beyond two groups. Our analyses are also limited by the age of respondents and validity of responses. Though children were asked to report exposure to firearms beyond television shows, movies, etc, it is possible the age of children limited their ability to accurately recall firearm exposure.

Our operationalization of firearm exposure is an additional limitation. For reasons previously mentioned, we opted for a broader measure of firearm exposure that included exposure to firearms in a household, but results may differ using a different conceptualization. Even so, our sensitivity analyses indicated removing "seen a firearm in the home" from the dependent variable did not change results substantively (see **Appendix C**; available online at www.jpeds.com). Future research should conduct measurement work to better understand the nuances associated with measuring firearm exposure broadly, as well as the ways in which firearm exposure may be a precursor to firearm violence exposure. Our results are also limited by our operationalization of ACEs as well as the limited inclusion of covariates. We chose to measure ACEs using the CDC Kaiser conceptualization and prior research using LONGSCAN data,[20,31] but it is possible alternative

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conceptualizations would lead to different results. Similarly, while we included important control variables like neighborhood disorder in our models, it is possible observed relationships would differ if a more robust set of controls were included. Finally, our sample size did not allow us to examine differences in the relationship between ACEs and firearm exposure by key demographic characteristics such as racial group or gender. Since young Black males are at particular risk for firearm exposure in the US,[42] researchers should consider further analyses among subgroups using larger samples if possible.

In conclusion, early ACE exposure is associated with high exposure to firearms during early and middle childhood (ages 5-9 years old). Pediatricians may be able to reduce this exposure by both screening for ACEs as well as using evidenced-based interventions, such as engaging in firearm counseling and handing out firearm locks within the clinical setting to further reduce exposure, unintentional injuries, and deaths. Still there is an ongoing need for future research to identify and evaluate interventions intended to address exposure to adversity and firearm exposure throughout childhood. ■

CRediT authorship contribution statement

Abigail Novak: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Daniel Semenza:** Writing – review & editing, Writing – original draft, Conceptualization. **Colleen Gutman:** Writing – review & editing, Writing – original draft, Conceptualization. **Nia Heard-Garris:** Writing – review & editing, Writing – original draft, Conceptualization. **Alexander Testa:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Dylan B. Jackson:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization.

Declaration of Competing Interest

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