Potential effects of adverse childhood experiences on school engagement in youth: a dominance analysis

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Abstract

Background: Adverse childhood experiences (ACEs) can have severe negative impacts on childhood and adult health via worsened school engagement and educational outcomes. This study seeks to identify the relative importance of various ACEs in predicting school engagement.

Methods: We analyzed data from the National Survey of Children's Health for school-aged children (ages 6-17) for 2018 and 2019. The primary outcome was school engagement, measured through three variables: repeating a grade, doing required homework, and caring about doing well in school. We conducted three logistic regression models with dominance analyses to identify the relative importance of ACE variables in predicting school engagement outcomes.

Results: In unadjusted and adjusted dominance analyses, parental incarceration was the most important ACE in predicting repeating a grade. Living in a household in which it was hard to cover basics like food or housing was the most important ACE in predicting doing required homework and caring about doing well in school.

Discussion: Our study points toward the large influence of out-of-school factors on school engagement. Parental incarceration and economic hardship, the most important predictors of engagement, are issues that can be addressed and mitigated through policy interventions. With limited funds available for education and public health interventions, it is crucial that these two ACEs be priority considerations when developing policy. A multi-faceted approach that reduces the incarcerated population, encourages economic well-being, and emphasizes early-childhood education has the potential to significantly improve school engagement in vulnerable populations and ultimately advance social equity.

Keywords: Adverse childhood experiences, School engagement, Dominance analysis, Parental incarceration, Economic hardship

Background

Preventing and mitigating the effects of Adverse Childhood Experiences (ACEs) is a priority for the US Centers for Disease Control and Prevention (CDC) because ACEs can have striking negative impacts on health [1]. ACEs are potentially traumatic events that occur before age 17, such as experiencing or witnessing violence in the family or community [2]. ACEs and early childhood stress influence developing bodies and brains of adolescents,
and can result in short- and long-term negative consequences such as learning, behavioral, and physiological issues [3–5]. ACEs are associated with altered stress responses where individuals are more sensitive to stress later in life [6]. This stress sensitivity results in individuals being particularly vulnerable to stress-related diseases including mental and somatic conditions [6]. Consequently, ACEs are associated with worse health during all stages of life [7–12]. Further, ACEs are directly and indirectly associated with worse school engagement and educational attainment during adolescence [7–12]. Educational attainment is a fundamental and well-described determinant of health [13], and ACEs effect on education can compound their lasting negative impact. ACEs can influence school engagement, and increasing numbers of ACEs are associated with decreasing levels of school engagement [7, 11, 12]. While the total number of ACEs and specific ACEs have been investigated, little evidence exists to evaluate the level of influence each contributes to school engagement.

As funding for school engagement interventions is limited, it is important to identify the most influential ACEs on predicting school engagement to maximize the benefits of future programs. Additionally, each ACE can be influenced to varying degrees through interventions, so identifying the most important ACE variables will help determine the best way to address the school engagement issue. While there is a vast body of research on ACEs, none has examined the relative importance of ACEs on an outcome using dominance analysis, and we evaluated and ranked selected ACEs’ influence in predicting school engagement with that technique. Existing research has used regression analyses to identify different ACEs and number of ACEs as predictors of school engagement; this study seeks to contextualize previous research by identifying the ranked order of importance of ACE variables on predicting school engagement. Findings will provide evidence to prioritize preventive interventions, inform public health policy decisions, and guide future research. Parental incarceration and economic hardship have been the primary focus of previous research, and thus, we hypothesize that these two ACEs will be most influential in predicting school engagement [14, 15].

**Methods**

**Dataset**

Data came from the National Survey of Children’s Health (NSCH) for 2018 and 2019. NSCH is a national survey conducted by the US Census Bureau and sponsored by the US Department of Health and Human Services’ Health Resources and Services Administration Maternal and Child Health Bureau. The survey investigated the health and well-being of non-institutionalized children ages 0-17 and was administered in web-based and paper format [16]. Households were randomly sampled using a complex sampling design, with parental or guardian surrogates completing the survey for one child in the household for all of the included variables [16]. In 2018 and 2019, 59,963 surveys were completed [16]. We used guidance provided by the US Census Bureau to combine, adjust, and weight the two years of data to yield nationally representative estimates [17].

Because of our focus on school engagement, analyses were restricted to children ages 6-17 (N= 43,213), with a mean unadjusted age of 12.11 years. Children with missing data on any of the variables discussed below were excluded from analysis, with the final dataset containing 39,347 individuals (52.1% male and 47.9% female). Additionally, the race and ethnicity distribution were 70.4% non-Hispanic White, 11.5% Hispanic, 6.2% non-Hispanic Black, 6.0% non-Hispanic other, and 6.0% two or more races. This project was reviewed and approved as exempt category human subjects research by the North Texas Regional Institutional Review Board.

**Outcome variables**

We examined three measures of school engagement. The first outcome variable we investigated was repeating a grade in school, which was measured with the following question: “Since starting kindergarten, has this child repeated any grades?” Responses included yes/no. The second outcome variable examined children’s interest in doing well in school: “How often does the child care about doing well in school?” Our final outcome variable explored whether children completed all required homework: “How often does the child do all required homework?” The responses to the second and third outcome variables were always/usually/sometimes/never; we dichotomized these responses in accordance with past research [12, 18].

**Main explanatory variables**

Nine different ACEs were assessed for the NSCH. They were economic hardship, parental/guardian incarceration, parental/guardian death, parental/guardian divorce, being a victim of or witnessing violence in the neighborhood, witnessing adult violence in the home, living with someone who was mentally ill, living with someone with a substance abuse issue, and discrimination on the basis of race or ethnicity. Detailed descriptions of these ACEs and how they were ascertained are available elsewhere (https://www.census.gov/programs-surveys/nsch.html).

**Explanatory covariates**

We included a number of covariates in our analyses to control for potential confounders. These included the
demographic variables sex, age, race, and ethnicity. Race is a social construct that interacts with the educational system [19]. Racial inequities influence educational outcomes [19]. Consequently, race and ethnicity are included throughout adjusted analyses. Additional covariates include the lowest household parental educational attainment and children with special health care needs (SHCN).

**Statistical analysis**

We produced descriptive statistics on the variables mentioned above and used chi-square analyses to identify unadjusted associations between our explanatory variables and outcomes. We estimated the adjusted associations between the explanatory variables and each outcome in three multiple logistic regression models. These models were subsequently used in dominance analyses to identify the relative importance of the main explanatory variables on predicting the school engagement outcome variables. We tested the multicollinearity assumption of logistic regression to identify any potential collinearity of the explanatory and covariables (Additional file 1).

Dominance analysis is a statistical method that ranks the importance of each of the main explanatory variables in predicting an outcome. This analysis considers the explanatory variable’s unique effect on the outcome as well as its joint effect with other variables [20]. Importance is determined by running a series of regression models (termed “submodels”), which incorporate each potential combination of explanatory variables and averages the change in the McFadden pseudo-R² values for each combination [20–22]. This average is termed a “general dominance statistic,” and reflects predictive strength; explanatory variables with a larger general dominance statistic are of greater importance than those with a relatively smaller general dominance statistic [20].

Three dominance analyses were conducted: one for each outcome variable. Covariates were held constant across all dominance analyses; only the importance of the ACE variables was examined. A model with \( p \) predictors requires the calculation of \( 2^{p-1} \) submodels to estimate dominance [22], resulting in 511 different submodels for each dominance analysis. All data analysis was conducted using Stata SE version 15.1 (College Station, TX). We accounted for complex survey design and set the significance level at \( p < 0.05 \).

**Results**

**Demographics**

Our sample (\( n = 39,347 \)) was weighted to be nationally representative of the US population for children ages 6-17. The most prevalent ACE was parental or guardian divorce at 28.8% (95% CI: 27.8, 29.8) of the population. This was followed by hard to cover basics like food or housing (15.6, 95% CI: 14.8, 16.5), living with someone with a substance abuse issue (10.2, 95% CI: 9.6, 10.9), living with someone with a mental illness (9.6, 95% CI: 9.0, 10.3), parental incarceration (8.7, 95% CI: 8.1, 9.3), witnessing adult violence (6.8, 95% CI: 6.2, 7.3), treated unfairly because of race (5.8, 95% CI: 5.3, 6.4), and victim of violence (5.2, 95% CI: 4.7, 5.7). The least prevalent ACE was parental or guardian death at 3.9% (95% CI: 3.5, 4.3) of the population (Fig. 1). Descriptive statistics for demographic, covariate, and ACE variables are detailed in Additional file 2.

Overall, 6.3% (95% CI: 5.7, 6.9) of the population repeated a grade at some point during their education.

**Fig. 1** Prevalence of reported Adverse Childhood Experiences from the National Survey of Children’s Health (2018-2019)
Additionally, 88.7% (95% CI: 88.0, 89.3) of the population always/usually did all required homework while 11.3% (95% CI: 10.7, 12.0) sometimes/never did all required homework. Finally, 89.1% (95% CI: 88.5, 89.7) of the population always/usually cared about doing well in school while 10.9% (95% CI: 10.3, 11.5) sometimes/never cared about doing well in school. Chi-squared analyses found significant differences between groups for all three outcomes for all demographic, covariate, and ACE variables ($p < 0.001$, Additional file 2).

**Logistic regression**

*Model 1: repeated grades*

In the first logistic regression model, we found a significant association between sex, age group, race/ethnicity, health issues, minimum parental education, ACE variables, and the repeated grades outcome. Of the nine ACE variables, three were significant: participants that experienced challenges in meeting basic needs (OR: 1.3, 95% CI: 1.0, 1.6), parental or guardian death (OR: 1.7, 95% CI: 1.1, 2.7), and parental or guardian incarceration (OR: 1.5, 95% CI: 1.1, 2.1) had increased odds of repeating a grade. Table 1 details all logistic regression results for Model 1.

*Model 2: does all required homework*

In the second logistic regression model, we found a significant association between sex, age group, race/ethnicity, health issues, minimum parental education, ACE variables, and the does all required homework outcome. Children in households that experienced challenges in meeting basic needs (OR: 0.5, 95% CI: 0.4, 0.6), racism (OR: 0.7, 95% CI: 0.5, 1.0), parental divorce (OR: 0.8, 95% CI: 0.6, 0.9), parental or guardian incarceration (OR: 0.8, 95% CI: 0.6, 1.0), or having lived with someone with a mental illness (OR: 0.8 95% CI: 0.6, 1.0) had significantly lower odds of doing required homework. Table 1 details all logistic regression results for Model 2.

*Model 3: cares about doing well in school*

In the third logistic regression model, we found a significant association between sex, age group, health issues, minimum parental education, ACE variables, and the cares about doing well in school outcome. Children in households that experienced challenges in meeting basic needs (OR: 0.6, 95% CI: 0.5, 0.7), parental divorce (OR: 0.7, 95% CI: 0.6, 0.8), or having been a victim of violence (OR: 0.7, 95% CI: 0.6, 1.0) had significantly lower odds of caring about doing well in school. Table 1 details all logistic regression results for Model 3.

**Dominance analysis**

*Model 1: repeated grades*

In both unadjusted and adjusted dominance analysis, parental incarceration was the most dominant ACE for predicting repeating a grade, accounting for 22.6% (unadjusted) or 3.1% (adjusted) of the change in pseudo-$R^2$ values. In unadjusted analyses, hard to cover basic needs like food or housing (2) and parental death (3) were the next most dominant variables in predicting repeating a grade. These two variables were also important in adjusted analyses but the order shifted, with parental death (2) and hard to cover basic needs like food or housing (3) being the second and third most dominant variables. Table 2 include all dominance analysis results for Model 1.

*Model 2: does all required homework*

In both unadjusted and adjusted dominance analysis, covering basic needs was the most dominant ACE for predicting doing all required homework, accounting for 28.4% (unadjusted) or 6.4% (adjusted) of the change in pseudo-$R^2$ values. In both unadjusted and adjusted analyses, parental divorce (2) and lived with someone with a mental illness (3) were the next most dominant variables in predicting doing all required homework. Table 3 include all dominance analysis results for Model 2.

*Model 3: cares about doing well in school*

In both unadjusted and adjusted dominance analysis, covering basic needs was the most dominant ACE for predicting caring about doing well in school, accounting for 29.5% (unadjusted) or 5.2% (adjusted) of the change in pseudo-$R^2$ values. In both unadjusted and adjusted analyses, parental divorce (2) was the next most dominant variable in predicting caring about doing well in school. The third most dominant variable shifted between unadjusted (lived with someone with a mental illness) and adjusted (victim of violence) analyses. Table 4 include all dominance analysis results for Model 3.

**Discussion**

We identified the relative importance of ACE variables on predicting school engagement in school-aged children as measured by repeating a grade, doing all required homework, and caring about doing well in school. We found that parental incarceration was the most dominant variable for predicting repeating a grade, while difficulty covering basic needs like food or housing was the most dominant for predicting doing all required homework and caring about doing well in school. Consequently, children with incarcerated parents and those in households without the ability to meet basic needs should be prioritized when developing interventions to improve
Table 1  Adjusted odds ratios of sociodemographic covariates and ACE predictors of repeated grade, does all required homework, and cares about doing well in school

| Variable               | Model 1: Repeated Grade |   | Model 2: Does All Required Homework |   | Model 3: Cares About Doing Well in School |   |
|------------------------|-------------------------|---|-------------------------------------|---|------------------------------------------|---|
|                        | Odds Ratio  | 95% Confidence Interval | P-value | Odds Ratio  | 95% Confidence Interval | P-value | Odds Ratio  | 95% Confidence Interval | P-value |
| Demographic Covariates |            |                           |         |            |                           |         |            |                           |         |
| Sex                    |            |                           |         |            |                           |         |            |                           |         |
| Male                   | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         |
| Female                 | 0.6        | (0.5, 0.7)                | <0.0001 | 2.0        | (1.7, 2.3)                | <0.0001 | 2.1        | (1.8, 2.4)                | <0.0001 |
| Age                    |            |                           |         |            |                           |         |            |                           |         |
| 6-9                    | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         |
| 10-13                  | 1.6        | (1.2, 2.1)                | 0.001   | 0.7        | (0.6, 0.9)                | 0.005   | 1.0        | (0.8, 1.1)                | 0.634   |
| 14-17                  | 2.2        | (1.7, 2.8)                | <0.0001 | 0.5        | (0.4, 0.7)                | <0.0001 | 0.8        | (0.7, 0.9)                | 0.009   |
| Race/Ethnicity         |            |                           |         |            |                           |         |            |                           |         |
| NH White               | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         |
| NH Black               | 1.4        | (1.1, 1.8)                | 0.009   | 0.7        | (0.5, 0.9)                | <0.0001 | 0.9        | (0.7, 1.1)                | 0.416   |
| Hispanic               | 1.2        | (0.9, 1.6)                | 0.255   | 1.0        | (0.8, 1.2)                | 0.719   | 1.1        | (0.9, 1.3)                | 0.547   |
| NH Other               | 1.0        | (0.7, 1.5)                | 0.876   | 0.9        | (0.7, 1.2)                | 0.632   | 0.9        | (0.7, 1.1)                | 0.327   |
| >2 Races, NH           | 1.0        | (0.7, 1.5)                | 0.938   | 1.4        | (1.0, 1.9)                | 0.058   | 1.1        | (0.8, 1.5)                | 0.701   |
| Health Issues          |            |                           |         |            |                           |         |            |                           |         |
| None                   | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         |
| Asthma, no ADHD        | 1.0        | (0.7, 1.3)                | 0.839   | 0.7        | (0.5, 0.9)                | 0.004   | 0.6        | (0.5, 0.8)                | 0.001   |
| ADHD, no asthma        | 3.1        | (2.4, 4.0)                | <0.0001 | 0.2        | (0.1, 0.2)                | <0.0001 | 0.1        | (0.1, 0.2)                | <0.0001 |
| Both Asthma, ADHD      | 2.6        | (1.6, 4.0)                | <0.0001 | 0.2        | (0.1, 0.2)                | <0.0001 | 0.2        | (0.1, 0.3)                | <0.0001 |
| Neither, other SHCN    | 2.2        | (1.7, 2.9)                | <0.0001 | 0.3        | (0.3, 0.4)                | <0.0001 | 0.3        | (0.2, 0.4)                | <0.0001 |
| Minimum Parent Education |          |                           |         |            |                           |         |            |                           |         |
| Less than HS           | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         | 1.00 (Ref) |                           |         |
| HS/GED/Voc             | 0.6        | (0.5, 0.8)                | 0.002   | 1.2        | (1.0, 1.5)                | 0.121   | 1.1        | (0.9, 1.4)                | 0.39    |
| Some college           | 0.4        | (0.3, 0.5)                | <0.0001 | 1.4        | (1.1, 1.8)                | 0.008   | 1.3        | (1.0, 1.7)                | 0.022   |
| Bachelors              | 0.3        | (0.2, 0.4)                | <0.0001 | 1.6        | (1.2, 2.1)                | 0.001   | 1.7        | (1.3, 2.2)                | <0.0001 |
| Masters or more        | 0.2        | (0.1, 0.3)                | <0.0001 | 2.1        | (1.4, 2.9)                | <0.0001 | 2.3        | (1.7, 3.1)                | <0.0001 |
| Adverse Childhood Experiences |        |                           |         |            |                           |         |            |                           |         |
| Basic Needs            |            |                           |         |            |                           |         |            |                           |         |
| Yes                    | 1.3        | (1.0, 1.6)                | 0.039   | 0.5        | (0.4, 0.6)                | <0.0001 | 0.6        | (0.5, 0.7)                | <0.0001 |
| Racism                 |            |                           |         |            |                           |         |            |                           |         |
| Yes                    | 1.4        | (1.0, 2.1)                | 0.054   | 0.7        | (0.5, 1.0)                | 0.023   | 0.9        | (0.7, 1.2)                | 0.477   |
| Divorce                |            |                           |         |            |                           |         |            |                           |         |
| Yes                    | 1.1        | (0.8, 1.3)                | 0.636   | 0.8        | (0.6, 0.9)                | <0.0001 | 0.7        | (0.6, 0.8)                | <0.0001 |
| Parental Death         |            |                           |         |            |                           |         |            |                           |         |
| Yes                    | 1.7        | (1.1, 2.7)                | 0.017   | 1.0        | (0.7, 1.3)                | 0.8     | 0.9        | (0.7, 1.2)                | 0.523   |
| Parental Incarceration |            |                           |         |            |                           |         |            |                           |         |
| Yes                    | 1.5        | (1.1, 2.1)                | 0.004   | 0.8        | (0.6, 1.0)                | 0.046   | 0.9        | (0.7, 1.1)                | 0.274   |
| Adult Violence         |            |                           |         |            |                           |         |            |                           |         |
| Yes                    | 1.3        | (0.9, 1.8)                | 0.15    | 0.9        | (0.7, 1.2)                | 0.564   | 1.1        | (0.8, 1.4)                | 0.628   |
| Neighborhood Violence  |            |                           |         |            |                           |         |            |                           |         |
| Yes                    | 0.8        | (0.6, 1.2)                | 0.366   | 0.8        | (0.6, 1.0)                | 0.068   | 0.7        | (0.6, 1.0)                | 0.037   |
| Lived with Mental Health |         |                           |         |            |                           |         |            |                           |         |
| Yes                    | 1.3        | (1.0, 1.8)                | 0.098   | 0.8        | (0.6, 1.0)                | 0.015   | 0.8        | (0.7, 1.0)                | 0.107   |
| Lived with Substance Abuse |        |                           |         |            |                           |         |            |                           |         |
| Yes                    | 0.9        | (0.6, 1.5)                | 0.813   | 1.0        | (0.8, 1.3)                | 0.988   | 0.9        | (0.7, 1.1)                | 0.227   |
Table 2  Unadjusted and adjusted dominance analyses for repeated grade logistic regression model. Unadjusted model does not control for demographic, parental education, or health issues

| Variable                                      | Unadjusted |                       |                         | Adjusted    |                       |                         |
|-----------------------------------------------|------------|------------------------|-------------------------|-------------|------------------------|-------------------------|
|                                               | Dominance  | Standardized           | Ranking                 | Dominance   | Standardized           | Ranking                 |
|                                               | Statistic  | Dominance Statistic    |                         | Statistic   | Dominance Statistic    |                         |
| Close with an individual with substance issue | 0.002      | 0.046                  | 8                       | 0.001       | 0.005                  | 8                       |
| Divorce                                       | 0.003      | 0.090                  | 6                       | 0.001       | 0.006                  | 7                       |
| Experienced racism/discrimination             | 0.003      | 0.089                  | 7                       | 0.002       | 0.014                  | 6                       |
| Hard to cover basics like food or housing     | 0.005      | 0.153                  | 2                       | 0.002       | 0.016                  | 3                       |
| Lived with someone with a mental illness      | 0.004      | 0.108                  | 5                       | 0.002       | 0.015                  | 5                       |
| Parental Death                                | 0.004      | 0.130                  | 3                       | 0.003       | 0.023                  | 2                       |
| Parental Incarceration                        | 0.007      | 0.226                  | 1                       | 0.003       | 0.031                  | 1                       |
| Victim of violence                            | 0.001      | 0.045                  | 9                       | 0.000       | 0.002                  | 9                       |
| Witnessed adult violence                      | 0.004      | 0.114                  | 4                       | 0.002       | 0.015                  | 4                       |

Table 3  Unadjusted and adjusted dominance analyses for does all required homework logistic regression model. Unadjusted model does not control for demographic, parental education, or health issues

| Variable                                      | Unadjusted |                       |                         | Adjusted    |                       |                         |
|-----------------------------------------------|------------|------------------------|-------------------------|-------------|------------------------|-------------------------|
|                                               | Dominance  | Standardized           | Ranking                 | Dominance   | Standardized           | Ranking                 |
|                                               | Statistic  | Dominance Statistic    |                         | Statistic   | Dominance Statistic    |                         |
| Close with an individual with substance issue | 0.003      | 0.050                  | 8                       | 0.001       | 0.007                  | 8                       |
| Divorce                                       | 0.010      | 0.165                  | 2                       | 0.004       | 0.023                  | 2                       |
| Experienced racism/discrimination             | 0.004      | 0.065                  | 7                       | 0.002       | 0.012                  | 6                       |
| Hard to cover basics like food or housing     | 0.016      | 0.284                  | 1                       | 0.010       | 0.064                  | 1                       |
| Lived with someone with a mental illness      | 0.008      | 0.143                  | 3                       | 0.003       | 0.016                  | 3                       |
| Parental Death                                | 0.001      | 0.011                  | 9                       | 0.000       | 0.001                  | 9                       |
| Parental Incarceration                        | 0.006      | 0.105                  | 5                       | 0.002       | 0.014                  | 5                       |
| Victim of violence                            | 0.006      | 0.108                  | 4                       | 0.002       | 0.014                  | 4                       |
| Witnessed adult violence                      | 0.004      | 0.070                  | 6                       | 0.001       | 0.009                  | 7                       |

Table 4  Unadjusted and adjusted dominance analyses for cares about doing well in school logistic regression model. Unadjusted model does not control for demographic, parental education, or health issues

| Variable                                      | Unadjusted |                       |                         | Adjusted    |                       |                         |
|-----------------------------------------------|------------|------------------------|-------------------------|-------------|------------------------|-------------------------|
|                                               | Dominance  | Standardized           | Ranking                 | Dominance   | Standardized           | Ranking                 |
|                                               | Statistic  | Dominance Statistic    |                         | Statistic   | Dominance Statistic    |                         |
| Close with an individual with substance issue | 0.004      | 0.079                  | 6                       | 0.002       | 0.011                  | 4                       |
| Divorce                                       | 0.009      | 0.194                  | 2                       | 0.004       | 0.027                  | 2                       |
| Experienced racism/discrimination             | 0.001      | 0.021                  | 8                       | 0.001       | 0.003                  | 8                       |
| Hard to cover basics like food or housing     | 0.014      | 0.295                  | 1                       | 0.008       | 0.052                  | 1                       |
| Lived with someone with a mental illness      | 0.007      | 0.144                  | 3                       | 0.002       | 0.010                  | 5                       |
| Parental Death                                | 0.001      | 0.012                  | 9                       | 0.000       | 0.001                  | 9                       |
| Parental Incarceration                        | 0.004      | 0.090                  | 5                       | 0.001       | 0.008                  | 6                       |
| Victim of violence                            | 0.005      | 0.108                  | 4                       | 0.002       | 0.013                  | 3                       |
| Witnessed adult violence                      | 0.003      | 0.057                  | 7                       | 0.001       | 0.004                  | 7                       |
school engagement. Additionally, strategies that decrease the likelihood of parental incarceration and increase the ability of households with children to meet basic needs are most likely to improve school engagement.

Our findings regarding the importance of parental incarceration in predicting repeating a grade align with previous research showing the negative effects of mass incarceration in the US on education and academic outcomes for children of those incarcerated [14, 23, 24]. The association between school engagement and parental incarceration is of concern given societal trends in incarceration. Since 1980, the incarcerated population in the US has grown exponentially, resulting in the highest incarceration rate in the world [25]. Mass incarceration is a structural inequity disproportionately impacting low-income communities and communities of color [26, 27]. Consequently, children in low-income households and children of color will be disproportionately affected by the negative educational outcomes associated with parental incarceration.

Children in low-income households also risk lower educational engagement as measured by other outcomes, and our analysis illuminates the influence of economic hardship on school engagement. We found that having had trouble meeting basic needs like food or housing played an important role in each measured school engagement outcome, and economic hardship was the most dominant variable in predicting whether children do all required homework or care about doing well in school. Previous research identified the importance of Socio-Economic Status (SES) plays in school engagement and educational attainment [28–30]. Children with higher SES have shown higher levels of school engagement and thus graduation rates [28]. Additionally, previous research identified the impact food insecurity has on health status, emotional well-being, and school engagement [29, 30].

There is an association between economic pressure and parental conflict [30], and this can lead to parental divorce. Further, children living in a single-parent household are more likely to live in low-income households [31]. Given the associations between economic hardship and other aspects of a family’s life, it is not surprising that this variable emerged as dominant in our analyses. Economic hardship influences or is influenced by many of the other ACEs in our analysis. Our results indicate that, while economic hardship is generally a stronger predictor, family structure ACEs are also important predictors of children repeating a grade and doing all required homework. Our study provides new evidence regarding the link between economic hardship, family structure, and school engagement. Previous research shows the negative associations between parental death and school performance [32] and between parental divorce and lower educational attainment [33].

Policy changes are needed at the state and federal levels for a successful reduction in the incarcerated population. Reducing the minimum sentencing or decriminalization of low-level drug offenses could reduce the federal prison population by 50% and state/local prison populations by 15% [26, 27]. Formerly incarcerated individuals face many obstacles when re-entering into society, including disenfranchisement and barriers to employment [27]. Policies promoting employment opportunities for formerly incarcerated individuals could diminish economic inequities resulting from mass incarceration [27].

In addition to the impact on school engagement that having a parent incarcerated has, economic well-being was an important factor in predicting school engagement. Addressing income inequality through policies encouraging economic well-being could have a substantial influence on school engagement. In recent decades, wages for low-income individuals have remained stagnant while higher-income groups have seen massive gains [27]. Minimum wage increase has garnered significant support within the US [34]. Furthermore, expanding the Supplemental Nutrition Assistance Program (SNAP) could decrease food insecurity and increase economic activity [27]. The policy approach should be multi-faceted and incorporate criminal justice reform, economic stimulus, and social programs to minimize the influences of ACEs on school engagement.

**Strengths and limitations**

The complex survey design of NSCH allowed for our study to be nationally representative of the US. Additionally, the current study’s innovative use of dominance analysis to understand the relative importance of ACEs in predicting school engagement yielded insights that will guide future research and policy interventions. Despite the noted strengths of the current study, we did have certain limitations. The NSCH made changes to survey questions included in our study from earlier iterations. This restricted our analysis to 2018/2019 data. Since then, the COVID-19 pandemic significantly changed the education landscape in the U.S., resulting in worse school engagement compared to before the onset of the pandemic [35]. Further, the prevalence of ACEs increased during the pandemic pointing towards a compounding impact on worse school engagement and health disparities [36]. While this study did not include data from COVID-19, the effect of the pandemic cannot be understated on ACEs and school engagement; future studies are needed to examine these impacts. Another limitation of the study includes recall bias as the data collection method for the NSCH relies on parental/guardian
reported data. Additionally, future studies may investigate additional covariates that may have an influence on school engagement including parental support, number of children in the household, parental immigration status, and primary caregiver physical health.

Furthermore, dominance analysis is a relatively new statistical approach in the field of public health and has its own set of restrictions. Dominance analysis was initially built to be used for ordinary least squares (OLS) multiple linear regression, wherein R² statistics can be used to measure the percent of variance accounted for by a statistical model [37–39]. Consequently, dominance analyses of OLS models can be interpreted in terms of explained variance [38]. However, the nature of our outcome variables required the use of logistic regression. While dominance analysis has been successfully adapted for use with logistic regression, the nature of pseudo-R² statistics results in an inability for us to report the percentage of variance accounted for by each ACE [20].

Conclusion
Despite the limitations, the results provide unique and actionable insights. Most notably, this study points toward the large influence out-of-school factors play on school engagement. Parental incarceration and economic hardship are issues that can be addressed and mitigated through policy interventions. With limited funds available for education and public health interventions, it is crucial that these two ACEs are tackled through significant policy changes. However, it is important to note that any ACEs can result in worse school engagement and health outcomes, which should be considered when developing interventions. Based on the results from this study, in the context of the study population, a multi-faceted policy approach that reduces the incarcerated population, encourages economic well-being, and emphasizes early-childhood education has the potential to significantly reduce the inequities our society is facing [27].

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Authors’ contributions
NW, conceptualized the study, carried out the analyses, drafted the initial manuscript, reviewed and revised the final manuscript. ES, conceptualized the study, guided analysis, and reviewed and revised the final manuscript. TM critically reviewed the manuscript and reviewed and revised the final manuscript. All authors approved of the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Availability of data and materials
The datasets analysed in this study are publicly available through the Health Resources and Services Association (HRSA) using this link https://mchb.hrsa.gov/data/national-surveys.

Declarations
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All methods were conducted in accordance to relevant guidelines and regulations.

Consent for publication
Not applicable.

Competing interests
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Additional file 1. Logistic regression assumption testing: multicollinearity of the explanatory and covariates form model 1 (outcome: repeated grades). Variance Inflation Factor (VIF) determines the correlation between the independent variables. A score close to 1 indicates that there is little correlation while a score close to 10 indicates a large correlation. This file includes a table that shows the test of the logistic regression assumption of multicollinearity.

Additional file 2. Unadjusted bivariate analyses for three model outcomes (repeated grades, does all required homework, and cares about doing well in school) by demographic, ACE, and other covariates for the National Survey of Children’s Health 2018–2019. This file contains descriptive analyses of the explanatory and covariate variables for the three model outcomes.
4. Shonkoff JP, Garner AS. The lifelong effects of early childhood adversity and toxic stress. Pediatrics. 2012;129(1):e232–46. https://doi.org/10.1542/peds.2011-2663.

5. Felitti VI, MD, FACP, ARF MD, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: the adverse childhood experiences (ACE) study. Am J Prev Med. 1998;16(4):245–58. https://doi.org/10.1016/S0749-3797(98)00017-8.

6. Herzog J, Schmah C. Adverse childhood experiences and the consequences on neurobiological, psychosocial, and somatic conditions across the lifespan. Front Psychiatry. 2018;8:420. https://doi.org/10.3389/fpsyg.2018.00420.

7. Bills MA, Hughes K, Ford K, et al. Adverse childhood experiences and sources of childhood resilience: a retrospective study of their combined relationships with child health and educational attainment. BMC Public Health. 2018;18(1):792. https://doi.org/10.1186/s12889-018-6599-8.

8. Fisherty EG, Thompson R, Dubowitz H, et al. Adverse childhood experiences and child health in early adolescence. JAMA Pediatr. 2013;167(7):622–9. https://doi.org/10.1001/jamapediatrics.2013.22.

9. van Tilburg MAL, Runyan DK, Zolotor AJ, et al. Unexplained gastrointestinal symptoms after abuse in a prospective study of children at risk for abuse and neglect. Ann Fam Med. 2010;8(2):134–40. https://doi.org/10.1370/afm.1053.

10. Basch CE. Healthier students are better learners: a missing link in school reforms to close the achievement gap. J Sch Health. 2011;81(10):593–9. https://doi.org/10.1111/j.1746-1561.2011.00632.x.

11. Bethell C, Newacheck P, Hawes E, Halfon N. Adverse childhood experiences: assessing the impact on health and school engagement and the mitigating role of resilience. Health Aff. 2014;33(1):2106–15. https://doi.org/10.1377/hlthaff.2014.0914.

12. Robbins A, Gelsvik A, Hinray P, Vivier PM, High P. Adverse childhood experiences and protective factors with school engagement. Pediatrics. 2019;144(2):e20182945. https://doi.org/10.1542/peds.2018-2945.

13. Public TL, Education H. A neglected social determinant of health. Lancet. 2020;395(10227):1633–42. https://doi.org/10.1016/S0140-6736(20)31441-4.

14. Shlafri RJ, Reedy T, Davis L. School-based outcomes among youth with incarcerated parents: differences by school setting. J Sch Health. 2017;87(9):687–95. https://doi.org/10.1111/josh.12539.

15. Simons LG, Steele ME. The negative impact of economic hardship on adolescent academic engagement: an examination parental investment and family stress processes. J Youth Adolesc. 2020;49(5):973–90. https://doi.org/10.1007/s10964-020-0210-4.

16. Child and Adolescent Health Measurement Initiative. Fast facts. 2018-2019 National Survey of Children’s Health: Data Resource Center for Child and Adolescent Health supported by the U.S. Department of Health and Human Services, Health Resources and Services Administration (HRSA), Maternal and Child Health Bureau (MCHB). www.childhealthdata.org, 2020.

17. U.S. Census Bureau. U.S. Department of Commerce. National survey of children’s health: guide to multi-year analysis. 2022. www2.census.gov/programs-surveys/nchs/technical-documentation/methodology/NSCH-Guide-to-Multi-Year-Estimates.pdf. Accessed 16 Nov 2022.

18. Karpur A, Lello A, Frazer T, Dixon PJ, Shih AJ. Health disparities among children with autism spectrum disorders: analysis of the national survey of children’s health 2016. J Autism Dev Disord. 2019;49(4):1652–64. https://doi.org/10.1007/s10803-018-3862-9.

19. Johnson-Staub C. Equity starts early: addressing racial inequities in child care and early education policy: Center for Law and Social Policy Inc (CLASP); 2017.

20. Tonstad S, LeBreton JM. Determining the relative importance of predictors in logistic regression: an extension of relative weight analysis. Organ Res Methods. 2010;13(4):767–81. https://doi.org/10.1177/109428109341993.

21. Luchman JN. Dominance analysis: Stata Help. 2020.

22. Stadler M, Cooper-Thomas HD, Greff S. A primer on relative importance analysis: illustrations of its utility for psychological research. Psychol Test Assess Model. 2017;59:381.

23. Murray J, Loeber R, Pardini D. Parental involvement in the criminal justice system and the development of youth theft, marijuana use, depression, and poor academic performance. Criminology. 2012;50(1):255–302.

24. Turney K, Haskins AR. Falling behind? Children’s early grade retention after paternal incarceration. SocioL Educ. 2014;8(4):241–58.

25. Wagner P, Sawyer W. State of incarceration: the global context 2018: Prison Policy Initiative; 2018. https://www.prisonpolicy.org/global/2018.html. Accessed 16 Nov 2022.

26. Bronson J, Carson EA. Prisoners in 2017: In: Justice USDo, editor. Bureau of Justice Statistics2019.

27. Khullar D. Health, income, and poverty: where we are and what could help. Health Aff. 2018.

28. Ermisch J, Jantti M, Smeeding TM. From parents to children: the intergenerational transmission of advantage: Russell Sage Foundation; 2012.

29. Ashiabi G. Household food insecurity and children’s school engagement. J Child Poverty. 2005;11(1):3–17. https://doi.org/10.1080/107961204200033027.

30. Landers-Potts MA, Wickrama KAS, Simons LG, et al. An extension and moderational analysis of the family stress model focusing on african american adolescents. Fam Relat. 2015;64(2):233–48. https://doi.org/10.1111/fer.12117.

31. Jiang Y, Granja MR, Koball H. Basic facts about low-income children: children 6 through 11 years, 2015. National Center for Children in Poverty; 2017.

32. Berg L, Rostila M, Saarela J, Hjern A. Parental death during childhood and subsequent school performance. Pediatrics. 2014;133(4):e682–9. https://doi.org/10.1542/peds.2013-2777.

33. Bernardi F, Radl J. The long-term consequences of parental divorce for children’s educational attainment. Demogr Res. 2014;30:1653–80 http://www.jstor.org/stable/26348252.

34. Davis L, Hartig H. Two-thirds of americans favor raising minimum wage to $15 an hour: Pew Research Center, 2019. https://www.pewresearch.org/fact-tank/2019/07/30/two-thirds-of-americans-favor-raising-federal-minimum-wage-to-15-an-hour/. Accessed 16 Nov 2022.

35. Salmela-Aro K, Upadya K, Vinn-Laasko J, Hietajärvi L. Adolescents’ longitudinal school engagement and burnout before and during covid-19—the role of socio-emotional skills. J Res Adolesc. 2021;31(3):796–807. https://doi.org/10.1111/jora.12654.

36. Sonu S, Marvin D, Moore C. The intersection and dynamics between covid-19, health disparities, and adverse childhood experiences: “intersection/dynamics across covid-19, health disparities, and aces”. J Child Adolesc Trauma. 2021;14(4):517–26. https://doi.org/10.1007/s40653-021-00363-z.

37. Azen R, Budescu DV. Comparing predictors in multivariate regression models: an extension of dominance analysis. J Educ Behav Stat. 2006;31(2):157–80.

38. Tonndandel S, LeBreton JM. Relative importance analysis: a useful supplement to regression analysis. J Bus Psychol. 2011;26(1):1–9.

39. Luchman JN. Relative importance analysis with multicategory dependent sources of childhood resilience: a retrospective study of their combined maximum visibility for your research: over 100M website views per year.

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