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Measuring adversity in the ABCD[®] Study: systematic review and recommendations for best practices

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Abstract

Background Early life adversity (ELA) has substantial, lifelong impacts on mental and physical health and development. Data from the ABCD[®] Study will provide essential insights into these effects. Because the study lacks a unified adversity assessment, our objective was to use a critical, human-driven approach to identify variables that fit ELA domains measured in this study.

Methods We clarify best practices in measurement of adversity in the ABCD Study through the creation of adversity scores based on the well-established Adverse Childhood Experiences (ACEs) questionnaire and another inclusive of broader ELA. Variables previously used to measure adversity in the ABCD dataset were determined via literature review. We assessed each variable to identify its utility in measuring domains of adversity at baseline and follow-up time points and by individual completing the assessment (i.e., youth or caregiver). Variables were selected that align with decades of ELA measurement, and therefore, can be used by research teams as measures of ELA.

Results The literature review and critical analysis of items led to the development of three measures of ELA: an ACESproxy score, a youth-reported ACEs-proxy score, and a broader ELA score (ELA⁺). We provide code using R to calculate these scores and their constituent domains for use in future ABCD adversity-related research.

Conclusions The ABCD Study is one of the largest longitudinal studies of youth development, with data available for secondary analysis. Our review of existing measures and development of a coding schema will allow examination of ELA using this dataset, informing our understanding of risk, resilience, and prevention.

Keywords ACEs, ABCD, Adversity, ELA, Early life adversity, Adverse childhood experiences

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Introduction

Early life adversity (ELA) can have deleterious effects on individual psychological, behavioral, and physiological functioning [1]. Broadly defined, ELA is an umbrella term for various adverse experiences occurring before the age of 18, including physical and emotional abuse and neglect, sexual abuse, household dysfunction, neighborhood violence, and material deprivation, among other adverse environmental influences [2]. Notably, while ELA incorporates traumatic and stressful events, not all stressful events are adverse experiences [3]. Associations between ELA and behavioral and neurological development are well documented. Indeed, ELA has



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lasting effects on physical and mental health evident in adulthood [4, 5]. Early childhood is characterized by rapid neurodevelopment and heightened neuroplasticity, allowing for the biological embedding of childhood adversity [6]. These harmful effects persist due to physiological alterations resulting from early adversity during critical periods.

There are multiple methods for measuring ELA, including the Childhood Trauma Questionnaire [7], Life Events and Difficulties Schedule [8], and the Stress and Adversity Inventory [9]. Perhaps the most commonly cited measure is the ten-item Adverse Childhood Experiences (ACEs) questionnaire, which encompasses physical, verbal, and sexual abuse; physical and emotional neglect; witnessing violence between family members; having a family member with a mental illness or substance use disorder; incarceration of a family member; and parental divorce [10]. As with other measures of ELA, ACEs are associated with harmful effects on individuals' mental and physical health in adulthood [10–12]. Studies consistently support a strong dose-response association between ACEs and mental and physical health problems in adulthood [11, 13–15]. These relationships are also detected in children and adolescents, including increased risk for childhood obesity, chronic medical conditions, internalizing and externalizing issues, and suicide [16-18]. Importantly, the adoption of health-risk behaviors (e.g., overeating, heavy drinking, illicit drug use) is thought to account for many of the deleterious effects of ACEs [19].

While ACEs is one of the most commonly cited measures of adversity, there are limitations to the measure, including the exclusion of other types of potentially detrimental life experiences. The ACEs measure was developed with a majority White sample of adults in the 1990s and is therefore unlikely to capture the diverse experiences of adversity faced by children and adolescents today (e.g., parent deportation; terrorism; natural disasters as a result of climate change). ACEs was designed as a retrospective assessment of childhood experience once in adulthood, limiting our ability to understand the impact of these experiences during development. Researchers have been adapting ACEs to measure these experiences from child report in a sensitive and age appropriate manner [20] to understand the developmental impacts as well as to support clinical intervention. Additionally, there is also a growing recognition that a lack of access to resources and services can compound the effects of ACEs [21]. A larger ELA framework is needed to encompass these adverse experiences. We developed both an ACEs-proxy score, to allow for comparison with the expansive ACEs work available, but also a more encompassing ELA score to incorporate other domains (e.g., lack of resources,

exposure to disaster and community violence) to explore this broader context.

Given the overarching impact of ELA across multiple health outcomes, measurement of these experiences is crucial to better understand alterations to the developmental trajectory following these experiences and to identify critical periods for prevention and intervention. The ongoing Adolescent Brain and Cognitive Development (ABCD) Study provides a unique opportunity to examine early life adversity in a large, diverse sample longitudinally, including an understanding of neurobiological effects. The ABCD Study enrolled over 11,000 9-10-year-olds at baseline across 21 sites nationwide and is now in year 8 of 10. The ABCD Study does not include a measure specific to ELA; however, many items reported by the youth and/or study caregiver (e.g., parent) indicate the youth's exposure to various adverse experiences [22, 23]. These include the Kiddie Schedule for Affective Disorders and Schizophrenia-Present and Lifetime (K-SADS-PL) computerized measure [24-26], Life Events Scale [27, 28], Family Environment Scale [29], and Parental Monitoring Questionnaire [30], among others. Thus far, scientists have measured ELA in ABCD using an assortment of items, often without justification as to why certain items were selected rather than others. The use of varied ELA measures results in inconsistent findings, which may be due to "true" effects or method variance, including variation by reporter (i.e. caregiver, youth, or both) and by surveys and items collected. Because of the size of the dataset, modifications across timepoints, and the variety of measures used, selection of the most suitable variables can be difficult for investigators and has resulted in adoption of many different measures of ELA. Like other large datasets, a thoughtful, comprehensive approach to measuring ELA in the ABCD Study is needed to assist investigators with these data.

To address the goal of identifying a recommended ELA measure in the ABCD data, we conducted a systematic review of ELA variables used in previously published studies on the ABCD dataset. From these previous studies, we examined the variables used to 1) create a measure corresponding to the 10-item ACEs questionnaire (ABCD-ACEs) and 2) create a measure we refer to as ABCD-ELA⁺ that includes additional adverse experiences likely to affect development. While many different experiences during childhood could be categorized as adverse, we chose to use the ACEs questionnaire as an anchor for our examination of the measurement of childhood adversity because it is the most commonly used measure of childhood adversity in community settings [31], with a significant role in societal and policy-based initiatives. Lastly, we will provide an in-depth discussion of these variables, including

recommendations and suggestions for use in future research.

Methods

Literature review

Articles were extracted in February 2025 using three search engines: Scopus, PsycINFO, and PubMed. Only articles published in peer-reviewed journals with a publication date no earlier than 2018 were used, as the earliest papers using the ABCD dataset were first published in 2018. The manuscript list was checked against the ABCD publication repository hosted at https:// abcdstudy.org/publications/ to verify all relevant publications were included in our literature review.

Keywords were "adverse childhood experiences" and "ACEs". We included "early life adversity" and "childhood adversity" as synonyms of adverse childhood experiences. "Adolescent Brain Cognitive Development Study" and the study acronym "ABCD" were used as keywords, as we were only interested in studies which used the ABCD Study sample/database. The following combinatory keywords were used across all selected search engines: "adverse childhood experiences & Adolescent Brain Cognitive Development Study;" "ACEs & Adolescent Brain Cognitive Development Study;" "ACEs & ABCD Study;" "early life adversity & Adolescent Brain Cognitive Development Study;" "early life adversity & ABCD Study;" "childhood adversity & Adolescent Brain Cognitive Development Study;" "childhood adversity & ABCD Study." Inclusion criteria were as follows: (1) original research articles (opinions, editorials, and reviews excluded), (2) analyses used the ABCD Study database, and (3) a sum score for childhood adversity was used as the independent variable or predictor. Articles that examined only specific types or domains of adversity, such as parental substance use or financial difficulties, were not included in the review. Articles utilizing a data-driven approach were not included in the table due to the sheer number of items examined in these papers (see [32, 33]).

Measures of ELA used in the literature were assessed in regard to the reporter (i.e., youth or caregiver report), wave of assessment, and the measure used. In addition, we assessed the scale and instructions that the item was nested in because when read alone specific variables may seem to fit into an adverse experience, but when taken into context of the scale, should not be included. There was also a careful review of all the ABCD variables to ensure any additional adversity-related items not previously included in publication were included (for example, experiencing family separation or entering foster care).

Coding creation

As with the traditional ACEs measure, we sought to create a group of variables that could be summed to calculate an overall ACEs score. The ABCD-ACEs score was created by sorting variables into the traditional ACEs domains: physical abuse, physical neglect, emotional abuse, emotional neglect, sexual abuse, parents' divorce, violence in the home, parental mental illness, parental incarceration, and parental substance abuse (see Fig. 1).

Additionally, a youth-derived ABCD-ACES score was created by deferring to only youth reports when available. This youth-derived score may align more closely with expectations of a traditional ACEs score, which is typically a self-report. In many domains (Fig. 1), there is a mix of youth *or* caregiver reported items; whereas, in other domains, youth and the caregiver completed all the same items, so the youth-derived score parallels the total ABCD-ACEs score, just from the youth perspective. There are some limitations to using the youth-deferred score in the current ABCD Study dataset, however, because some domains (Figs. 1 and 2) only have items with caregiver-report.

The ABCD-ELA⁺ score is more broadly inclusive of early life adversity. In addition to the traditional ACEs domains, this score includes exposure, lack of safety, lack of economic resources, and separation from caregiver.

To create the ABCD-ACEs and ABCD-ELA⁺ scores, specific variables were sorted into adversity domains and a score of 1 was assigned if either caregiver or youth endorsed any of the variables in that domain. Answering no to all items resulted in a score of 0. Otherwise, if no data were available for any variables in a specific domain, that domain score was assigned "NA." The resultant score allows for changes in adversity across the life course. Therefore, if a youth participant endorsed physical abuse at Baseline, that item would score as a 1 throughout data collection. If there was no endorsement of sexual abuse at Baseline, but endorsement occurred in Year 2, this would be reflected by a change from 0 ("no") to 1 ("yes") for the sexual abuse domain from Baseline to Year 2.

Consent for publication: Not applicable.

Clinical trial number: Not applicable.

Results

Literature review

The literature review yielded 36 studies on childhood adversity which used the ABCD dataset. These studies [34–69] are listed in Supplementary Table S1, along with the items used to create each manuscript's adversity measure. Many variables were selected in only one or two papers, while others were present in most of the papers reviewed. Results of the review revealed that the



Fig. 1 Adversity domains in ABCD. For each of the ABCD-ACEs domains, each variable included in that domain, the measure it was collected from, and reporter (^CCaregiver Report, ^YYouth Report) is provided. Additional ABCD-ELA⁺ domains are included in the inner circle. CRPBI=Children's Report of Parent Behavior Inventory; Exposure = Exposure to Disaster and Community Violence; FES = Family Environment Scale. KSADS = Kiddie Schedule for Affective Disorders and Schizophrenia; Life Events = Life Events Scale

most commonly used items assessed financial adversity (demographics survey; caregiver report) and traumatic experiences, such as abuse (K-SADS; typically, caregiver report).

Domain creation

While the ACEs questionnaire is a commonly reported adversity score, there are additional adversities that youth may experience that can detrimentally impact development. Thus, an ABCD-ELA⁺ variable was created with an additional 4 domains: exposure to disaster and community violence (exposure), lack of safety, lack of economic resources, and separation from caregiver. Additionally, to allow for the best possible replication of a traditional ACEs score, an ABCD-ACEs-Youth score was created to include the two youth-only reported domains (Emotional Abuse and Emotional Neglect) and the four domains that contain caregiver- and youthreport (Divorce, Incarceration, Parental Substance Use, Parental Mental Health). Table 1 indicates which reporters are included for each domain. For these four domains in the ABCD-ACEs-Youth score, only the youth-report is included in the score creation (Fig. 2).

ABCD-ELA⁺ and ABCD-ACEs scores were created after thorough review of all items included in the early life adversity papers identified above, as well as variables from within the data-driven manuscripts that capture adversity and a review of the ABCD Data Dictionary. As noted above, these items were assessed for fit. For example, "Family members sometimes hit each other" was not included in the final score because this item was not in the specific context of physical abuse; children frequently endorse this item based on sibling behaviors, including babies or toddlers hitting their older siblings. Supplementary Table S2 lists all variables found in the review but not included in the scores with an explanation for each. In some cases, a sum score from the ABCD tabulated data was used as an "item" in the ABCD-ACEs or ABCD-ELA⁺ scores. In these instances, the individual items used to create the sum score were also not separately included in the ABCD-ELA⁺ or ABCD-ACEs score to avoid overinflation of any area. For example, the Family History Survey includes a summary score indicating



Fig. 2 ABCD-ACEs-Youth Domains. Side-by-side comparisons of the total (parent- and/or youth-report) and youth-only report are shown for the domains Divorce, Mental Illness, Incarceration, and Substance Use. Emotional Abuse and Emotional Neglect are only youth report for both the total scores and the youth report scores. Violence in the Home, Sexual Abuse, Physical Abuse, and Physical Neglect only contain parent-reported items and are therefore not shown

Domain	Parent report	Youth report
ABCD-ACEs		
Physical Abuse	Х	
Sexual Abuse	Х	
Emotional Abuse		Х
Physical Neglect	Х	
Emotional Neglect		Х
Divorce	Х	Х
Violence	Х	
Parental Mental Health	Х	Х
Parental Incarceration	Х	Х
Parental Substance Use	Х	Х
Additional Domains included i	n ABCD-ELA+	
Exposure	Х	
(Lack of) Safety	Х	Х
(Lack of) Resources	Х	
Family Separation	Х	Х

Table 1 Data available for each adversity domain by reporter

the presence of alcohol use disorder in a biological parent. Therefore, only this item was used in the creation of ABCD-ACEs and ABCD-ELA⁺; the separate items assessing this for the biological mother and father were not used, as their presence is reflected in the summary score. Of note, the K-SADS variables included in the code were asked to each reporter at the timepoints collected; none of these variables were nested under screening variables. The rates for ABCD-ACEs and ABCD-ELA⁺ by domain can be seen in Fig. 3, while Fig. 4 depicts the sum scores for these two created variables (see Figures S1-S4 for ABCD-ACEs and ABCD-ELA+domains and sum scores by individual timepoint).

The specific R code used to create the ABCD-ELA⁺, ABCD-ACEs, and ABCD-ACEs-Youth score is available at https://github.com/karalk07/abcd-ela.

Variables/measures requiring additional coding

Four measures (Children's Report of Parent Behavior Inventory (CRPBI; [23, 70]), Adult Self-Report [ASR], Life Events Scale, and Neighborhood Safety and Crime) required additional coding, as the tabulated variables provided by ABCD were not dichotomous.

CRPBI

A reverse score of the CRPBI Warmth/Acceptance Scale was created for the adversity domain of emotional neglect. Youth in the ABCD Study complete the CRPBI for the study caregiver (parent/caregiver participating in the study with them) and, optionally, for a second caregiver. For our measure of adversity, the CRPBI sum score was included just for the study



Fig. 3 ABCD-ACEs (A) and ABCD-ELA⁺ (B) Domains stacked by unique, new reports at each timepoint. Note that some domains do not have updated data for every time point. Exposure = Exposure to Disaster and Community Violence

caregiver, since every child completed that set of items. The response options for each item in the CRPBI (for example: "Believes in showing his/her love for me.") are 1- "not like him/her," 2- "somewhat like him/her," 3- "a lot like him/her," with the Warmth/Acceptance scale reflecting an average of these response. For our adversity measures, the average score was coded as "yes (1)" if it was less than 2 (indicating a lack of parental warmth/acceptance) and "no (0)" if it was greater than or equal to 2 (scale 1–3).

ASR

The Adult Self-Report (ASR) total problems T-score was coded as "no (0)" for scores less than 64 and "yes (1)" for scores greater than or equal to 64, which are considered within the clinical range [22, 71, 72], and are included as parental mental health variables in our mental health domain.

Life Events Scale The Life Event Scale [22, 27, 28] was first collected at Year 1. However, because these items include additional sub-items related to when the experi-



Fig. 4 Number of participants with each ABCD-ACEs (A) and ABCD-ELA.⁺ (B) sum score by timepoint (scores over 8 enlarged for clarity)

ence occurred, timing of items can be approximated for Baseline. If a caregiver or youth endorsed that an item occurred, but not in the past year at the Year 1 assessment, the variable was coded as occurring prior to Baseline. If the item was endorsed during the past year, it was coded as occurring at the Year 1 timepoint. It is possible that in the latter situation, the exposure could have also occurred before Baseline and in the past year (for example, a family member with a substance use disorder that was present both at Baseline and Year 1).

Neighborhood Safety and Crime This measure is taken from the PhenX Toolkit to assess environmental safety (for example, "Violence is not a problem in my neighborhood;" [23, 73, 74]. The variables are reverse scored, with responses of "strongly disagree" and "disagree" coded as "yes (1)" and all other responses coded as "no (0)."

Longitudinal assessment

Current studies using ABCD Study data have largely relied on Baseline and/or Year 1 measures of adversity. As the study continues, updates to adversity measures are needed to better reflect the child's adversity exposure and measure change over time. It is best not to calculate lifetime adversity based on data from any single followup timepoint because not all items are collected at each timepoint and measures vary on the time frame they are assessing (e.g., did this "ever" occur versus has this occurred since the last data collection visit). Baseline data is sufficient for an initial adversity score. Following Baseline, if a measure was not collected and an entire domain is absent of data, our procedure allows the same score from the previous timepoint in a given domain. Our current code and reported scores did not include Year 4 data because the Year 4 KSADS data is not yet available.

Discussion

The primary aims of the current study were to 1) conduct a systematic review of the current literature on early life adversity (ELA) in the ABCD Study and 2) develop a longitudinal measure of ELA based on the results of this review and analysis of item content. Traumatic experiences, such as abuse (K-SADS; typically, caregiver report), and financial adversity (demographics survey; caregiver report) were some of the most common themes reported. These items are included in our ABCD-ACEs score, along with at least one item approximating each of the 10 items from the original ACEs survey. We also created an ABCD-ELA⁺ measure with additional items reflecting ELA (e.g., exposure to natural disasters; deportation of a parent/caregiver). The ABCD-ELA⁺ measure provides a more comprehensive assessment of ELA that can be used unless the investigators' primary aim is to measure ACEs specifically.

We are not the first to work on rectifying this issue. ABCD Study investigators recognized the need to more thoroughly assess stressful and adverse experiences and added the Life Events Scale to the study protocol as both a caregiver- and youth-report beginning in Year 1 [75]. On this scale, respondents are asked whether the event occurred, and if it did, whether it was a positive or negative experience for the youth. This scale includes many adversity-related events and a total measure for the number of events the parent or youth reported as negative for both lifetime and the past year. This negative life events score has been used as an ELA measure in recent studies (e.g. [46, 56]). This scale, however, includes life events that have not been traditionally considered adverse experiences. For example, one item asks if the child "Attended a new school?" If this is reported as a negative experience, it would be included in the overall score, although no past studies of ELA have assessed going to a new school as an adverse experience, and nearly every child attends a new school at some point between ages 9 and 18. This scale score is therefore more appropriately used as negative life events or even stressful events the youth has experienced, rather than adversity perse.

Others have taken data-driven approaches to quantifying ELA in the ABCD Study data. Brieant et al. [32] identified 10 dimensions based on 60 ELA-related variables and demonstrated their utility in predicting relevant outcomes, such as mental health symptoms and executive functioning. Orendain et al. [33] took a similar factor analytic approach with a smaller number of items, resulting in six factors that predicted youths' mental health symptoms. These studies have added to our understanding of ELA measurement in the ABCD Study and its relation to concurrent symptoms in study participants. Many of the factors can be explained, however, by common method or reporter (caregiver vs youth) variance. For example, the Brieant et al. [32] factors include one factor ("Youth report of family conflict") that is entirely from the youth-reported Family Environment Scale (FES) and another ("Family anger and arguments") that is entirely based on items from the caregiver-reported FES. Additionally, both factor analyses were performed only on Baseline data, and thus do not include any times from the Life Events Scale and are unable to be used to look at new adverse experiences between data collection time points.

The current study therefore took a "human-driven, data-informed" approach that examined items previously used in ELA studies using ABCD Study data to select those that best reflect the decades of past research on ELA. First, an ABCD-ACEs measure was created as a 10-item proxy score comparable to that of the original ACEs survey. This measure scores each ACE domain as a 0 or 1, thus reducing inflation of scores for domains that are overrepresented by survey items in ABCD (e.g., 6 items measure physical abuse compared to 1 item for emotional abuse). We formed this measure to be used for replication studies of findings from other samples that have used the ACEs survey, but we, like others, recognize and acknowledge the limitations of the original ACEs survey (see Supplement). We thus created the ABCD-ELA⁺ measure as a broader measure of ELA that includes items not assessed in the original ACEs survey but that are commonly considered adversity, including exposure to natural disasters and violence, lack of access to resources, and long-term separation from caregivers. We recommend that this broader measure be used for researchers interested in ELA, and the ABCD-ACEs measure be used for those specifically interested in replicating findings from previous ACEs studies. Our measure does not include any prenatal exposure to adversity, which aligns with much of the childhood adversity research, due to the limited data collected by ABCD and the conceptualization of what childhood adversity experiences entail.

Additionally, because ABCD is a longitudinal study across adolescence, we were interested in methods of ELA measurement that consider new experiences at additional timepoints. The brain is still developing across this age range and is impacted by new experiences, and past research on childhood adversity typically includes experiences up through age 18. It is therefore important to not stop our ELA measurement at the Baseline timepoint. The ABCD-ELA⁺ measure includes updates for each time point for those variables that are measured repeatedly, allowing for the examination of effects of recent experiences as well as possible sensitive periods of development for the effects of ELA. We have additionally created a measure that defers to youth self-report of their own experiences rather than the caregiver-report, when possible, which may more closely approximate past research using self-reported data. This measure is limited, however, by necessarily including items with caregiver report, as not all items were administered to youth. Future data collection waves may increase the items asked directly to youth, which would enhance the utility of this youth-deferred measure.

These measures will provide a starting point for researchers examining the impacts of adversity on adolescent development, allowing them to focus on these impacts rather than spending an inordinate amount of time searching the dataset for relevant items. Pulling items from different surveys and reporters has its limitations, however. While the available data has allowed us to add new domains in the ABCD-ELA⁺ measure, some domains in the original ACEs survey are not well assessed. For example, the wording of items in the physical neglect domain focuses more on affordability rather than if the child's physical needs were neglected (e.g., a parent might say yes to "Needed food but couldn't afford to buy it," when they went to a food bank to ensure their child's needs were met). Similarly, there are no items directly measuring emotional neglect, leading us to reverse score the CRPBI as a measure of parental warmth and acceptance and impose a minimum threshold reflecting adequate emotional support. All items are also solely based on parent/caregiver- and/or self-report, which may differ from documented cases of child maltreatment. It should also be noted that measuring adversity during childhood/adolescence often deviates from adults' reports of experiences in their childhood [76]. Researchers must consider this when comparing ABCD Study findings with those from broader literature.

Our aim was to create measures that could be easily used by researchers interested in examining the effects of adversity in the ABCD Study dataset but not to hold these measures as the only way adversity can be measured. We hope that by reviewing the literature and providing justification for decisions made about including or excluding certain items we have provided a starting point for researchers in the field, who are encouraged to make their own decisions regarding which items to include based on their research question. For example, some research questions may be better answered by a narrower focus on traumatic events, such as physical or sexual abuse, and exclude items such as parental divorce. Researchers may also wish to create other variations of these scores, such as a caregiver-report only score.

Our review of the literature supports the use of the ABCD Study dataset for examining questions related to childhood adversity, including domains outside of traditional ACEs that may nevertheless have substantial impacts on physical and mental health outcomes. Our primary objective is to reduce the amount of time researchers spend sifting through the data determining which adversity-related items were administered to whom at which time point and to increase the time they can spend analyzing the data and answering their research questions, moving our field forward at a pace necessary to address the effects of early life adversity.

Abbreviations

ABCD	Adolescent Brain Cognitive Development Study	
ELA	Early Life Adversity	
ACEs	Adverse Childhood Experiences	
K-SADS-PL (K-SADS)	Kiddie Schedule for Affective Disorders and Schizo- phrenia—Present and Lifetime	
CRPBI	Children's Report of Parent Behavior Inventory	
ASR	Adult Self-Report	
FES	Family Environment Scale	
ABCD-ACEs	Proxy score created from the Adverse Childhood Expe- riences domains	
ABCD-ELA+	Broader Early Life Adversity Score created with ABCD variables	
ABCD-ACEs-Youth	Proxy score created from the Adverse Childhood Expe- riences domains, relying on only youth-report when available	

Supplementary Information

The online version contains supplementary material available at https://doi. org/10.1186/s12874-025-02521-5.

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Authors' contributions

Conceptualization: FB, ER, ZC, JC, KK; Methodology: FB, ER, ZC, KK; Formal analysis: FB; Writing – original draft: FB, ER, ZC, KK; Writing – review & editing: FB, ER, ZC, JC, KK; Visualization – FB, KK; Funding acquisition: FB, JC, KK.

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Data availability

Data used in the preparation of this article were obtained from the Adolescent Brain Cognitive Development (ABCD) Study (https://abcdstudy.org), held in the NIMH Data Archive (NDA). This is a multisite, longitudinal study designed to recruit more than 10,000 children age 9e10 and follow them over 10 years into early adulthood. The ABCD Study is supported by the National Institutes of Health and additional federal partners under award numbers U01DA041048, U01DA050989, U01DA051016, U01DA041022, U01DA051018, U01DA041028, U01DA050987, U01DA041174, U01DA041106, U01DA041117, U01DA041028, U01DA041134, U01DA050988, U01DA051039, U01DA041156, U01DA041025, U01DA041120, U01DA051038, U01DA041148, U01DA041093, U01DA041089, U24DA041123, and U24DA041147.

A full list of supporters is available at https://abcdstudy.org/federal-partners. html. A listing of participating sites and a complete listing of the study investigators can be found at https://abcdstudy.org/consortium_members/. ABCD consortium investigators designed and implemented the study and/or provided data but did not necessarily participate in the analysis or writing of this report. This manuscript reflects the views of the authors and may not reflect the opinions or views of the NIH or ABCD consortium investigators. The ABCD data repository grows and changes over time. The ABCD data used in this report came from 10.15154/z563-zd24 (https://doi.org/10.15154/z563-zd24).

Declarations

Ethics approval and consent to participate

This manuscript consists of secondary data analyses of the ABCD Study data, which can be accessed at NIMH Data Archives (see below). As such, it has been determined that this project does not qualify as human subjects research as defined in 45 CFR 46.102 (d) and (f) and is not subject to oversight by the authors' institutional review board.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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