



# Adversity and child body mass index in Fragile Families over 15 years: Do type and timing matter?

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## ABSTRACT

**Background:** Weight status has been linked to adverse childhood experiences. Existing research, however, is limited to unidimensional assessments of cumulative risk and does not account for the complex nature of adversity experienced by children in high-risk settings. We fill existing gaps by assessing how four subtypes of adversity across two primary dimensions of threat and deprivation-based adversity are associated with changes in body mass index (BMI) across child ages 3 through 15 years.

**Method:** U.S. mothers and fathers ( $n = 2412$ ) in the Fragile Families and Child Wellbeing Study were interviewed when children were born, and again at ages 1, 3, 5, 9, and 15 years. Independent variables include interpersonal (e.g., domestic violence), family (e.g., mental health), economic (e.g., housing insecurity), and community (e.g., witness/victim of violence) adversity from ages 1 through 9 years. Path analysis regressed changes in BMIz from ages 3 through 15 on past adversity exposures.

**Results:** Increased interpersonal and community adversity subtypes from ages 3 to 5 were associated with decreased BMIz from ages 5–9 years. Increased economic adversity from age 3 to 5 was associated with increased BMIz from ages 5 to 9, adjusted for mother age, race, and education.

**Conclusion:** Findings highlight the differential influence of past adversity type and timing on child BMI. Interpersonal and community adversity were associated with decreased BMIz, and economic adversity with increased BMIz. Differences in directionality of associations suggest research should capture multiple dimensions of adversity in early childhood and possible positive and negative trends in effects on child weight as children grow from early to mid-childhood.

## 1. Introduction

Adverse childhood experiences negatively impact childhood weight status, or childhood obesity risk, a common indicator of physical health (Danese & Tan, 2014; Elsenburg et al., 2017; Schroeder et al., 2021). However, measures of adverse experiences have relied primarily on unidimensional assessments of cumulative risk that may not adequately capture the dimensional nature of adversity experienced by diverse families from disadvantaged communities, or differences in sensitivity to risk across stages of development (Flaherty et al., 2013; Lanier et al., 2018). Cumulative risk models assume impacts of adversity on health are due to the accumulation of the number of discrete exposures as representative of the accumulation of toxic stress, regardless of timing

and form (McLaughlin et al., 2019). However, contradictory findings from large national studies of families with higher social disadvantage suggest pathways from adversity to weight status are less straightforward. Research in Fragile Families, (Fragile Families and Child Wellbeing Study [FFCWS]), a national study that oversampled Black, Hispanic, and low-income families from U.S. cities (Reichman et al., 2001), demonstrates how more exposure to cumulative adversity of any kind in the first three years of life may not be associated with obesity risk at child age 5 years (Suglia et al., 2012), or increased body-mass index (BMI) percentile growth rates from ages 3 through 9 years (Liu et al., 2019). Existing research on the links between adversity and childhood obesity risk has predominantly examined the accumulation of interpersonal and family forms of adversity, is not developmentally specific,

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and has not operationalized adversity comprehensively. Although the accumulation of adversity likely has detrimental effects on child physical growth (Schroeder et al., 2021), contradictions in existing studies suggest a better understanding of the type and timing of exposure may improve our understanding of associations with child BMI in underserved communities.

Cumulative risk approaches demonstrate how childhood obesity risk may be the consequence of disrupted neurodevelopment pathways that result from exposure to highly stressful, adverse circumstances. A heightened stress response, especially when prolonged, can incite dysregulated immune, metabolic, neuroendocrine, behavioral, and psychosocial responses that can impact BMI (Wiss & Brewerton, 2020). Such impacts can hinder social, cognitive, and emotional functioning and contribute to health risk behaviors, such as dysregulated sleeping or eating patterns, which can ultimately increase BMI and obesity risk (Conger et al., 2002; Masarik & Conger, 2017; McCubbin & Patterson, 1983; Schuler et al., 2021; Shonkoff et al., 2012; Sominsky & Spencer, 2014). Recent theories on the neurological mechanisms of adversity and child mental health conceptualize adversity with two primary dimensions: threat and deprivation (Berman et al., 2022; McLaughlin et al., 2014, 2021; Miller et al., 2018). The threat dimension is consistent with traditional definitions of adversity and includes unexpected events that harm, victimize (i.e., physical abuse, crime victim) or threaten children (i.e., neglect, witnessing domestic violence). Deprivation refers to the absence of necessary social, emotional, or material resources for growth (McLaughlin, 2016) during critical stages of development, such as the loss of a parent (social) or food insecurity (material). (Desmond, 2015).

### 1.1. Threat dimension: Interpersonal and community violence

Under the threat dimension, harm or threat of harm can occur in settings proximal to the child in their household (e.g., child maltreatment, domestic violence), or in the surrounding community (e.g., witnessing or being the victim of a crime). Existing research on forms of victimization in the home setting show cortisol increases among 150 girls ages 6 through 16 with childhood sexual abuse histories had higher BMI growth trajectories from ages 6 through 27 years (Li et al., 2021). Parental neglect, a form of harm or emotional victimization (Freyd et al., 2007), has been linked to significant changes in child weight from early childhood through young adulthood. For example, neglect was cross-sectionally associated with higher obesity risk among preschool-aged children and was associated with a steeper increase in BMI among young adults (Anderson et al., 2014; Shin & Miller, 2012; Whitaker et al., 2007). Significant decreases in weight were observed among 8 and 9 year old children ( $n = 185$ ) exposed to chronic neglect at ages 4 through 6 years (Bennett et al., 2010), and among adolescents ( $n = 2078$ ) with multiple abuse reports (JUSmith et al., 2013). Like physical and sexual forms of abuse, when perpetrated by a trusted caregiver, neglect is similarly processed and remembered as betrayal trauma (Freyd et al., 2007). Similarly, domestic violence, even if not directly involving the child, can have a significant interpersonal impact when involving the child's trusted caretakers. Like abuse and neglect, domestic violence has been found to significantly increase numerous risks to child physical health (Holmes et al., 2022), including dietary intake (e.g., lower consumption of fruits and vegetables, higher consumption of sugar-sweetened beverages and sweet snacks) (Schuler et al., 2021). Children exposed to domestic violence were at increased risk for childhood obesity (Holmes et al., 2022; Jun et al., 2012), as early as child age 5 years (Boynton-Jarrett et al., 2010) (Boynton-Jarrett et al., 2010) and during adolescence; (Gooding et al., 2015) however, one study found domestic violence exposure in early childhood was not significantly associated with BMI in middle childhood (Schnurr & Lohman, 2013).

Although exposure to threats or actual violence at home and in the community may operate through similar mechanisms to effect child BMI

(Forsyth et al., 2015; Wiss & Brewerton, 2020), impacts from being victimized or threatened at home-based may differ from distal threats in the community. Violence in the community can distinctly hinder levels of physical activity, promote sedentary behaviors, and limit where and when parents shop for food. Community violence is associated with lower social cohesion which reduces trust, exacerbates concerns over physical safety, and can place limitations on activity outside the home (Datar et al., 2013; Forsyth et al., 2015), increasing risks for overweight or obesity (Forsyth et al., 2015). Research specific to community violence and child weight is limited, suggesting further research on this aspect of the threat dimension is needed. Further exploration of whether threats occurring at home versus in the community is warranted given the different underlying mechanisms of exposure in proximal home (i.e., interpersonal) compared to distal community environments.

### 1.2. Deprivation dimension: Family and economic

Deprivation, or the absence of expected, social, emotional, or material resources needed for growth may differ from threat-based forms of adversity in the impact on physical child health. Inconsistencies in the parent-child bond that are often a byproduct of parental incarceration, substance use, or mental health concerns, are forms of social deprivation that can impair a child's ability to regulate stress (Rees, 2007) and adversely impact child weight without necessarily involving direct victimization. The temporary or long-term loss of a parent or change in the nature of the parent-child relationship due to mental health, substance use, or incarceration of a biological parent may also lead to changes in the child's health routines – where kids live, eat, sleep, and play, how they access food and caregiver feeding practices. For example, both maternal and paternal incarceration were associated with higher odds of risky sleep and eating behaviors linked to obesity risk during childhood (Jackson & Vaughn, 2017), even if the parent was not currently incarcerated (Hiolski et al., 2019). Parental imprisonment before child age 5 years was associated with later higher BMI at ages 14, 21, and 30 (Roettger et al., 2022). Decreases in overweight risk have also been observed if one or both parents were ever incarcerated (Branigan & Wildeman, 2019), though two studies have found father incarceration alone was unrelated to risk for childhood overweight (Branigan & Wildeman, 2017, 2019). Poorer maternal mental health may be linked to higher obesity risk among 10 to 17 year-old, observed in a national study of U.S. children ( $n = 14,733$ ) (Foster et al., 2020), though mental health was unrelated to overweight and obesity risk in a study of Australian youth (Gibson et al., 2007). Evidence also suggests that parental nicotine, alcohol, and illicit drug use are associated with obesogenic behaviors, including significantly greater reward-driven and less healthful eating behaviors in both childhood and adolescence (Boswell & Lydecker, 2021; Cummings et al., 2020; Cummings & Gearhardt, 2020). However, no existing research was identified that examined how the accumulation of household-specific aspects of social deprivation may uniquely impact child weight.

Material deprivation refers to the lack of necessary basic resources for survival and promoting a healthful environment, such as food, housing, or income insecurity (Berman et al., 2022; Schuler, 2019; Schuler et al., 2021). Like other forms of adversity, economic adversity can increase stress on the family system, impairing protective health behaviors that minimize risks on weight status (Conger et al., 2002). Further, economic deprivation can limit access to inputs needed for health behavior promotion. This includes household food insecurity and lack of affordable housing that meets family size needs and provides a place for quality sleep. Studies suggest higher levels of household poverty and socioeconomic status (e.g., lower education) have been linked to obesogenic childhood eating behaviors, including larger serving sizes (Rigal et al., 2019) and higher intake of energy-dense, nutrient-poor items (Grimes et al., 2013; Pabayo et al., 2012). Housing-specific economic adversity in early childhood was not associated with obesity at ages 5, 9, or 15 years (Leifheit et al., 2020), but the

accumulation of economic risk was associated less healthful eating patterns in adolescence that contribute to obesity risk (Schuler et al., 2021). Because families can experience economic challenges that extend beyond separate income, food, or housing issues alone, a better understanding of the accumulation of economic risks on child physical growth across stages of development is greatly needed.

### 1.3. Developmental timing

Exposure to different forms of adversity may differ in their impact child weight depending on timing of exposure and the child's developmental stage. For example, child victimization was related to early childhood and later adolescent weight risks, but lower obesity risk during middle childhood (Bennett et al., 2010; JUSmith et al., 2013; Knutson et al., 2010; Li et al., 2021; Shin & Miller, 2012; Whitaker et al., 2007). On the other hand, research on community violence suggests no significant association with weight patterns in early or mid-childhood (Burdette & Whitaker, 2004; Datar et al., 2013), though effects may emerge in adolescence, when children are more likely to be out in the community with peers and not under parental supervision (Forsyth et al., 2015; Schuler & O'Reilly, 2017). Some research has suggested the impacts of economic adversity on obesogenic behaviors may also be more sensitive at younger ages when children eat and spend more time at home (Fram et al., 2015; Min et al., 2018; Rossen & Kobernik, 2016). However, research on economic deprivation and child weight at other stages of development is limited.

Overall, equivocal findings related to the adversity-obesity risk association may be due in part to the lack of comprehensive and developmental specific conceptualizations of adversity in the current literature. Existing research is similarly limited by measuring adversity as it relates to a single parent or caregiver—typically the mother, rather than reflecting present day family structures. Children from single-headed households, or those that split their time between different households experience disproportionate rates of adversity, which can increase risks for unhealthy growth patterns (Schuler et al., 2021; Schuler, 2019; Schuler & O'Reilly, 2017). Children who spend time living separately with their mother or father may be exposed to forms of adversity in one or both settings. Research that assesses both mother and father reports of adversity exposure, particularly when residing in different households, may help shed light on different pathways between adversity types and impacts on weight. Understanding how the hypothesized underlying types of adversity may differentially impact child weight across critical stages of development may help advance developmentally appropriate interventions for obesity prevention.

## 2. Study aim

The aim of this study was to address major gaps in existing literature by characterizing and assessing how two forms of threat-based adversity occurring at home and in the community, and two forms of deprivation-based adversity, family deprivation and economic deprivation, are associated with child weight at four critical stages of child development over the first 15 years of life among Fragile Families. FFCWS is a national study of new mothers, fathers, and children born in large U.S. cities (population over 200,000), where births to unmarried mothers were oversampled by a ratio of 3 to 1, resulting in the inclusion of a large number of Black, Hispanic, and low-income families (Reichman et al., 2001). Specifically, this study aimed to answer the following research question and hypothesis: How is BMI a function of adversity types experienced across critical stages of child development? *Hypothesis:* Increased exposure to the accumulation of each type of prior adversity exposure—interpersonal, community, family, and economic— will be associated with increases in child BMI at ages 3, 5, 9 and 15.

## 3. Method

### 3.1. Procedure and sample

Data were drawn from the FFCWS, a publicly available data set (Office of Population Research, 1998–2020). New mothers ( $n = 4898$ ) and fathers ( $n = 3830$ ) were recruited and interviewed shortly after the child's birth and follow-ups were conducted at child ages 1, 3, 5, 9, and 15 years (Reichman et al., 2001). Approximately 75% of parents were unmarried at baseline. Data were collected using a combination of phone and in-home interviews and assessments with mothers or the primary caregiver, fathers, and the focal child. Primary caregivers consisted mostly of mothers (99% at age 3, 98% at age 5, 92% at age 9, 88% at age 15 years), and will be referred to as mothers throughout this paper. The FFCWS excluded parents who did not speak English or Spanish, parents planning for adoption, parents too ill to complete the interview, and families in which the father was deceased prior to the interview. For the present study, cases were excluded if the mother was under age 18 at baseline ( $n = 140$ ), the child had a disability that could impair growth ( $n = 812$ ), was born a non-singleton birth ( $n = 95$ ), or cases were missing data on dependent variables. Eligible cases with available BMI data include  $n = 1579$  at age 3,  $n = 1735$  at age 5,  $n = 2687$  at age 9, and  $n = 659$  at age 15. Note, at age 15, a subsample was selected for in home BMI measures, resulting in a smaller sample size. This final analytic sample for this study included  $N = 2412$  cases.

### 3.2. Measures

#### 3.2.1. Adversity types

Adversity exposure was reported to reflect past year exposures at all data collection points ages 1, 3, 5, and 9. The sum of exposures reported at each wave was calculated separately to reflect the accumulation of each adversity type at each developmental stage measured (i.e., sum of each type of exposure reported at ages 1, 3, 5, and 9). The number of items assessing each type of adversity varied slightly across waves and is

**Table 1**  
Indicators of adversity subtype exposure measures by respondent.<sup>a</sup>

Adversity Subtype	Child Age				
	1 Year	3 Years	5 Years	9 Years	15 Years
<b>Interpersonal</b>					
Child maltreatment <sup>b</sup>	0	3 (M)	4 (M)	4 (M)	4 (M)
Domestic violence	4 (M)	4 (M)	4 (M)	4 (M)	4 (M)
Total items	4	7	8	8	8
<b>Family</b>					
Mental health <sup>c</sup>	4 (M, F)	4 (M, F)	2 (M, F)	2 (M, F)	2 (M)
Substance use <sup>d</sup>	2 (M, F)	4 (M, F)	4 (M, F)	4 (M)	3 (M, F)
Incarceration <sup>e</sup>	2 (M, F)	3 (M, F)	3 (M, F)	3 (M, F)	3 (M, F)
Total items	8	11	9	9	8
<b>Economic</b>					
Income	2 (M, F)	2 (M, F)	2 (M, F)	2 (M, F)	1 (M)
Food	2 (M, F)	2 (M, F)	2 (M, F)	2 (M, F)	1 (M)
Bill	8 (M, F)	8 (M, F)	8 (M, F)	8 (M, F)	4 (M)
Housing	6 (M, F)	6 (M, F)	6 (M, F)	6 (M, F)	3 (M)
Total Items	18	18	18	18	9
<b>Community<sup>f</sup></b>					
		7 (M)	10 (M)	5 (M)	6 (M)

<sup>a</sup> Respondents were M = Mother or F= Father.

<sup>b</sup> Child maltreatment was not measured at age 1. Psychological aggression, physical assault and neglect were collected at ages 3 – 15; sexual abuse was collected at age 5–15, not prior.

<sup>c</sup> At ages 5 and 9, the CIDI for anxiety was not collected. At age 15, only the mother was interviewed.

<sup>d</sup> Ages 3–9 includes mother and father report of other partner's use. At age 15, mothers reported their, their partner's, and nonresident parent's substance use.

<sup>e</sup> At ages 3–15, incarceration includes mother report of current partner's incarceration.

<sup>f</sup> Community adversity items were not asked at age 1. Fear of community violence was not collected at age 3.

described in detail and depicted in [Table 1](#). At age 15, only mother report was collected. Because the FFCWS oversampled children from unmarried homes, data from the father interview, in addition to mother interview, were included to capture adversity exposure occurring when the child is with either parent, if they were living separately at the time of the interview. Responses for both mothers and fathers were otherwise counted separately unless the biological father resided in the same household or is otherwise noted below.

**3.2.1.1. Interpersonal.** Interpersonal adversity included child maltreatment and domestic violence. Four forms of child maltreatment were measured by mother-only reports (i.e. asked to primary caregiver) to the Parent-Child Conflict Tactics Scale (CTS-PC) and of Child Protective Services (CPS) contact: physical aggression, physical assault, neglect, and sexual abuse ([Berger et al., 2005](#)). Four different forms of domestic violence were measured using mother-only report to the Conflict Tactics Scale: physical, sexual, economic, emotional. Because domestic violence items were asked to both parents but involve the other parent, mother-only (i.e., primary caregiver) report was used to capture exposure based on the child's primary residence. Child maltreatment was not collected at age 1, and sexual abuse was not collected at age 3.

**3.2.1.2. Family.** Family-based forms of adversity included having a parent, caregiver, or household member with a mental health condition (depression/anxiety), substance use concern, or history of incarceration. Both parents responded to depression and anxiety measures at ages 1 and 3, and depression measures at ages 5 and 9. The Composite International Diagnostic Interview-Short Form (CIDI-SF) with liberal depression and anxiety criteria and Generalized Anxiety Disorder criteria was used for scoring ([Kessler et al., 1998](#)). Substance use was measured by mother and father self-report and report of their partner's substance use using validated scales ([Kessler et al., 1998](#)). Parents self-reported up to 3 exposures to household incarceration, including whether or not they, the other parent, or the mother's current partner had a history of incarceration. Positive endorsement from either parent was coded as a single dichotomous exposure.

**3.2.1.3. Economic.** Economic adversity included income, food, bill, and housing insecurity. Income-based poverty was measured using the income-to-needs ratio calculated based on parent report of all household income in the past year divided by the official U.S. Census Bureau poverty threshold specific to family size for the year preceding the interview ([United States Census Bureau, 2020](#)). Those with a household income at or below 200% of the federal poverty line were considered to have economic adversity based on safety net income guidelines. Food insecurity was assessed by proxy of asking whether the family received free food or meals in the past year because there was not enough money. Indicators of monthly bill insecurity were derived from the basic needs section of the Survey on Income and Program Participation ([Survey on Income and Program Participation, 1996](#)) to assess whether parents didn't have enough money for the following monthly essentials over the past year: rent/mortgage, utility bills (gas/oil/electric bills), medical care needs, or whether they needed to borrow money to pay bills. Exposure to housing insecurity risk included being evicted for not paying rent/mortgage, moving in with people because of financial problems, and staying in a place not meant for regular housing.

**3.2.1.4. Community.** Community adversity items refer to violent things carried out by people outside the child's circle of family or loved ones, selected based on prior acceptance and validation ([Chen & Lee, 2021](#); [Schneider, 2020](#)). Violence exposure was measured as frequency of experiencing or witnessing someone being: (1) beaten up; (2) attacked with a weapon; and (3) shot at ([Chen & Lee, 2021](#)), or witnessing someone be killed through violence in the community. Parent report of whether they were ever afraid to let the child outside because of violence

and fear of gang violence in the neighborhood was included from ages 5 through 15 ([James et al., 2018](#)). All community adversity data reflect mother report as items were only asked of primary caregivers except for a single wave. Items were not asked at child aged 1 year.

### 3.2.2. BMI

BMI z-score is optimal for assessing adiposity across occasions ([Cole et al., 2005](#)) and was used to measure child growth status from ages 3 through 15. BMI z-scores are based on Centers for Disease Control and Prevention growth charts for age and sex ([Kuczmarski et al., 2000](#)), calculated from height and weight measurements taken by trained researchers during in-home assessments.

### 3.2.3. Control variables

To assess the impact of adversity on change in BMIz within discrete stages of development, we examine models both with adjustment for prior wave BMIz. Due to evidence of associations between child and parent characteristics and child BMIz, control variables included mother's age and education level at child's birth, and child race/ethnicity (White = 0 [reference category], Black, Hispanic, other [Asian/Pacific Islander, American Indian/Eskimo/Aleut, other-not specified]).

## 3.3. Data analysis

All analysis was conducted in *Mplus*. Path analysis, with maximum likelihood estimation was used for the main analysis. To assess overall model fit, chi-square goodness-of-fit indices were assessed as well as the comparative fit index (CFI) > 0.90, and root mean square error of approximation (RMSEA) < 0.08 ([Hu & Bentler, 1999](#)). Change in BMIz from child ages 3 to 5, 5 to 9, and 9–15 years were the dependent variables regressed on past wave change in interpersonal, community, family, and economic, and forms of adversity, adjusted for prior wave BMIz (see [Fig. 1](#)). As shown in [Fig. 1](#), autoregressive parameterization of independent and dependent variables was included in the model to account for the lagged effect of prior wave adversity on later change in BMIz (e.g., the change in interpersonal adversity from ages 3 to 5 predicted the change in BMIz from 5 to 9 years). We examined unconditional models, and models conditional upon adjustment for sociodemographic control variables.

Due to missing data on eligible cases with available BMIz compared to the original FFCWS sample, and attrition at follow-up periods, missing data analysis was conducted to determine the extent to which data were missing at random or completely at random. Cases with available BMIz data included mothers that were slightly younger, on average, at child ages 3, 5 and 9, but not 15 years (independent *t*-tests: age 3 BMIz:  $t = -3.06, p = .002, M \text{ diff} = -0.58$ ; age 5 BMIz:  $t = -3.61, p = <.001, M \text{ diff} = -0.69$ ; age 9 BMIz:  $t = -4.34, p = <.001, M \text{ diff} = -0.86$ ; age 15 BMIz:  $t = -0.46, p = .65$ ). Education level was slightly lower on average for those with available data at age 3 (independent *t*-tests:  $t = -2.96, p = .003, M \text{ diff} = -0.10$ ), but slightly higher for those with available data at 15 ( $t = 2.12, p = .03, M \text{ diff} = 0.09$ ), and no difference for those with data at ages 5 ( $t = -1.99, p = .05$ ) or 9 years ( $t = 0.22, p = .82$ ). Chi square tests of independence show that missing BMI data did not differ by child sex at age 3 (Fisher's Exact  $\chi^2 p = .21$ ) or age 15 ( $\chi^2 p = .10$ ), but at ages 5 and 9, missing BMI data was slightly higher for females (51.8%, 53.5%, respectively) compared to males (48.2%;  $\chi^2 p = .02, 46.5\%; \chi^2 p = .02$ , respectively). The mixed pattern of significant findings regarding missing data suggests that data are missing at random but not missing completely at random. Given this, missing data were handled via Full Information Maximum Likelihood estimation, which applies a casewise likelihood function to draw on all available datapoints and decreases bias due to sample size attrition relative to listwise deletion ([Enders, 2001](#); [Wothke, 2000](#)).



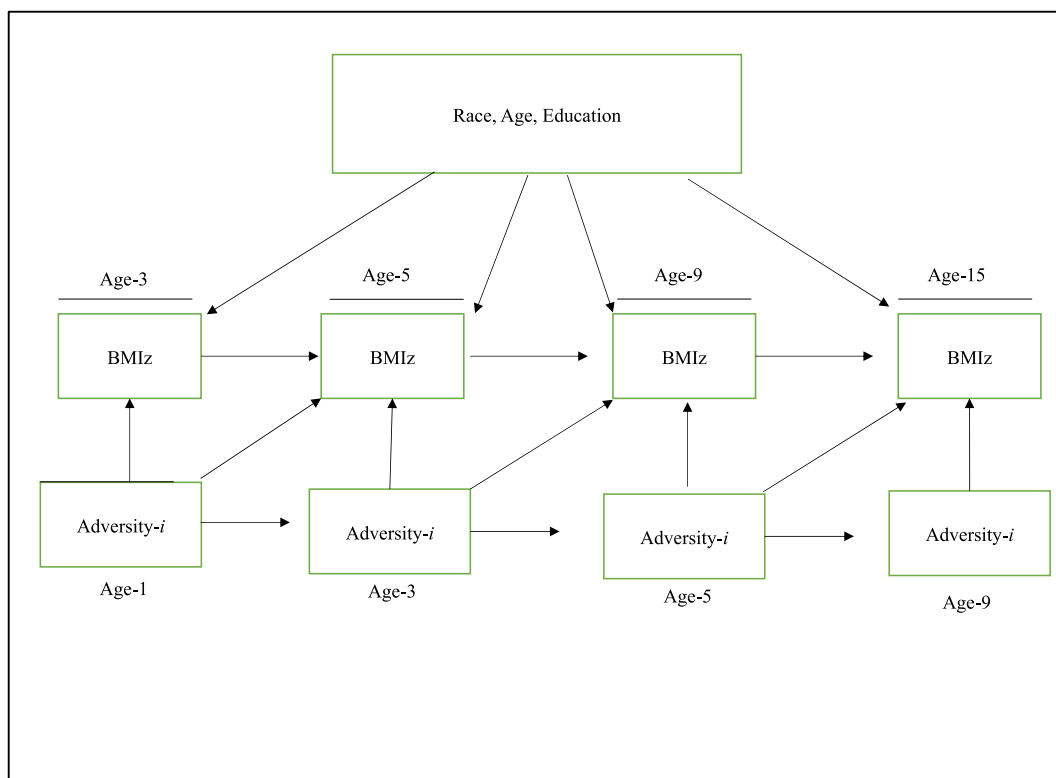


Fig. 1. Path model tested in MPLUS.

Notes. Adversity type-*i* = 1 Interpersonal, 2 Family, Economic, 4 Community  
Race, Age, Education are time invariant (baseline) covariates.

### 4. Results

#### 4.1. Sample characteristics

Most participants were primarily non-Hispanic Black (46.2%), followed by Hispanic (28.5%), and non-Hispanic white (21.2%; see Table 2). A total of 29.7% had less than a high school education, 29.3% had a high school degree or GED, 28.9% had some college, and 12.1% had a college degree. Mothers were 25.6 years old, on average (*SD* = 5.92) at the focal child’s birth. By age 3, approximately 25% of children

resided in single-parent households, 57% with their biological father, and 18% with a partner that was not the child’s biological father. Mean BMIz ranged from 0.60 to 0.87 across waves. Approximately 16% of the sample were obese at age 5, and 24% were obese at age 9 years.

Average exposure and observed ranges for each adversity subtype are provided in Table 3. Most children experienced some form of family or economic adversity at each wave, and interpersonal adversity at ages 3 through 9, but not the youngest (age 1) or oldest (age 15) timepoints. Bivariate correlations between adversity types across time were all significant (*p* < .05). Effect sizes varied from small to medium, with strength generally decreasing as time between measures increased. See Supplemental Table 1 for Pearson’s correlations between each adversity type at each wave.

#### 4.2. Main analysis

Model fit statistics were acceptable (unadjusted model fit indices: CFI = 0.96, RMSEA = 0.04; adjusted model fit indices: CFI = 0.90,

Table 2

Sample characteristics and descriptive statistics for baseline sample N = 2412.

Variable (Min-Max)	M or % (SD or n)
Mom age (18–43)	25.31 (5.92)
Race/ethnicity	
Non-Hispanic White	21.2% (822)
Non-Hispanic Black	46.2% (1792)
Hispanic	28.5% (1105)
Other	4.2% (163)
Education Age 1	
< High school	29.7% (1014)
High school equivalent	29.3% (1001)
Some college	28.9% (989)
College degree	12.1% (413)
Employed in past week Age 3	56.1% (2364)
Relationship Status Age 3	
Single	24.6% (1039)
With child father	57.0% (2410)
With other partner	18.4% (780)
Child gender - male	50.3% (1959)
BMIz Age 3 (–0.99–5.46)	0.81 (1.01)
BMIz Age 5 (–4.16–4.74)	0.60 (1.13)
BMIz Age 9 (–7.52–2.97)	0.74 (1.12)
BMIz Age 15 (–4.21–2.97)	0.87 (1.01)

Table 3

Descriptive statistics for adversity subtypes: Interpersonal, family, economic, community M(SD).

Adversity Subtype	Age 1	Age 3	Age 5	Age 9
Interpersonal	.67 (0.90)	1.15 (1.24)	0.97 (1.21)	0.95 (1.13)
Range <sup>a</sup>	0–4	0–6	0–7	0–6
Family	1.28 (1.34)	1.55 (1.56)	1.35 (1.42)	1.56 (1.46)
Range	0–7	0–10	0–10	0–8
Economic	1.79 (1.71)	1.82 (1.78)	1.86 (1.81)	2.08 (2.00)
Range	0–13	0–13	0–14	0–12
Community	0.61 (1.01)	0.84 (1.26)	0.66 (1.12)	0.66 (1.12)
Range	0–7	0–10	0–10	0–5

<sup>b</sup>Accumulation is the sum of dichotomous exposures for concurrent and prior reports of exposure.

<sup>a</sup> Range is observed range. See Table 1 for expected range.

RMSEA = 0.06). In models adjusted for baseline control variables, change in interpersonal adversity from ages 3 to 5 was associated with decreased BMIz from age 5 to 9 ( $b = -0.04, p = .04$ ). Change in economic adversity from ages 3 to 5 was significantly associated with change in BMIz from ages 5 to 9 ( $b = 0.03, p = .03$ ). Further, higher community adversity from ages 3 to 5 was associated with decreased BMIz from age 5 to 9 ( $b = -0.03, p = .04$ ). Results of adjusted models can be found in Tables 4 and 5.

5. Discussion

This is the first known study to assess the relations between four adversity subtypes—interpersonal, family, economic, community—and change in child BMIz from ages 3 through 15 in a high-risk, national sample. In our sample, rates of obesity were 24% by age 9, which is higher than national rates (Ogden et al., 2018, 2020). Main findings indicate that the presence and direction of the association of adversity on changes in child BMIz differ by the specific form of past adversity and according to the developmental stage during which adversity and BMIz were measured. Increased interpersonal and community forms of violence or threat of violence exposure from ages 3 to 5 were significantly associated with decreased child BMIz from ages 5 to 9, though not in the hypothesized direction. Increased economic adversity from ages 3 to 5 was associated with increased BMIz at from ages 5 to 9. Developmentally, changes in adversity between the ages of 3 and 5 were predictive of subsequent changes in BMIz between the ages of 5 and 9 years, but not other timepoints.

Findings for economic adversity were in line with study hypotheses but developmentally specific: increased economic adversity from ages 3 to 5 was associated with increased BMIz from ages 5 to 9. The findings for economic adversity are consistent with past research indicating associations of early childhood economic adversity with BMI percentile growth through age 9 (Liu et al., 2019). Broader economic shifts leading to rapid increases in food, housing, and utility costs (Garner & Short, 2008) absorb substantially larger proportions of income for households

with economic adversities, which can ultimately negatively affect health behaviors that impact weight gain (Bureau of Labor Statistics Reports, 2017). Further, high levels of economic hardship can increase parenting stress, which can result in poorer dietary outcomes (Schuler et al., 2020), and protective health routines (e.g., physical activity, sleep) that impair balanced weight gain (Jones et al., 2014).

Prior family adversity was not significantly associated with BMIz at any wave. Although no prior research has examined the accumulation of family-specific adversity, our results are in contrast with prior studies specific to children of incarcerated parents from Fragile Families (Branigan and Wildeman, 2017, 2019). These null results have some precedent. For example, an analysis of the Fragile Families cohort found adversity experienced at ages 1 and 3 was not significantly associated with obesity at age 5 (Suglia et al., 2012). In regard to parent mental health, the literature points to a pattern of better maternal mental health being associated with lower risk for child obesity (Foster et al., 2020; Moens et al., 2009), but null results are also found within this literature (Gibson et al., 2007). Findings related to parent substance abuse show a positive association with substance abuse and obesogenic eating behaviors for children, but not directly associated with BMI (Boswell & Lydecker, 2021; Cummings et al., 2020; Cummings & Gearhardt, 2020; Moens et al., 2009).

An intriguing pattern of findings was that, contrary to hypotheses, early childhood interpersonal and community forms of adversity from ages 3 to 5 were associated with decreased BMIz from ages 5–9 years. Notably, these findings conflict with most of the past literature. However, they are consistent with several prior studies examining similar developmental periods that have found associations between higher adversity and lower BMIz (Bennett et al., 2010; JUSmith et al., 2013; Veldwijk et al., 2012). Specifically, a two state study found that interpersonal adversity beginning at ages 4 through 6 was inversely related to weight at ages 8 and 9 (Bennett et al., 2010). Another found that physical and emotional abuse were associated with underweight status in 13–16 year olds (Veldwijk et al., 2012). Further, again, this finding, along with prior work suggesting that forms of adversity are associated

Table 4  
Path analysis results: Adversity types and BMIz, ages 3 through 9 (N = 2,412, fully adjusted estimates).

BMIz																
Controls	Age 3				Age 5				Age 9				Age 15			
	b	Beta	S.E.	p	b	Beta	S.E.	p	b	Beta	S.E.	p	b	Beta	S.E.	p
Age	0.01	.05	0.01	.08	0.0001	-.003	0.01	.92	0.01	.06	0.004	.003	-0.004	-.02	0.01	.46
Education	-0.05	-.05	0.03	.11	-0.01	-.01	0.03	.72	-0.08	-.07	0.02	.001	-0.02	-.02	0.03	.56
Race <sup>a</sup>																
Black	0.07	.03	0.07	.32	0.04	.02	0.07	.53	0.27	.12	0.06	<.001	-0.14	-.07	0.07	.05
Hispanic	0.35	.15	0.08	<.001	0.11	.04	0.08	.20	0.16	.06	0.06	.02	-0.11	-.05	0.08	.16
Other	0.07	.01	0.16	.67	-0.18	-.03	0.16	.27	0.19	.03	0.12	.11	-0.02	-.004	0.15	.89
Prior BMIz <sup>b</sup>					0.54	.51	0.03	<.001	0.65	.67	0.02	<.001	0.70	.76	0.02	<.001
<b>Adversity Age 1</b>																
Interpersonal	0.05	.05	0.03	.07	-0.05	-.04	0.03	.14								
Family	-0.03	-.03	0.02	.23	-0.02	-.02	0.02	.48								
Economic	-0.01	-.02	0.02	.46	0.03	.04	0.02	.16								
<b>Adversity Age 3</b>																
Interpersonal					0.03	.03	.02	.19	0.01	.01	0.02	.52				
Family					-0.01	-.02	0.02	.49	0.01	.01	0.02	.51				
Economic					-0.02	-.03	0.02	.35	-0.01	-.01	0.02	.76				
Community					0.02	.02	0.03	.41	-0.002	-.003	0.01	.90				
<b>Adversity Age 5</b>																
Interpersonal									-0.04	-.04	0.02	.04	-0.01	-.01	0.02	.83
Family									0.01	.01	0.02	.64	0.0001	.0001	0.02	.99
Economic									0.03	.05	0.01	.03	0.04	.07	0.02	.07
Community									-0.03	-.04	0.02	.04	-0.02	-.02	0.02	.45
<b>Adversity Age 9</b>																
Interpersonal													0.004	.004	0.03	.88
Family													0.01	.02	0.02	.54
Economic													-0.03	-.06	0.02	.08
Community													0.03	.03	0.03	.29

<sup>a</sup> Reference group is White.

<sup>b</sup> Prior Wave BMIz is age 3 BMIz for age 9 BMIz outcome, age 5 BMIz for age 9 outcome, and age 9 BMIz for age 15 outcome.

**Table 5**  
Path analysis results: Paths of prior and inter- adversity.

	b	Beta	se	p
Age 3 Interpersonal				
Age 1 Interpersonal	0.48	0.34	0.03	<.001
Age 3 Family	0.14	0.17	0.04	<.001
Age 3 Economic	0.09	0.12	0.03	.004
Age 3 Community	0.13	0.10	0.02	<.001
Age 5 Interpersonal				
Age 3 Interpersonal	0.36	0.37	0.02	<.001
Age 5 Family	0.03	0.03	0.04	.52
Age 5 Economic	0.02	0.03	0.03	.46
Age 5 Community	0.10	0.11	0.02	<.001
Age 9 Interpersonal				
Age 5 Interpersonal	0.23	0.25	0.02	<.001
Age 3 Interpersonal	0.10	0.11	0.02	<.001
Age 9 Family	-0.10	-0.13	0.04	.009
Age 9 Economic	0.02	0.04	0.03	.35
Age 9 Community	0.06	0.06	0.02	.01
Age 3 Family				
Age 1 Family	0.31	0.27	0.03	<.001
Age 3 Interpersonal	0.07	0.06	0.06	.22
Age 3 Economic	0.29	0.32	0.04	<.001
Age 3 Community	0.13	0.08	0.03	<.001
Age 5 Family				
Age 3 Family	0.28	0.31	0.02	<.001
Age 1 Family	0.24	0.23	0.02	<.001
Age 5 Interpersonal	0.18	0.16	0.04	<.001
Age 5 Economic	0.01	0.01	0.03	.83
Age 5 Community	0.08	0.08	0.02	<.001
Age 9 Family				
Age 5 Family	0.26	0.25	0.02	<.001
Age 3 Family	0.25	0.27	0.02	<.001
Age 9 Interpersonal	0.20	0.15	0.05	<.001
Age 9 Economic	0.09	0.12	0.03	.001
Age 9 Community	0.08	0.06	0.03	.002
Age 3 Economic				
Age 1 Economic	0.48	0.47	0.02	<.001
Age 3 Interpersonal	0.03	0.02	0.05	.51
Age 3 Family	0.03	0.03	0.05	.49
Age 3 Community	0.19	0.11	0.03	<.001
Age 5 Economic				
Age 3 Economic	0.37	0.37	0.02	<.001
Age 1 Economic	0.16	0.16	0.02	<.001
Age 5 Interpersonal	0.07	0.05	0.05	.18
Age 5 Family	0.23	0.19	0.04	<.001
Age 5 Community	0.16	0.12	0.02	<.001
Age 9 Economic				
Age 5 Economic	0.38	0.34	0.02	<.001
Age 3 Economic	0.30	0.27	0.02	<.001
Age 9 Interpersonal	0.04	0.03	0.06	.44
Age 9 Family	0.15	0.11	0.04	.001
Age 9 Community	0.11	0.07	0.03	.001
Age 5 Community				
Age 3 Community	0.46	0.35	0.03	<.001
Age 9 Community				
Age 5 Community	0.29	0.34	0.02	<.001
Age 3 Community	0.20	0.18	0.02	<.001

with lower obesity risk (Bennett et al., 2010; JUMennen et al., 2012; JUSmith et al., 2013; Veldwijk et al., 2012), indicates considering health behavior patterns that contribute to lower weight as well as weight increases may be important for future research on children exposed to threat-based forms of adversity. Inverse associations between both threat-based forms of adversity may be explained in part by heightened hyperactivity resulting from traumatic stress (Spencer et al., 2016; Weinstein et al., 2000). Equivocal findings regarding the association between community violence and obesity risk in this and prior work suggests the need for future research on factors that help explain this unexpected finding and assess potential cross-over effects over time. Other factors that may be impacting this association, such as school or neighborhood level poverty (Vazquez et al., 2022), distance to grocery stores, and access to spaces for play and recreation, for example, may play a role and should be explored in future research.

In the context of past research, findings suggest that the positive association of adversity with child BMI manifests gradually over time. Specifically, our study finds some sensitivity for interpersonal, community, and economic adversity during early childhood (ages 3 to 5) on changes in BMIz from ages 5 to 9 only. Developmentally, these findings are consistent with prior research finding greater sensitivity exposure during the preschool stage (Anderson et al., 2014; Whitaker et al., 2007). Indeed, a prior systematic review also suggests that the effects of adverse experiences on obesity risk may take 2–5 years to manifest (Schroeder et al., 2021). The delayed effect of adversity exposure on BMIz may reflect the slow accumulation of biological and physiologic processes that are adversely affected by heightened stress exposure over long periods of time. However, interpersonal and community adversity were in the opposite direction than hypothesized. This mixed evidence points to the need for additional studies to corroborate our findings and further clarify these relationships through a developmental lens.

Our study findings should be interpreted in the context of the overall pattern of null findings. Thus, while we have some support for study hypotheses, many findings are null or demonstrate relationships in the opposite direction than hypothesized. Rather, study findings suggest that the temporal examination of adversity exposure over discrete periods of child development may be informative for understanding adversity-physical growth associations. Our study has the strength of considering a broad range of developmental periods but extended only to 15 years. Because children are generally growing and developing rapidly during the stages of data collection, effects on weight moreover may not be observed immediately. They may reflect changes in health behaviors that contribute to weight (eating patterns, physical activity and sedentary behaviors, sleep) that are less sensitive to BMI change while physical growth is still occurring. Null findings may also be due to our operationalization of child growth as BMIz. Other studies have included other measures of child weight, for example unstandardized BMI (Shin & Miller, 2012), BMI percentile (Bennett et al., 2010), or categorical measures of overweight or obese weight status (Knutson et al., 2010; Suglia et al., 2012; Whitaker et al., 2007). Each of these measures has a different interpretation and can lead to different effects. In our study, BMI z-score is optimal for interpreting weight cross-sectionally across subjects for research purposes (Cole et al., 2005).

### 5.1. Limitations

First, there are several measurement limitations due to the secondary nature of the analysis. Our sample size was limited to cases with available BMI data, which resulted in a smaller sample size at each wave compared to the original FFCWS sample. At age 15 a subsample was selected for in-home BMI measurements, further limiting follow-up data. However, estimation techniques provide the most robust protection against missing data, allowing us to make use of all available data in the dataset. Measures of child BMIz do not provide indication of overweight or obese status; however, BMIz is recommended for use to assess adiposity across occasions (Cole et al., 2005). Measures of adversity are not comprehensive; for example, they do not include any measures that reflect discrimination, dating violence, or peer victimization/bullying which can be especially prominent among adolescents. Further, aspects of social and economic deprivation in the surrounding community environment were not measured and should be included in future research with representative national samples. Some types of adversity may be more likely to co-occur and impact growth at different stages of development. Future research should closely examine chronicity of exposures and the co-occurrence of adversity types across developmental periods, and importantly what factors may protect or interrupt potential links between early childhood adversity and mid-childhood weight-related risks. For example, co-habitation, co-residence, in addition to levels of father engagement may buffer against harmful effects of early life adversity and should be examined along with father reported

adversity in the future (Wang et al., 2021). Measures of adversity were not standardized across waves of data collection. Although many items remained the same, some items were not asked across all waves, limiting our ability to assess within and between variation in study measures. Further, the FFCWS had a higher representation of racial and ethnic minority families, and those from unmarried households than national samples, a population that experiences higher risk for socioeconomic instability, and findings may not be generalizable to other populations. Lastly, as with any study using a non-experimental design, the present study cannot account for all potential confounds, and it should be acknowledged that a complex constellation of factors may contribute to child BMI.

## 6. Conclusions

Although adverse childhood experiences have been linked to childhood obesity risk, and childhood obesity risk is disproportionately higher among Fragile Families, results of the present study suggest that the effects of adversity on child physical growth depend on both the type and timing of exposure, rather than on the accumulation of adversity over time. Specifically, study findings provide the specificity needed in order to test meaningful protective factors, specifically on the paths from interpersonal and community adversity to BMI between the ages of 5 and 9, and on the paths from economic deprivation to BMI during the same developmental frame. Future research is needed to examine protective factors that can help prevent adversity-related impacts on health that are specific to safety in the child's proximal and distal environment and ensuring basic material needs are met.

## Ethics approval and consent to participate

The Fragile Families and Child Wellbeing Study is a publicly available data set and institutional review board approval was not needed. The primary study was conducted according to the guidelines laid down in the Declaration of Helsinki and all families provided informed consent before participating in the study.

## Consent for publication

Not applicable.

## Availability of data and materials

The FFCWS is publicly available from the Office of Population Research, Princeton University: <https://fragilefamilies.princeton.edu/documentation>.

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## Author statement

Schuler: conceptualization, methodology, data curation, data analysis, original draft preparation; Vazquez: conceptualization, original draft preparation, reviewing and editing; Kobulsky: conceptualization, original draft preparation, reviewing and editing. Dumenci: analysis supervision, reviewing and editing.

## Declaration of competing interest

The authors declare that they have no competing interests.

## Data availability

Public dataset

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2022.101197>.

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