CHILDHOOD OBESITY
April 2019 | Volume 15, Number 3

DOI: 10.1089/chi.2018.0225

Adverse Childhood Experiences in Infancy and Toddlerhood Predict Obesity and Health Outcomes in Middle Childhood

Lorraine M. McKelvey, PhD, Jennifer E. Saccente, BS, and Taren M. Swindle, PhD

Abstract

Background: The Adverse Childhood Experiences (ACEs) study articulated the negative effects of childhood trauma on adult weight and health. The purpose of the current study is to examine the associations between ACEs in infancy and toddlerhood and obesity and related health indicators in middle childhood.

Methods: We used data collected from a sample of low-income families enrolled in the national evaluation of Early Head Start (EHS). Data come from 1335 demographically diverse families collected at or near children's ages 1, 2, 3, and 11. An EHS-ACE index was created based on interview and observation items from data collected at ages 1, 2, and 3, which were averaged to represent exposure across infancy and toddlerhood. At age 11, children's height and weight were measured and parents were asked about their child's health.

Results: Children were exposed at rates of 30%, 28%, 15%, and 8% to one, two, three, and four or more EHS-ACEs, respectively. Logistic regressions revealed significant associations between EHS-ACEs in infancy/toddlerhood and obesity, respiratory problems, taking regular nonattention-related prescriptions, and the parent's global rating of children's health at age 11. Across all outcomes examined, children with four or more ACEs had the poorest health. Compared with children with no ACE exposure, the odds of each of the examined health outcomes were over twice as high for children who experienced four or more ACEs.

Conclusions: Findings highlight that ACEs experienced very early in development are associated with children whose health is at risk later in childhood.

Keywords: Adverse Childhood Experiences; child health; child maltreatment; obesity

Introduction

Obesity rates continue to rise in the United States despite decades of clinical and community-based interventions.[1] Obesity is a condition with serious physical (*e.g.*, asthma, allergy, other inflammatory conditions)[2,3] and psychological (*e.g.*, low subjective health, low health-related quality of life)[4] correlates that complicate patients' medical care. Obesity is also difficult to treat[5] as diet- and exercise-based lifestyle interventions, the mainstays of obesity treatment, tend to have poor long-term outcomes.[6,7] Therefore, identifying the factors that contribute to the development of obesity and using that information to develop preventive interventions may be effective for promoting optimal health outcomes for future generations.

Based on a recent meta-analysis, Hemmingsson et al. describe the association between psychological stress and obesity as a causal chain of events starting with disharmonious family environments, which may include child neglect or abuse.[8] The ultimate result is physiological disturbance that contributes to inflammation and weight gain.[9,10] As the individual becomes obese, obesity negatively impacts one's mental health, social standing, and levels of inflammation.[8]

A specific definition of stressors in childhood, Adverse Childhood Events (ACEs), was developed based on clinical work with obese adults.[11] ACEs include indicators of child abuse and neglect, as well as multiple family dysfunctions (*e.g.*, household mental illness, substance abuse, incarceration, parental separation/divorce and domestic violence). Compared with healthy-weight adults, obese applicants to a weight loss program were found to have significantly higher ACE exposure.[11] Indeed, longitudinal studies have identified increased obesity rates among survivors of physical[12,13] and sexual[14] abuse, and retrospective and cross-sectional studies have described the effects of multiple varieties of abuse on weight status.[15,16] In addition to obesity, this line of research has documented a vast array of negative health

Department of Family and Preventive Medicine, College of Medicine, University of Arkansas for Medical Sciences, Little Rock, AR.

outcomes associated with ACEs. For example, ACEs are associated with an increased likelihood of riskier health behaviors (*e.g.*, physical inactivity, smoking, alcohol and/or substance abuse, and unsafe sexual behavior) and negative outcomes (*e.g.*, obesity, chronic diseases, and cancer).[17,18]

While the original ACE studies assessed adults retrospectively, newer studies have shown that the consequences of ACEs can manifest during childhood. Cross-sectional data from the 2011–2012 National Survey of Children's Health (NSCH) showed that being exposed to two or more ACEs was associated with increased risk of being overweight or obese in a population 10–17 years of age.[19] A cross-sectional study of Canadian 11–14 year olds found that having experienced four or more ACEs resulted in higher BMI, resting heart rate, and waist circumference,[20] which are important risk factors for adult obesity.[21] A Norwegian study of younger children (mean age 8.3 years) demonstrated increased abdominal and general obesity in children with divorced parents, which is one ACE.[22] One cross-sectional U.S. study found that exposure to emotional neglect, another ACE, predicted overweight and obesity in children 5–11 years of age, but not 12–17.[23] Altogether, these studies demonstrate that ACEs may increase the risk of being overweight or obese in childhood and earlier exposures may be particularly salient.

In addition to obesity, the existing literature has shown associations between ACEs and children's health. Particularly, strong associations with psychological and behavioral outcomes, examined concurrently and longitudinally, have emerged.[24–26] However, exploration of relation to physical health outcomes and comorbid conditions of obesity have not been studied to the same extent. A longitudinal study of children exposed to abuse and/or neglect from birth to age 11 demonstrated effects on parameters such as peak air flow, C-reactive protein, and blood pressure into middle age,[27] each, consistent with Hemmingsson's models, are indicators of inflammation.[28,29] Also reflective of increased inflammation,[30] severely stressful life events have been shown to increase the likelihood of new asthma attacks in children ages 6–13 with diagnosed asthma.[31]

Findings from the aforementioned NSCH documented an association between ACE exposure and children having special health care needs, and similarly,[32] children under six who have experienced ACEs are at increased risk of chronic medical conditions.[26,33] In the period of very early childhood, increasing ACE exposure was associated with increased likelihood of having chronic medical conditions and screening at risk for developmental delay.[34] These studies demonstrate the potential for ACEs to contribute to inflammation and comorbid conditions of obesity. Yet, more research is needed to clarify the specifics of these health outcomes and their timing.

In summary, the existing literature shows an association between ACEs and poor adult and child health. Much has been reported about the association between ACEs and childhood obesity and health, however, the vast majority of studies are cross-sectional in nature and do not allow for an understanding of the exact age at which negative health consequences began to appear.[19,20,22] We could not identify existing literature focusing specifically on ACE exposure in very early childhood from birth to age three on childhood weight and associated health outcomes.

The present study contributes to our understanding of ACEs by taking a longitudinal approach to examining the relationship between very early exposure to ACEs, in infancy and toddlerhood, and the development of obesity and related health outcomes (respiratory problems, regular prescription use, and parent-reported subjective health ratings) into middle childhood. Furthermore, the current study used longitudinal data from families eligible for Early Head Start (EHS) to gain a better understanding of the health consequences of ACE exposure specifically in children from low-income families.

Methods

Study Design

EHS is a program that serves low-income families (defined as family incomes at or below 100% of federal poverty) with prenatal through the child's age of 3 years. This study used data from the EHS Research and Evaluation (EHSRE) Project, an experimental study in which families with a child under 1 year were randomly assigned to receipt of EHS or a comparison group.[35] The EHS sites ($n = 17$) were competitively chosen to ensure a diverse sample with respect to geography, ethnicity, and rural versus urban setting.

Families were interviewed and observed when the child was at or near ages 1, 2, 3, and 11. Data were collected by trained interviewers, who demonstrated a minimum of 85% consistency in following the study's standardized procedures. Informed consents were completed with participants in accordance with the Institutional Review Boards of each of the participant research institutions.[35] The University of Arkansas for Medical Sciences' Institutional Review Board approved the current study.

Participants

Data from 1335 families were included in this study. At the time of enrollment, parents were 23 years old ($SD = 6$) on average when the child was born. The parents were 39.9% white, 33.5% black, 22.6% Hispanic, and 4% other. There was variability in the education of parents with 43.8% completing less than a high school degree, 29.3% with a high school diploma or equivalency, and 26.9% completing at least some college. Children were slightly more likely to be male (51.7%). Descriptive statistics and associations with outcomes are provided in Table 1.

Measures

Adverse childhood experiences. An EHS-ACE Index was established to closely parallel the original ACE constructs of emotional abuse/neglect, physical abuse/neglect, sexual abuse, domestic violence, household substance abuse,

Table 1. Characteristics of the Sample and Unadjusted Associations with Adverse Childhood Experiences ($n = 1335$)

		No. of ACEs				
	Total sample	0	1	2	3	4 or more
Demographics						
Parent age, *M* (*SD*)	23.1 (5.8)	24.7 (5.8)	23.5 (5.9)	22.4 (5.6)	22.0 (5.9)	22.0 (5.3)
Race/ethnicity						
Caucasian	38.9	38.6	40.8	38.5	35.0	40.3
African American	34.0	16.1	28.2	41.5	49.1	47.3
Hispanic	22.7	37.3	27.3	16.4	13.2	8.1
Other	4.4	8.0	3.7	3.6	2.8	4.3
Education						
Less than high school	45.7	37.7	42.5	48.2	51.9	57.4
High school graduate/GED	28.9	23.7	31.7	29.1	30.8	27.3
College	25.4	38.6	25.8	22.7	17.3	15.3
Covariates[a]						
Male child	50.9	51.6	47.0	53.6	51.6	53.7
Household income, *M* (*SD*)	$36,563 ($31,255)	$48,4560 ($24,229)	$39,709 ($32,880)	$31,870 ($27,710)	$29,478 ($28,276)	$24,473 ($21,821)
Smoking in the home	19.1	6.5	14.0	20.6	31.3	42.4
Child outcomes in fifth grade						
BMI >95th percentile	29.1	26.6	29.2	26.9	25.1	46.3
Regular prescriptions	18.3	12.2	17.5	17.8	22.2	30.5
Respiratory problems	35.7	24.7	33.5	38.7	39.2	53.9
Health rating risk	17.6	13.3	16.9	18.6	19.8	22.9

Percentages shown unless otherwise noted. [a]Covariates also include program and site, not shown.

ACEs, Adverse Childhood Experiences; GED, General Education Diploma.

household mental illness, parental separation or divorce, and incarcerated household member. Based on answers to hypothetical discipline scenarios, an index of stressful life events, and multiple standardized instruments, an EHS-ACE Index was computed at ages 1, 2, and 3 (Table 2). This index has been fully described elsewhere, including detail on the specific questions and/or scale information for each ACE indicator.[25,36] Furthermore, the EHS-ACE Index has been shown to relate to internalizing problems, externalizing problems, and attention problems in a stepwise or dose–response pattern (*i.e.*, greater problems with greater ACE exposure), providing evidence of construct validity.[25]

The EHS-ACE scores at ages 1, 2, and 3 were significantly correlated (ages 1 and 2: Pearson $r = 0.53$, $p < 0.001$; ages 2 and 3: Pearson $r = 0.53$, $p < 0.001$; ages 1 and 3: Pearson $r = 0.46$, $p < 0.001$). We computed an average EHS-ACE score to provide an estimate of ACE exposure during the infancy and toddlerhood period. The estimate of internal reliability of the scale was high (Cronbach's alpha = 0.77).

As shown in Table 2, the ACEs pertaining to child maltreatment were computed based on hypothetical discipline scenarios and several standardized instruments. Individual items from the Infant–Toddler version of the Home Observation for Measurement of the Environment (HOME)[37,38] were used as indicators of child maltreatment. HOME had high internal consistency reliability at all ages (>0.76).[35]

Two scales from the Three-Bag Task, Detachment, and Negative Regard, were also included as indicators of child maltreatment.[39,40] During the Three-Bag Task, parent–child dyads received three bags of toys with the instruction to play with them in order. The interactions were videotaped and coded using a 7-point scale modified from the NICHD Study of Early Child Care[41] and with high level of agreement (94%) among coders.[40] *Detachment* measures low parental attention, awareness, and engagement (*e.g.*, ''not talking to the child,'' ''rarely making eye contact.''). *Negative Regard* measures negative emotions toward the

Table 2. Adverse Childhood Experiences in the Early Head Start Research and Evaluation Project: Exposure in Percentages

Original construct/question	Scale/items	*n* = 1335
1. Emotional abuse: "Did a parent or other adult in the household often or very often swear at you, insult you, put you down, or humiliate you? or Act in a way that made you afraid that you might be physically hurt?"	HOME Inventory[37,38]: Shouted at Child during Assessment; High Parent Negative Regard in Three-Bag Task[39,40]; Hypothetical Discipline ("Shout at", "Punish verbally", "Shake")	16.4
2. Physical abuse: "Did a parent or other adult in the household often or very often push, grab, slap, or throw something at you? or Ever hit you so hard that you had marks or were injured?"	HOME Inventory[37,38]: Slapped/Spanked Child during Assessment; Hypothetical Discipline ("Slap or physically punish"); Child Spanked Daily	15.2
3. Sexual abuse: "Did an adult or person at least 5 years older than you ever touch or fondle you or have you touch their body in a sexual way? or Attempt or actually have oral, anal, or vaginal intercourse with you?"	Child in Foster Care; Child Attacked	1.8
4. Emotional neglect: "Did you often or very often feel that no one in your family loved you or thought you were important or special? or Your family didn't look out for each other, feel close to each other, or support each other?"	High Family Environment Scale[42] Family Conflict; High Parent Detachment in Three-Bag Task[39,40]	15.1
5. Physical neglect: "Did you often or very often feel that you didn't have enough to eat, had to wear dirty clothes, and had no one to protect you? or Your parents were too drunk or high to take care of you or take you to the doctor if you needed it?	HOME Inventory[37,38]: Unsafe Play Environment and/or Did Not Keep Child in Visual Range	27.9
6. Parental separation: "Were your parents ever separated or divorced?"	Current Relationship with Child's Father ("Not in any Relationship", "Separated/Divorced", "Deceased")	27.3
7. Domestic violence: "Was your mother or stepmother often or very often pushed, grabbed, slapped, or had something thrown at her? or Sometimes, often, or very often kicked, bitten, hit with a fist, or hit with something hard? or Ever repeatedly hit over at least a few minutes or threatened with a gun or knife?"	Stress Checklist: Mother Abused	11.0
8. Substance abuse: "Did you live with anyone who was a problem drinker or alcoholic, or who used street drugs?"	Stress Checklist: Lived with Addict	10.3
9. Household mental illness: "Was a household member depressed or mentally ill, or did a household member attempt suicide?"	Center for Epidemiological Studies-Depression-Short Form[43] (Score ≥16) at ages 1 and 3; Composite International Diagnostic Interview Short Form[44] (Score ≥0.80) at age 2	14.1
10. Household incarceration: "Did a household member go to prison?"	Stress Checklist: Friend/Relative in Jail	33.6
Totals: none		18.8
One		30.4
Two		27.9
Three		14.9
≥Four		8.0
Total, *M* (*SD*)		1.72 (1.22)

HOME, Home Observation for Measurement of the Environment.

child, including discontent, anger, disapproval, and/or rejection. To approximate adversity as defined in the original ACE study, we included the most extreme behaviors (scores in the top 10% of the distribution; three or higher) as ACE indicators.

Family conflict, used as an indicator of emotional neglect, was measured by one subscale of the Family Environment Scale.[42] This subscale assessed the degree to which aggression, anger, and conflictual exchanges are typical of the family. Parents responded to five items on a

4-point scale, in which four signified a high level of agreement. Cronbach's alpha in the EHSRE was adequate (≥0.65 at all ages). Again, in an effort to approximate adversity as defined in the original ACE study, families with the highest 10% of scores (scores of 2.5 and higher) on the family conflict subscale were defined as having the risk.

ACEs related to family functioning were mainly assessed by a checklist of stressful life events. Additionally, parental mental illness was determined through measures of depression: the Center for Epidemiological Studies Depression Scale–Short Form (CESD-SF),[43] collected at ages 1 and 3, and the Composite International Diagnostic Interview Short Form (CIDI-SF),[44] collected at age 2. For the CESD-SF, scores of 16 or greater were used to indicate risk.[43] In the CIDI-SF, each participant's score was converted to a probability from 0 to 1 of having had major depression in the past year. A cutoff of 0.8 (an 80% probability of having a Major Depressive Disorder) was used to indicate risk, which identified 12% of the sample.

Body mass index. During the interview at age 11, the children's height and weight were measured to calculate BMI and determine BMI percentage. To assure consistency of measurement, each of the 17 sites in the national evaluation was provided digital scales and stadiometers for use by the funding agency. There were also standardized instructions for the measurement of weight and height.

For weight measurement, children were asked to remove shoes and heavy clothing. Each child was weighed twice and the weights were recorded each time to the nearest 0.1 kg. If the first two measures differed by more than 0.2 kg, a third measurement was performed. Likewise, each child's height was measured twice and recorded to the nearest 1 cm. If the first two measures differed by more than 2 cm, a third measurement was performed. For the height measurement, each child was instructed to stand erect and look straight ahead, with the vertical surface touching the head, back, buttocks, and heels. The BMI percentage was then cut at the 95th percentile, which corresponds to the Centers for Disease Control and Prevention's definition of obesity.[45]

Child Health

During the interview at age 11, parents were asked a series of questions about their children's health and well-being. Parents were asked to report if children had been diagnosed with multiple health conditions.

Respiratory Problems includes parental report of allergies, chronic sinusitis, and/or asthma. Parents were also asked whether the child regularly takes prescribed medications. As a follow-up to that question, parents were asked if the medications were for asthma, attention deficit disorder–attention-deficit/hyperactivity disorder (ADD/ADHD), or other. Because the association between ACEs and behavioral development, including clinically elevated attention problems, has already been established in this sample,[25] we created a dichotomous variable, *Regular Prescriptions*, to include regular prescriptions taken by the child for reasons other than attention problems (ADD/ADHD). Finally, parents rated their child's health on a 5-point scale from excellent to poor. The *Health Rating* variable represents a dichotomy of parents rating their children's health as "excellent" and "very good" or less ("good," "fair," or "poor"). In previous studies, parental health ratings have predicted future outpatient treatment and child behavior problems providing evidence of validity of this approach.[46]

Covariates. To separate the influence of EHS-ACEs from related correlates, all analyses included variables about parent (age at enrollment, education, race, and family income when the child was 11) and child (gender) demographics and EHS program location and assignment. An additional covariate, smoking inside the home at age 11, was included for the model predicting respiratory problems. Insurance status at age 11 was considered as a covariate but not included due to all children (99.8%) having some form of insurance (60.3% Medicaid, 40.7% private insurance).

Approach to Analysis

We used logistic regression analyses (IBM SPSS Statistics Version 24.0)[47] to examine the association between EHS-ACE groups (children in families with scores of 0, 1, 2, 3, and 4 or more) and health and weight outcomes. All analyses included the covariates described above. Our data meet the assumption of independence, and variance inflation (max = 1.34) and tolerance values (min = 0.75) indicated no problem with multicollinearity between model predictors and covariates.[48,49] With alpha at 0.05 and power at 0.95, we were able to detect an odds ratio of 1.73 for the smallest (0.03) and 1.28 for the largest (0.8) effect sizes published in previous studies examining child health and obesity outcomes.[19,32,50,51]

Results

In our sample, children were exposed to zero (18.8%), one (30.4%), two (27.9%), three (14.9%), and four or more ACEs (8%) when scores are averaged across ages 1, 2, and 3 ($M = 1.72$, $SD = 1.22$). In total, 29.1% of children had a BMI greater than the 95th percentile, 18.6% had regular prescription use, 36% had respiratory problems, and 17.6% had suboptimal health ratings.

Logistic regression analyses,[52] controlling for the aforementioned covariates, showed ACEs were significantly associated with health outcomes (Table 3). There was a significant association between ACEs and excess weight as defined as having a BMI greater than the 95th percentile ($Wald(4) = 17.33$, $p < 0.001$). Compared with children with no ACE exposure, the odds of exhibiting a BMI greater than the 95th percentile were significantly higher for those who experience four or more ACEs [$OR = 2.65$, $p < 0.001$, confidence interval (CI; 1.51–4.67)].

Early childhood ACEs were also associated with other indicators of health at age 11. ACEs were associated with respiratory problems ($Wald(4) = 19.22$, $p < 0.001$). The

Table 3. Adjusted[a] Odds Ratios for Health Outcomes by Adverse Childhood Experiences Scores

	No. of ACEs				
Construct	**1**	**2**	**3**	**4 or more**	**Wald**
Weight					
BMI >95th percentile	1.07 (0.71–1.61)	0.98 (0.63–1.53)	1.01 (0.61–1.71)	2.65*** (1.51–4.67)	17.33***
Health outcomes					
Respiratory problems[c]	1.44† (0.99–2.09)	1.74** (1.18–2.58)	1.64* (1.03–2.60)	3.18*** (1.87–5.39)	19.22**
Regular prescriptions[b]	1.46 (0.90–2.38)	1.52 (0.91–2.53)	1.65† (0.92–2.97)	2.71** (1.45–5.09)	9.88*
Health ratings	1.20 (0.74–1.95)	1.60† (0.97–2.66)	1.29 (0.71–2.35)	2.21** (1.16–4.21)	7.59†

Odds ratios (95% confidence intervals) represent comparisons to a zero ACE score.

[a]Adjustments included Early Head Start random assignment and location, parental race, education, and age at enrollment, child gender, and family income at age 11.

[b]Prescriptions for attention deficit disorder–attention-deficit/hyperactivity disorder excluded from construct.

[c]Additional covariate for household smoking at age 11 included in analysis.

†$p < 0.10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

odds of reporting respiratory problems were nearly two times higher for children with two ACEs [$OR = 1.74$, $p = 0.005$, CI (1.18–2.58)] and three ACEs [$OR = 1.64$, $p = 0.03$, CI (1.03–2.60)] and over three times higher for children with four or more average ACEs [($OR = 3.18$, $p < 0.001$, CI (1.87–5.39)] compared with children with no ACEs.

ACEs were also associated with regular prescription use for reasons other than ADD/ADHD ($Wald(4) = 9.88$, $p = 0.04$), where the odds were significantly greater for children with four more average ACEs [$OR = 2.71$, $p = 0.002$, CI (1.45–5.09)] than those with no ACEs. Finally, we examined parents' rating of health. While the effect was not significant for the overall variable ($Wald(4) = 3.19$, $p = 0.11$), the odds of the rating being less than very good or excellent were over twice as likely for children with four or more ACEs [$OR = 2.65$, $p < 0.001$, CI (1.58–4.44)] compared with children in families with no ACEs.

Discussion

This study provides one of the first longitudinal examinations of early exposure to ACEs, specifically in infancy and toddlerhood, on weight, and related health outcomes in middle childhood. In this study, ACE exposure in infancy and toddlerhood was associated with an increased likelihood that a child would have obesity, respiratory problems, regular prescriptions not associated with attention problems, and a health rating below excellent or very good at age 11. This study adds to the existing literature that demonstrates exposure to ACEs in infancy and toddlerhood are associated with clinically significant behavior problems in middle childhood[34] by demonstrating that poor health outcomes are also seen in children exposed to ACEs very early in development. Our finding is particularly noticeable as multiple ACEs accumulate.

Our outcomes can be interpreted using the 2014 model of Hemmingsson et al. associating toxic stress with obesity and negative health consequences, especially in young children. This model and our findings are consistent with studies showing an association between general caregiver stress[53] and child stress[54] and increased BMI in childhood. However, our study expands the literature on the longitudinal impact of ACEs on children's weight and health by examining all of the original ACEs, rather than a specific subset, on which the original association between obesity and adversity was developed.[11,12,14–16,19,22,23,55] Additionally, this study focuses on health in middle childhood, which has been studied with less frequency than outcomes in adolescence[19,20,55] and adulthood.[11,12,15,16,18]

The key finding in our study is that of the association between early ACE exposure and weight outcomes by age 11. This outcome is consistent with other studies relating ACE exposure to childhood obesity.[19,20,22,23,55] Our study advances our understanding of this link by being the first to document the relationship between exposure to the full range of ACEs before age 11 and obesity in middle childhood. It is inconsistent with a recent study that found no association between physical, emotional, or sexual abuse and BMI at ages 13 and 16[56]; however, that study examined only a subset of the full ACE spectrum and therefore did not take into account the diverse range of experiences that can negatively impact children. Our finding of ACE exposure being associated with increased weight at age 11 is significant because of the known positive association between childhood obesity and adult obesity[21] and a lifetime of related health correlates.[2]

Obesity is associated with every organ system in the body, increasing the risk of conditions such as asthma,[57,58] and obstructive sleep apnea[57] that require long-term management and medical care. Indeed, there is evidence from our data that these comorbidities start early. Children with high levels of ACEs were already demonstrating less optimal lung health as respiratory problems were significantly more likely in children with high ACE exposure. There is some indication from existing studies that children in families with ACEs are living in less optimal environments, including homes with secondhand smoke exposure and greater access to risks for injuries.[34] Our analyses controlled for smoking in the home, but the effects of ACEs on respiratory health were evidenced even at lower levels of ACEs.

Additionally, children with ACEs experienced significantly higher odds of regular prescription use for asthma and other health conditions. This is consistent with previous studies that showed a positive association between ACE exposure and adult prescription drug use.[59,60] Findings are also consistent with studies, which demonstrate that children exposed to ACEs are more likely to have special health care needs and chronic health conditions.[26,32,34] Not surprisingly, this outcome is in keeping with our finding that children with exposure to four or more ACEs were more likely to have parental ratings of less than very good or excellent health, as children who are frequently sick are likely to require regular prescription drugs.

There is evidence from existing studies that as ACEs increase, the probability of children receiving preventive health care is reduced.[34,61] This reduction in the use of preventive health care is evidenced in children as early as infancy and toddlerhood.[34] While our study does not examine health care utilization, it is clear that the health environments at high levels of adversity represent a potential avenue of intervention.

There are a few limitations to our study. Our study used existing data from a randomized trial of EHS. Eligibility for EHS included families living at 100% of federal poverty or less; therefore, the families in this study have a higher level of socioeconomic risk than the general population and do not represent wide economic diversity. Because the sample was economically disadvantaged, we examined the children's insurance status as a possible covariate to include in analyses, but there was almost no variability in insurance status as nearly all of the children in our study were insured. Furthermore, both the comparison group and EHS program group in the study may have been eligible for other services for low-income families, which we were not able to include in the current study.

Like several other studies in this field,[17,26,31] we were unable to control for earlier weight status to examine the unique association between ACEs and respiratory problems after adjusting for earlier weight. Given the association between excess weight and immune system dysregulation,[3] it would have been ideal to control for previous BMI as has been done in existing studies regarding ACEs and respiratory problems.[62,63] However, the EHS study only collected weight data at the 11-year-old follow-up. Furthermore, because of the strong association between ACEs and behavioral problems,[36,64] we purposely excluded prescriptions for attention problems. Therefore, the findings should indicate that ACEs are associated with conditions that require ongoing medical intervention; however, prescriptions for ''other'' reasons might have been for mental health reasons other than associated with difficulties with attention.

Finally, our study used an index of ACE exposure to reflect prior ACE work and to highlight the importance of the collected exposure to ACEs rather than to isolate the effect of any one particular ACE. While there is existing research that examines the association between individual ACE constructs and the outcomes in this study,[65–69] our analyses do not demonstrate how specific ACEs or combinations of ACEs may influence children's health outcomes.

Our longitudinal findings have implications for shifting the public's perspective toward ACEs as a public health concern to develop appropriate screenings and interventions for children at risk. In particular, our results suggest a need to prevent the accumulation of ACEs for young children given that exposure to a higher number of ACEs was consistently associated with greater risk, regardless to which ACEs or combinations of ACEs children were exposed.

As we expand our knowledge about the consequences of ACEs and of effective interventions, the need for assessing ACE exposure in pediatric clinics is becoming clear. In fact, it is plausible that early identification and intervention of one ACE may prevent the accumulation of additional related traumatic experiences. Our study provides strong evidence that the link between the dose exposure to ACEs, weight, and associated health outcomes emerges early in life, and prevention efforts are one key response.

In addition to screening for prevention, implementing routine screening to assess for ACE exposures in medical, educational, and community settings is another action step toward reduction of long-term exposure to multiple ACEs. Practitioners can help families recognize and mitigate their stressors to change the trajectory of children's heath, preventing negative outcomes such as childhood obesity.

In addition to the adoption of trauma-informed care models among service providers, two recent reviews of possible interventions for children exposed to ACEs highlight possible points of intervention at the family and child levels.[70,71] Family interventions include referrals to parenting education programs,[72–76] therapy aimed at cultivating parent–child attachment,[77,78] mental health treatment,[79] and case management support.[80] Child-directed interventions for supporting executive functioning and promoting emotion regulation, such as mindfulness-based and mind–body approaches, have also shown promising results.[81–84] Unfortunately, while there is evidence that interventions for individuals impacted by ACEs can be effective, not all are widely available and there is still much to understand.[85] Future studies should evaluate the feasibility and acceptability of ACE screening and intervention while

also examining impact on children's health outcomes, including excess weight.

Acknowledgments

This project was supported, in part, by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) under R40MC29441/R40 MCH Secondary Data Analysis Studies.

Findings reported in this study are based on research conducted as part of the national EHSRE Project funded by the HHS Administration for Children and Families (ACF) under Contract 105-95-1936 to Mathematica Policy Research, Princeton, NJ, and Columbia University's Center for Children and Families, Teachers College, in conjunction with the Early Head Start Research Consortium. The Consortium consists of representatives from 17 programs participating in the evaluation, 15 local research teams, the evaluation contractors, and ACF. Research institutions in the Consortium include ACF; Catholic University of America; Columbia University; Harvard University; Mathematica Policy Research; Medical University of South Carolina; Michigan State University; New York University; NPC Research; University of Arkansas; University of California at Los Angeles; University of Colorado Health Sciences Center; University of Missouri-Columbia; University of Pittsburgh; University of Washington College of Education; University of Washington School of Nursing; and Utah State University.

Taren Swindle is supported by NIH K01 DK110141, NIGMS P20GM109096, the Lincoln Health Foundation, and by the Arkansas Bioscience Institute.

This information or content and conclusions are those of the author and should not be construed as the official position or policy of, nor should any endorsements be inferred by HRSA, ACF, HHS, or the U.S. Government.

Author Disclosure Statement

No competing financial interests exist.

References

1. Ogden CL, Carroll MD, Lawman HG, et al. Trends in obesity prevalence among children and adolescents in the United States, 1988–1994 through 2013–2014. *JAMA* 2016;315:2292–2299.
2. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA* 2003; 289:76–79.
3. Kelishadi R, Roufarshbaf M, Soheili S, et al. Association of childhood obesity and the immune system: A systematic review of reviews. *Child Obes* 2017;13:332–346.
4. De Beer M, Hofsteenge GH, Koot HM, et al. Health-related-quality-of-life in obese adolescents is decreased and inversely related to BMI. *Acta Paediatr* 2007;96:710–714.
5. Felitti V. Obesity: Problem, solution, or both? *Perm J* 2010;14:24–30.
6. Benton D, Young HA. Reducing calorie intake may not help you lose body weight. *Perspect Psychol Sci* 2017;12:703–714.
7. Franz MJ, Boucher JL, Rutten-Ramos S, et al. Lifestyle weight-loss intervention outcomes in overweight and obese adults with type 2 diabetes: A systematic review and meta-analysis of randomized clinical trials. *J Acad Nutr Diet* 2015;115:1447–1463.
8. Hemmingsson E, Johansson K, Reynisdottir S. Effects of childhood abuse on adult obesity: A systematic review and meta-analysis. *Obes Rev* 2014;15:882–893.
9. Danese A, McEwen BS. Adverse childhood experiences, allostasis, allostatic load, and age-related disease. *Physiol Behav* 2012;106: 29–39.
10. Johnson SB, Riley AW, Granger DA, et al. The science of early life toxic stress for pediatric practice and advocacy. *Pediatrics* 2013;131:319–327.
11. Felitti VJ. Childhood sexual abuse, depression, and family dysfunction in adult obese patients: A case control study. *South Med J* 1993;86:732–736.
12. Rehkopf DH, Headen I, Hubbard A, et al. Adverse childhood experiences and later life adult obesity and smoking in the United States. *Ann Epidemiol* 2016;26:488–492.e5.
13. Thomas C, Hypponen E, Power C. Obesity and type 2 diabetes risk in midadult life: The role of childhood adversity. *Pediatrics* 2008; 121:e1240–e1249.
14. Richardson AS, Dietz WH, Gordon-Larsen P. The association between childhood sexual and physical abuse with incident adult severe obesity across 13 years of the National Longitudinal Study of Adolescent Health. *Pediatr Obes* 2014;9:351–361.
15. Fuemmeler BF, Dedert E, McClernon FJ, et al. Adverse childhood events are associated with obesity and disordered eating: Results from a U.S. population-based survey of young adults. *J Trauma Stress* 2009;22:329–333.
16. Remigio-Baker RA, Hayes DK, Reyes-Salvail F. The relationship of adverse childhood events to smoking, overweight, obesity and binge drinking among women in Hawaii. *Matern Child Health J* 2017;21:315–325.
17. Felitti VJ, Anda RF, Nordenberg D, 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;14:245–258.
18. Anda RF, Felitti VJ, Bremner JD, et al. The enduring effects of abuse and related adverse experiences in childhood: A convergence of evidence from neurobiology and epidemiology. *Eur Arch Psychiatry Clin Neurosci* 2006;256:174–186.
19. Lynch BA, Agunwamba A, Wilson PM, et al. Adverse family experiences and obesity in children and adolescents in the United States. *Prev Med* 2016;90:148–154.
20. Pretty C, O'Leary DD, Cairney J, et al. Adverse childhood experiences and the cardiovascular health of children: A cross-sectional study. *BMC Pediatr* 2013;13:208.
21. Craigie AM, Matthews JNS, Rugg-Gunn AJ, et al. Raised adolescent body mass index predicts the development of adiposity and a central distribution of body fat in adulthood: A longitudinal study. *Obes Facts* 2009;2:150–156.
22. Biehl A, Hovengen R, Groholt E-K, et al. Parental marital status and childhood overweight and obesity in Norway: A nationally representative cross-sectional study. *BMJ Open* 2014;4:e004502.
23. Garasky S, Stewart SD, Gundersen C, et al. Family stressors and child obesity. *Soc Sci Res* 2009;38:755–766.
24. McKelvey LM, Whiteside-Mansell L, Conners-Burrow NA, et al. Assessing adverse experiences from infancy through early child-

hood in home visiting programs. *Child Abuse Negl* 2016;51:295–302.

25. McKelvey LM, Edge NC, Mesman GR, et al. Adverse experiences in infancy and toddlerhood: Relations to adaptive behavior and academic status in middle childhood. *Child Abuse Negl* 2018;82: 168–177.
26. Kerker BD, Zhang J, Nadeem E, et al. Adverse childhood experiences and mental health, chronic medical conditions, and development in young children. *Acad Pediatr* 2015;15:510–517.
27. Widom CS, Horan J, Brzustowicz L. Childhood maltreatment predicts allostatic load in adulthood. *Child Abuse Negl* 2015;47: 59–69.
28. Porsbjerg C, Brannan JD, Anderson SD, et al. Relationship between airway responsiveness to mannitol and to methacholine and markers of airway inflammation, peak flow variability and quality of life in asthma patients. *Clin Exp Allergy* 2008; 38:43–50.
29. Bautista LE. Inflammation, endothelial dysfunction, and the risk of high blood pressure: Epidemiologic and biological evidence. *J Hum Hypertens* 2003;17:223–230.
30. Pohunek P, Warner JO, Torzíková J, et al. Markers of eosinophilic inflammation and tissue re-modelling in children before clinically diagnosed bronchial asthma. *Pediatr Allergy Immunol* 2005;16: 43–51.
31. Sandberg S, Paton JY, Ahola S, et al. The role of acute and chronic stress in asthma attacks in children. *Lancet* 2000;356: 982–987.
32. Bethell CD, Newacheck P, Hawes E, et al. Adverse childhood experiences: Assessing the impact on health and school engagement and the mitigating role of resilience. *Health Aff* 2014;33: 2106–2115.
33. Flaherty EG, Thompson R, Litrownik AJ, et al. Adverse childhood exposures and reported child health at age 12. *Acad Pediatr* 2009; 9:150–156.
34. McKelvey LM, Edge NAC, Fitzgerald S, et al. Adverse childhood experiences: Screening and health in children from birth to age 5. *Fam Syst Health* 2017;35:420–429.
35. Love JM, Kisker EE, Ross C, et al. The effectiveness of early head start for 3-year-old children and their parents: Lessons for policy and programs. *Dev Psychol* 2005;41:885–901.
36. McKelvey LM, Selig JP, Whiteside-Mansell L. Foundations for screening adverse childhood experiences: Exploring patterns of exposure through infancy and toddlerhood. *Child Abuse Negl* 2017;70:112–121.
37. Bradley RH, Caldwell BM, Rock SL, et al. Home observation for measurement of the environment: Development of a Home Inventory for use with families having children 6 to 10 years old. *Contemp Educ Psychol* 1988;13:58–71.
38. Bradley RH. The Home Inventory: Review and reflections. *Adv Child Dev Behav* 1994;25:241–288.
39. Fuligni AS, Brady-Smith C, Tamis-LeMonda CS, et al. Patterns of supportive mothering with 1-, 2-, and 3-year-olds by ethnicity in early head start. *Parenting* 2013;13:44–57.
40. Fuligni AS, Brooks-Gunn J. Mother-child interactions in early head start: Age and ethnic differences in low-income dyads. *Parenting* 2013;13:1–26.
41. Owen M, Barfoot B, Vaughn A, et al. *54-Month Parent-Child Structured Interaction Qualitative Rating Scales*. NICHD Study of Early Child Care Research Consortium, Washington, DC, 1996.
42. Moos R, Moos B. *Family Environment Scale Manual: Development, Applications, Research,* 3rd ed. Consulting Psychologist Press: Palo Alto, CA, 1994.
43. Ross CE, Mirowsky J, Huber J. Dividing work, sharing work, and in-between: Marriage patterns and depression. *Am Sociol Rev* 1983;48:809–823.
44. Kessler RC, Andrews G, Mroczek D, et al. The World Health Organization Composite International Diagnostic Interview short-form (CIDI-SF). *Int J Methods Psychiatr Res* 1998;7:171–185.
45. Lahti-Koski M, Gill T. Defining childhood obesity. In: Keiss W, Marcus C, and Wabitsch M (eds), *Obesity in Childhood and Adolescence*. KARGER: Basel, 2004, pp. 1–19.
46. Scholle SH, Whiteside L, Kelleher K, et al. Health status of preterm low-birth-weight infants: Comparisons of maternal reports. *Arch Pediatr Adolesc Med* 1995;149:1351–1357.
47. International Business Machines Corporation (IBM). IBM SPSS Statistics for Windows, Version 24 IBM Corporation, Armonk, NY, 2016.
48. O'Brien RM. A caution regarding rules of thumb for variance inflation factors. *Qual Quant* 2007;41:673–690.
49. Pedhazur E. *Multiple Regression in Behavioral Research: Explanation and Prediction*, 3rd ed. Holt, Rinehart and Winston: New York, 1997.
50. Motrenko A, Strijov V, Weber GW. Sample size determination for logistic regression. *J Comput Appl Math* 2014;255:743–752.
51. Chinn S. A simple method for converting an odds ratio to effect size for use in meta-analysis. *Stat Med* 2000;19:3127–3131.
52. Peng C-YJ, So T-SH. Logistic regression analysis and reporting: A primer. *Underst Stat* 2002;1:31–70.
53. Isasi CR, Hua S, Jung M, et al. The association of parental/caregiver chronic stress with youth obesity: Findings from the Study of Latino Youth and the Hispanic Community Health Study/Study of Latinos Sociocultural Ancillary Study. *Child Obes* 2017;13:251–258.
54. Nelson DS, Gerras JM, McGlumphy KC, et al. Racial discrimination and low household education predict higher body mass index in African American youth. *Child Obes* 2018;14:114–121.
55. Heerman WJ, Krishnaswami S, Barkin SL, et al. Adverse family experiences during childhood and adolescent obesity. *Obesity* 2016;24:696–702.
56. Hawton K, Norris T, Crawley E, et al. Is child abuse associated with adolescent obesity? A population cohort study. *Child Obes* 2018;14:106–113.
57. Daniels SR. The consequences of childhood overweight and obesity. *Future Child* 2006;16:47–67.
58. Luder E, Melnik TA, DiMaio M. Association of being overweight with greater asthma symptoms in inner city black and Hispanic children. *J Pediatr* 1998;132:699–703.
59. Anda RF, Brown DW, Felitti VJ, et al. Adverse childhood experiences and prescription drug use in a cohort study of adult HMO patients. *BMC Public Health* 2008;8:198.
60. Anda RF, Brown DW, Felitti VJ, et al. Adverse childhood experiences and prescribed psychotropic medications in adults. *Am J Prev Med* 2007;32:389–394.
61. Duke NN, Borowsky IW. Adverse childhood experiences: Evidence for screening beyond preventive visits. *Child Abuse Negl* 2018;81:380–388.
62. Wright RJ, Cohen S, Carey V, et al. Parental stress as a predictor of wheezing in infancy: A prospective birth-cohort study. *Am J Respir Crit Care Med* 2002;165:358–365.
63. Cardet JC, Louisias M, King TS, et al. Income is an independent risk factor for worse asthma outcomes. *J Allergy Clin Immunol* 2018;141:754–760.e3.
64. Hunt TKA, Slack KS, Berger LM. Adverse childhood experiences and behavioral problems in middle childhood. *Child Abuse Negl* 2017;67:391–402.

65. Midei AJ, Matthews KA. Interpersonal violence in childhood as a risk factor for obesity: A systematic review of the literature and proposed pathways. *Obes Rev* 2011;12:e159–e172.
66. Roettger ME, Boardman JD. Parental incarceration and gender-based risks for increased body mass index: evidence from the national longitudinal study of adolescent health in the United States. *Am J Epidemiol* 2012;175:636–644.
67. Yannakoulia M, Papanikolaou K, Hatzopoulou I, et al. Association between family divorce and children's BMI and meal patterns: The GENDAI study. *Obesity* 2008;16:1382–1387.
68. Lampard AM, Franckle RL, Davison KK. Maternal depression and childhood obesity: A systematic review. *Prev Med* 2014;59: 60–67.
69. Norman RE, Byambaa M, De R, et al. The long-term health consequences of child physical abuse, emotional abuse, and neglect: A systematic review and meta-analysis. *PLoS Med* 2012;9: e1001349.
70. Biglan A, Van Ryzin MJ, Hawkins JD. Evolving a more nurturing society to prevent adverse childhood experiences. *Acad Pediatr* 2017;17:S150–S157.
71. Traub F, Boynton-Jarrett R. Modifiable resilience factors to childhood adversity for clinical pediatric practice. *Pediatrics* 2017; 139:pii: e20162569.
72. Borowsky IW, Mozayeny S, Stuenkel K, et al. Effects of a primary care-based intervention on violent behavior and injury in children. *Pediatrics* 2004;114:e392–e399.
73. Olds DL, Eckenrode J, Henderson CR, et al. Long-term effects of home visitation on maternal life course and child abuse and neglect. Fifteen-year follow-up of a randomized trial. *JAMA* 1997; 278:637–43.
74. Kitzman H. Effect of prenatal and infancy home visitation by nurses on pregnancy outcomes, childhood injuries, and repeated childbearing. A randomized controlled trial. *JAMA* 1997;278:644–652.
75. Duggan A, Caldera D, Rodriguez K, et al. Impact of a statewide home visiting program to prevent child abuse. *Child Abuse Negl* 2007;31:801–827.
76. Duggan A, McFarlane E, Fuddy L, et al. Randomized trial of a statewide home visiting program: Impact in preventing child abuse and neglect. *Child Abuse Negl* 2004;28:597–622.
77. Bernard K, Simons R, Dozier M. Effects of an attachment-based intervention on child protective services-referred mothers' event-related potentials to children's emotions. *Child Dev* 2015;86:1673–1684.
78. Murphy A, Steele H, Bate J, et al. Group attachment-based intervention: Trauma-informed care for families with adverse childhood experiences. *Fam Community Health* 2015;38:268–279.
79. Marie-Mitchell A, Studer KR, O'Connor TG. How knowledge of adverse childhood experiences can help pediatricians prevent mental health problems. *Fam Syst Health* 2016;34:128–35.
80. Dubowitz H, Feigelman S, Lane W, et al. The role of the pediatrician in recognizing and intervening on behalf of abused women. *Pediatrics* 1998;101:1091–1092.
81. Bethell CD, Gombojav N, Solloway M, et al. Adverse childhood experiences, resilience and mindfulness-based approaches: Common denominator issues for children with emotional, mental, or behavioral problems. *Child Adolesc Psychiatr Clin N Am* 2016;25: 139–156.
82. Kallapiran K, Koo S, Kirubakaran R, et al. Review: Effectiveness of mindfulness in improving mental health symptoms of children and adolescents: A meta-analysis. *Child Adolesc Ment Health* 2015;20:182–194.
83. Diamond A, Lee K. Interventions shown to aid executive function development in children 4 to 12 years old. *Science* 2011;333:959–964.
84. Cameron LD, Carroll P, Hamilton WK. Evaluation of an intervention promoting emotion regulation skills for adults with persisting distress due to adverse childhood experiences. *Child Abuse Negl* 2018;79:423–433.
85. Flynn AB, Fothergill KE, Wilcox HC, et al. Primary care interventions to prevent or treat traumatic stress in childhood: A systematic review. *Acad Pediatr* 2015;15:480–492.

Address correspondence to:
Lorraine M. McKelvey, PhD
Department of Family and Preventive Medicine
College of Medicine
University of Arkansas for Medical Sciences
4301 W. Markham
Little Rock, AR 72205

E-mail: mckelveylorraine@uams.edu