From Childhood Trauma to Elevated C-Reactive Protein in Adulthood: The Role of Anxiety and Emotional Eating

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Objective: Childhood trauma is known to be related to inflammatory processes in adulthood, but underlying psychological/behavioral mechanisms have not been fully characterized. To investigate associations between childhood trauma and inflammation (indexed by C-reactive protein [CRP]), we used a structural equation modeling approach on a subsample of the Midlife in the United States biomarker project. **Methods:** Participants included 687 men and women without history of cancer, diabetes, cardiovascular disease, or stroke who completed a physical examination and extensive questionnaires and provided blood. To test for sex differences, we held as many parameters invariant across sexes as possible while still retaining good model fit. **Results:** Tests of direct and indirect effects revealed that childhood trauma was significantly associated with elevated CRP, via elevated body mass index (BMI; $p < .001$). This relationship was mediated by a broad latent measure of distress, which was associated with using food as a coping mechanism. Men and women differed in reported levels of physical abuse, sexual abuse, and physical neglect. Compared with men, women showed a stronger association between BMI and CRP, whereas men had a stronger association between use of food to cope and elevated BMI. **Conclusions:** Our results are consistent with a model in which childhood trauma is associated with elevated CRP, a relationship associated with stress reactivity and compensatory emotional eating. Men and women may experience trauma in qualitatively distinct patterns but share many vulnerabilities, which can lead to elevated health risks. Emotional eating may be an important target for intervention in this population. **Key words:** C-reactive protein, inflammation, emotional eating, childhood trauma, anxiety, stress, cardiovascular disease.

BIC = Bayesian Information Criteria; **BMI** = body mass index; **CFI** = comparative fit index; **CRP** = C-reactive protein; **CT** = childhood trauma; **CTQ** = Childhood Trauma Questionnaire; **GAD** = generalized anxiety disorder; **HPA** = hypothalamic-pituitary-adrenal; **IL-6** = interleukin 6; **MASQ** = Mood and Anxiety Symptom Questionnaire; **MGA** = multiple group analysis; **MIDUS** = Midlife in the United States; **PSS** = Perceived Stress Scale; **PTSD** = posttraumatic stress disorder; **SAS** = Social Anxiety Scale.

INTRODUCTION

In the past 15 years, a link between a history of childhood trauma (CT) and increased levels of circulating inflammatory molecules has been supported by numerous studies (1–3).

One longitudinal prospective study found that adults with a history of CT had elevated markers of inflammation as adults, even when controlling for other early life risk factors such as birth weight, childhood intelligence quotient, and childhood socioeconomic status (1). In a sample of 17,000 community participants, approximately 28% had experienced physical abuse in childhood and approximately 20% had experienced sexual abuse, along with other forms of abuse and neglect (4,5) Given the high prevalence of CT and the seriousness of inflammation-linked diseases such as cardiovascular disease and cancer, understanding the relationship between adversity in early life and adult health is an important public health concern (6). Many physiological mechanisms have been implicated as consequences of CT, including dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis (7), alterations of sympathetic and parasympathetic nervous system reactivity and balance (8), and a general tendency to develop metabolic syndrome (9).

In addition, a variety of psychological and environmental factors such as concurrent mood disorders, socioeconomic status, substance abuse, and altered health behaviors have been implicated as contributing factors to the relationship between CT and inflammation (10,11). For example, CT has been linked to later-life obesity in multiple studies (12–14). Because obesity is associated with serious illnesses, is highly prevalent in the United States, and has a strong association with circulating markers of inflammation, understanding its relationship to CT and adult health risk factors has substantial implications for public health (15,16). The mechanisms underlying the CT-obesity relationship are not fully understood. Although no one theory can adequately address the etiology of obesity, many researchers have found a useful framework in identifying patterns of dysregulation in stress systems (17,18). Dysregulation of the HPA axis, for instance, has been associated with a history of CT and with excess adipose tissue in adulthood (7,19). Importantly, physiological alterations associated with CT are paralleled by alterations in behavior that have the potential to affect obesity and inflammation. One perhaps underappreciated factor is emotional eating, or the use of food as a coping mechanism in response to stress. It has long been recognized that some individuals may overeat or select high-calorie foods with hedonic associations, whereas others may undereat, or not alter eating behavior, when faced with stressful circumstances (20). Importantly, maladaptive food coping may occur in individuals who are free of diagnosable eating psychopathology such as binge eating disorder (21) Furthermore, some obese individuals do not engage in emotional eating, whereas some normal-weight individuals do (22). Patterns of emotional eating are thought to be linked to individual differences related to life events and associated psychological patterns (23). Determining whether and how CT might serve as a predisposing factor toward emotional eating could help in identifying vulnerabilities to negative health consequences and targets for intervention.

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In addition, anxiety and distress in adulthood have been consistently linked to a history of CT. Individuals with CT have a higher incidence of clinical diagnoses involving distress and anxiety, such as generalized anxiety disorder (GAD) and posttraumatic stress disorder (PTSD), along with greater reactivity on behavioral tasks designed to elicit stress responses (i.e., the Trier Social Stress Test (24,25)). Importantly, features of anxiety and other psychiatric symptoms are apparent even in children who experienced trauma early in life (26) and in adults who experienced trauma in childhood but not adulthood (27). One study found that PTSD-like symptoms in traumatized children predicted the appearance of non-PTSD anxiety symptoms 12 to 18 months later (28), suggesting that anxious symptoms may be established early in the lives of traumatized individuals. These findings are echoed by a substantial animal literature suggesting that traumatic experiences prime biological systems for stress reactivity (25) Understanding how traumatized individuals compensate for additional stress is crucial because anxiety and distress are associated with maladaptive coping, poor health behaviors, and emotional eating (29–32).

Sex differences in the experience and impact of CT remain an important and poorly characterized facet of trauma research. Studies have found, for instance, that men and women with a history of CT differ in HPA responses to stressful tasks (33), incidence of adult depression, neuroendocrine function (34) and the likelihood of relapse among individuals with substance abuse disorder (35). Emotional eating has generally been associated with elevated body mass index (BMI) in both men and women, but observations of sex-based differences in emotional eating and its attendant consequences have been reported. One review found that the preference for energy-dense food in response to stressful life events was stronger in men than in women (18). Exploring sex differences in emotional eating and its association with distress and BMI has the potential to identify sex-specific vulnerabilities to elevated BMI in the context of CT. Multiple group analysis (MGA) in structural equation modeling approaches allows for the determination, for instance, if emotional eating is more strongly associated with elevated BMI in men than in women.

Using the National Survey of Midlife Development in the United States (MIDUS II) biomarker data (Project 4), we undertook exploratory analyses to examine the associations between CT, distress, emotional eating, BMI, and inflammation. We also examined sex differences in the experience of CT and the differential associations of trauma with factors associated with inflammation. We hypothesized that a history of CT would be associated with elevated distress, that distress would be associated with the use of food as a coping mechanism, that the use of food as a coping mechanism would be associated with elevated BMI, and that BMI would be associated with elevated serum C-reactive protein (CRP), a marker of systemic inflammation. Our model assumed that CT preceded the appearance of anxious symptoms and patterns of emotional eating. See Figure 1 for the conceptual model of these hypothesized relationships.

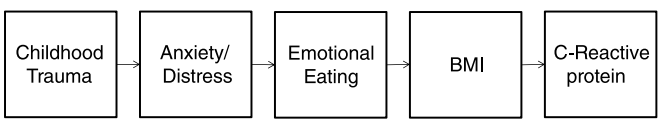

Figure 1. Hypothesized relationship between childhood trauma and inflammation in adulthood. BMI = body mass index.

METHODS

Sample

Participants were enrolled in the Biomarker Project (Project 4) of MIDUS II, a subsample of the original MIDUS longitudinal study. In brief, 7189 noninstitutionalized adults were recruited between 1995 and 1996 for participation in a unique, multidisciplinary survey of midlife and aging in the United States. Participants aged 25 to 74 years were recruited using random-digit dial. The response rate was approximately 70%. The original MIDUS study consisted of a telephone interview and self-administered questionnaire. More detailed information about the recruitment, enrollment processes, and scientific aims of the original MIDUS study is available (36–38). Between 2004 and 2005, 4963 original MIDUS participants were contacted for a follow-up (MIDUS II). Project 4 was undertaken to add biological and physiologic data for a subsample of MIDUS II participants and included a physical examination during which BMI was calculated from participant height and weight, extensive questionnaires, and the acquisition of blood and urine for analysis. All MIDUS II participants were considered eligible for Project 4 and were provided with compensation to cover travel expenses to the three sites established for participant evaluation. Ultimately, 39.3% (1255) of eligible participants agreed to participate. The Milwaukee sample (201), collected in 2005, was not available. Thus, the initial sample consisted of 1054 individuals. Individuals with a history of cardiovascular disease (i.e., stroke; $n = 126$), transient ischemic attack/stroke ($n = 30$), diabetes ($n = 84$), and cancer ($n = 112$) were not included in the current analyses because of well-established relationships between these diseases and inflammatory processes. Of the remaining 702 individuals, 15 were missing data on a variable of interest and were removed. Thus, the final sample consisted of 687 individuals.

Measures

Distress/Anxiety

The 11-item General Distress/Anxious Symptoms portion of the Mood and Anxiety Symptom Questionnaire (MASQ (39)) assesses recent feelings of distress and anxiety ($\alpha = .82$). Individuals respond to the general query "How much have you felt or experienced things this way during the past week, including today?" for a subset of responses (i.e., "was unable to relax") on a scale of 1 (not at all) to 5 (extremely.)

Perceived Stress

The Perceived Stress Scale (PSS) is a 10-item measure assessing individual perceptions of how overwhelmed an individual feels by life stress. (40). Individuals respond to the general query "In the last month, how often have you…" for a subset of responses (i.e., "been upset because of something that happened unexpectedly?") on a scale of 1 (never) to 5 (very often; $\alpha = .86$).

Social Anxiety

The Social Anxiety Scale (SAS) is a nine-item measure assessing feelings of distress and anxiety associated with social interactions (41). Individuals were asked to circle a number between 1 (none) and 4 (severe) to indicate how much fear and anxiety they generally feel in a variety of situations (i.e., "going to a party"; $\alpha = .85$)

Using Food to Cope

Two items from a multidimensional coping inventory (42) were used to assess an individual's tendency to use food as method of coping in response to a stressful event. Individuals respond on a scale of 1 (a lot) to 4 (not at all) for the items "I eat more than I usually do" and "I eat more of my favorite foods to make myself feel better" as coping techniques. This scale has previously been linked to childhood adversity and diabetic risk factors in the broader MIDUS

sample, with the correlation between the two items reported as.81 in nondiabetic participants (43–44).

Childhood Trauma

The Childhood Trauma Questionnaire (CTQ (45)) is a 28-item self-report measure designed to assess the frequency of CT. The respondent endorses specific questions (i.e., "People in my family hit me so hard that it left me with bruises or marks") on a scale of 1 ("never true") to 5 ("very often true"). The measure can be further divided into five subscales: physical abuse (α = .79), sexual abuse (α = .94), emotional abuse (α = .88), physical neglect (α = .70), and emotional neglect (α = .89).

C-reactive Protein

Fasting blood serum samples were obtained from participants during an overnight visit. CRP was assayed by immunophelometric assay using a BNII nephelometer (Dade Behring Inc) Additional information about collection procedures is available (36). Eleven values more than four standard deviations were removed from the sample, and the remaining values were log transformed to normalize their distribution. Laboratory coefficients of variance for CRP were less than 11%. (In secondary analyses, serum interleukin (IL) 6 collected in the same manner was used as the dependent variable in place of CRP. IL-6 was assayed by Quantikine High-sensitivity ELISA [#HS600B; R&D Systems, Minneapolis, MN]. Laboratory coefficients of variance were <12%.)

Demographic and Health Behavior Information

Demographic information including age, sex, and reported income were extracted from the original MIDUS II database. Level of education attained was also extracted and recoded into a three-level variable, with one indicating high school or less, a two indicating a bachelor's degree or less, and a three indicating a completed graduate degree or less. In addition, age, exercise status (moderate exercise 3 times a week/20 min at a time), alcohol consumption (more than recommended 14 drinks a week for men, 7 for women), and smoking status (never, former, current smoker/tobacco user) were extracted for each participant.

Statistical Analyses

Structural equation model analyses were undertaken to test the proposed hypothetical model, namely, that CT is associated with self-reported distress and that this construct, in turn, is associated with emotive eating, elevated BMI, and elevated CRP.

First, we tested the measurement portion of the model by modeling hypothesized latent variables and examining various measures of model fit. Next, we examined modification indices for potential adjustments. The model with the best fit according to several fit indices was retained for the structural portion of the analysis.

Two of the latent variables established in the measurement portion of the model were then used as independent variables in a series of multiple regression equations, with serum levels of CRP as the dependent variable of interest. The CTQ subscale scores were loaded on to the first latent variable representing CT, whereas the scores of the SAS, PSS, and the distress/anxiety subscale of the MASQ were loaded on to the second latent variable representing general distress. Model fit for both the structural and measurement portions of the model was estimated in MPLUS version 6.11 (Muthen & Muthen, 2011). The model was estimated using maximum likelihood to assess the difference between the covariance matrix of the sample and an estimated covariance matrix of the best-fitting model. The fit of all models was evaluated by the comparative fit index (CFI; values >0.95 indicate good model fit) and root mean square error of approximation (RMSEA; values <.06 indicate good model fit). In addition, standardized residuals and modification indices were examined for plausible improvements of model fit. We calculated indirect effects for a variety of paths in the model to determine which reached statistical significance and to examine the estimates of their effect on the outcome variables. The structural portion of the model also included a number of relevant continuous outcome variables, including BMI, use of food as coping mechanism, and several covariates (level of education, tobacco use, alcohol use, regular exercise, and age). We then established a model in which the impact of CT and the distress latent variable affected CRP indirectly through the use of food as a coping mechanism and elevated BMI. We compared this model to models in which both direct and indirect effects were included and examined differences in χ^2 values for significance at the $p < .01$ level and Bayesian Information Criteria (BIC) values. Sex differences were tested with an MGA by beginning with a model, which included the same indicators of latent variables and same specified relationships, but in which all loadings and intercepts (except those used as fixed indicators of the latent variables and those required for model identification) were freely estimated for both men and women. We then proceeded to sequentially hold each parameter invariant between sexes and retained the invariant parameter in the final model if it did not affect model fit using the standards proposed by Cheung and Rensvold (46). We conducted nested model testing to determine if the hypothesized mediational model was also best supported in the sex MGA.

RESULTS

Demographic Information

As seen in Table 1, participants had a mean (standard deviation) age of 52 (10.9) years at study entry, were almost evenly split between men and women, and were predominantly

TABLE 1. Demographic and Health Characteristics

Measure	*n* = 687
Age, y	
Mean (SD)	52.2 (10.9)
Sex	
Male	44%
Female	56%
Marital status	
Single	9.7%
Divorced/Separated	15%
Widowed	5.1%
Married/Living with partner	69.9%
Education	
High school or less	25.0%
Bachelor's degree or less	51.4%
Graduate degree or less	23.7%
Race	
American Indian/Alaskan Native	1.0%
Asian	0.3%
African American	2.6%
White	92.5%
Other	3.4%
Ethnicity	
Hispanic	4.6%
Non-Hispanic	95.2%
Tobacco use	
Never used	55.5%
Former user	30.3%
Currently use	14.3%
Alcohol use	
Within guidelines	73.4%
Above	26.6%
Exercise	
≥3× weekly (20 min moderate)	79.9%
<3× weekly (20 min moderate)	20.1%

SD = standard deviation.

married or living with a partner. Most participants were nonsmokers and had some college education.

Correlation Matrix

The correlation matrix for the full model is seen in Table 2. (The covariance matrix is shown in Table S1, Supplemental Digital Content, http://links.lww.com/PSYMED/A141.) In bivariate correlation analyses, CRP was significantly associated with the emotional abuse, physical abuse, and physical neglect subscales of the CTQ; the use of food to cope scale; BMI; and exercise (all, $p < .034$). Sex-specific covariance and correlation matrices from MGA are shown in Tables S2 to S5 (Supplemental Digital Content, http://links.lww.com/PSYMED/A141). (IL-6 was significantly associated with the emotional abuse, physical abuse, sexual abuse, and physical neglect subscales of the CTQ; the use of food to cope scale; BMI; exercise; tobacco use; level of education; and age [all $p < .016$; correlation and covariance matrices are shown in Tables S6 and S7, Supplemental Digital Content, http://links.lww.com/PSYMED/A141]).

TABLE 2. Correlation Matrix for Full Model

	EA	PA	SA	EN	PN
EA	1.000				
PA	0.801	1.000			
SA	0.477	0.496	1.000		
EN	0.808	0.731	0.425	1.000	
PN	0.757	0.818	0.521	0.774	1.000
ANX	0.357	0.281	0.214	0.315	0.300
SOCANX	0.352	0.331	0.229	0.338	0.397
PSS	0.432	0.415	0.247	0.434	0.431
FDCOP	0.184	0.119	0.092	0.101	0.084
BMI	0.075	0.096	0.070	0.020	0.022
CRP	0.111	0.101	0.070	0.059	0.081
EDU	−0.087	−0.117	−0.031	−0.096	−0.115
SMOKE	0.132	0.151	0.018	0.142	0.131
DRINK	0.005	0.006	−0.016	0.002	−0.007
EXERCISE	0.072	0.052	0.05	0.062	0.111
AGE	−0.115	−0.091	−0.041	−0.052	−0.010
	ANX	**SOCANX**	**PSS**	**FDCOP**	**BMI**
ANX	1.000				
SOCANX	0.440	1.000			
PSS	0.633	0.513	1.000		
FDCOP	0.204	0.192	0.228	1.000	
BMI	0.020	−0.012	0.074	0.388	1.000
CRP	−0.008	−0.034	0.004	0.181	0.461
EDU	−0.012	−0.050	−0.083	0.027	−0.106
SMOKE	0.060	−0.034	0.085	0.015	0.036
DRINK	0.052	−0.024	0.045	0.077	−0.030
EXERCISE	0.025	0.068	0.054	0.102	0.121
AGE	−0.158	−0.101	−0.186	−0.072	−0.003
	CRP	**EDU**	**SMOKE**	**DRINK**	**EXERCISE**
CRP	1.000				
EDU	−0.063	1.000			
SMOKE	0.044	−0.167	1.000		
DRINK	0.062	−0.032	0.179	1.000	
EXERCISE	0.159	−0.068	0.034	−0.039	1.000
AGE	0.017	−0.088	0.032	−0.146	0.047
	AGE				
AGE	1.000				

EA = emotional abuse; PA = physical abuse; SA = sexual abuse; EN = emotional neglect; PN = physical neglect; ANX = general distress/anxious symptoms subscale of the Mood and Anxiety Symptom Questionnaire; SOCANX = Social Anxiety Scale; PSS = Perceived Stress Scale. FDCOP = Use of Food to Cope score; BMI = body mass index; CRP = C-reactive protein, in micrograms per milliliter, log transformed; EDU = level of education attained; SMOKE = currently uses tobacco; DRINK = exceeds the recommended number of drinks per week (14 for men, 7 for women); EXERCISE = does not exercise regularly (20 minutes, 3 times/wk); AGE = age.

Measurement Model

The final measurement model is presented in Figure 2. The first proposed latent variable representing CT was indicated by the five subscales of the CTQ. The second latent variable, representing general distress, was indicated by the SAS, the PSS, and the distress/anxiety subscale of the MASQ. The temporal precedence of CT precluded our examining any models which would have allowed indicators of trauma to load on to latent variables, which also included current measures of distress. After examining modification indices and residual variances, we included one additional parameter, allowing the residual errors of the emotional abuse and physical neglect subscales to covary. This model demonstrated good fit (CFI = 0.989, RMSEA = 0.055).

Path From CT to Inflammation Via BMI: Structural Model

The final structural model is presented in Figure 3. We tested a variety of nested models in which CT and distress were allowed to directly and indirectly predict the use of food as a coping mechanism, BMI, and CRP. The only constraint we imposed across all models is that the latent variable representing CT always be an exogenous predictor variable because of its temporal precedence. χ^2 Difference testing and BIC did not support models that included direct paths between CT and use of food as a coping mechanism, BMI, or CRP, and did not support models that included direct paths between distress and BMI or CRP. Rather, this supports a mediational model in which CT is associated with distress, distress with use of food coping, use of food coping with elevated BMI, and BMI with serum CRP. Of covariates, older age was associated with lower distress ($p < .001$); lack of regular exercise was associated with higher use of food to cope ($p = .012$), elevated BMI ($p = .044$), and elevated CRP ($p = .002$); use of alcohol beyond recommended guidelines was associated with elevated CRP ($p = .018$); and higher level of education attained was associated with lower BMI ($p = .002$). This model demonstrated very good fit (CFI = 0.977; RMSEA = 0.043). See Table 3 for details of nested model testing and Table 4 for parameter estimates.

The best-fitting model was consistent with our hypothesis that CT would be associated with higher levels of distress in adulthood and, in turn, emotional eating, elevated BMI, and

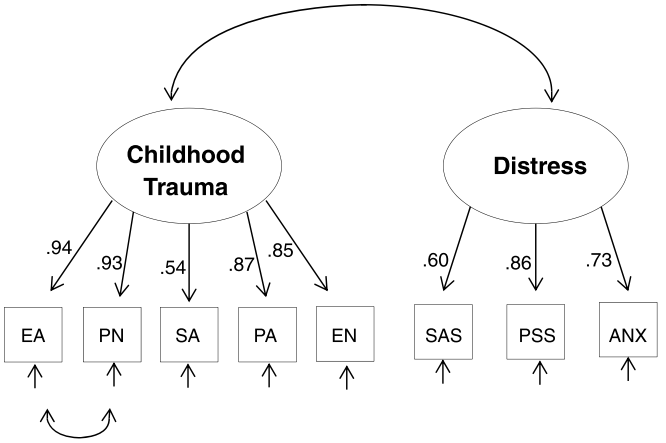

Figure 2. Measurement model. EA = emotional abuse; PN = physical neglect; SA = sexual abuse; PA = physical abuse; EN = emotional neglect; SAS = Social Anxiety Scale; PSS = Perceived Stress Scale; ANX = general distress/anxious symptoms subscale of the Mood and Anxiety Symptom Questionnaire;

elevated CRP. CT was significantly associated with food coping via distress (β = .14, p < .001) and with BMI via distress and food coping (standardized β = .06, p < .001). The indirect effect of CT on CRP was small but significant (standardized β = .03,

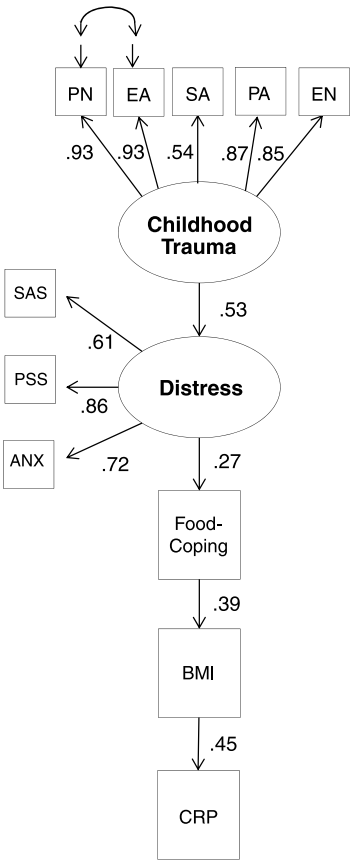

Figure 3. Structural model with standardized estimates. Covariates not shown. See Table 4 for all standardized paths in model. PN = physical neglect; EA = emotional abuse; SA = sexual abuse; PA = physical abuse; EN = emotional neglect; SAS = Social Anxiety Scale; PSS = Perceived Stress Scale; ANX = general distress/anxious symptoms subscale of the Mood and Anxiety Symptom Questionnaire; BMI = body mass index; CRP = C-reactive protein, in micrograms per milliliter, log transformed.

TABLE 3. χ^2 Difference Testing for Direct Effects of CT, Distress, and Food Coping on CRP, and CT and Distress on BMI, in Full Model and MGA

Model	χ^2	*df*		*p*	BIC
Full					
Mediational	162.368	72			45,367.13
With CRP on CT	158.118	71	4.250	.039	45,369.42
With CRP on distress	161.867	71	0.501	.48	45,373.17
With CRP on FDCOP	162.285	71	0.083	.77	45,373.58
With BMI on CT	161.879	71	0.489	.48	45,373.18
With BMI on distress	159.657	71	2.711	.10	45,370.954
Men					
Mediational	253.578	154			44,583.80
With CRP on CT	253.358	153	0.220	.64	44,590.11
With CRP on distress	252.493	153	1.085	.30	44,589.25
With CRP on FDCOP	246.130	153	7.448	**.006**	**44,582.88**
With BMI on CT	251.885	153	1.693	.19	44,588.64
With BMI on distress	251.807	153	1.771	.18	44,588.56
Women					
Mediational	253.578	154			44,583.80
With CRP on CT	249.991	153	3.587	.06	44,586.74
With CRP on distress	252.925	153	0.653	.42	44,589.68
With CRP on FDCOP	253.251	153	0.327	.54	44,590.00
With BMI on CT	252.909	153	0.669	.41	44,589.66
With BMI on distress	252.728	153	0.850	.36	44,589.48

CT = childhood trauma; CRP = C-reactive protein; BMI = body mass index; MGA = multiple group analysis; FDCOP = Use of Food to Cope score; BIC = Bayesian Information Criteria.
Bold results show agreement between χ^2 test (<.01) and BIC (lower).

p < .001), indicating that self-reported CT is associated with slight elevations in this index of systemic inflammation via this distinct behavioral pathway. Food coping was associated with CRP through elevated BMI (β = .18, p < .001). Overall, the model accounted for a significant proportion of the variance in CRP (r^2 = 0.230) and BMI (r^2 = 0.174). (The results of the model when IL-6 was used as the dependent variable were similar. All significant paths included in the CRP model were significant with IL-6. The model accounted for a significant proportion of the variance in IL-6 [r^2 = 0.178] and BMI [r^2 = 0.164]. Food coping was significantly associated with IL-6 via distress [standardized β = .13, p < .001]. This model displayed good model fit [CFI = 0.976, RMSEA = 0.043].)

MGA by Sex

Parameters that varied between sexes are presented in Table 5. Means and standard deviations by sex are presented in Table 6 (parameter estimates for sex-specific models can be found in Tables S5 and S6, Supplemental Digital Content, http://links.lww.com/PSYMED/A141). The latent construct representing CT differed between men and women. The estimated intercept of physical abuse, physical neglect, and emotional neglect was higher in men than in women at the same level of the trauma latent CT variable. In contrast, the estimated intercept of sexual abuse endorsed by women was higher than that endorsed by men at the same level of the trauma latent variable. In addition, the factor

TABLE 4. Standardized Parameter Estimates for Full Model

			p
DISTRESS by	ANX	0.724	<.001
	SOCANX	0.613	<.001
	PSS	0.861	<.001
CT by	EA	0.933	<.001
	PA	0.869	<.001
	SA	0.536	<.001
	PN	0.931	<.001
	EN	0.849	<.001
DISTRESS on	CT	0.526	<.001
	SMOKE	−0.004	.91
	EDU	−0.032	.40
	AGE	−0.174	<.001
	DRINK	0.020	.59
	EXERCISE	0.019	.61
FDCOP on	DISTRESS	0.270	<.001
	EDU	0.054	.15
	AGE	−0.004	.91
	DRINK	0.072	.60
	EXERCISE	0.093	.012
	SMOKE	−0.012	.75
BMI on	FDCOP	0.388	<.001
	SMOKE	0.021	.55
	EDU	−0.110	.002
	AGE	0.001	.97
	DRINK	−0.065	.07
	EXERCISE	0.070	.044
CRP on	BMI	0.450	<.001
	SMOKE	0.008	.81
	EDU	−0.002	.95
	AGE	0.025	.47
	DRINK	0.082	.018
	EXERCISE	0.106	.002
EDU with	CT	−0.109	.003
SMOKE with	CT	0.142	<.001
DRINK with	CT	−0.001	.98
EXERCISE with	CT	0.096	.013
AGE with	CT	−0.069	.07

DISTRESS = distress latent variable; CT = childhood trauma latent variable; FDCOP = Use of Food to Cope score; BMI = body mass index; CRP = C-reactive protein, in micrograms per milliliter, log transformed; EDU = level of education attained; SMOKE = currently uses tobacco; DRINK = exceeds the recommended number of drinks per week (14 for men, 7 for women); EXERCISE = does not exercise regularly (20 minutes, 3 times/wk); AGE = age; ANX = general distress/anxious symptoms subscale of the Mood and Anxiety Symptom Questionnaire; SOCANX = Social Anxiety Scale; PSS = Perceived Stress Scale; EA = emotional abuse; PA = physical abuse; SA = sexual abuse; PN = physical neglect; EN = emotional neglect.

loadings varied between groups, with men displaying lower associations between physical neglect, physical abuse, sexual abuse, and the latent construct representing CT, implying that men experience different types of CT independent of each other more often than women. The latent construct representing general distress and anxiety was very similar between sexes; the estimated level of endorsement of perceived stress was slightly higher for men than for women at the same level of the latent variable. Women displayed higher estimated mean levels of food coping. Food coping was more strongly associated with elevated BMI in men than in women ($B = 0.1.60$, standard error [SE] = 0.13, $p < .001$, for men; $B = 1.10$, SE = 0.11, $p < .001$, for women). Conversely, elevated BMI was more strongly associated with elevated serum CRP in women than in men ($B = 0.044$, SE = 0.003, $p < .001$, for women; $B = 0.037$, SE = 0.004, $p < .001$, for men). All other parameters were invariant between sexes.

Examination of indirect effects in parallel revealed that the CT latent variable was more strongly associated with elevated BMI in men than in women ($B = 0.070$, SE = 0.016, $p < .001$, in men; $B = 0.059$, SE = 0.013, $p < .001$, in women); this was due to the stronger association between food coping and elevated BMI in men noted above. The indirect effect of CT on food coping via distress was identical because both contributing paths did not vary between sexes (both sexes: $B = 0.048$, SE = 0.009, $p < .001$), and the overall effect of CT on CRP via distress, food coping, and BMI was very similar (both sexes: $B = 0.003$, SE = 0.001, $p < .001$) because the stronger association of food coping with BMI in men was counteracted by the stronger association of BMI with CRP in women (see Table 7 for estimated indirect effects by sex).

In both men and women, older age was associated with decreased distress (both, $p < .001$), higher level of education attained was associated with lower BMI (both, $p < .001$), and lack of exercise was associated with elevated serum CRP (both, $p < .042$). In women only, lack of exercise was also associated with elevated BMI ($p < .001$). In men only, tobacco use was associated with elevated CRP ($p = .002$), higher level of education attained was associated with greater food coping ($p = .013$), and lack of exercise was also associated with greater food coping ($p < .001$).

Nested model testing suggested that CRP should be directly regressed on the food coping score in addition to its relationship with food coping via BMI in men but not women (Table 3). Modification indices suggested that residual errors between emotional neglect and emotional abuse were correlated for women but not men, indicating that emotional abuse and neglect were more strongly related to each other in women than in men. After holding as many parameters equal between sexes as allowed by the adopted guidelines, the model fit the data well (CFI = 0.974; RMSEA = 0.042).[1]

DISCUSSION

The key findings of this secondary analysis of data from MIDUS II are that CT is associated with systemic inflammation, as indicated by CRP, indirectly through associations with BMI and the use of food as a coping mechanism. Self-reported recent distress and anxiety were associated with both CT and

[1]We have also included Tables S8 and S9, Supplemental Digital Content, http://links.lww.com/PSYMED/A141, showing parameter estimates when male and female specific models are estimated simultaneously (i.e., no MGA test of invariance). The central mediational path remained statistically significant, and both estimated parameters and indirect effects were similar to those in sex MGA models.

TABLE 5. Unstandardized Sex-Specific Parameter Estimates by Maximum Likelihood

Measure	Intercept, Mean (SE), Women	Intercept, Mean (SE), Men	Factor Loading/ Coefficient (SE), Women	Factor Loading/ Coefficient (SE), Men
Physical abuse	6.02 (0.20)	6.86 (0.15)	0.87 (0.03)	0.55 (0.04)
Sexual abuse	6.70 (0.43)	5.63 (0.11)	0.89 (0.07)	0.26 (0.04)
Emotional neglect	8.79 (0.22)	9.61 (0.22)	N/A	N/A
Physical neglect	5.95 (0.20)	6.56 (0.13)	0.90 (0.03)	0.54 (0.05)
Use of food to cope	4.50 (0.66)	2.58 (0.59)	N/A	N/A
PSS	25.23 (0.33)	26.76 (0.32)	N/A	N/A
BMI on food coping	N/A	N/A	1.23 (0.13)	1.46 (0.16)
CRP on BMI	N/A	N/A	0.042 (0.00)	0.037 (0.00)

PSS = Perceived Stress Scale; BMI = body mass index; CRP = C-reactive protein; SE = standard error; N/A = not applicable.

the use of food as a coping mechanism. Men and women differed in the patterns of trauma they reported, but CT was broadly associated with a tendency to engage in emotional eating. These findings are consistent with associations reported previously in trauma literature, including the association between CT and CRP (1) and CT and elevated adult BMI (14), but go beyond existing literature by identifying distress/anxiety and emotional eating as potential mediators of the association between CT BMI and inflammation. They are also in keeping with the results of a recent longitudinal, prospective study linking GAD to CRP through elevated BMI in a community sample (47). We demonstrate for the first time how CT may be associated with inflammation via psychological and behavioral variables, and we identify emotional eating as an important correlate of systemic inflammation. The mean CRP level in this sample (2.34 mg/l) already falls in a range considered elevated (>2.1 mg/l (48)), so even small fluctuations associated with behavioral factors may be important from a clinical perspective. Multiple prospective longitudinal studies have identified CRP levels in the range of our sample mean as conferring significant additional risk for coronary events (49,50). For instance, in a sample of initially healthy women, individuals with CRP levels in the second quartile (1.5-3.7 mg/l) had relative risk ratios of 2.4 for any future cardiac event compared with those in the first quartile and had 3.5 relative risk for myocardial infarction or stroke (49). Clearly, even small fluctuations in CRP levels due to interindividual differences in life events and psychological characteristics could be relevant to health outcomes. Emotional eating seems to be an underappreciated correlate of systemic inflammation. In fact, the relationship between emotional eating and CRP (β = .18) was stronger than current tobacco use, excessive alcohol use, or failure to exercise, and this was also true in the sex-specific models. In men, for instance, the effect of food coping on CRP via BMI (β = .20) was greater than the direct effects of tobacco use (β = .17), excessive alcohol use (β = .10), or lack of exercise (β = .14) and was much greater in women (β = .22) than any of these other health-related factors (all, β < .12). Clearly, emotional eating is a relevant target for clinical intervention for individuals with a history of CT.

Although this cross-sectional analysis used current self-reported measures of distress as predictors of maladaptive

TABLE 6. Means and SDs by Sex

	Men, Mean (SD)	Women, Mean (SD)
Emotional abuse	7.47 (3.45)	6.60 (6.35)
Physical abuse	6.84 (2.7)	6.97 (5.41)
Sexual abuse	5.62 (2.03)	7.66 (9.09)
Emotional neglect	9.58 (3.05)	9.83 (6.29)
Physical neglect	6.54 (2.29)	6.92 (5.42)
Social Anxiety Scale	1.77 (0.51)	1.94 (0.63)
Distress/Anxiety MASQ	15.99 (3.97)	17.22 (4.95)
Perceived Stress Scale	21.5 (5.98)	22.39 (7.48)
Level of education attained	2.03 (0.66)	1.96 (0.72)
Tobacco use	1.68 (0.76)	1.51 (0.68)
Alcohol use	0.20 (0.40)	0.320 (0.46)
Exercise	0.18 (0.39)	0.215 (0.41)
Age, y	52.4 (10.9)	52.5 (11.0)
Use of food to cope	3.30 (1.61)	4.20 (2.03)
Body mass index, kg/m^2	29.39 (5.19)	28.44 (6.19)
C-reactive protein, μg/ml (log transformed)	0.015 (0.45)	0.156 (0.50)
IL-6, pg/ml (log transformed)	0.247 (0.28)	0.276 (0.30)

MASQ = Mood and Anxiety Symptom Questionnaire; IL-6 = interleukin-6; SD = standard deviation.

TABLE 7. Unstandardized Indirect Estimates and SEs of Effects of Childhood Trauma and Distress Latent Variables on Dependent Variables by Multiple Regression Through Central Mediational Path

	Men (n = 301), B (SE)	Women (n = 381), B (SE)
Trauma		
Food coping	0.048 (0.009)	0.048 (0.009)
BMI	0.070 (0.016)	0.059 (0.013)
CRP	0.003 (0.001)	0.003 (0.001)
Distress		
BMI	0.204 (0.043)	0.172 (0.036)
CRP	0.007 (0.002)	0.007 (0.002)
Food coping		
CRP	0.054 (0.009)	0.054 (0.007)

SEs = standard errors; BMI = body mass index; CRP = C-reactive protein.

emotional eating, it is quite possible that patterns of stress reactivity and compensatory eating may have been in place for much of the individual's lifetime, but this cannot be ascertained from available data. For example, the latent variable representing recent anxiety and distress was constructed from diverse measures reflecting many facets of anxiety. For instance, anxiety was represented by internal emotional experiences (i.e., fear), as well as by reactions to external events (i.e., unexpected disruptions and social interactions). Thus, distress in this model likely reflects a global and possibly more persistent psychological factor. This is consistent with literature linking CT to more stable personality constructs such as higher neuroticism and lower openness (51). Recent contributions to the literature have provided an important theoretical framework in which to view analyses like these. A 2013 review of literature linking early life adversity to inflammation introduced the concept that individuals who experience early life trauma experience a dearth of personal and environmental resources to buffer the effects of stress while experiencing heightened stress sensitivity (52). In this context, individuals may develop maladaptive coping mechanisms such as substance use or emotional eating early in life. These patterns may be reinforced by the greatly enhanced vulnerability to various forms of psychopathology including major depressive disorder, PTSD, and GAD. In fact, there is evidence to suggest that there are CT-related structural and functional alterations of the central nervous system that would support the development of specific vulnerabilities to stress (53,54).

The present analyses address only one mediating pathway between CT and inflammation. A review by Miller et al. (10) addressed the emergence of a proinflammatory phenotype at an early age in response to CT. Specifically, CT is associated with the clustering of depressive symptoms, inflammatory markers, exaggerated in vitro responses to bacterial stimulation, and desensitization of the glucocorticoid receptor in adolescents (55,56). CRP is synthesized in the liver after stimulation by proinflammatory cytokines such as IL-6 and IL-1β; however, it has also known to be secreted by adipose tissue in response to these same cytokines (57). Thus, it is possible that weight gain associated with emotional eating might have especially deleterious implications for health in individuals with a history of CT.

The MGA by sex revealed several informative differences. First, there were significant sex differences in the types of abuse and neglect experienced, with women reporting more sexual abuse and men reporting more physical abuse, emotional neglect, and physical neglect. For sexual and physical abuse, these findings were in keeping with large-scale studies of sex differences in abuse prevalence in the United States (58). The differential findings between men and women with respect to physical and emotional neglect, likewise, were similar to findings from other community samples that used the CTQ to examine CT (59). Differences in factor loadings between sexes suggest that women are more likely to report multiple forms of abuse and neglect than men, and that sexual abuse of men occurs much more frequently in isolation from other forms of abuse and neglect. According to one broad community survey, men who were sexually abused as children were twice as likely as women to report that the perpetrator was a stranger (60), suggesting a possible explanation for the relative independence of sexual abuse in men. Despite these differences, the association of CT with distress was the same in both men and women, and the association between distress and use of food to cope was also the same. If the distress construct is indicative of an underlying, persistent vulnerability to stress, it would seem to be similarly affected by a traumatic history in both men and women and to similarly affect a tendency to use food as a coping mechanism.

Interestingly, although women were more likely to engage in emotional eating, the relationship between emotional eating and elevated BMI was stronger in men. This may be due to countervailing forces such as concern about weight gain and body image, which tend to affect women more strongly than men (61). An alternative explanation may be that emotional eating has different emotional consequences for men and women. One study found that men experienced a more reliable improvement in negative mood after eating than women did, which might more effectively reinforce the behavior or promote more bouts of emotional eating in men (62). Another alternative explanation may be that stress influences food choices in a sex-specific manner. A recent investigation determined that stress increased the preference of men, but not women, for sweet, calorie-rich foods (63). Interestingly, in the current study greater educational attainment was associated with a greater tendency to eat emotionally in men only, which could indicate a sex-specific response to occupational stressors. In addition, men who reported not exercising regularly were also more likely to engage in food coping. The finding that there was a small but significant inverse association ($B = -0.04$, SE = 0.02) between food coping and CRP independent of BMI in men only is interesting if difficult to interpret. In the current study, elevated BMI was more strongly associated with elevated serum CRP in women than in men. Similar patterns have been observed in a community sample of obese women, who had three times the risk of obese men for clinical levels of serum CRP (64), a fact that likely reflects the higher fat composition of women versus men at the same BMI (65).

Limitations

Substantial amounts of unavailable data precluded a rigorous examination of racial differences in the construction of our model. The sample was largely white and non-Hispanic (see Table 1). Other work has suggested that inflammation may be differentially affected by early life events in the context of race (37). In addition, although CRP is a reliable index of inflammation, inflammatory processes are complex and interactive; no single biomarker can assess overall health risk or proclivity to disease. Furthermore, although CRP has emerged as a biomarker of great interest in CVD and cancer, no causal action in either disease process has been conclusively demonstrated. Our analysis focused on the concept of CT and not on the related notion of early life adversity. Thus, we caution that these findings may not generalize to other distressing childhood experiences. As mentioned above, CT is associated with a greatly

increased vulnerability to psychopathology, but the MIDUS data do not include clinical assessments of specific psychiatric diagnoses such as GAD or PTSD. This is a significant limitation, given that physiological arousal and hypervigilance, both of which are associated with PTSD, might also be strongly correlated with the distress/anxiety latent construct used in this analysis. In addition, there is a high prevalence of medication use among community-dwelling older adults, and higher medication use might be associated with CT and/or anxiety (66). It is possible that some of these medications could be associated with alterations in inflammatory markers, which might have altered model parameters. For instance, the longitudinal analysis described above found that use of medication partially mediated the impact of GAD on CRP levels, although elevated BMI remained a significant independent predictor as well (49). Thus, the lack of available information on medications in this data set is a limitation. The cross-sectional nature of the analyses precludes any causal claims and limits conclusions about the temporal precedence of the examined constructs. It is possible, for instance, that emotional eating, obesity, and body image issues contribute to the subsequent development symptoms of anxiety and distress. Furthermore, it is possible that self-report measures of CT are subjective to forms of bias, including underreporting of sexual abuse, sex differences in recall, and the influence of current negative emotionality or psychopathology. Although our model included a number of relevant covariates, self-report is not an ideal way to monitor health behaviors, and our sample reported engaging in regular exercise at an unlikely rate for a community sample. These analyses can only demonstrate that these data are consistent with our hypotheses but do not preclude the potential for alternative models. We would particularly draw the reader's attention to results of χ^2 difference testing, which resulted in p values ranging between .01 and .05 (Table 3) but not lower BIC values. In these instances, the researcher's adopted criteria play a critical role in model selection. However, we would note that in models with a variety of additional paths, the parameter estimates, indirect effects, and significance tests of the central mediational model were essentially unchanged.

Conclusions and Future Directions

It is becoming clear that a history of CT is an important risk factor influencing adult health. Data from community samples, like MIDUS, offer unique opportunities to assess particular vulnerabilities in individuals with a history of CT and to begin to parse the relationships between complex behavioral and psychosocial determinants of disease. The experience and evaluation of stressors is an important determinant of compensatory behaviors, such as emotional eating, which ultimately can have a serious adverse impact on health. Further elucidating the pathways by which trauma can lead to maladaptive health behaviors may help clinicians better tailor interventions and identify individual vulnerabilities.

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