Relationship of Early Life Stress and Psychological Functioning to Adult C-Reactive Protein in the Coronary Artery Risk Development in Young Adults Study

Shelley E. Taylor, Barbara J. Lehman, Catarina I. Kiefe, and Teresa E. Seeman

Background: *Low socioeconomic status (SES) and a harsh family environment in childhood have been linked to mental and physical health disorders in adulthood. The objective of the present investigation was to evaluate a developmental model of pathways that may help explain these links and to relate them to C-reactive protein (CRP) in the Coronary Artery Risk Development in Young Adults (CARDIA) dataset.*

Methods: *Participants (*n *= 3248) in the CARDIA study, age 32 to 47 years, completed measures of childhood SES (CSES), early family environment (risky families [RF]), adult psychosocial functioning (PsyF, a latent factor measured by depression, mastery, and positive and negative social contacts), body mass index (BMI), and C-reactive protein.*

Results: *Structural equation modeling indicated that CSES and RF are associated with C-reactive protein via their association with PsyF (standardized path coefficients: CSES to RF, RF to PsyF, PsyF to CRP, CSES to CRP, all* $p < .05$*), with good overall model fit. The association between PsyF and CRP was partially mediated by BMI (PsyF to BMI, BMI to CRP, both* $p < .05$*).*

Conclusions: *Low childhood SES and a harsh early family environment appear to be related to elevated C-reactive protein in adulthood through pathways involving psychosocial dysfunction and high body mass index.*

Key Words: Stress, family, health, SES, comorbidities, HPA

Striking comorbidities have been observed between psychiatric illness and some chronic disorders such as hypertension, coronary heart disease (CHD), and compromised immunologic functioning (Barth et al 2004; Van Melle et al 2004). Understanding the mechanisms that link these processes is, therefore, an important research priority. C-reactive protein (CRP), a biomarker of inflammatory processes, may play an important role in these relations. C-reactive protein has been reliably related to depression (Suarez 2004; Jousilahti et al 2003; Hemingway et al 2003; Miller et al 2005) and to enhanced risk for cardiovascular disease (King et al 2004), among other disorders.

Our research has developed and tested a model that relates childhood stressors to risk for mental and physical health disorders in adulthood. The model maintains that the effects of early life stress are cumulative, adversely affecting psychosocial resources, as by contributing to low social support and risk for depression, which, in turn, may enhance risks for health disorders in adulthood. Specifically, we link low childhood socioeconomic status (SES) and risky family (RF) environment marked by harsh parenting to the development of negative affect and low social support as predictors of risk factors for mental and physical illness (Repetti et al 2002; Lehman et al 2005; Taylor et al 2004). In the present research, we explore whether this theoretical model explains significant variance in CRP, thereby clarifying both the psychosocial factors that contribute to elevated CRP and elucidating processes that may contribute to the comorbidities between mental and physical health more generally.

The model is presented in Figure 1 (which details both the model itself and the upcoming analyses). The first link in the model is childhood SES. Health-related risks of low SES begin in childhood (Francis et al 2000; Singer and Ryff 2000), and family environment is implicated in these processes (Repetti et al 2002). Substantial research links economic adversity in the family to a poor or deteriorating quality of parenting, including higher levels of family conflict, a harsh restrictive parenting style, and chaotic or neglectful parenting (Dodge et al 1994; Emery and Laumann-Billings 1998; McLoyd 1998). In the model, childhood SES is temporally prior, has been tied to subsequent variables in the model, and is minimally affected by them in return; specifically, in addition to being related to parenting style, low childhood SES has been related to the development of depression (Gallo and Matthews 2003) and to problems in the enlistment and/or use of social support (Repetti et al 2002). Low socioeconomic status is associated with elevated CRP, and this association may contribute to the SES gradient in coronary heart disease and immune-related disorders (Owen et al 2003; Hemingway et al 2003).

The next variable in the model, risky early family environment, is temporally prior to the subsequent variables in the model and has been independently correlated with each of the subsequent steps as well. Early family environments marked by harsh or chaotic parenting are reliably associated with deficits in offspring emotion regulation skills, including both internalizing and externalizing behavior in children (Repetti et al 2002). A harsh early environment has been related to higher levels of depression (Repetti et al 2002); to lower levels of social support (Repetti et al 2002); to preclinical risk factors for illness, including elevated autonomic and cortisol responses to stress (Matthews et al 1996; Taylor et al 2004) and compromised metabolic functioning (Lehman et al 2005); and to major physical health disorders (Felitti et al 1998).

With respect to psychosocial functioning, the next step in the model, depression, has been tied to increased body mass index

From the Departments of Psychology (SET, BJL) and Geriatics (TES), University of California, Los Angeles, California; and Division of Preventive Medicine (CIK), University of Alabama at Birmingham and Birmingham Veterans Affairs Medical Center, Birmingham, Alabama.

Address reprint requests to Shelley E. Taylor, Ph.D., Distinguished Professor, University of California, Los Angeles, Department of Psychology, 1282A Franz Hall, 405 Hilgard Ave, Los Angeles, CA 90095; E-mail: taylors@psych.ucla.edu.

Received August 16, 2005; revised March 3, 2006; accepted March 7, 2006.

0006-3223/06/$32.00
doi:10.1016/j.biopsych.2006.03.016

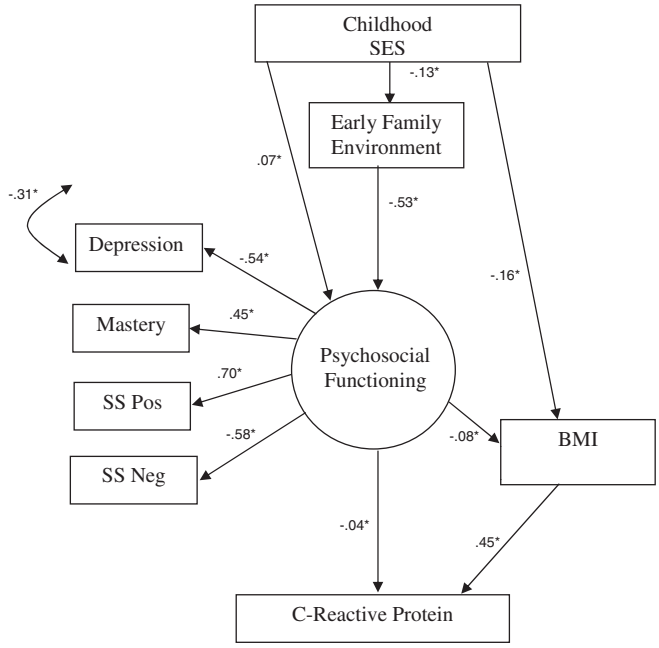

Figure 1. Standardized path coefficients for the entire sample. Solid lines indicate that each pathway is statistically significant. A circle was used to represent the unmeasured (latent) PsyF variable. Consistent with SEM conventions, the arrows are shown as going from the latent construct to boxes indicating measured variables in the model. To aid interpretability, the weights between PsyF and depression and negative social contacts are negative, indicating that higher PsyF values indicate more adaptive psychosocial functioning. PsyF, psychosocial functioning.

(BMI) (Stice et al 2005; Pine et al 2001) and to elevated CRP (Hemingway et al 2003; Ford and Erlinger 2004; Douglas et al 2004). Mastery is related directly to SES and inversely to depression and to adverse health outcomes (Taylor and Seeman 2000). A lack of social support has been tied to elevated CRP (Bouhuys et al 2004), and social support is a predictor of morbidity and all-cause mortality in humans (House et al 1988; Seeman 1996).

The fact that the emotional and social consequences of growing up in a risky family are seen early in life, coupled with the relation of these variables to risk for mental and physical health disorders later in life, makes them potential candidates for mediators of the association between early family environment and health-related risk factors, such as elevations in CRP.

Body mass index has also been related to elevated CRP (Douglas et al 2004), and it is possible that the relations of childhood SES and RF to CRP are mediated entirely or in part via changes in BMI. Studies that examine predictors of CRP frequently control for BMI (Douglas et al 2004; Ford and Erlinger 2004), with one study finding that the relation of depression to elevated CRP was entirely explained by BMI (Douglas et al 2004). Accordingly, BMI was included as a variable in the model.

We tested whether the theoretical model (see Figure 1) would be substantiated, and hypothesized support for each of the proposed pathways by which psychosocial and biological risk factors may influence CRP. In addition, because Coronary Artery Risk Development in Young Adults (CARDIA) is a large sample, relatively evenly balanced between African American and white subjects and between men and women, the research afforded an opportunity to examine whether the model would be supported in each of the four race-sex subgroups.

Methods and Materials

Participants

The research made use of the Year 15 CARDIA dataset (with the exception of childhood SES, which was measured at baseline). Coronary Artery Risk Development in Young Adults is an ongoing epidemiologic study in which African American and white participants from a broad range of SES backgrounds took part in six assessments over 15 years. The CARDIA study tracks predictors of coronary artery disease as young people transition to adulthood. To be enrolled, participants must have identified themselves as either black or white, had a permanent address in one of four urban areas (Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; or Oakland, California), have been without symptoms of long-term disease or disability, and not have been pregnant (see Cutter et al 1991 and Friedman et al 1988 for further detail on the methodology of the CARDIA study). The original assessment was in 1985 to 1986 when participants were 18 to 30 years old. All procedures were approved by University of Alabama at Birmingham Institutional Review Board.

At the time of the most recent assessment (2000 to 2001), participants ranged in age from 32 to 47 years. Of the initial sample of 5115 participants, 3671 were examined at the Year 15 assessment. Participation among the living members of the original sample was 73.5% in Year 15; attrition analyses suggested that those who remained at Year 15 were more likely than the baseline sample to be white, well educated, older, and female. Those included in the final sample for this study had complete data on the eight measures used in the analyses, including a report of childhood socioeconomic status that was obtained during the 1985 to 1986 baseline assessment. The final sample consisted of 3248 participants: 625 African American men; 831 African American women; 846 white men; 946 white women. Participants with CRP values higher than 10 were excluded from all analyses, because extremely high CRP values likely indicate infection at the time of assessment.

Procedure

For the Year 15 CARDIA assessment, participants were asked not to exercise on the day of the examination, to fast for 12 hours, and to refrain from smoking for one half hour prior to the examination. The examination took approximately 3 hours, during which participants completed informed consent and provided blood and urine samples, blood pressure measurements, and anthropomorphic measurements. After being given a small snack, they participated in interviews concerning their health and completed a set of self-administered questionnaires, including the psychosocial and risky family measures used for this study.

Measures

Early Family Environment. The Risky Families questionnaire was adapted from an instrument developed by Felitti et al (1998). Respondents rated aspects of their family environment on 4-point scales from 1 (rarely or none of the time) to 4 (most or all of the time), including whether the individual felt loved and cared for; was shown physical affection; was verbally abused; was physically abused; lived with a substance abuser; lived in a well-organized, well-managed household; and whether family members knew what the child was up to. Because individual items differed in their variability, each item was *z*-scored before a composite measure was formed; Cronbach's alpha was .77.

Higher values represent a riskier family environment; we observed the full range of possible values on this measure.

Psychosocial Functioning. Depression was assessed using the 20-item Center for Epidemiologic Studies Depression Scale (Radloff 1977). Possible values ranged from 0 to 60; we observed values from 0 to 54. Cronbach's alpha was .89. Mastery was measured through the Personal Mastery Scale (Pearlin et al 1981), with response options ranging from 1 to 5. Cronbach's alpha was .79, and observed values ranged from 1.3 to 5. Social contacts were assessed by an 8-item scale adapted from Schuster et al (1990) that included both supportive and unsupportive interactions. Four items comprised the positive social contacts (PSC) subscale (alpha = .83), and four items measured negative social contacts (NSC) (alpha = .72). The subscales were correlated ($r = -.37$, $p < .001$). Response scales for PSC and NSC ranged from 1 to 4, and values along that entire continuum were observed in this sample.

Childhood SES (CSES) was assessed at the baseline 1984 CARDIA assessment by using parental educational attainment as a proxy for CSES. Participants indicated the highest level of education obtained by the participant's parents or primary caregivers. The mean of standardized *z*-scores of the primary male and female caregivers' levels of education ($r = .56$, $p < .001$) was used as a measure of CSES.

Body Mass Index. To measure height, each participant stood against a wall, and a plane was used to form a right angle between the wall and the top of the head. All measurements were rounded to the nearest half centimeter. Weight was rounded to the nearest half pound. Lightweight attire and no shoes were worn during anthropomorphic measurements. To calculate BMI, pounds were converted to kilograms, and BMI was calculated to equal weight (in kilograms) divided by height squared (in meters). Observed BMI values in our sample ranged from 15.73 to 65.61.

C-Reactive Protein. Plasma samples were stored in a citrated vacutainer tube, centrifuged, and transferred to a cryovial for analysis by the University of Vermont. C-reactive protein was measured using the BNII nephelometer from Dade Behring (Deerfield, Illinois) utilizing a particle-enhanced immunonephelometric assay. The assay range was .175 to 1100 mg/L. Expected values for CRP in normal, healthy individuals are ≤3 mg/L. After excluding participants with extremely high CRP ($n = 60$), observed CRP values in the sample ranged from .24 to 9.98. Intra-assay coefficients of variation (CVs) ranged from 2.3% to 4.4%, and interassay CVs ranged from 2.1% to 5.7%.

Results

Table 1 presents summary statistics for our overall sample.

Statistical Analysis: Overview

To test whether the theoretical model shown in Figure 1 explained variability in C-reactive protein in the CARDIA dataset, a series of structural equation models using EQS 6.0 was conducted. The data were first evaluated for multivariate normality. Second, a latent psychosocial functioning factor was created by combining the measures of depression, mastery, and positive and negative social contact. It was tested first on the entire CARDIA sample, and then a multigroup analysis was conducted to test for invariance of the latent factor across the four race-sex subgroups. Third, the latent psychosocial factor was incorporated into a test of the whole model (shown in Figure 1) using the entire CARDIA sample. This model was also compared with an alternative model that gave psychosocial functioning (PsyF) causal priority to examine whether deficits in PsyF influenced the retrospective reporting of childhood family environment, which then influenced BMI and C-reactive protein. Fourth, the model in Figure 1 was tested through a series of multiple groups analyses to determine whether the model fit the data equally well for the four race-sex subgroups in the CARDIA sample.

Table 1. Demographic, Psychosocial, and Physiological Characteristics of Participants

Variables in the RF Model	Mean	SD
Mother's Education (years)	13.15	2.24
Father's Education (years)	13.23	2.57
Early Family Environment	1.66	.58
Depression	8.98	7.80
Mastery	4.11	.61
Positive Social Contacts	3.51	.56
Negative Social Contacts	2.05	.62
Body Mass Index	28.48	6.59
C-Reactive Protein	1.76	1.54
Sample Descriptive Information (in 2000–2001)		
Age	40.1	3.6
Percent with College Degrees	48.2	
Percent Income <$75,000	61.7	

RF, risky family.

Examination of Assumptions

To address skew, BMI and CRP were logarithmically transformed prior to their inclusion in analyses. However, because transformed data were still not normally distributed, multivariate outliers were examined, and robust standard errors were used for indices of model fit (Satorra and Bentler 1994).

We used several indicators of model fit to determine the adequacy of the theoretical models. Models that fit the data had standardized discrepancies close to 0 and root mean-square error of approximation (RMSEA) of .05 or less; those with RMSEA lower than .08 were acceptable. Normed Fit Index (NFI) and Comparative Fit Index (CFI) estimates greater than .90 were indicators of acceptable model fit. The Satorra-Bentler scaled chi-square (Satorra and Bentler 1994) is also reported, although nonsignificance of the scaled chi-square value is an inappropriate criterion of model fit in the present analyses because of the large sample size. Model chi-square, NFI, CFI, and RMSEA are reported for each of the major analyses. When nested models are compared, a chi-square change statistic that accounts for the use of robust indicators is also presented (Satorra and Bentler 2001).

PsyF Confirmatory Factor Analysis

A confirmatory factor analysis was conducted to determine whether depression, mastery, positive and negative social contacts were appropriately modeled as indicators of a single latent factor of psychosocial functioning. An exploratory factor analysis, conducted for the entire sample as well as separately for each of the race/sex subgroups, indicated that a single factor was appropriate. The path to depression was fixed to 1, and depression and mastery were allowed to covary.[1] This model fit the data

[1]When conducting this analysis and those that follow, it was necessary to reverse code the negative psychosocial indicators (depression and negative social contacts). However, for ease of interpretation, all associations are shown in their original form. Consistent with SEM conventions, the arrows are shown going from the latent construct to its observed indicators.

Table 2. Correlation Matrix (Below Diagonal) for Entire Sample and Discrepancies for Final Model (Above Diagonal)

	1.	2.	3.	4.	5.	6.	7.	8.
1. Childhood SES	—	.00	.03	−.03	.00	−.01	.00	−.04
2. Early Family Environment	−.13[b]	—	.05	.04	−.04	.00	−.03	−.03
3. Depression	−.11[b]	.27[b]	—	.00	−.00	.04	−.01	−.03
4. Mastery	.03	−.21[b]	−.50[b]	—	−.00	.04	.03	.01
5. Positive Social Contacts	.10[b]	−.41[b]	−.41[b]	.31[b]	—	−.03	−.00	.01
6. Negative Social Contacts	−.07[b]	.31[b]	.37[b]	−.30[b]	−.37[b]	—	−.02	−.02
7. Body Mass Index	−.17[b]	.04[a]	.07[b]	−.02	−.08[b]	.09[b]	—	.00
8. C-Reactive Protein	−.12[b]	.02	.08[b]	−.03	−.05[b]	.07[a]	.46[b]	—

Zero-order correlation coefficients for all variables used in the analysis are shown below the diagonal. Standardized residuals computed for the final model are presented above the diagonal; lower residuals indicate better model fit. $N = 3248$.

SES, socioeconomic status.

[a] $p < .05$.

[b] $p < .001$.

[Satorra-Bentler χ^2 (1) = .10, $p > .10$; NFI = 1.00; CFI = 1.00; RMSEA = .00], and each indicator made a statistically significant contribution to the latent factor.

Next, a multiple groups SEM was conducted to determine whether the factor loadings were invariant across the four race-sex subgroups in the CARDIA sample. If factor loadings across the subgroups are equivalent, then it is appropriate for the entire model to be tested using the entire sample. An initial multiple groups analysis confirmed that the latent model fit after the grouped data structure was considered [Satorra-Bentler χ^2 (4) = .67, $p > .10$; NFI = 1.00; CFI = 1.00; RMSEA = .00]. Likewise, the model continued to fit the data when constraints of factor loading equality were introduced [Satorra-Bentler χ^2 (13) = 10.27, $p > .10$; NFI = .99; CFI = 1.00; RMSEA = .00]. Lagrange multiplier tests indicated that factor loadings were consistent across the subgroups.

Test of the RF Model

The correlation matrix of variables in the model is shown below the diagonal of Table 2. Model fit statistics for the model shown in Figure 1 indicated a good fit with the data [Satorra-Bentler χ^2 (16) = 87.69, $p > .05$; NFI = .97; CFI = .98; RMSEA = .037] and required no post hoc modification to fit the data. (Note that the individual PsyF measures (e.g., depression) are to be interpreted as indicators of the latent (unmeasured) PsyF construct). Neither Lagrange multiplier tests nor standardized residuals suggested that conceptually important links were missing from the model. Standardized discrepancies for the final model are shown above the diagonal in Table 2, and summary statistics for model fit are shown in Table 3.

As shown in Figure 1, all of the links proposed in the risky families model were supported. As predicted, children from lower SES families were more likely to report growing up in a household characterized by harsh parenting. A risky early family environment was, in turn, associated with less adaptive psychosocial functioning. Psychosocial functioning, as indicated by depression, mastery, and low positive/high negative social contacts, predicted higher body mass index and increased levels of C-reactive protein. Childhood SES also predicted BMI, which was closely linked to C-reactive protein.

An alternative model addressed the possibility that a negative response bias (as embodied in the PsyF variable) might predict the reconstruction of RF. Accordingly, we repeated the SEM analysis but gave PsyF causal priority over RF. The fit of the alternative model was significantly poorer [χ^2 (2) = 30.91, $p < .001$], and fit indices indicated that the alternative model was not as successful at explaining the data.

Multiple Groups Analyses of the RF Model

Several steps were used to determine whether the RF model differed significantly among the four race-sex subgroups. An initial analysis tested whether the model fit the data when the grouped structure was considered. This model did fit the data. Second, factor loadings were constrained to be equal across the four groups. This model was also supported. Third, all model paths were constrained to be equal. Lagrange multiplier tests indicated that the theorized model paths did not differ significantly among the four subgroups. However, these tests did

Table 3. Fit Indices and Unstandardized Path Coefficients (with Robust Standard Errors) for Model Paths, Latent Factor, and Covariances

	Coefficient	Robust Standard Error
Fit Indices		
Chi-square (16 *df*)	92.79	
Satorra-Bentler Chi-square (16 *df*)	87.69	
NFI (robust)	.97	
CFI (robust)	.98	
RMSEA (robust)	.037	
Path Model[a]		
Childhood SES → Early Family Environment	−.092	.012
Early Family Environment → Psychosocial Functioning	−.384	.022
Childhood SES → Psychosocial Functioning	.033	.010
Childhood SES → BMI	−.036	.004
Psychosocial Functioning → BMI	−.039	.011
Psychosocial Functioning → CRP	−.026	.012
BMI → CRP	.614	.021
Psychosocial Functioning Latent Factor[b] →		
Mastery	.588	.030
Positive Social Contacts	.834	.043
Negative Social Contacts	.761	.040
Covariance Between Depression and Mastery	.124	.010

$N = 3248$.

NFI, normed fit index; CFI, comparative fit index; RMSEA, root mean-square error of approximation; SES, socioeconomic status; BMI, body mass index; CRP, C-reactive protein; PsyF, psychosocial functioning.

[a] The error variance of each measured variable was fixed to 1.

[b] The path from PsyF to depression (not shown) was fixed to 1. All error and disturbance variances were statistically significant.

indicate that links from PsyF to BMI [χ^2 (1) = 5.72, $p < .02$], and from CSES to BMI [χ^2 (1) = 10.67, $p < .01$] differed among the four subgroups. Specifically, the link from CSES to BMI was significantly less important for African American men and women than for white men and women, whereas the path between PsyF and BMI was less important for the male subgroups than for the two female subgroups. Because of these differences, a final multigroup model allowed the CSES to BMI and the PsyF to BMI paths to vary freely. This model was a good fit with the data [Satorra-Bentler χ^2 (79) = 142.48, $p < .05$; NFI = .96; CFI = .98; RMSEA = .016] and was a significant improvement over the previous model [χ^2 (6) = 25.01, $p < .01$].

Discussion

We proposed a theoretical developmental model to address the robust relations between a harsh early environment in childhood and mental and physical health outcomes in adulthood (Repetti et al 2002). We hypothesized that one underlying mechanism may be elevated C-reactive protein, which has been tied to both depression and to physical health outcomes. To test the model, we related childhood SES and risky family background to elevations in C-reactive protein via psychosocial functioning and body mass index. The model was supported and accounted for 21% of the variance in CRP. The model was largely supported for all four subgroups of white and African American men and women as well. The significance of the findings lies in the ability of the model to explain how developmentally early psychosocial processes may predict a significant biological risk factor later in life. The results not only clarify how childhood SES and family background may contribute to elevations in C-reactive protein but also clarify how psychosocial factors, including depressive symptomatology, mastery, and social support, influence these pathways.

Low childhood SES affected early family environment directly and adversely. A risky family environment, as predicted, was strongly related to indicators of psychosocial functioning, including depression, mastery (negatively), and social support (negatively), consistent with previous evidence (Taylor et al 2004; Lehman et al 2005). The pathway from body mass index to C-reactive protein was very strong, whereas the pathways from psychosocial functioning to CRP, both directly and indirectly through BMI, were less strong. Nonetheless, the evidence is consistent with the prediction that psychosocial variables, including family environment and psychological and social functioning, play a role in developing risk factors prognostic for illness, specifically BMI and C-reactive protein.[2] Of note, these results are also consistent with the conclusions of Miller et al (2003) that depressive symptoms promote weight accumulation (as opposed to a model which maintains that inflammatory molecules arising from expanded adipose tissue promote depressive symptoms).

The results are also generally consistent with models that emphasize the cumulative significance of stress exposure on mental and physical health outcomes across the life span (McEwen 1998). As previous research has noted (Allen et al 1997), processes underlying chronic illness can begin in early childhood, and the present results suggest that both low SES in childhood and a stressful early family environment can contribute to these accumulating risks.

[2]Childhood SES affected the propensity to develop obesity (BMI) directly, at least among white subjects. Consistent with previous work (Lehman et al 2005), we found that childhood SES had a negligible role in predicting BMI among African American subjects. Also consistent with that work, psychosocial functioning predicted BMI only for women.

Limitations

There are several limitations to the present findings. The model does not include variability in CRP that is due to genetic factors or unmeasured health behaviors. Genetic factors are estimated to account for 13% to 30% of the intraindividual variability in CRP (Pankow et al 2001). Second is the fact that, with the exception of childhood SES, the data are largely cross-sectional, not longitudinal. Consequently, we have inferred causal paths from correlational data. Experimental tests of these hypotheses are not feasible except with animals, and even within the constraints of structural equation modeling, inferring causality from correlational evidence has attendant risks. Third, reconstructions of family environments may include an emotional overlay, contributing to response bias that may influence relations among model variables. However, the instrument on which our assessment of family environment is based (Felitti et al 1998) has demonstrated a dose-response relationship to a broad array of hard health outcomes (e.g., cancer, CHD), and a response bias is highly unlikely to yield such effects. Nonetheless, to further assess this possibility, we evaluated the fit of an alternative model that gave psychosocial functioning priority to see if it explained the reconstruction of childhood events. This model was a weak fit to the data. We note that this alternative model has been ruled out in other tests of the risky families model as well (Taylor et al 2004; Lehman et al 2005).

Alterations in sample composition due to attrition is also a limitation, resulting in an underrepresentation of African American men in the sample. Nonetheless, the model was largely supported in all race-sex subgroups.

Finally, it should be noted that C-reactive protein is only one marker of inflammation and its relation to disease is still incompletely understood. Nonetheless, it is regarded as the most clinically useful inflammatory marker tied to cardiovascular risk (King et al 2004), and its relation to depression makes it an excellent candidate for exploring comorbidities between mental and physical disorders.

Clinical implications of these findings should be drawn with caution, as CRP is a single risk factor for mental and physical health disorders. Nonetheless, the results point to the importance of intervening early with troubled families, especially with respect to the psychosocial sequelae that may result from problematic family dynamics. Early interventions aimed at poor psychosocial functioning (Rozanski and Kubzansky 2005) and at weight control would appear to be especially promising. Targeting depressive symptomatology early may help to avoid the cascade of mental and physical health risks that follow.

Conclusions

This study suggests that low SES and a harsh family environment in childhood may be related to inflammatory processes in adulthood via psychosocial functioning (depression, mastery, social support) and body mass index. The results underscore the potential role of childhood SES and early family environment in a trajectory of emotional distress, poor social functioning, obesity, and inflammatory processes in later years. As such, the results have implications for understanding the development of psychological distress, for understanding comorbidities involving mental and physical illness, and for understanding SES-related gradients in mental and physical health disorders. In addition,

the results suggest the potential value of intervening with troubled families to enhance the likelihood of improving offspring long-term mental and physical health.

Work on this manuscript was supported by contracts University of Alabama at Birmingham, Coordinating Center, N01-HC-95095; University of Alabama at Birmingham, Field Center, N01-HC-48047; University of Minnesota, Field Center, N01-HC-48048; Northwestern University, Field Center, N01-HC-48049; Kaiser Foundation Research Institute, N01-HC-48050; University of California, Irvine, Echocardiography Reading Center, N01-HC-45134; and Harbor-UCLA Research Education Institute, Computed Tomography Reading Center, N01-HC-05187 from the National Heart, Lung and Blood Institute, through a grant from the MacArthur Research Network on SES and Health, and by Grant R01-MH56880-05. The second author was supported by National Institute of Mental Health (NIMH) Training Grant MH15750.

We are grateful to the MacArthur Network on SES and Health for the inclusion of the Early Family Environment measure in the Year 15 CARDIA assessment; to Karen Matthews for her comments on an earlier draft; and to Margaret Samotyj for help in preparing this manuscript.

Allen MT, Matthews KA, Sherman FS (1997): Cardiovascular reactivity to stress and left ventricular mass in youth. *Hypertension* 30:782–787.

Barth J, Schumacher M, Herrmann-Lingen M (2004): Depression as a risk factor for mortality in patients with coronary heart disease: A meta-analysis. *Psychosom Med* 66:802–813.

Bouhuys AL, Flentge F, Oldehinkel AJ, van den Berg MD (2004): Potential psychosocial mechanisms linking depression to immune function in elderly subjects. *Psychiatry Res* 127:237–245.

Cutter GR, Burke GL, Dyer AL, Friedman MD, Hilner JE, Hughes GH, et al (1991): Cardiovascular risk factors in young adults. The CARDIA baseline monograph. *Control Clin Trials* 12:1–77.

Dodge KA, Pettit GS, Bates JE (1994): Socialization mediators of the relation between socioeconomic status and child conduct problems. *Child Dev* 65:649–665.

Douglas KM, Taylor AJ, O'Malley PG (2004): Relationship between depression and C-reactive protein in a screening population. *Psychosom Med* 66:679–683.

Emery RE, Laumann-Billings L (1998): An overview of the nature, causes, and consequences of abusive family relationships. *Am Psychol* 53:121–135.

Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Apitz AM, Edwards V, et al (1998): Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. *Am J Prev Med* 14:245–258.

Ford DE, Erlinger T (2004): Depression and C-reactive protein in US adults: Data from the third national health and nutrition examination survey. *Arch Intern Med* 164:1010–1014.

Francis D, Champagne F, Liu D, Meaney M (2000): Maternal care, gene expression, and the development of individual differences. In: Adler N, Marmot M, McEwen B, editors. *Socioeconomic Status and Health in Industrial Nations: Social, Psychological, and Biological Pathways*. New York: New York Academy of Sciences.

Friedman GD, Cutter GR, Donahue RP, Hughes GH, Hulley SB, Jacobs DR, et al (1988): Cardia: Study design, recruitment, and some characteristics of examined subjects. *J Clin Epidemiol* 41:1105–1116.

Gallo LC, Matthews KA (2003): Understanding the association between socioeconomic status and physical health: Do negative emotions play a role? *Psychol Bull* 129:10–51.

Hemingway H, Shipley M, Mullen MJ, Kumari M, Brunner E, Taylor M, et al (2003): Social and psychosocial influences on inflammatory markers and vascular function in civil servants (The Whitehall II Study). *Am J Cardiol* 92:984–987.

House JS, Landis KR, Umberson D (1988): Social relationships and health. *Science* 241:540–545.

Jousilahti P, Salomaa V, Rasi V, Vahtera E, Palosuo T (2003): Association of markers of systemic inflammation, C-reactive protein, serum amyloid A, and bibrinogen, with socioeconomic status. *J Epidemiol Community Health* 57:730–733.

King DE, Mainous AG, Taylor ML (2004): Clinical use of C-reactive protein for cardiovascular disease. *South Med J* 97:985–988.

Lehman BJ, Taylor SE, Kiefe CI, Seeman TE (2005): Relation of childhood socioeconomic status and family environment to adult metabolic functioning in the CARDIA study. *Psychosom Med* 67:846–854.

Matthews KA, Woodall KL, Kenyon K, Jacob T (1996): Negative family environment as a predictor of boys' future status on measures of hostile attitudes, interview behavior, and anger expression. *Health Psychol* 15: 30–37.

McEwen BS (1998): Protective and damaging effects of stress mediators. *N Engl J Med* 338:171–179.

McLoyd VC (1998): Socioeconomic disadvantage and child development. *Am Psychol* 53:185–204.

Miller G, Freedland K, Carney R (2005): Depressive symptoms and the regulation of proinflammatory cytokine expression in patients with coronary heart disease. *J Psychosom Res* 59:231–236.

Miller G, Freedland K, Carney R, Stetler C, Banks W (2003): Pathways linking depression, adiposity, and inflammatory in healthy adults. *Brain Behav Immun* 17:276–285.

Owen N, Poulton T, Hay FC, Mohamed-Ali V, Steptoe A (2003): Socioeconomic status, C-reactive protein, immune factors, and responses to acute mental stress. *Brain Behav Immun* 17:286–295.

Pankow JS, Folsom AR, Cushman M, Borecki IB, Hopkins PN, Eckfeldt JH, et al (2001): Familial and genetic determinants of systematic markers of inflammation: The NHLBI family heart study. *Atherosclerosis* 154:681–689.

Pearlin LI, Lieberman MA, Menaghan EG, Mullan JT (1981): The stress process. *J Health Soc Behav* 22:337–356.

Pine DS, Goldstein RB, Wolk S, Weissman NM (2001): The association between childhood depression and adulthood body mass index. *Pediatrics* 107:1049–1056.

Radloff LS (1977): The CES-D Scale: A self-report depression scale for research in the general population. *Appl Psychol Meas* 1:105–117.

Repetti RL, Taylor SE, Seeman TE (2002): Risky families: Family social environments and the mental and physical health of offspring. *Psychol Bull* 128:330–366.

Rozanski A, Kubzansky L (2005): Psychologic functioning and physical health: A paradigm of flexibility. *Psychosom Med* 67:547–553.

Satorra A, Bentler PM (1994): Corrections to test statistics and standard errors in covariance structure analysis. In: von Eye A, Clogg CC, editors. *Latent Variables Analysis: Applications for Developmental Research*. Thousand Oaks, CA: Sage, 399–419.

Satorra A, Bentler PM (2001): A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika* 66:507–514.

Schuster TL, Kessler RC, Aseltine RH (1990): Supportive interactions, negative interactions and depressed mood. *Am J Community Psychol* 18:423–438.

Seeman TE (1996): Social ties and health. *Ann Epidemiol* 6:442–451.

Singer B, Ryff C (2000): Hierarchies of life histories and associated health risks. In: Adler N, Marmot M, McEwen B, editors. *Socioeconomic Status and Health in Industrial Nations: Social, Psychological, and Biological Pathways*. New York: New York Academy of Sciences.

Stice E, Presnell K, Shaw H, Rohde P (2005): Psychological and behavioral risk factors for obesity onset in adolescent girls: A prospective study. *J Consult Clin Psychol* 73:195–202.

Suarez EC (2004): C-reactive protein is associated with psychological risk factors of cardiovascular disease in apparently healthy adults. *Psychosom Med* 66:684–691.

Taylor SE, Lerner JS, Sage RM, Lehman BJ, Seeman TE (2004): Early environment, emotions, responses to stress, and health. *J Pers* 72:1365–1393.

Taylor SE, Seeman TE (2000): Psychosocial resources and the SES-health relationship. In: Adler N, Marmot M, McEwen B, Stewart J, editors. *Socioeconomic Status and Health in Industrial Nations: Social, Psychological, and Biological Pathways*. New York: New York Academy of Sciences, 210–225.

Van Melle J, De Jonge P, Spijkerman T, Tijssen J, Ormel J, Van Veldhuisen DJ, et al (2004): Prognostic association of depression following myocardial infarction with mortality and cardiovascular events: A meta-analysis. *Psychosom Med* 66:814–822.