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C-Reactive Protein Levels Among U.S. Adults Exposed to Parental Incarceration

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Abstract

Previous studies have linked childhood adversity to low-grade inflammation via C-reactive protein (CRP) levels. This study analyzed the association between low-grade inflammation and prior biological parental incarceration. Data from the National Longitudinal Study of Adolescent to Adult Health (1994–2008) were analyzed using multinomial logistic regression models. Measures included high-sensitivity (hs)-CRP (<3 mg/L = reference, 3–10 mg/L = low-grade inflammation, and >10 mg/L = acute inflammation), parent incarceration occurring in the child's lifetime, and frequency and timing of incarceration with respect to child's age (0–18 years or >18 years vs. never) of incarceration. Analyses were stratified by child's gender. Final sample sizes were *n* = 5,396 males and *n* = 6,447 females for maternal incarceration and *n* = 4,956 males and *n* = 5,860 females for paternal incarceration. In models with and without potential mediators, females whose fathers were ever incarcerated were more likely to have hs-CRP levels of 3–10 mg/L than females whose fathers were never incarcerated (adjusted odds ratio [AOR]: 1.44, 95% confidence interval [CI]: [1.09, 1.91]). Additionally, daughter's age (<18 years; AOR: 1.48, 95% CI: [1.11, 1.97]) and frequency of father's incarceration were significant (AOR: 1.24, 95% CI: [1.04, 1.49]). No mediating effects were observed. Males whose fathers were incarcerated when they were ≥ 18 years were less likely to have hs-CRP levels of 3–10 mg/L than those whose father was never incarcerated; the association was nonsignificant in the mediated model. Further investigation is needed on the physiological effects of exposure to parental incarceration and interventions to support children.

Keywords

parental incarceration; C-reactive protein; childhood adversity; inflammation

The vast size of the U.S. prison system, currently the largest of all industrialized countries (Walmsley, 2013), has prompted researchers to investigate the negative effects of parental

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incarceration on child and adolescent health and well-being. In 2007, the Bureau of Justice Statistics estimated that approximately 1.7 million, or 1 of 43, children under the age of 18 years had a parent incarcerated in either a state or federal prison—a rate they reported as having been fairly stable since 1997 (Maruschak, Glaze, & Mumola, 2010). Lee, Fang, and Luo (2013), studying a national sample of young adults aged 24–34 years, found that 12.5% of the respondents reported having had a parent in jail or prison in their lifetime. However, because reliable statistics that estimate the total number of children whose parents are under any correctional oversight, including parole, probation, jail, or prison, are currently unavailable, the prevalence of children and adolescents exposed to the various levels of the correctional system is most likely underestimated.

Research has uncovered a number of deleterious physical and psychosocial outcomes among children exposed to parental incarceration, findings that are consistent with extant studies linking other adverse childhood experiences (e.g., parental separation, low socioeconomic status, or child maltreatment) to later adulthood health outcomes (Shonkoff et al., 2012). Researchers hypothesize that childhood adversity contributes to poor health across the life course as a consequence of the associated chronic stress and subsequent dysregulation of physiological processes (Miller, Chen, & Parker, 2011). In addition, engagement in maladaptive coping behaviors (e.g., substance use) in response to the stress can further impair physiological processes and subsequent health outcomes as well as potentially increase exposure to other adverse events.

Extant research has linked exposure to parental incarceration to an increased likelihood of economic (Geller, Garfinkel, & Western, 2011), educational (Cho, 2011; Hagan & Foster, 2012), and behavioral difficulties (Foster & Hagan, 2013; Geller, Cooper, Garfinkel, Schwartz-Soicher, & Mincy, 2012; Wakefield & Wildeman, 2011) and to numerous physical (Lee, Fang, & Luo, 2013; Roettger & Boardman, 2012), and mental health conditions (Foster & Hagan, 2013; Lee et al., 2013; Murray & Farrington, 2005; Wildeman, 2009). Furthermore, the timing of parental incarceration with respect to the child's age, repeated parental incarceration, and the gender of the incarcerated parent and the child have also been found to affect outcomes. For example, Foster and Hagan (2013) found that maternal incarceration experienced between 0 and 18 years of age and repeated episodes of incarceration increased the risk of adult depression, whereas paternal incarceration experienced between 0 and 18 years of age and repeated episodes of incarceration increased the likelihood of adult substance use. These findings are consistent with life-course theories on human development, specifically, the role of accumulative stress across the life span and during vulnerable or sensitive periods and its effects on health and development (Elder, Johnson, & Crosnoe, 2003; Shonkoff et al., 2012).

To date, few studies have examined the effects of parental incarceration on more distal physical health outcomes that could be shaped by the negative mental health, behavioral, and social consequences of parental incarceration. However, one recent study using data from the National Longitudinal Survey of Adolescent Health (Add Health) supports this line of inquiry, as findings showed that adults (aged 24–32) who reported that their biological father had been incarcerated in the past were more likely than those whose father had never been incarcerated to have received a prior diagnosis of migraines, asthma, or high

cholesterol (a biomarker predictive of heart disease; Lee et al., 2013). The study revealed no significant effect of maternal incarceration on children's physical health. In addition, neither paternal nor maternal incarceration was found to be significantly associated with a prior diagnosis of cancer or chronic health conditions, such as heart disease or diabetes. However, the participants' ages (24–32 years) may have accounted for the null findings, as chronic physical health conditions are more likely to occur and be diagnosed in middle and late adulthood (Schiller, Lucas, Ward, & Peregoy, 2012). Thus, investigations on the effects of parental incarceration on adult chronic diseases may need to focus on early biomarkers known to be precursors of disease, particularly when the sample consists of children, adolescents, or young adults.

This study builds on the aforementioned research through the examination of the effects of biological parental incarceration on low-grade inflammation measured via high sensitivity C-reactive protein (hs-CRP). Because depression, obesity, substance use, and social conditions such as poverty and low educational attainment have been linked to parental incarceration and to CRP, we explore these measures as potential mediators. CRP is an acute-phase protein in the systemic inflammatory process and is associated with type 2 diabetes (Cox et al., 2012), cardiovascular disease (Buckley, Fu, Freeman, Rogers, & Helfand, 2009), and some cancers (Allin & Nordestgaard, 2011). CRP is mainly induced by certain cytokines (such as interleukin-1, interleukin-6, and tumor necrosis factor-α) activated by the stress response (Black, 2002). The failure of the hypothalamic–pituitary–adrenal (HPA) axis to regulate the production of local proinflammatory cytokines and the inflammatory response then contributes to the risk for clinical disease (Cohen et al., 2012). Elevated CRP levels have been found in adults who experienced childhood adversity, such as parental separation (Lacey, Kumari, & McMunn, 2013), child maltreatment (Coelho, Viola, Walss-Bass, Brietzke, & Grassi-Oliveira, 2014; Slopen et al., 2010), and low socioeconomic status (Miller et al., 2009; Taylor, Lehman, Kiefe, & Seeman, 2006). However, researchers have yet to examine linkages between parental incarceration and CRP.

Method

Study Design and Sample

For this study, we analyzed secondary data from the National Longitudinal Study of Adolescent to Adult Health (Add Health). Add Health is a school-based longitudinal study in which researchers employed a multistage, stratified, and clustered sampling design at the first wave of data collection to ensure a nationally representative sample of U.S. schools (Harris et al., 2009). To date, four waves of data have been collected. The first wave of data was collected in 1994–1995 when the participants were in the 7th–12th grades, with subsequent data collections in 1996 (Wave 2), 2001–2002 (Wave 3), and 2007–2008 (Wave 4). The overall unweighted response rate for all four waves was 80.3%; bias due to non-response was reported to be negligible, and participants in Wave 4 are representative of those in Wave 1 (Brownstein et al., 2010).

We drew the sample for this study from Waves 1 and 4. The sampling frame was comprised of those participants who had data on biological parental incarceration and hs-CRP. Due to a greater proportion of participants not knowing information about their biological father

(6.8%, or *n* = 1,012) compared to their mother (1.8%, or 263), we conducted analyses assessing the effects of father incarceration and the effects of mother incarceration separately to utilize the available sample size. This strategy is consistent with previous research examining parental incarceration using the Add Health data (Foster & Hagan, 2013). Sensitivity analyses found that those missing information on a parent had CRP levels consistent with those who never had a parent incarcerated (results available upon request). We focused on biological parents in this study, as sample sizes for other primary caregiver categories who were incarcerated were small and limited the study's power. We stratified the sample by gender for analysis to control for pregnancy and hormonal contraceptive use among female participants as both can increase hs-CRP levels (Pitiphat et al., 2005). Participants missing data on measures of interest were listwise deleted (missing data for biological mother analyses: male *n* = 466, or 8.0%, and female *n* = 489, or 7.1%; missing data for biological father analyses: male *n* = 414, or 7.7%, and female *n* = 416, or 6.6%). The final sample sizes for biological mother analyses were male *n* = 5,396 and female *n* = 6,447 and for biological father analyses were male *n* = 4,956 and female *n* = 5,860.

Measures

Dependent variable: hs-CRP—Add Health-trained field interviewers collected capillary whole blood samples via finger stick on the day of the Wave 4 in-home interview. The blood was applied to filter paper, dried, and mailed with a desiccant to the Department of Laboratory Medicine at the University of Washington for assay analysis (Whitsel et al., 2012). Sandwich enzyme-linked immunosorbent assay methodology was employed to measure the level of hs-CRP from the dried capillary blood spot, consistent with prior research (McDade, Burhop, & Dohnal, 2004; Whitsel et al., 2012). The sensitivity of the CRP assay was 0.035 mg/L, the within-assay coefficient was 8.1%, and the between-assay coefficient of variation was 11.0% (Whitsel et al., 2012). Comparison of hs-CRP values from the dried blood spot and plasma was conducted in a sample of 87 participants; linear correlations were high with a Pearson's *R* = .98 (Whitsel et al., 2012). Based on our interest in the effects of parental incarceration on low-grade inflammation, we categorized the continuous hs-CRP levels into the following risk-based cut points, consistent with previous clinical health research (Pearson et al., 2003): <3 mg/L (low-to-average risk, reference), 3–10 mg/L (high-risk, low-grade inflammation marker), and >10 mg/L (high risk, but generally indicative of an acute inflammatory process).

Primary independent variables of interest: Biological maternal and paternal incarceration—Lifetime, frequency, and timing—Add Health collected identical questions related to maternal and paternal incarceration for the first time at Wave 4. The questions retrospectively assessed lifetime incarceration, frequency of incarceration, and timing of parent's first incarceration with respect to child's age. Specifically, participants were asked, “Has/did your biological mother (father) ever spent/spend time in jail or prison?” From this question, we created separate lifetime incarceration measures: mother ever incarcerated (*yes* = 1) and father ever incarcerated (*yes* = 1). The timing of mother's (father's) first incarceration with respect to the child's age was assessed via the question, “How old were you when your biological mother (father) went to jail or prison (the first time)?” Consistent with previous research examining adverse childhood experience, we

categorized child's age at mother (father) first incarceration as “0–17 years,” “18 years and older,” and the reference category of “never incarcerated.” In addition, Add Health assessed the frequency of incarceration with the question, “How many times has/did your biological mother (father) spent/spend time in jail or prison?” Because the data were right skewed, we created the following ordinal measures: 0 = *mother* (*father*) *never in jail*, *1 time*, or *2 or more times*.

Potential mediators—We included several measures that could be potential mediators of the relationship between parental incarceration and hs-CRP in the analyses. The measures were derived from the Wave 4 in-home survey and included currently married, economic hardship (received public assistance, welfare payments, or food stamps between Waves 3 and 4), level of education (bachelor's degree or higher), daily smoker, physically active, alcohol abuse (number of DSM4 alcohol abuse symptoms 0–4), depression symptoms (number of DSM4 Center for Epidemiologic Studies Depression Scale symptoms 0–15), body mass index (BMI = weight [kg]/height [m^2] with BMI categories as under-to-normal weight [16.5 to <25], over-weight [25 to <30], and obese [30 and higher]), and waist circumference.

Control variables—We included sociodemographic and health-related factors in the model as control variables. Although some of the measures could be potential mediators (e.g., abuse history), temporality was difficult to ascertain due to the wording of the questions. Because the inclusion of these measures as either controls or potential mediators did not change the size or the significance of the associations, they are included in the analyses as controls. Measures were self-reported and created using items from the Wave 1 participant in-home interview, Wave 1 parent questionnaire, and the Wave 4 participant in-home interview. Wave 1 measures included race–ethnicity (Black/African American, Hispanic, Asian/Pacific Islander, multiracial, “other,” or White), foreign birth, lived in household with both biological parents, parental economic hardship (received food stamps, housing assistance, or Aid to Families with Dependent Children in the past year), and parental level of education (college degree or more). In addition, we included a sibling measure to account for those who had a sibling who also participated in the Add Health study (approximately 10% of the sample was composed of sibling pairs). Wave 4 measures of participant-related factors included experienced emotional, sexual, or physical abuse from an adult caregiver prior to age 18 years; mother died (yes vs. don't know/no; maternal analyses only); father died (yes vs. don't know/no; paternal analyses only); ever in prison or jail; count of current subclinical symptoms (e.g., fever, range 0–3); count of current inflammatory/infectious diseases (e.g., rheumatoid arthritis, range 0–3), any anti-inflammatory medication use in prior 4 weeks (e.g., nonsteroidal anti-inflammatory drugs/salicylate, Cox-2 inhibitor, oral or inhaled glucocorticoid); current pregnancy (females only); and hormonal contraceptive use in past year (females only).

Analysis

We conducted descriptive analyses to better understand the characteristics of the samples. Bivariate multinomial logistic regression analyses were conducted on all measures with the outcome variable. With respect to the multivariate analyses, multinomial logistic regression

analyses were conducted with the male and female samples to examine the relationships between biological mother (ever, frequency, and child's age of first incarceration) and hs-CRP and between biological father incarceration (ever, frequency, and child's age of first incarceration) and hs-CRP. Two models for each outcome were examined with the first including parental incarceration and the control measures and the second including the potential mediators along with the parental incarceration and control measures. All analyses were weighted and adjusted for the complex survey design using SAS survey procedures, version 9.2 (SAS Institute, Cary, NC). Multicollinearity was assessed prior to multivariable analyses; tolerance and variance inflation factors were within normal limits.

Results

Descriptive Statistics

Table 1 presents the characteristics of the male and female samples for the biological mother incarceration analyses, including bivariate associations between the independent variables and hs-CRP. Among the male sample, approximately 24% had hs-CRP levels between 3 and 10 mg/L, suggestive of low-grade inflammation. A total of 3% of the male respondents reported that their biological mother had been incarcerated in jail or prison in their lifetime, with 2% reporting that the incarceration took place when they were under 18 years of age. The average ordinal number of times their mother was incarcerated was 0.04 (range 0–2). With respect to the female sample, nearly 32% had hs-CRP levels between 3 and 10 mg/L. In addition, 3% of the female respondents reported that their biological mother had been incarcerated in jail or prison in their lifetime, with 2% reporting that the incarceration took place when they were under 18 years of age. The average ordinal number of times their mother was incarcerated was 0.04 (range 0–2).

Table 2 presents the characteristics of the male and female samples for the biological father incarceration analyses, including bivariate associations between the independent variables and hs-CRP. Among the male sample, approximately 23% had hs-CRP levels between 3 and 10 mg/L, a marker for low-grade inflammation. A total of 12% of the male respondents reported that their biological father had been incarcerated in jail or prison in their lifetime, with 9.7% reporting that the incarceration took place when they were under 18 years of age. The average ordinal number of times their father was incarcerated was 0.17 (range 0–2). With respect to the female sample, nearly 32% had hs-CRP levels between 3 and 10 mg/L. In addition, 11% of the female respondents reported that their biological father had been incarcerated in jail or prison in their lifetime, with 9.7% reporting that the incarceration took place when they were under 18 years of age. The average ordinal number of times their father was incarcerated was 0.16 (range 0–2).

Multivariable Logistic Regression Results

Table 3 presents the findings from the multivariable logistic regression models regarding the associations between maternal and paternal incarceration and hs-CRP for the female sample. We found no significant associations in models with or without the potential mediators for females with respect to biological mother ever incarcerated, child's age of biological mother's incarceration or number of times biological mother was incarcerated, and hs-CRP

levels. However, we found significant associations for females who had biological father incarcerated in Model 1, and the size of the effect and significance level increased slightly when the Wave 4 potential mediators were included in the analyses. Specifically, in Model 2, females whose biological father was ever incarcerated were more likely to have an hs-CRP level between 3 and 10 mg/L versus <3 mg/L than females whose biological father was never incarcerated (adjusted odds ratio [AOR] = 1.44, 95% confidence interval [CI] = [1.09, 1.91]). In addition, child's age at father incarceration was significant, such that females whose biological father was incarcerated when they were *less than 18 years of age* were more likely to have an hs-CRP level between 3 and 10 mg/L versus <3 mg/L than those females whose biological father was never incarcerated (AOR = 1.48, 95% CI: [1.11, 1.97]). Frequency of incarceration was significant, as hs-CRP levels were more likely to be between 3 and 10 mg/L versus <3 mg/L and the number of times the biological father was incarcerated increased (AOR = 1.24, 95% CI: [1.04, 1.49]).

Table 4 presents the findings of the associations between maternal and paternal incarceration and hs-CRP for the male sample. We found no significant associations for males with respect to biological mother ever incarcerated, child's age at biological mother's incarceration, or number of times biological mother was incarcerated and hs-CRP levels. In addition, we found no significant associations among males with respect to biological father ever incarcerated or number of times biological father was incarcerated and hs-CRP levels. However, in Model 1, males whose father was incarcerated when they were aged 18 years or older had reduced odds of having an hs-CRP level between 3 and 10 mg/L versus <3 mg/L than those males whose father was never incarcerated (AOR = 0.45; 95% CI = [0.21, 0.97]). In Model 2, the association was nonsignificant with the addition of the mediators, although the direction of the relationship was consistent with Model 1 (AOR = 0.50; 95% CI = [0.24, 1.07]). We observed no significant differences in hs-CRP levels between males whose father was incarcerated when they were less than 18 years of age and those whose father was never incarcerated.

Discussion

Our study is among the first to find evidence that adult women exposed to paternal incarceration are more likely than their unexposed peers to experience low-grade inflammation—a risk factor for cardiovascular, metabolic, and cancer pathologies. Furthermore, women who experienced paternal incarceration during their childhood or adolescence (<18 years) had greater odds of low-grade inflammation than those whose fathers were never incarcerated as did those women whose fathers were repeatedly incarcerated. These findings are consistent with the life-course perspective, prior research investigating childhood adversities and adult inflammation (Coelho et al., 2014; Lacey et al., 2013; Miller et al., 2009; Slopen et al., 2010; Taylor et al., 2006), and the growing evidence on the negative effects of exposure to parental incarceration during childhood on adult health (Foster & Hagan, 2013; Lee et al., 2013; Murray & Farrington, 2005; Wildeman, 2009).

Parental incarceration has been linked to an increased risk of exposure to a variety of social stressors, such as economic disadvantage (Geller et al., 2011; Western, 2002), poor parent–

child attachment and relationship quality due to separation (Gabel & Johnston, 1995), childhood subjective weathering (Foster, 2012), and stigma (Schnittker & John, 2007) that may in turn lead to chronic activation of the HPA axis and subsequent low-grade inflammation. For example, a recent study of female undergraduate college students highlighted the salience of father–daughter relationships, as poorer quality relationships were associated with irregularities in awakening salivary cortisol, a stress hormone released during HPA activation (Byrd-Craven, Auer, Granger, & Massey, 2012). In addition, numerous studies have linked poor father–daughter relationships to high-risk sexual behaviors among adolescent and young adult females (West, 2010), which could correspond with sexually transmitted infections and low-grade inflammation. Thus, further nursing research investigating the linkages between the social and biological mechanisms through which fathers' incarceration contributes to low-grade inflammation among daughters is needed to facilitate the development of interventions for the prevention of future clinical disease.

In contrast to paternal incarceration, maternal incarceration was not associated with low-grade inflammation among the adult women in the study. Potential reasons for the disparate findings between maternal and paternal incarceration may be related to sentence length and frequency, as men are more likely to serve longer sentences and to be repeat offenders in comparison to women (Maruschak et al., 2010). In addition, more than half of fathers in prison report that they were the primary source of financial support for their children; thus, household economic strain as a consequence of incarceration may be an important risk factor leading to low-grade inflammation. Further, incarcerated mothers are more likely than incarcerated fathers to stay in contact with their children during their incarceration period, which may enhance maternal attachment and relationship quality. While several studies endorse the overall benefit that parent management training and visitations may have on the incarcerated parents and their children (Poehlmann, Dallaire, Loper, & Shear, 2010), a paucity of research exists for whether continued contact might mitigate the stress of experiencing parental incarceration.

With respect to the adult males in our study, maternal incarceration was also not associated with low-grade inflammation. However, males whose father was first incarcerated when they were aged 18 years or older had reduced odds of having low-grade inflammation compared to males whose father was never incarcerated. The association is rendered nonsignificant when the potential mediators—current socioeconomic status, substance use, and mental and physical health outcomes—are included in the analyses, but the change in the size of the effect is small. Although these findings seem counterintuitive, incarceration of a biological father may reduce stress for adult males exposed to their father's criminal activity. Further research is needed to better understand the context of paternal incarceration with respect to timing of the incarceration in the life course for male children.

Several limitations to this study warrant discussion. First, information on the length or reason for parental incarceration, parent–child visitation during incarceration, the type of correctional involvement (jail, prison, parole, or probation), or child placement during incarceration (e.g., with other parent, family member, or foster care) was not included in Add Health, thus we were unable to explore their potential effects on inflammation. Further

investigation on the context surrounding incarceration and the subsequent changes in home environment is needed to better understand children's experiences and their impact on long-term outcomes. Second, because Add Health is a school-based study, higher risk families may not be represented, leading to a conservative bias related to the proportion of youth exposed to parental incarceration. Third, the study only examines low-grade inflammation at one time point, and the measures of parental incarceration are retrospective in nature, precluding causal associations. Fourth, although our study included a range of health, social, and behavioral measures from Wave 4 as potential mediators, the analysis was not exhaustive. Qualitative and longitudinal research to better understand the mechanisms (e.g., exposure to other adverse life events, posttraumatic stress disorder, stigma, and physiological stress) through which exposure to parental incarceration contributes to low-grade inflammation in children is needed. Finally, the low proportion of mothers who had been incarcerated in the study may have limited statistical power to detect significant differences.

Despite these limitations, our study contributes novel findings on the physiological effects of paternal incarceration on young adult women. The findings add to the burgeoning literature of the collateral health consequences of the American correctional system on children, an ever-growing childhood adversity and risk factor for poor health outcomes across the life course. Future longitudinal research is needed with repeated survey and biological measures to test the mechanisms through which paternal incarceration contributes to low-grade inflammation among young adult women, thus facilitating the development of nursing interventions for the prevention of future clinical disease.

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Table 1

Characteristics of the Female and Male Samples and Bivariate Associations Between hs-C-Reactive Protein (hs-CRP) Levels and Covariates for Analyses for Maternal Incarceration, Weighted Proportions and Means, National Longitudinal Study of Adolescent to Adult Health, Waves 1 and 4 (W1 and W4).

	Females (Sample *n* = 6,447)			Males (Sample *n* = 5,396)		
Variable	**Weighted % (sample *n*) or weighted *M* (*SE*)**	**hs-CRP 3–10 mg/L *OR* [95% CI]**	**hs-CRP > 10 mg/L *OR* [95% CI]**	**Weighted % (sample *n*) or weighted *M* (*SE*)**	**hs-CRP 3–10 mg/L *OR* [95% CI]**	**hs-CRP > 10 mg/L *OR* [95% CI]**
Outcome variable						
hs-CRP, W4, % (*n*)						
3–10 mg/L	31.9 (1,994)	NA	NA	24.2 (1,289)	NA	NA
>10 mg/L	17.8 (1,149)	NA	NA	5.8 (331)	NA	NA
<3 mg/L (reference)	50.3 (3,304)	NA	NA	70.0 (3,776)	NA	NA
Predictor variables of interest						
Mother ever incarcerated, % (*n*)	3.1 (220)	0.96 [0.64, 1.44]	0.86 [0.56, 1.31]	3.0 (154)	1.43 [0.84, 2.43]	1.52 [0.75, 3.07]
Timing of mother incarceration, % (*n*)						
Child < 18 years	2.0 (157)	0.90 [0.57, 1.43]	0.78 [0.47, 1.29]	2.0 (105)	1.93 [1.04, 3.57]*	1.68 [0.28, 1.69]
Child ≥ 18 years	1.1 (63)	1.07 [0.51, 2.27]	1.01 [0.46, 2.25]	1.0 (49)	0.68 [0.28, 1.69]	1.29 [0.36, 4.64]
Mother never incarcerated	96.9 (6,227)	1.00	1.00	97.0 (5,242)	1.00	1.00
Frequency of mother incarceration, W4, mean (*SE*) range 0–2	0.04 (0.004)	0.96 [0.73, 1.26]	0.91 [0.68, 1.22]	0.04 (0.01)	1.28 [0.87, 1.90]	1.40 [0.89, 2.19]
Potential mediators						
Married, W4, % (*n*)	44.6 (2,826)	1.09 [0.92, 1.28]	0.92 [0.77, 1.11]	37.3 (2,097)	1.14 [0.93, 1.39]	0.89 [0.62, 1.29]
College degree or more, W4, % (*n*)	33.9 (2,289)	0.79 [0.65, 0.95]	0.68 [0.54, 0.85]	27.2 (1,493)	0.72 [0.57, 0.90]	0.72 [0.47, 1.11]
Public assistance, W4, % (*n*)	29.7 (1,831)	1.26 [1.05, 1.52]	1.315 [1.063, 1.627]	18.7 (924)	1.34 [1.07, 1.67]	2.13 [1.48, 3.06]
BMI categories, W4, % (*n*)						
Obese	38.6 (2,476)	6.39 [5.25, 7.77]	14.9 [11.3, 19.7]	36.4 (2,002)	4.96 [3.89, 6.32]	4.63 [3.12, 6.89]
Overweight	25.0 (1,652)	4.52 [3.77, 5.42]	9.4 [7.67, 11.4]	34.6 (1,900)	1.97 [1.51, 2.59]	1.32 [0.82, 2.11]
Under/normal weight	36.5 (2,319)	2.23 [1.82, 2.73)	2.74 [2.07, 3.71]	29.0 (1,494)		
Waist circumference, W4, mean (*SE*), range 50–197 cm	97.3 (0.46)	1.05 [1.05, 1.06]	1.08 [1.07, 1.09]	99.8 (0.37)	1.05 [1.04, 1.06]	1.07 [1.06, 1.08]
DSM-IV depression symptoms, W4, mean (*SE*), range 0–15	2.84 (0.05)	1.02 [0.99, 1.05]	1.05 [1.01, 1.08]	2.28 (0.12)	1.01 [0.98, 1.05]	1.04 [0.99, 1.09]
Daily smoking, W4, % (*n*)	22.3 (1,247)	0.83 [0.69, 1.01]	0.91 [0.71, 1.17]	28.2 (1,356)	1.44 [1.21, 1.71]	1.24 [0.91, 1.69]
Number alcohol abuse symptoms, W4, mean (*SE*), range 0 4	0.33 (0.02)	0.96 [0.87, 1.07]	0.98 [0.87, 1.10]	0.58 (0.03)	0.92 [0.86, 0.99]	1.02 [0.89, 1.16]
Physically active, W4, % (*n*)	16.2 (1,108)	1.29 [1.05, 1.59]	1.49 [1.17, 1.89]	12.2 (689)	1.28 [0.99, 1.66]	1.28 [0.99, 1.66]
Control variables						
Race and ethnicity, W1, % (*n*)						

Variable	Females (Sample *n* = 6,447)			Males (Sample *n* = 5,396)		
	Weighted % (sample *n*) or weighted *M* (*SE*)	hs-CRP 3–10 mg/L *OR* [95% CI]	hs-CRP > 10 mg/L *OR* [95% CI]	Weighted % (sample *n*) or weighted *M* (*SE*)	hs-CRP 3–10 mg/L *OR* [95% CI]	hs-CRP > 10 mg/L *OR* [95% CI]
Black/African American	14.7 (1,328)	1.19 [0.94, 1.50]	1.74 [1.37, 2.21]	13.1 (935)	1.13 [0.85, 1.51]	1.41 [0.90, 2.20]
Hispanic	11.9 (1,025)	1.23 [0.99, 1.53]	1.62 [1.24,2.14]	11.5 (862)	1.06 [0.84, 1.34]	1.38 [0.93, 2.04]
Asian/Pacific Islander	2.8 (320)	0.43 [0.290, 0.64]	0.38 [0.22, 0.65]	3.0 (318)	0.51 [0.33, 0.77]	0.04 [0.01, 0.10]
Multiracial	3.5 (266)	1.27 [0.83, 1.84]	1.62 [1.01, 2.61]	3.0 (188)	1.35 [0.87, 2.10]	1.03 [0.43, 2.47]
“Other”	0.9 (63)	0.84 [0.39, 1.83]	1.33 [0.53, 3.34]	1.4 (63)	1.08 [0.40, 2.90]	1.31 [0.40, 4.27]
White	67.1 (2,428)	1.00	1.00	68.0 (3,030)	1.00	1.00
Foreign birth, W1, % (*n*)	5.3 (453)	0.84 [0.59, 1.18]	0.51 [0.33, 0.77]	5.2 (400)	0.56 [0.35, 0.88]	0.82 [0.40, 1.67]
Lived in two-biological-parent household, W1, % (*n*)	55.7 (3,456)	1.05 [0.88, 1.25]	0.93 [0.76, 1.14]	57.3 (3,041)	0.918 [0.77, 1.10]	0.79 [0.59, 1.05]
Public assistance, W1, % (*n*)	18.1 (1,135)	1.23 [0.99, 1.53]	1.34 [1.06, 1.68]	16.9 (851)	1.41 [1.11, 1.80]	1.26 [0.85, 1.88]
Parent college degree or more, W1, % (*n*)	21.4 (1,533)	0.75 [0.65, 0.87]	0.66 [0.53, 0.81]	22.6 (1,325)	0.65 [0.52, 0.82]	0.51 [0.37, 0.71]
Sibling in Add Health, % (*n*)	10.6 (775)	0.84 [0.67, 1.07]	0.68 [0.45, 1.02]	9.9 (674)	1.27 [0.97, 1.66]	1.13 [0.68, 1.88]
Age in years, W4, mean (*SE*), range 24–34	28.2 (0.12)	1.01 [0.97, 1.05]	1.01 [0.96, 1.07]	28.4 (0.12)	1.04 [0.99, 1.10]	1.02 [0.94, 1.10]
Anti-inflammatory medications, W4, % (*n*)	32.7 (2,033)	1.10 [0.93, 1.29]	1.36 [1.13, 1.64]	26.6 (1,433)	1.30 [1.06, 1.60]	1.86 [1.38, 2.50]
Ever been in jail/prison, % (*n*)	7.8 (500)	1.01 [0.79, 1.29]	1.02 [0.70, 1.48]	24.4 (1,278)	1.32 [1.08, 1.61]	1.44 [1.01, 2.04]
Physical abuse by caregiver at < 18 years, W4, % (*n*)	17.5 (1,143)	0.86 [0.70, 1.04]	0.88 [0.68, 1.13]	18.0 (1,048)	0.99 [0.77, 1.29]	1.15 [0.81, 1.62]
Sexual abuse by caregiver at < 18 years, W4, % (*n*)	7.9 (490)	1.19 [0.92, 1.54]	1.16 [0.84, 1.60]	2.6 (137)	1.003 [0.51, 1.98]	0.96 [0.37, 2.49]
Emotional abuse by caregiver at < 18 years, W4, % (*n*)	53.2 (3,376)	1.04 [0.89, 1.21]	0.90 [0.77, 1.06]	41.3 (2,234)	1.13 [0.96, 1.32]	0.99 [0.75, 1.30]
Pregnant, W4, % (*n*)	6.4 (410)	4.19 [3.18, 5.51]	3.17 [2.15, 4.66]	NA	NA	NA
Hormonal contraceptive use past year, W4, % (*n*)	40.8 (2,650)	1.17 [0.99, 1.38]	1.06 [0.88, 1.26]	NA	NA	NA
Mother died, W4, % (*n*)	4.6 (326)	1.25 [0.88, 1.77]	0.99 [0.66, 1.49]	4.8 (264)	1.06 [0.69, 1.62]	1.15 [0.61, 2.17]
# subclinical conditions, W4, mean (*SE*), range 0–3	0.53 (0.01)	1.26 [1.13, 1.39]	1.51 [1.33, 1.71]	0.39 (0.01)	1.35 [1.19, 1.53]	1.91 [1.61, 2.26]
# infectious/inflammatory conditions, W4, mean (*SE*), range 0–3	0.50 (0.01)	1.05 [0.94, 1.18]	1.31 [1.15, 1.48]	0.42 (0.01)	1.16 [1.03, 1.32]	1.12 [0.90, 1.39]

Note. hs-CRP = high sensitivity CRP; CI = confidence interval; *OR* = odds ratio; BMI = body mass index; NA = not applicable; Add Health = National Longitudinal Survey of Adolescent to Adult Health; *DSM-IV* = Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition.

* Significant bivariate association at $p < .05$.

Table 2

Characteristics of the Female and Male Samples and Bivariate Associations Between hs-C-Reactive Protein (hs-CRP) Levels and Covariates for Analyses of Paternal Incarceration, Weighted Proportions and Means, National Longitudinal Study of Adolescent to Adult Health, Waves 1 and 4.

	Females (sample *n* = 5,860)			Males (sample *n* = 4,956)		
Variable	**Weighted % (sample *n*) or weighted *M* (*SE*)**	**hs-CRP 3–10 mg/L *OR* [95% CI]**	**hs-CRP > 10 mg/L *OR* [95% CI]**	**Weighted % (sample *n*) or weighted *M* (*SE*)**	**hs-CRP 3–10 mg/L *OR* [95% CI]**	**hs-CRP > 10 mg/L *OR* [95% CI]**
Outcome variable						
CRP, W4, % (*n*)						
3–10 mg/L	31.9 (1,805)	NA	NA	23.4 (1,172)	NA	NA
> 10 mg/L	17.9 (1,050)	NA	NA	5.8 (302)	NA	NA
<3 mg/L (reference)	50.2 (3,005)	NA	NA	70.7 (3,482)	NA	NA
Independent variables of interest						
Father ever incarcerated,% (*n*)	11.0 (669)	1.37 [1.07, 1.76]*	1.24 [0.92, 1.65]	12.0 (588)	1.08 [0.80, 1.45]	1.27 [0.79, 2.05]
Timing of father incarceration, % (*n*)						
Child < 18 years	9.7 (570)	1.41 [1.08, 1.84]*	1.25 [0.90. 1.73]	9.7 (492)	1.25 [0.92, 1.69]	1.41 [0.86, 2.32]
Child ≥ 18 years	1.2 (99)	1.15 [0.59, 2.24]	1.13 [0.58, 2.22]	2.3 (96)	0.50 [0.24, 1.04]	0.81 [0.23, 2.87]
Father never incarcerated	89.0 (5,191)	1.00	1.00	88.0 (4,368)	1.00	1.00
Frequency of father incarceration, W4, mean (*SE*), range 0–2	0.16 (0.01)	1.22 [1.04, 1.43]*	1.16 [0.96, 1.40]	0.17 (0.01)	1.07 [0.89, 1.29]	1.24 [0.92, 1.68]
Potential mediators						
Married, W4, % (*n*)	45.2 (2,602)	1.07 [0.89, 1.27]	0.87 [0.72, 1.06]	37.7 (1,941)	1.15 [0.93, 1.42]	0.92 [0.62, 1.36]
College degree or more, W4, % (*n*)	35.6 (2,181)	0.80 [0.66, 0.97]	0.67 [0.53, 0.86]	28.5 (1,439)	0.75 [0.59, 0.95]	0.70 [0.44, 1.10]
Public assistance, W4, % (*n*)	27.9 (1,558)	1.30 [1.07, 1.58]*	1.31 [1.04, 1.64]*	18.0 (810)	1.35 [1.08, 1.67]*	2.18 [1.50, 3.18]*
BMI categories, W4, % (*n*)						
Obese	38.3 (2,227)	6.42 [5.25, 7.85]*	16.1 [12.4, 20.9]*	35.8 (1,817)	5.22 [3.99, 6.84]*	4.57 [3.04, 6.87]*
Overweight	24.8 (1,494)	2.23 [1.79, 2.77]*	3.01 [2.30, 3.90]*	35.1 (1,766)	2.08 [1.57, 2.77]*	1.31 [0.81, 2.10]
Under/normal weight	36.9 (2,139)	1.00	1.00	29.1 (1,373)	1.00	1.00
Waist circumference, W4, mean (*SE*), range 50–197 cm	97.2 (0.48)	1.05 [1.05, 1.06]*	1.08 [1.07, 1.09]*	99.6 (0.37)	1.05 [1.41, 1.06]*	1.07 [1.06, 1.08]*
DSM-IV depression symptoms, W4, mean (*SE*), range 0–15	2.79 (0.05)	1.01 [0.98, 1.04]	1.06 [1.02, 1.09]*	2.24 (0.05)	1.01 [0.98, 1.04]	1.05 [1.02, 1.09]*
Daily smoking, W4, % (*n*)	21.4 (1,091)	0.81 [0.66, 0.99]	0.90 [0.70, 1.17]	27.8 (1,217)	1.46 [1.20, 1.77]*	1.27 [0.93, 1.75]
Number alcohol abuse symptoms, W4, mean (*SE*), range 0–4	0.33 (0.02)	0.97 [0.87, 1.07]	0.96 [0.85, 1.09]	0.59 (0.02)	0.92 [0.85, 1.00]	1.02 [0.88, 1.18]
Physically active, W4, % (*n*)	15.9 (973)	1.27 [1.02, 1.57]*	1.49 [1.14, 1.94]*	12.0 (621)	1.24 [0.95, 1.64]	1.84 [1.21, 2.79]*
Control variables						

Variable	Females (sample *n* = 5,860)			Males (sample *n* = 4,956)		
	Weighted % (sample *n*) or weighted *M* (*SE*)	hs-CRP 3–10 mg/L *OR* [95% CI]	hs-CRP > 10 mg/L *OR* [95% CI]	Weighted % (sample *n*) or weighted *M* (*SE*)	hs-CRP 3–10 mg/L *OR* [95% CI]	hs-CRP > 10 mg/L *OR* [95% CI]
Race and ethnicity, W1, % (*n*)						
Black/African American	14.1 (1,166)	1.16 [0.91, 1.49]	1.76 [1.39, 2.24]*	12.3 (822)	1.14 [0.84, 1.56]	1.52 [0.99, 2.31]
Hispanic	11.7 (933)	1.22 [0.98, 1.52]	1.61 [1.20, 2.15]*	11.3 (786)	1.07 [0.82, 1.39]	1.56 [1.06, 2.30]*
Asian/Pacific Islander	2.9 (313)	0.44 [0.30, 0.65]*	0.39 [0.22, 0.67]*	3.2 (313)	0.48 [0.32, 0.70]*	0.04 [0.01, 0.11]*
Multiracial	3.2 (225)	1.70 [1.08, 2.67]*	2.21 [1.32, 3.70]*	2.8 (172)	1.37 [0.84, 2.25]*	0.84 [0.33, 2.17]
"Other"	0.9 (57)	0.72 [0.33, 1.55]	1.06 [0.41, 2.74]	1.4 (55)	0.72 [0.33, 1.61]	1.02 [0.32, 3.21]
White	67.1 (3,166)	1.00	1.00	70.0 (2,808)	1.00	1.00
Foreign birth, W1, % (*n*)	5.5 (431)	0.86 [0.61, 1.22]	0.51 [0.34, 0.77]	5.5 (385)	0.55 [0.34, 0.90]	0.86 [0.42, 1.76]
Lived in two-biological-parent household, W1, % (*n*)	59.9 (3,395)	1.01 [0.84, 1.21]	0.90 [0.73, 1.11]	61.2 (2,986)	1.01 [0.83, 1.23]	0.76 [0.56, 1.02]
Public assistance, W1, % (*n*)	16.6 (952)	1.26 [1.01, 1.57]*	1.40 [1.09, 1.80]*	15.3 (716)	1.41 [1.07, 1.86]*	1.35 [0.88, 2.06]
Parent college degree or more, W1, % (*n*)	22.4 (1,445)	0.77 [0.66, 0.89]*	0.66 [0.53, 0.81]*	23.7 (1,259)	0.68 [0.54, 0.85]*	0.50 [0.35, 0.71]*
Sibling in Add Health, % (*n*)	10.5 (689)	0.85 [0.66, 1.08]	0.73 [0.47, 1.12]	9.7 (599)	0.86 [0.67, 1.11]	0.73 [0.47, 1.12]
Age in years, W4, mean (*SE*), range 24–34	28.2 (0.12)	0.99 [0.95, 1.04]	1.01 [0.96, 1.07]	28.4 (0.12)	1.05 [0.99, 1.12]	1.00 [0.92, 1.09]
Anti-inflammatory medications, W4, % (*n*)	32.1 (1,826)	1.07 [0.91, 1.27]	1.40 [1.16, 1.68]*	26.4 (1,312)	1.38 [1.12, 1.71]*	1.93 [1.38, 2.68]*
Ever been in jail/prison, % (*n*)	7.0 (409)	0.95 [0.73, 1.24]	0.98 [0.65, 1.47]	23.1 (1,111)	1.24 [1.00, 1.53]*	1.40 [0.96, 2.03]
Physical abuse by caregiver at < 18 years, W4, % (*n*)	16.6 (995)	0.91 [0.73, 1.13]	1.00 [0.77, 1.31]	17.7 (940)	0.90 [0.73, 1.11]	0.99 [0.76, 1.29]
Sexual abuse by caregiver at < 18 years, W4, % (*n*)	6.9 (396)	1.16 [0.88, 1.52]	1.22 [0.87, 1.72]	2.5 (120)	1.11 [0.84, 1.47]	1.17 [0.83, 1.65]
Emotional abuse by caregiver at < 18 years, W4, % (*n*)	52.0 (3,015)	1.06 [0.90, 1.24]	0.92 [0.77, 1.10]	40.8 (2,021)	1.05 [0.89, 1.23]	0.92 [0.77, 1.10]
Pregnant, W4, % (*n*)	6.6 (384)	4.05 [3.06, 5.35]*	2.95 [2.01, 4.33]*	NA	NA	NA
Hormonal contraceptive use past year, W4, % (*n*)	41.2 (2,435)	1.22 [1.03, 1.44]*	1.09 [0.90, 1.31]	NA	NA	NA
Father died, W4, % (*n*)	11.9 (699)	1.11 [0.88, 1.39]	1.53 [1.14, 2.07]*	9.6 (511)	1.24 [0.94, 1.62]	1.87 [1.15, 3.03]*
# subclinical conditions, W4 mean (*SE*), range 0–3	0.52 (0.01)	1.28 [1.15, 1.43]*	1.55 [1.36, 1.77]*	0.40 (0.01)	1.32 [1.16, 1.51]	1.90 [1.60, 2.27]*
# infectious/inflammatory conditions, W4, % (*n*) mean (*SE*), range 0–3	0.49 (0.01)	1.07 [0.95, 1.20]	1.33 [1.16, 1.51]*	0.43 (0.01)	1.21 [1.06, 1.38]	1.10 [0.88, 1.39]

Note. *DSM IV* = *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition; *SE* = standard error; hs-CRP = high sensitivity CRP; *OR* = odds ratio; CI = confidence interval; NA = not applicable; *SE* = standard error; BMI = body mass index; Add Health = National Longitudinal Survey of Adolescent to Adult Health.

*Significant bivariate association at $p < .05$.

Table 3

Adjusted Multinomial Logistic Regression of Associations Between Biological Parental Incarceration and Inflammation (as Measured by hs-C-reactive protein [hs-CRP] Level) Among Young Adult Females Aged 24 to 34 Years, National Longitudinal Study of Adolescent to Adult Health, Waves 1 and 4.

	Model 1 without mediators, adjusted for controls				Model 2 with mediators, adjusted for controls			
	hs-CRP 3–10 mg/L		hs-CRP > 10 mg/L		hs-CRP 3–10 mg/L		hs-CRP > 10 mg/L	
Variable	**AOR**	**[95% CI]**	**AOR**	**[95% CI]**	**AOR**	**[95% CI]**	**AOR**	**[95% CI]**
Biological mother[a]								
Mother ever incarcerated	0.94	[0.60, 1.47]	0.74	[0.47, 1.17]	0.97	[0.61, 1.55]	0.76	[0.46, 1.27]
Timing of mother incarceration								
Child < 18 years	0.88	[0.54, 1.43]	0.64	[0.36, 1.12]	0.93	[0.56, 1.54]	0.65	[0.34, 1.26]
Child ≥ 18 years	1.06	[0.47, 2.39]	1.01	[0.40, 2.53]	1.07	[0.46, 2.51]	1.01	[0.40, 2.53]
Mother never incarcerated	1.00		1.00		1.00		1.00	
Frequency of mother incarceration	0.94	[0.69, 1.27]	0.81	[0.59, 1.12]	0.96	[0.70, 1.31]	0.82	[0.57, 1.16]
Biological father[b]								
Father ever incarcerated	1.37	[1.05, 1.78]*	1.13	[0.84, 1.51]	1.44	[1.09, 1.91]*	1.23	[0.89, 1.72]
Timing of father incarceration								
Child < 18 years	1.38	[1.05, 1.81]*	1.12	[0.81, 1.55]	1.48	[1.11, 1.97]**	1.25	[0.88, 1.78]
Child ≥ 18 years	1.26	[0.63, 2.55]	1.15	[0.58, 2.28]	1.19	[0.51, 2.80]	1.13	[0.47, 2.70]
Father never incarcerated	1.00		1.00		1.00		1.00	
Frequency of father incarceration	1.21	[1.02, 1.43]*	1.09	[0.90, 1.32]	1.24	[1.04, 1.49]*	1.15	[0.92, 1.43]

Note. AOR = adjusted odds ratio; CI = confidence interval; hs-CRP = hs-C-reactive protein.

[a] Female n = 6,447.

[b] Female n = 5,860.

* $p < 0.05$;

** $p < 0.01$.

Table 4

Adjusted Multinomial Logistic Regression of Associations Between Biological Parental Incarceration and Inflammation (as Measured by hs-C-reactive Protein [hs-CRP] level) Among Young Adult Males Aged 24 to 34 Years, National Longitudinal Study of Adolescent to Adult Health, Waves 1 and 4.

	Model 1 without mediators, adjusted for controls				Model 2 with mediators, adjusted for controls			
	hs-CRP 3–10 mg/L		hs-CRP > 10 mg/L		hs-CRP 3–10 mg/L		hs-CRP > 10 mg/L	
Variable	**AOR**	**[95% CI]**	**AOR**	**[95% CI]**	**AOR**	**[95% CI]**	**AOR**	**[95% CI]**
Biological mother[a]								
Mother ever incarcerated	1.17	[0.66, 2.06]	1.24	[0.58, 2.63]	1.06	[0.58, 1.95]	1.03	[0.45, 2.33]
Timing of mother incarceration								
Child < 18 years	1.59	[0.82, 3.09]	1.32	[0.53, 3.28]	1.34	[0.63, 2.83]	0.93	[0.34, 2.53]
Child ≥ 18 years	0.55	[0.21, 1.47]	1.15	[0.31, 4.33]	0.61	[0.24, 1.55]	1.50	[0.45, 5.00]
Mother never incarcerated	1.00		1.00		1.00		1.00	
Frequency mother incarceration	1.13	[0.74, 1.71]	1.25	[0.77, 2.02]	1.03	[0.67, 1.59]	1.08	[0.62, 1.90]
Biological father[b]								
Father ever incarcerated	0.95	[0.69, 1.31]	0.98	[0.59, 1.64]	1.01	[0.71, 1.43]	1.01	[0.58, 1.75]
Timing of father incarceration								
Child < 18 years	1.09	[0.78, 1.55]	1.06	[0.62, 1.84]	1.15	[0.79, 1.67]	1.11	[0.60, 2.03]
Child ≥ 18 years	0.45	[0.21, 0.97]*	0.66	[0.21, 2.13]	0.50	[0.24, 1.07]	0.66	[0.21, 2.11]
Father never incarcerated	1.00		1.00		1.00		1.00	
Frequency father incarceration	0.99	[0.80, 1.21]	1.05	[0.75, 1.48]	1.00	[0.80, 1.25]	1.07	[0.75, 1.52]

Note. hs-CRP = hs-C-reactive protein; AOP = adjusted odds ratio; CI = confidence interval.

[a] Male (n = 5,396).

[b] Male (n = 4,956).

* $p < .05$.