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# Associations Between Maternal Experiences of Discrimination and Biomarkers of Toxic Stress in School-Aged Children

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## Abstract

**Objective—**To examine associations between maternal experiences of discrimination and child biomarkers of toxic stress in a multiethnic, urban sample of mothers and children (4–9 years).

**Methods—**Data were drawn from a cross-sectional study of maternal-child dyads (N=54) living in low-income neighborhoods in New Haven, Connecticut, USA. Mothers reported experiences of discrimination. Noninvasive biomarkers of toxic stress were collected to assess neuroendocrine (hair cortisol), immune (salivary cytokines, c-reactive protein), and cardiovascular (blood pressure) functioning in children.

**Results—**Maternal experiences of discrimination were associated with increased log-transformed salivary interleukin-6 (IL-6) levels in children ($\beta$=0.15, $p$=.02).

**Conclusions—**Vicarious racism, or indirect exposure to discrimination experienced by caregivers, is associated with poor health outcomes for children. Immune pathways may be a biological mechanism through which racial discrimination “gets under the skin,” but additional research is needed to fully understand these relationships. Uncovering the physiological



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mechanisms linking vicarious racism with child health is an important step towards understanding possible early roots of racial and ethnic health inequities.

### Keywords

Social discrimination; racism; stress; physiological; child health; parenting; vicarious racism

## Introduction

Toxic stress refers to chronic elevation of a child's stress-response-system, which occurs in response to persistent stressors and leads to disrupted physiological development and poor health over time (Shonkoff et al., 2012). For ethnic minority children, exposure to racism and discrimination may be important sources of toxic stress. Children may not only experience stress in response to distressing interpersonal experiences (Priest et al., 2013), but also through indirect (vicarious) exposure to discrimination experienced by others, such as their caregivers (e.g. listening to a caregiver describe unfair treatment at work, witnessing discriminatory behaviors towards a caregiver in a store or restaurant; Heard-Garris, Cale, Camaj, Hamati, & Dominguez, 2018). Vicarious racism is associated with a range of poor outcomes in children including preterm birth, behavior problems, obesity, and depressive symptoms, but the biological mechanisms involved remain unclear (Heard-Garris et al., 2018).

An extensive body of literature demonstrates that exposure to racism and racial/ethnic discrimination contributes to health inequities across the lifespan (Paradies et al., 2015; Phelan & Link, 2015). As toxic stress may be an underlying mechanism linking exposure to racism/discrimination with child health, the purpose of this study was to explore associations between maternal experiences of discrimination and child indicators of toxic stress in a multiethnic, urban sample of mothers and children (age 4–9 years). Although reliable indicators of toxic stress have yet to be defined (Author blinded, 2018a)., we examined noninvasive biomarkers across a range of physiological systems associated with the stress response in an effort to inform future research studies on vicarious racism, toxic stress, and the possible intergenerational roots of health inequities among vulnerable families.

## Methods

We analyzed data from a larger cross-sectional study designed to examine risk and protective factors for toxic stress among multiethnic maternal-child dyads living in low-income, urban neighborhoods in New Haven Connecticut (Authors blinded, 2018b). [Blinded] Institutional Review Board approved the study. Participants were recruited from the control group arm (receiving usual care only) of a home visiting intervention, *Minding the Baby*® (MTB), conducted as a randomized controlled trial (RCT) for first time mothers with histories of poverty, trauma, or young maternal age [ClinicalTrials.gov Identifier: NCT01458145; Ordway et al., 2014; Sadler et al., 2013; Slade et al., 2019). In the current study, participants were included if (i) the child was between 4–9 years of age at the time of data collection, (ii) the child's mother had custody or regular contact with the child, (iii) the dyad was residing within the state, and (iv) the dyad participated in the control group arm of the MTB RCT.

The MTB RCT included only first-time, biological mothers, and thus only oldest children were included in the present study. Data were collected from mothers and children at a single research visit, occurring between October 2017 and March 2018. See [Authors blinded] (2018b) for a complete description of the study protocol.

## Variables and Measures

Mothers reported on demographic characteristics for the dyad, including race/ethnicity, age, education level, employment, marital status, and child gender.

**Maternal Experiences of Discrimination—**Using the Experiences of Discrimination scale, mothers reported whether they had ever experienced lifetime discrimination or unfair treatment due to their race or ethnicity in the following nine situations: at school, getting a job, at work, getting housing, getting medical care, getting service in a store/restaurant, getting credit, bank loans or a mortgage, on the street or in a public setting, or from the police or in the courts (Krieger, Smith, Naishadham, Hartman, & Barbeau, 2005). Mothers also reported the frequency with which they had experienced discrimination in each of the nine situation types (e.g. never, once, 2–3 times, 4 or more times). The number of situation types (range 0–9) and frequency of experiences (range 0 to 45) were summed to create a total score for each. Cronbach's alpha was $\alpha$ =.63 for the current study.

**Child Immune Functioning—**The principal investigator (PI) collected saliva from children to measure C-reactive protein (CRP) via enzyme immunoassay and a panel of four proinflammatory cytokines [interleukin-1 beta (IL-1β), interleukin-6 (IL-6), interleukin-8 (IL-8), and tumor necrosis factor-alpha (TNF)] via a 4-plex electrochemiluminescence immunoassay (Cook et al., 2000; Haddad, Saadé, & Safieh-Garabedian, 2002). Intra-assay coefficients of variability were acceptable (2.8–6.9%). As oral inflammation may affect salivary cytokine levels (Riis, Granger, DiPietro, Bandeen-Roche, & Johnson, 2015), the PI, an advanced practice nurse, conducted a gross oral exam prior to saliva collection to assess for sores, dental caries, and loose/missing teeth.

**Child Neuroendocrine Functioning—**The PI collected 3cm of hair from the posterior vertex of the scalp to assess systemic cortisol exposure in children over the past three months. Hair cortisol was analyzed using a high-sensitivity enzyme immunoassay kit. Information on corticosteroid use and hair characteristics/care was recorded (Meyer & Novak, 2012). See (Authors Blinded, 2018b) for detailed biomarker collection and storage procedures.

**Child Cardiovascular Functioning—**Following standard measurement procedures, the PI took three seated manual blood pressure measurements at least one minute apart, and systolic and diastolic percentiles were calculated based on child age, height and gender (Bird & Michie, 2008).

## Analyses

Data were analyzed using SAS 9.4®. Natural-log transformation was applied to the cytokine and cortisol measures to improve normality of the distributions. Two-sample t-tests and

analysis of variance tests were used to conduct sensitivity analyses by comparing all variables for differences by demographic characteristics (e.g. race/ethnicity, education level). Race/ethnicity was categorized as Hispanic, non-Hispanic Black, and other/mixed race; however, we did not use the other/mixed race group for comparison analyses due to small sample size (N<5). Two-sample t-tests were also used to compare salivary biomarker levels for children with and without missing teeth, loose teeth, unfilled caries, recent dental work (past 1 week), and other mouth issues (crowns, fillings, braces). Hair cortisol levels were compared for differences by hair shape (curly, wavy, straight), color, style, washing frequency, product use, length (if hair < 3cm), and corticosteroid use.

Next, we used Pearson correlations (r) or Spearman's rank (ρ) to examine associations between maternal measures and child biomarkers. For correlations with a p-value of less than 0.1, we then conducted simple linear regressions with child biomarkers as the dependent variable. We did not adjust for multiple hypothesis testing due to the risk of missing an association in this exploratory study (Bender & Lange, 2001). Sample size and power estimates were based on primary relationships examined in the larger study (see Authors blinded, 2018b).

## Results

Fifty-four maternal-child dyads participated in the study (Table 1). Mean maternal age was 26.8 (*SD*=3.3) years and child age was 6.7 (*SD*=2.1) years. Mothers reported an average of 13.0 (*SD*=1.6) years of education, and all reported receiving public assistance. Twenty-seven (50%) mothers identified as Hispanic and 26 (48%) identified as Black. Mothers reported experiencing discrimination in an average of 1.3 (*SD*=1.6) situation types with a frequency of 3.1 (*SD*=4.4) total occurrences (Table 2). Maternal experiences of discrimination did not differ by racial/ethnic group or other demographic characteristics (e.g. education level, employment status, marital status). IL-6 levels were elevated in children with unfilled caries (N=6) compared with the rest of the sample ($t$=2.34, $p$=.02), but no other group differences (e.g. child gender, race/ethnicity, hair characteristics, oral exam findings) were detected in sensitivity analyses.

Correlations are presented in Table 3. By both number of situations and frequency of occurrences, maternal experiences of discrimination were associated with significantly elevated natural log-transformed IL-6 levels in children (ρ=.34, $p$=.01 and ρ=.33, $p$=.02, respectively). Based on the findings of our sensitivity analyses, we adjusted only for unfilled caries in regression models. In these adjusted models, the relationship between discrimination situations and natural log-transformed child salivary IL-6 levels remained significant ($\beta$=0.15, $p$=.02) (Table 4).

## Discussion

The results of this study suggest that effects on immune pathways, specifically the pro-inflammatory cytokine IL-6, may be one mechanism through which vicarious racism influences child health. IL-6 plays a role in inflammatory, metabolic and neural processes, as well as infection response (Scheller, Chalaris, Schmidt-Arras, & Rose-John, 2011), and has

been associated with a number of psychosocial risks for children, including environmental adversity, maltreatment history, behavioral problems, mental health disorders, and sleep disturbances (Author blinded, 2018a; Slopen, Koenen, & Kubzansky, 2012). Though the effects detected here were generally small, these findings align with other pediatric biomarker studies and may reflect the complexity of factors that influence developing physiology (Author blinded, 2018a).

While it is possible that in a more highly powered study we might have been able to detect links between maternal experiences of discrimination and the other biomarkers measured, such as hair cortisol and salivary CRP, we did not detect significant relationships in this study. Interestingly, mothers reported fewer experiences of discrimination than expected when compared with other samples; this may be due to mothers living and working in ethnically homogenous environments, or because other variables important for understanding discrimination, such as nativity and social desirability, were not measured (Krieger et al., 2005; Krieger, 2012). Data collection was also conducted by a white researcher, which may have influenced responses to the questionnaire in ways that could not be detected. Despite these limitations, these findings contribute to the literature on toxic stress, as measurement of chronic stress biomarkers has been limited in ethnic minority children, and to our knowledge, this is the first study to examine these biomarkers as they relate to maternal experiences of discrimination (Gray et al., 2018; Heard-Garris et al., 2018; Riis, Granger, DiPietro, Bandeen-Roche, & Johnson, 2015).

While we collected noninvasive biomarkers of stress to improve acceptability and feasibility with our community sample of mothers and children, future confirmatory analysis with blood samples may be necessary. Research with other biomarker of chronic stress, such as salivary cortisol, urinary catecholamines, or metabolic markers (e.g. glucose, leptin, alpha-amylase) may also provide valuable insight into the relationship between vicarious racism and child health (Author blinded, 2018a). In addition, future research would be strengthened by inclusion of multiple measures to assess children's exposure to vicarious racism, including the specific timing and chronicity of exposure (Heard-Garris et al., 2018). Caregivers' efforts to help children cope with experiences of racism, such as racial socialization, also warrant investigation. Racial socialization includes strategies to encourage children's self-esteem, prepare children to understand racial barriers, instill a sense of cultural pride, and develop coping mechanisms to manage and succeed in a racially-biased society (Hughes et al., 2006; Yasui, 2015). These coping skills may protect against toxic stress by helping children to regulate their stress-response systems in the presence of direct or vicarious racism, and thus represents an important direction for future research in this area (Jones & Neblett, 2016; Wilson, Foster, Anderson, & Mance, 2009).

Racism and discrimination are increasingly being recognized as powerful social determinants of health that must be addressed through concerted research and policy efforts (Acevedo-Garcia, Rosenfeld, Hardy, McArdle & Osypuk, 2013; Svetaz et al., 2018). The effect sizes detected in this exploratory study can be used to design future hypothesis-driven research studies with large, diverse samples to better understand the biological pathways explored here. Understanding the physiologic mechanisms through which vicarious racism

influences child health is an important step towards developing and testing precision health interventions designed to reduce health inequities stemming from racial and ethnic bias.

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## Significance

Racism and discrimination are powerful social determinants of health, and vicarious (indirect) racism is associated with poor health and developmental outcomes for children. Childhood toxic stress, which involves persistent elevation of the stress response, may be one explanation for this relationship. Examination of noninvasive stress-related biomarkers across a range of physiological systems revealed that maternal experiences of racial discrimination may influence child health through immune pathways. Additional research with large, diverse samples is needed to further explicate these relationships.

**Table 1**

Characteristics of Mothers and Children in the Study Sample

| Characteristic | Mothers (n=54) | Children (n=54) |
|---|---|---|
| Age in years, *M (SD)* | 26.79 (3.32) | 6.68 (2.08) |
| Years education *M (SD)* | 12.98 (1.56) | 3.23 (1.97) |
| Grade level, *n* (%) | | |
| Not enrolled/Other | | 6 (11.1) |
| Pre-K to First grade | | 27 (50.0) |
| Second to Fourth | | 21 (38.9) |
| Grade | | |
| Race, *n* (%) | | |
| White | 14 (25.9) | 9 (16.7) |
| Black | 26 (48.1) | 27 (50.0) |
| Other | 14 (25.9) | 18 (33.3) |
| Hispanic Ethnicity, *n* (%) | 27 (50) | 28 (51.9) |
| Hispanic Cultural | | |
| Group, *n* (%) | 21 (77.8) | 20 (71.4) |
| Puerto Rican | 2 (7.4) | 2 (7.1) |
| Mexican | 4 (14.8) | 6 (21.4) |
| Other/Multiple | | |
| Groups | | |
| Marital Status, *n* (%) | | |
| Single | 37 (68.5) | |
| Married | 12 (22.2) | |
| Living Together | 5 (9.3) | |

*Note: M*, mean; *SD*, standard deviation. Participant characteristics originally reported in (Authors Blinded, 2019).

**Table 2**

Descriptive Statistics for Maternal and Child Measures

| Variables | N | Mean | SD |
|---|---|---|---|
| Mothers | | | |
| EOD Situations | 54 | 1.3 | 1.6 |
| EOD Frequency | 54 | 3.1 | 4.4 |
| Children | | | |
| Salivary IL-1 β | 51 | 79.24 | 108.27 |
| Salivary IL-6 | 51 | 9.13 | 11.74 |
| Salivary IL-8 | 51 | 903.03 | 978.42 |
| Salivary TNF | 51 | 5.37 | 5.71 |
| Salivary CRP | 50 | 14413 | 24195 |
| Hair cortisol | 41 | 57.25 | 112.67 |
| SBP Percentile | 53 | 63.73 | 22.16 |
| DBP Percentile | 53 | 71.24 | 15.71 |

*Note:* SD, standard deviation; EOD=Experiences of Discrimination; IL=interleukin; TNF=tumor necrosis factor-alpha; CRP=c-reactive protein; SBP=systolic blood pressure; DBP=diastolic blood pressure. Biomarker data originally reported in (Authors Blinded, 2019)

## Table 3

Correlations between Maternal Experiences of Discrimination and Child Biomarkers of Toxic Stress

| Measure | EOD Situations | EOD Frequency |
|---|---|---|
| IL-1β[a] | −0.12 | −0.12 |
| IL-6[a] | 0.34* | 0.33* |
| IL-8[a] | −0.10 | −0.10 |
| TNF-a[a] | 0.16 | 0.12 |
| CRP | 0.11 | −0.13 |
| Hair cortisol[a] | −0.11 | −0.17 |
| SBP % | 0.06 | −0.06 |
| DBP % | 0.09 | 0.03 |

*Note*:

*$p$-value <.05

[a]= log-transformation applied

†indicates Pearson correlation conducted, all other correlations conducted using Spearman's rho

EOD = Experiences of Discrimination; IL=Interleukin; TNF-a=Tumor Necrosis Factor-alpha; CRP = C-reactive Protein; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure

**Table 4**

Linear Regression Analyses Between Maternal Experiences of Discrimination and Child Biomarkers of Toxic Stress

| Independent Variable | Dependent Variable | N | β | P-value | Notes |
|---|---|---|---|---|---|
| EOD Situations | IL-6[a] | 51 | 0.15 | .02 | Adjusted for unfilled caries |
| EOD Frequency | IL-6[a] | 51 | 0.05 | .08 | Adjusted for unfilled caries |

*Note*: Regression analyses conducted for correlations with significant (<.05) or near significant (<.1) p-values.

[a] = log-transformation applied; EOD = Experiences of Discrimination; IL=Interleukin.