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Short Communication

Brief report: Neighborhood disadvantage and hair cortisol among older urban African Americans

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ABSTRACT

Previous studies have shown that living in poor neighborhoods is associated with increased morbidity and mortality. However, researchers are now investigating the biological pathways responsible for the deleterious effects of neighborhood disadvantage on health. This study investigated whether neighborhood disadvantage (i.e., a measure of relative neighborhood quality derived by combining social and built environmental conditions) was associated with hair cortisol—a retrospective indicator of long-term hypothalamic pituitary adrenal (HPA) axis activation—and whether this link would be mediated by self-reported neighborhood satisfaction. Forty-nine older African Americans were recruited from thirty-nine Detroit census tracts across five strata of census tract adversity. Participants were interviewed face-to-face to collect psychosocial measures. Each provided a hair sample for analysis of cortisol. Multiple regression analyses revealed that higher neighborhood disadvantage was associated with higher levels of hair cortisol levels and that neighborhood satisfaction partially explained this association. These results are the first to our knowledge to demonstrate a direct link between neighborhood disadvantage and hair cortisol in a sample of older adults and to show that self-reported neighborhood satisfaction may be a psychological intermediary of this association.

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Three decades of research have established that living in poor neighborhoods leads to increased morbidity (Diez-Roux et al., 2001) and mortality (Haan et al., 1987). Researchers have started to investigate the biological pathways responsible for the deleterious effects of neighborhood disadvantage on health. One of the main biomarkers of chronic stress under investigation in this field has been cortisol, which is produced by the hypothalamic pituitary adrenal (HPA) axis. Cortisol is a steroid hormone responsive to physical and psychosocial stressors and known for its regulatory effects on various biological systems implicated in disease pathogenesis, such as the immune system and the metabolic system. Chronic neighborhood stressors, such as neighborhood violence (Do et al., 2011), compromised neighborhood safety (Karb et al., 2012; Hajat et al., 2015), physical deterioration (Karb et al., 2012), and lower neighborhood socioeconomic status (SES) (Hajat et al., 2015) have been associated with aberrant patterns of diurnal cortisol secretion (i.e., low cortisol morning levels and flatter cortisol slopes). In turn, individual differences in diurnal cortisol secretion have been found to predict morbidity and mortality (e.g., Kumari et al., 2011). However, because of the ability of the HPA axis to respond dynamically to daily stressors and challenges, the stability over time of these daily cortisol parameters is limited (Ross et al., 2014). Integrating salivary cortisol measures with other types of cortisol measures then becomes important to establish robust individual differences in cortisol profiles.

From this perspective, a promising measure is hair cortisol. Deposition of cortisol in the hair follicles through passive diffusion from blood is constant and accumulates over time. For this reason, cortisol extracted from hair is thought to reflect long-term (i.e. weeks and months) HPA activity, serving as an indicator of cumulative cortisol release (Russell et al., 2012). To our knowledge, only one study to date has investigated the link between residential environment and hair cortisol. In their work, Vliegenthart and colleagues (Vliegenthart et al., 2016) found that neighborhood SES negatively correlated with hair cortisol in a group of Dutch children and adolescents. Whether the same association is observed in adults or older adults has not yet been tested.

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Evidence in favor of the hypothesis that neighborhood disadvantage would be associated with higher levels of hair cortisol comes from a handful of recent studies showing that individuals living in adverse neighborhoods score higher on measures of cumulative biological risk (i.e., allostatic load) (Merkin et al., 2009; Schulz et al., 2012). However, as this area of research matures, focus should shift towards understanding the mechanisms by which neighborhood disadvantage affects biology. For this reason, in the current pilot study of older African Americans in Detroit, MI, we not only tested the direct association between neighborhood disadvantage and hair cortisol, but also tested whether neighborhood satisfaction acted as pathway for the neighborhood/cortisol link. The hypothesis that self-reported neighborhood satisfaction would mediate the link between neighborhood disadvantage and cortisol is grounded in the Lazarus' appraisal theory (Lazarus and Folkman, 1984), according to which events, environments, and situations that are perceived as harmful, threatening, and unmanageable, elicit negative emotional responses with downstream effects on physiology.

1. Method

1.1. Participants

From a larger sample of 100 people enrolled from 74 census tracts, a subset of 49 people from 39 census tracts consented to provide a hair sample for cortisol analysis. Participants were recruited from a volunteer registry of approximately 1400 African-Americans age 55 and older willing to participate in research of interest to them. From the registry, we drew a stratified random sample based on a census tract index of neighborhood quality. The response rate for our random sample was 21%, meaning that among the 323 people that were initially contacted by phone, 69 ultimately participated in the study. We augmented random sampling with snowball sampling. The latter approach contributed 31% of the full sample. All participants identified themselves as African-American. The university's Institutional Review Board approved all study procedures.

1.2. Measures

1.2.1. Neighborhood disadvantage

Census tracts were used as a proxy for neighborhood. Neighborhood disadvantage was measured by an index composed by 3 census tract measures derived from the 2010 U.S. Census and Data Driven Detroit (collected in 2009): percent of persons living below the poverty line, percentage of housing units unoccupied, and percentage of housing units in less than good condition. The three measures were transformed into z-scores and added to create an index of neighborhood disadvantage.

1.2.2. Self-reported neighborhood satisfaction

Neighborhood satisfaction was assessed using a 3-item instrument developed for the purposes of this study and based on items in the neighborhood satisfaction subscale of the Perceived Neighborhood Scale (Martinez et al., 2002). Participants were asked to indicate on a Likert-type scale ranging from 0 (strongly disagree) to 4 (strongly agree) to what extent they agreed with the following statements: "My neighborhood is a good place to live" (reverse-scored), "My neighborhood has been getting worse", "I would move out of my neighborhood if I could". Cronbach's alpha = 0.80.

1.2.3. Hair cortisol

A collection of hair strands approximately 3–4 millimeters wide and at least 2 cm long were cut at 2 cm below the crown of the head. The cut was made as close as possible to the scalp. Cortisol levels were determined via luminescence immunoassay (IBL-International, Hamburg, Germany) at the laboratory of Dr. Clemens Kirschbaum at the Technical University of Dresden. Average hair cortisol concentration was 67.2 pg/mg (SD = 114.89). Cortisol values were natural log-transformed to correct for positive skew in the cortisol distribution.

1.3. Statistical analyses

Multiple regression analyses were conducted to test whether neighborhood disadvantage predicted hair cortisol concentrations and neighborhood satisfaction, and whether neighborhood satisfaction was associated with hair cortisol while controlling for neighborhood disadvantage. Next, we used the PROCESS macro in SPSS to perform bootstrap analyses (20,000 repetitions) to derive a 95% confidence interval (CI) for the indirect effect linking neighborhood disadvantage to hair cortisol via neighborhood satisfaction. CIs not including 0 indicate statistically significant indirect effects. To facilitate interpretation, continuous predictors and potential covariates were standardized, while dichotomous variables were coded as 0 and 1. Analyses were conducted controlling for age, gender (0 = male, 1 = female), SES (derived by adding together education and income after having z scored them), and living status (0 = living with others, 1 = living alone).

2. Results

Descriptive statistics are reported in Table 1. Hair cortisol was positively associated with SES ($r = 0.343$, $p = 0.016$), neighborhood disadvantage ($r = 0.336$, $p = 0.018$), and neighborhood satisfaction ($r = 0.406$, $p = 0.004$). Neighborhood disadvantage and neighborhood satisfaction were also positively correlated ($r = 0.338$, $p = 0.018$).

Table 1
Descriptive Statistics.

Descriptive variables	M or%	SD	Min	Max
Female	89.80%	–	–	–
Living Alone	63.27%	–	–	–
Age	69.10	8.18	55.00	91.00
SES	0.00	1.73	−5.03	4.31
Income	5.62	1.83	Less than $5000	Over $70,000
Education	4.27	0.91	Some high school	Graduate Degree
Neighborhood disadvantage	0.00	2.49	−3.55	5.43
People below the poverty line	33.84%	12.69%	8.40%	62.77%
Housing units in less than good condition	3.42%	5.58%	0.00%	21.00%
Unoccupied housing units	13.97%	12.08%	0.00%	42.38%
Neighborhood satisfaction	1.36	1.01	0.00	3.67
Hair Cortisol (Log)	3.23	1.38	0.93	6.35

Note: For income, category "5" corresponds to an annual wage between $20,000 and $29,999. For education, category "4" corresponds to "some college or technical school, but no degree".

Regression analyses controlling for covariates revealed a significant effect of neighborhood disadvantage on neighborhood satisfaction [b = 0.351, 95% CI: 0.0589: 0.6440, $p = 0.020$]. Further, neighborhood satisfaction predicted higher levels of hair cortisol [b = 0.439, 95% CI: 0.0693: 0.8083, $p = 0.021$]. Bootstrapping analyses revealed a significant indirect effect of neighborhood disadvantage on hair cortisol via neighborhood satisfaction [95% CI: 0.0086, 0.3943]. Notably, results remained significant after analyses were conducted without controlling for covariates. Next, we calculated the ratio of the indirect effect to the total effect (i.e., indirect effect + direct effect) (Preacher and Kelley, 2011) and found that neighborhood satisfaction mediated approximately one-third of the total effect of neighborhood disadvantage on hair cortisol.

3. Discussion

In a sample of older African Americans, we found that higher neighborhood disadvantage predicted higher levels of hair cortisol, and self-reported neighborhood satisfaction partially explained this association. These results did not change when analyses were run controlling for covariates, which included participants' age, gender, living status, and SES.

Previous work showed that low neighborhood SES and poor environmental physical conditions disrupt the circadian rhythm of cortisol secretion (Karb et al., 2012; Hajat et al., 2015) and are associated with higher levels of allostatic load (Schulz et al., 2012), particularly in African Americans (Merkin et al., 2009). Our findings add hair cortisol—a retrospective indicator of long-term HPA axis activation—to the list of biomarkers affected by neighborhood disadvantage among adults; and we note that this is among the first studies to measure hair cortisol in African Americans. Similar to diurnal cortisol and allostatic load, hair cortisol has been found to predict morbidity (Manenschijn et al., 2013), thus offering a novel biological substrate for research showing greater rates of morbidity and mortality among people living in disadvantage neighborhoods (Diez-Roux et al., 2001). Indeed, hair cortisol as a measure of longer-term or chronic stress offers unique strengths for studying the effects of chronic stressors such as neighborhood disadvantage.

The present results also point to neighborhood satisfaction as a potential psychological pathway by which the effect of neighborhood disadvantage operates on heightened HPA axis activation. This finding is congruent with recent evidence showing that self-reported neighborhood environmental stress mediates the link between low neighborhood SES and allostatic load (Schulz et al., 2012). Future studies could test the mediating role of other psychological and behavioral factors strongly patterned by neighborhood disadvantage, such as exposure to negative events, reduced physical activity, and substance abuse.

Our findings remained significant after controlling for individual SES, suggesting that neighborhood disadvantage heightened HPA axis activity above and beyond individual differences in education and income. Somewhat surprisingly, however, individual SES *positively* correlated with hair cortisol, with low SES individuals having lower levels of hair cortisol. One possible explanation for this result can be found in the John Henryism (JH) hypothesis; the idea that sustained high-effort coping in face of recurrent psychosocial stressors (e.g., neighborhood disadvantage) can increase risk for poor health among individuals with reduced personal coping resources (James, 1994). Based of recent formulations of the JH hypothesis (e.g., Chen et al., 2014) high SES individuals in our sample might represent a group of tenacious adults who were able to attain higher levels of education and better paying occupations against the odds of living in impoverished neighborhoods in Detroit. In this context, high levels of hair cortisol in this group might then reflect the physiological cost to upholding high levels of JH required to succeed. Future studies would benefit from testing this hypothesis by using direct measures of John Henryism as well as by sampling individuals across the full continuum of neighborhood SES.

Results presented in this paper should be considered in light of their limitations. Therefore, a first limitation of the study is the small sample size, especially given that larger sample sizes are typically expected when testing psychosocial mechanisms. Another limitation concerns the fact that women constituted the majority of our sample, which warrants caution when considering the generalizability of the present findings to men. Despite these caveats, these findings represent some of the first empirical evidence for the association between objective measures of neighborhood disadvantage and hair cortisol in older adults as well as the role played by subjective appraisal of neighborhood in mediating this relationship.

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