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Socioeconomic deprivation, perceived neighborhood factors, and cortisol responses to induced stress among healthy adults

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Abstract

Associations between measures of neighborhood socioeconomic deprivation and health have been identified, yet work is needed to uncover explanatory mechanisms. One hypothesized pathway is through stress, yet the few studies that have evaluated associations between characteristics of deprived neighborhoods and biomarkers of stress are mixed. This study evaluated whether objectively measured neighborhood socioeconomic deprivation and individual perceived neighborhood characteristics (i.e. social control and fear of crime) impacted cortisol responses to an induced stressor among older healthy adults. Data from Heart Scan, a sub-study of the Whitehall II cohort, were used to generate multilevel piecewise growth-curve models of cortisol trajectories after a laboratory stressor accounting for neighborhood and demographic characteristics. Neighborhood socioeconomic deprivation was significantly associated with individual perceptions of social control and fear of crime in the neighborhood while an association with blunted cortisol reactivity was only evidence among women. Social control was significantly associated with greater cortisol reactivity and mediation between neighborhood deprivation and cortisol reactivity was suggested among women. These findings support a gender-dependent role of neighborhood in stress process models of health.

Keywords

neighborhood deprivation; stress; social control; cortisol

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1. Introduction

Recent reviews of the neighborhood effects literature have concluded that neighborhood deprivation, typically measured by aggregated census information on income, employment and education, is modestly associated with chronic disease and mortality after adjustment for individual-level socioeconomic factors (Diez Roux and Mair, 2010, Meijer M et al., 2012). Neighborhood effects on mental health have also been demonstrated(Truong and Ma, 2006). Although associations between neighborhood deprivation and health outcomes may be small, addressing these exposures is of public health importance given the large absolute number of persons exposed to deprived neighborhoods and associated neighborhood factors as well as the socioeconomic and racial disparities in exposure to these neighborhoods (Diez Roux and Mair, 2010). Identifying potential mechanisms that explain how living in deprived neighborhoods influence more proximal health-related processes may contribute to our understanding of associations between neighborhoods and health and ultimately inform efforts to reduce health disparities. To this end, stress has emerged as one potential embodiment framework for neighborhood effects on health (Diez Roux and Mair, 2010, Brenner et al., 2013, Schulz et al., 2013).

Stress has been defined as a condition of living resulting in the activation of neurobiological systems that preserve viability through change or allostasis (Cohen et al., 2007, McEwen and Seeman, 1999). When external demands exceed the adaptive capacity of an individual, cognitive, behavioral, as well as physiological processes occur which may increase disease risk (Cohen et al., 2007, McEwen and Seeman, 1999). Stress may stem from the presence of socio-environmental demands such as social or physical factors associated with deprived neighborhoods or other elements of disadvantaged social status (Pearlin et al., 1981, Steptoe and Feldman, 2001) and these demands may be more frequent, severe, and sustained (Latkin and Curry, 2003). Studies among adults evaluating neighborhood influences on perceived stress after controlling for individual socioeconomic factors are inconclusive (Brenner et al., 2013, Everson-Rose et al., 2011). More evidence of the impact of neighborhood factors on biomarkers of stress among adults is emerging related to diurnal cortisol profile (Karb et al., 2012, Do et al., 2011, Roe et al., 2013). While no studies have evaluated neighborhood context with respect to cortisol reactivity among adults, a related and mixed literature among adolescents does exist (Brenner et al., 2012, Hackman et al., 2012, Kapuku et al., 2002, Rudolph et al., 2013). While it is has been suggested that alterations to biomarkers of stress, either diurnal cortisol profile or cortisol reactivity, may more accurately reflect the cumulative effects of chronic exposure to neighborhood stressors (Brenner et al., 2012), it is still possible that the severity and timing of the exposure varied across studies and contribute to the lack of consistent findings.

The hypothalamic-pituitary-adrenal (HPA) axis is one of the major systems that modulate physiologic responses to stress (Cohen et al., 2007). Cortisol, the main regulatory hormone of the HPA axis, exhibits a basal diurnal profile with superimposed fluctuations when cortisol temporarily increases in response to an encountered stressor. Cortisol is regulated by feedback loops that may be disrupted by the effects of previous stress exposure (Cohen S et al., 2012). A departure from normal HPA functioning could manifest as differences in total daily cortisol output (i.e. hypo- and hyper-cortisolism) (Miller et al., 2007, Fries et al., 2005)

as well as differences in cortisol responses to stress (i.e. blunted and exaggerated responses) (Cohen S et al., 2012, Silverman MN and Sternberg EM, 2012) which may have health consequences (Phillips AC et al., 2013, Cohen S et al., 2012, Hamer et al., 2012).

Diurnal profile and acute stress responsivity measures of cortisol likely measure distinct functional aspects of the HPA system; separate evaluation of the impact of neighborhood deprivation on these patterns is needed (van Eck M et al., 1996). Studies linking neighborhood factors and diurnal cortisol are emerging; exposure to neighborhood stressors has been associated with blunting of the diurnal cortisol secretory profile among adults in two large diverse samples (Karb et al., 2012, Do et al., 2011). With respect to cortisol reactivity, one of three studies among predominantly African-American adolescents found that measures of neighborhood deprivation were associated with blunted cortisol responses to induced stress (Hackman et al., 2012, Kapuku et al., 2002, Brenner et al., 2012). Studies relating measures of neighborhood to cortisol stress reactivity in adults, however, are lacking. To address this gap in the literature, the primary objective of this study was to evaluate whether neighborhood socioeconomic deprivation was associated with the acute responsivity of cortisol among older white British adults.

Furthermore, individual perceptions of the neighborhood may also be important to consider when assessing associations between neighborhood deprivation and cortisol response as perception is integral to the appraisal of stress. Social control and perceived crime are individual-level neighborhood perceptions that are associated with deprivation and may mediate associations with health (Ross and Mirowsky, 2001, Feldman and Steptoe, 2004). These perceptions may provide a means of internalizing the effects of neighborhood deprivation: social control has been shown to attenuate the impact of neighborhood stressors on depression (Diez Roux and Mair, 2010) while fear of crime has been associated with poorer mental health, reduced physical functioning, and lower quality of life in the larger Whitehall II cohort (Stafford et al., 2007). These relationships suggest that individual perceptions of the neighborhood could mediate associations between neighborhood deprivation and cortisol responses to stress (Figure 1). Our secondary objective, therefore, was to determine whether individual-level social control or fear of crime explained any relationship between neighborhood socioeconomic deprivation and cortisol response.

2. Methods

Data were drawn from the Heart Scan Study, an ancillary investigation of socioeconomic and psychosocial factors, physiological stress responsivity, and sub-clinical cardiovascular outcomes within the Whitehall II cohort(Steptoe et al., 2010). Inclusion of men and women aged 53–76 years was determined by eligibility criteria: no history or clinical signs of coronary heart disease; no previous diagnosis or treatment for hypertension, inflammatory diseases, or allergies; and no intake of medication which might affect cortisol levels and sympathetic nervous system activity (i.e. hormone treatment and beta-blockers). The study group comprised 543 individuals of white European ancestry; our sample is limited to those living in England without missing data on exposures, covariates, or outcome for a total of 514 individuals. Individual-level age, gender, income, and employment as well as

neighborhood-level socioeconomic deprivation were similar between the study sample and those dropped from the analysis (p>0.06 for all).

2.1 Cortisol stress responses

Psychophysiological testing for the Heart Scan Study occurred between 2006–2008 and methodology has been described elsewhere (Hamer et al., 2010). Briefly, saliva was collected for baseline assessment of cortisol after the participant rested for 30 minutes. Two 5-minute behavioral tasks (color/word interference and mirror-tracing) were then administered in random order. After completion of both tasks, a saliva sample was collected along with subjective stress ratings of each task. Participants then rested for 75 minutes and provided post-task cortisol measurements at 30 minutes, 55 minutes, and 85 minutes after baseline. Levels of cortisol (nmol/L) were assessed using a time resolved immunoassay with fluorescence detection where the intra and inter-assay coefficients of variation were <8%.

2.2 Perceived neighborhood factors

Social control—We used a modified scale of informal social control (Sampson et al., 1997) during the 2006–2008 survey administration to assess whether respondents perceived that their neighbors would take action to safeguard the welfare of the neighborhood. Participants responded whether they thought that their neighbors could be counted on to intervene in various ways if: 1) children were truant and loitering; 2) children were doing graffiti on a local building; 3) children were showing disrespect to an adult; 4) fighting broke out in front of your home; and 5) the school closest to home was threatened with budget cuts (Feldman and Steptoe, 2004). Responses ranged from “very unlikely” to “very likely” on a 5 point Likert scale. The social control scale ranged from 0 to 25 (Cronbach’s alpha=0.87).

Fear of crime—To assess the level of perceived danger due to violence in their neighborhood, participants indicated how worried they were regarding: 1) having their home broken into; 2) being mugged or robbed; 3) having their car broken into or stolen; and 4) being raped. Possible responses were “very worried”, “fairly worried”, “not very worried”, or “not worried at all”. This measure originated from the British Crime Survey (Kaewthummanukul and Brown, 2006) and was included during the 2002–2004 survey administration. We dropped the last scale item as the relationship between fear of crime and neighborhood context likely differs for men and women, especially with respect to the fear of sexual assault (Lane et al., 2009). The modified fear of crime score ranged from 0–9 (Cronbach’s alpha=0.78).

2.3 Neighborhood socioeconomic deprivation

Participants provided their home address as well as the number of years they lived at that address at the time of psychophysiological testing. Each postcode was matched to a lower layer super output area (LSOA), the smallest aggregation used to disseminate census information in England and Wales. There are 32,482 LSOAs in England with a population range of 1,000 to 3,000 and an average of 1,500 people (Department for Communities and Local Government) which is analogous to a US Census blockgroup (Kim D et al., 2010). The mean number of participants per LSOA was 5.1 with a range between 4 and 10.

Linked neighborhood socioeconomic measures were obtained from the Index of Multiple Deprivation (IMD) 2007 which provides deprivation information based on 38 indicators grouped in seven domains including income and employment (UK Statistics Authority). Percent income and employment deprivation within each LSOA are each based on six indicators capturing proportions of residents living in poverty and in receipt of unemployment-related government support, respectively. We linked IMD income and employment deprivation variables to participants via matching each person to the LSOA within which they resided. The percent income and employment deprivation variables were highly correlated (r=0.89): we therefore standardized and averaged both to create a composite continuous z score of socioeconomic deprivation (Nazmi et al., 2010).

2.4 Independent Variables and Covariates

Grade of employment and household income were used as individual-level socioeconomic measures. Employment categories corresponding to status included low (i.e. grades 7 to 1), intermediate (i.e. higher executive office and senior executive office), and high (i.e. administrative assistant, administrative officer, executive officer). Participant's household income comprised three categories: less than 20,000 pounds; 20,000–39,999 pounds; greater than 40,000 pounds. Covariates used in all analyses included age, gender, number of years lived at provided address, time of day of stress testing (am or pm), and subjective stress rating of administered tasks (response range from 1 to 7 with higher ratings indicative of higher stress). Other psychosocial and behavioral variables such as depression, anxiety, smoking-status, and body mass index (BMI) were not included as confounding variables in these analyses as we conceptualized these variables as potential mediators linking associations between our neighborhood-related measures and cortisol response.

2.5 Statistical analysis

For descriptive purposes, differences in socio-demographic characteristics, length of neighborhood residence, and neighborhood perceptions were examined by tertile of neighborhood deprivation using chi-square test for trend. The data had a hierarchical structure with cortisol measurements over time (level 1) nested with individuals (level 2) nested within neighborhoods (level 3). We first plotted unadjusted mean cortisol values over time using a two-power fractional-polynomial curve. Visual inspection of the plotted data suggested two linear functions for the reactivity period (baseline to immediately post-task) and the recovery period (immediately post-task to 75 minutes post-task).

We used piecewise multilevel growth curves to describe cortisol trajectories with respect to time and to assess whether neighborhood deprivation and perceptions of the neighborhood were associated with cortisol trajectories while controlling for covariates. These methods have been employed in similar studies (Goldman-Mellor et al., 2012, Hackman et al., 2012) with coding of the time variable derived from Llabre and colleagues (Llabre et al., 2001). In brief, time is partitioned into "reactivity" and "recovery" vectors. The reactivity time vector corresponds to the total slope between baseline (time 0) and immediately post-task (time 1) while the recovery time vector corresponds to the total slope between immediately post-task (time 1) and 75 minutes post-task (time 4). The main effects of variables in the model specify the relationship of that variable with absolute baseline levels of cortisol while

variable interactions with time (i.e. reactivity and recovery) specify that variable's relationship with those pieces of the cortisol trajectory. We log transformed cortisol values to account for skewness and attempted to fit a quadratic term when modeling recovery, but this variable did not significantly improve model fit (p=0.11).

Model 1 included fixed effects for neighborhood deprivation and its interaction with the time vectors (i.e. reactivity and recovery) while accounting for time of laboratory visit, task stress rating, and individual-level demographic characteristics. This allowed us to test for differences corresponding to neighborhood deprivation in both baseline cortisol levels and slopes during the two time periods. Models 2 and 3 included fixed effects for fear of crime and social control, respectively. These models also specified interactions between these variables and the reactivity and recovery time vectors Model 4 included fixed effects for both neighborhood deprivation and social control to evaluate whether social control accounted for any association between neighborhood deprivation and cortisol response. Random effects were specified for the intercept as well as reactivity and recovery slopes for both level 2 (person) and level 3 (neighborhood). An unstructured working correlation structure was assumed. For illustrative purposes, we also plotted the adjusted predicted mean cortisol values (untransformed) over time by tertile of neighborhood deprivation (Model 1) and social control (Model 3). All analyses were conducted using XTMIXED in Stata SE version 12.1 (College Station, TX, USA).

3. Results

The mean baseline cortisol of the total group was 6.7 nmol/dL, the mean age was 62.9 years (SD= 5.7), slightly more than half of individuals were male (54.9%), 21.5% had an income < £20,000, and 19.8% were of lower employment grades. The mean social control score was 11.7 (SD=4.7) and mean fear of crime score was 2.7 (SD=1.6). Within represented LSOAs, income deprivation ranged between 1% and 46% of persons (Mean= 9.5%, SD=7.5) and employment deprivation ranged between 1% and 24% of persons (Mean=6.3%, SD=3.7).

Table 1 shows selected characteristics of Heart Scan participants by tertile of neighborhood socioeconomic deprivation score. Individuals living in more deprived areas were more likely to be female, of lower employment status, and have lower incomes ($p<0.0001$ for all). Individuals living in more deprived areas also reported greater fear of neighborhood crime as well as lower neighborhood social control ($p<0.0001$ for both). The subjective stress rating from laboratory tasks did not vary by level of neighborhood deprivation. The average number of years participants lived in their neighborhood was high (>20 years) and did not vary across levels of deprivation. Individual reports of fear of crime and social control varied across tertiles of neighborhood deprivation ($p<0.0001$ for both). Social control and fear of crime were not significantly correlated.

Table 2 displays multivariate results from piecewise growth curve models. In model 1, neighborhood deprivation bore little relation to baseline cortisol values or recovery slope, but was marginally associated with a significant decrement in reactivity. In model 2, we tested whether these cortisol profiles were related to fear of crime, but this was not the case. In model 3, social control was significantly positively associated with cortisol reactivity. For

each unit increase of social control, there was a significantly steeper (i.e. positive) cortisol reactivity slope of 0.01 nmol/L per minute. Model 4 tested whether variations in social control were responsible for the association we observed between greater socioeconomic deprivation and reduced cortisol reactivity. Yet, social control did not appear to mediate the association between neighborhood deprivation and cortisol trajectories. Although including social control in the model of neighborhood deprivation and cortisol dramatically improved model fit (as demonstrated by the lower log-likelihood of model 4 vs. model 1), its presence in the model did not appreciably alter the relationship between neighborhood deprivation and cortisol trajectories as evidenced by the lack of change in regression coefficients. Higher age and lower individual-level SES (as measured by employment grade) was also associated with higher baseline cortisol levels in this model. For illustrative purposes, adjusted predicted cortisol trajectories over the laboratory testing session are presented by tertiles of socioeconomic deprivation (Figure 2) and social control (Figure 3).

As previous studies among adolescents have reported gender differences in associations between neighborhood and cortisol reactivity (Hackman et al., 2012), we explored differences in relationships between neighborhood-related variables and cortisol reactivity by gender. While the relationship between neighborhood deprivation and fear of crime did not vary by gender ($p=0.66$), there was a significant gender interaction in the relationship between neighborhood deprivation and social control ($p<0.0001$). Given the complexity of modeling an overall three-way gender x neighborhood x time interaction, we chose to stratify our models by gender and found that higher neighborhood deprivation ($p=0.047$) and lower social control ($p=0.006$) were both significantly associated with blunted cortisol among women only (see Figures 2 and 3). Furthermore, the magnitude of association between neighborhood deprivation and cortisol reactivity decreased and became marginally significant when social control was also included in the model. This suggests a partial mediating role of social control in the relationship between neighborhood deprivation and cortisol reactivity among women.

We also explored whether other potential mediators such as depression, anxiety, smoking-status or BMI could instead explain relationships between neighborhood socioeconomic deprivation and cortisol reactivity in women. Separate models for women were generated comprising variables in Model 4 with fixed effects for depression and its interactions with reactivity and recovery time vectors. Similarly, separate models were also generated to evaluate anxiety, smoking-status, and BMI. Independent associations between social control and cortisol reactivity remained in separate models where depression, anxiety, smoking-status, and BMI were added ($p<0.02$ for all) and partial mediation by social control in the relationship between neighborhood deprivation and cortisol reactivity was still suggested.

4. Discussion

Stress has been put forward as a mode of embodiment for neighborhood influences on health(Diez Roux and Mair, 2010, Truong and Ma, 2006). Neighborhood factors related to socioeconomic deprivation have been conceptualized as chronically experienced stressors (Pearlin et al., 1981, Steptoe and Feldman, 2001); cumulative stress exposure induces alterations to HPA functioning that have been linked to health outcomes (Cohen et al.,

2007). The aim of this study was to explore associations between neighborhood deprivation and related individual-level perceptions of the neighborhood and cortisol stress reactivity to an induced stressor as a functional measure of the HPA system. Here, lower perceived social control in the neighborhood was significantly associated with blunted cortisol response to an induced stressor. Higher neighborhood socioeconomic deprivation exhibited a similar relationship that did not reach statistical significance. Exploratory analyses by gender, however, revealed that both neighborhood socioeconomic deprivation and social control were significantly associated with cortisol reactivity among women. Furthermore, a mediating role of social control in the relationship between neighborhood socioeconomic deprivation and cortisol reactivity was suggested. Perceiving less social control in one's neighborhood may be indicative of perceiving more physical and/or social threats which, in turn, gives rise to psychological and physiologic stress responses which affect health (Hill et al., 2005). Specifically, these blunted cortisol responses might reflect exhaustion of allostatic regulatory mechanisms, including cortisol down-regulation or alterations in feedback sensitivity, associated with chronic stress exposure (Hellhammer and Wade, 1993, Phillips et al., 2013, Fries et al., 2005). Our results are consistent with some (Roy MP, 2004, Roy et al., 1998), but not all (Brenner et al., 2012) studies finding that individual-level social support is associated with greater cortisol reactivity. Another study among adolescents did find that measures of neighborhood socioeconomic deprivation was associated with blunted cortisol reactivity only among those reporting a high number of chronic stressors (Brenner et al., 2012). Differences by gender were not noted in these studies, however. Relatedly, the magnitude of associations between our exposure variables and cortisol trajectories were similar to associations seen between early-life stress and recurrent distress (as indicators of chronic stress) and cortisol trajectories within this same cohort (Goldman-Mellor et al., 2012).

Individual fear of crime did not impact cortisol responses in these data. It is possible that there was not a sufficient range in this exposure to detect associations as overall fear of crime was low in this cohort. Another study among African-American adolescents also found no association between fear of violence in the neighborhood and cortisol reactivity (Brenner et al., 2012). In one longitudinal study among adolescents, however, recent exposure to violence was associated with blunted reactivity in boys (Peckins et al., 2012). It is plausible that exposure to violence may be positively correlated with fear of crime and thus be similarly related to cortisol reactivity. Evaluating objective crime statistics for neighborhoods with respect to reactivity may therefore be informative.

While the present study is the first to evaluate neighborhood-related influences on cortisol reactivity among older white adults, three other studies have evaluated exposure to neighborhood deprivation and cortisol reactivity among predominantly African-American adolescents (Hackman et al., 2012, Brenner et al., 2012, Kapuku et al., 2002). In one study, concentrated neighborhood disadvantage was associated with greater cortisol reactivity among African-American boys, but not girls (Hackman et al., 2012). In 2 other studies among African-American boys, neighborhood deprivation was not associated cortisol reactivity (Brenner et al., 2012, Kapuku et al., 2002). Inconsistencies between the present study findings and those from studies of African-American youth could be attributed to differences in HPA responses based on age, sex, and race (Kudielka et al., 2004, Birditt et

al., 2011, Wilcox et al., 2005). Additionally, although perceived social control in the neighborhood was measured at the individual-level, our findings may also complement other studies demonstrating associations between objective and perceived neighborhood factors and differences in diurnal cortisol pattern, another measure of HPA functioning (Do et al., 2011, Karb et al., 2012).

There were limitations and strengths to our study that should be acknowledged. First, perceptions of the neighborhood were measured by self-report and at the individual- rather than neighborhood-level. Neighborhood perceptions were also measured at a single-point in time which prevents clear conclusions about the directionality of the association we observed with social control. Cortisol reactivity was also measured during a single laboratory session, although strong reproducibility of these responses over two repeated stress sessions have been demonstrated (Hamer M et al., 2006). The Heart Scan Study comprised mostly white individuals with selection criteria aiming to minimize variation in physiologic stress responses due to health conditions such as coronary heart disease. It is possible that selection criteria may have controlled for downstream consequences of the exposure, thereby attenuating associations of interest. These findings may only generalize to white individuals who have lower exposures to neighborhood stressors. It is possible that ethnic or racial minority groups or those with greater exposure to neighborhood stressors may exhibit different reactivity patterns. There were also several assumptions to our model specifications which may be incorrect. First, we visualized cortisol response as a curve with one inflection point located at post-task. Due to the timing of cortisol collection, the measurement immediately post-task was designated as the maximum; it is possible that peaks in cortisol occurred somewhere in between immediately post-task and 20 minutes post-task. There were also several strengths to our study including the use of a large well-characterized sample to evaluate associations. We were also able to minimize extraneous variation in cortisol response by evaluating associations within a group of similar age and race and by using a controlled physiologic stress measure that accounted for differences in stress perception.

In conclusion, these findings indicate that neighborhood may play an important role in HPA functioning among adults, especially among women. Addressing individual perceptions of social control may facilitate mental health promotion efforts in neighborhoods. These findings may therefore provide weak support of stress process models linking neighborhood and health. Further investigation is warranted to verify the robustness of these findings.

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- Associations between neighborhood and stress reactivity were evaluated among healthy adults.
- Socioeconomic deprivation was associated with blunted cortisol reactivity among women.
- Social control was associated with higher cortisol reactivity among women.
- Improving social control may aid community mental health promotion efforts among women.
- These findings provide weak support of stress process models linking neighborhoods and health.

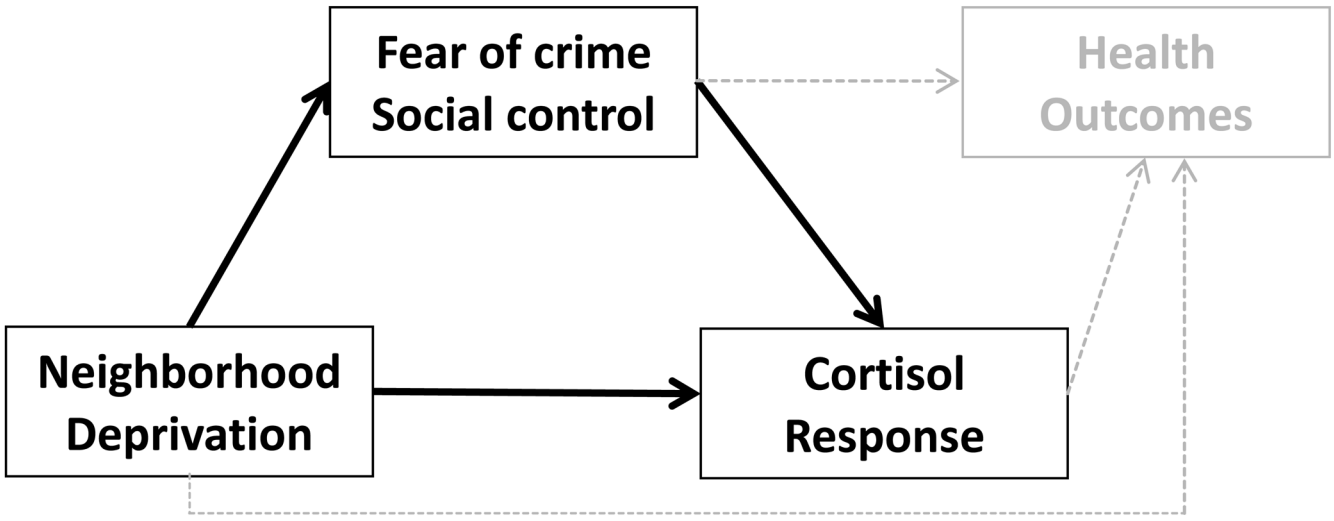

Figure 1.
Conceptual model relating neighborhood deprivation, fear of crime, social control, and cortisol responses to stress.

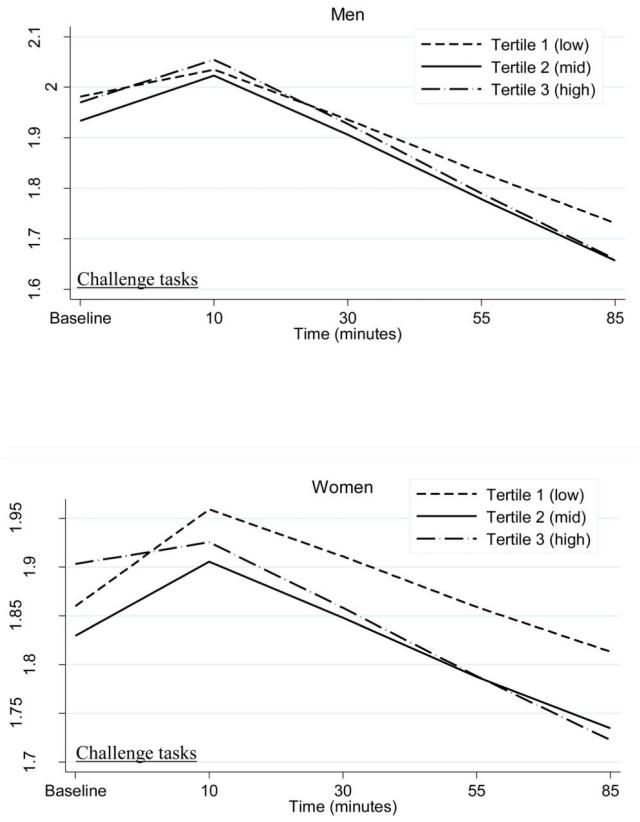

Figure 2.

Predicted cortisol reactivity to acute stressor over time among men and women by tertiles of neighborhood deprivation score.

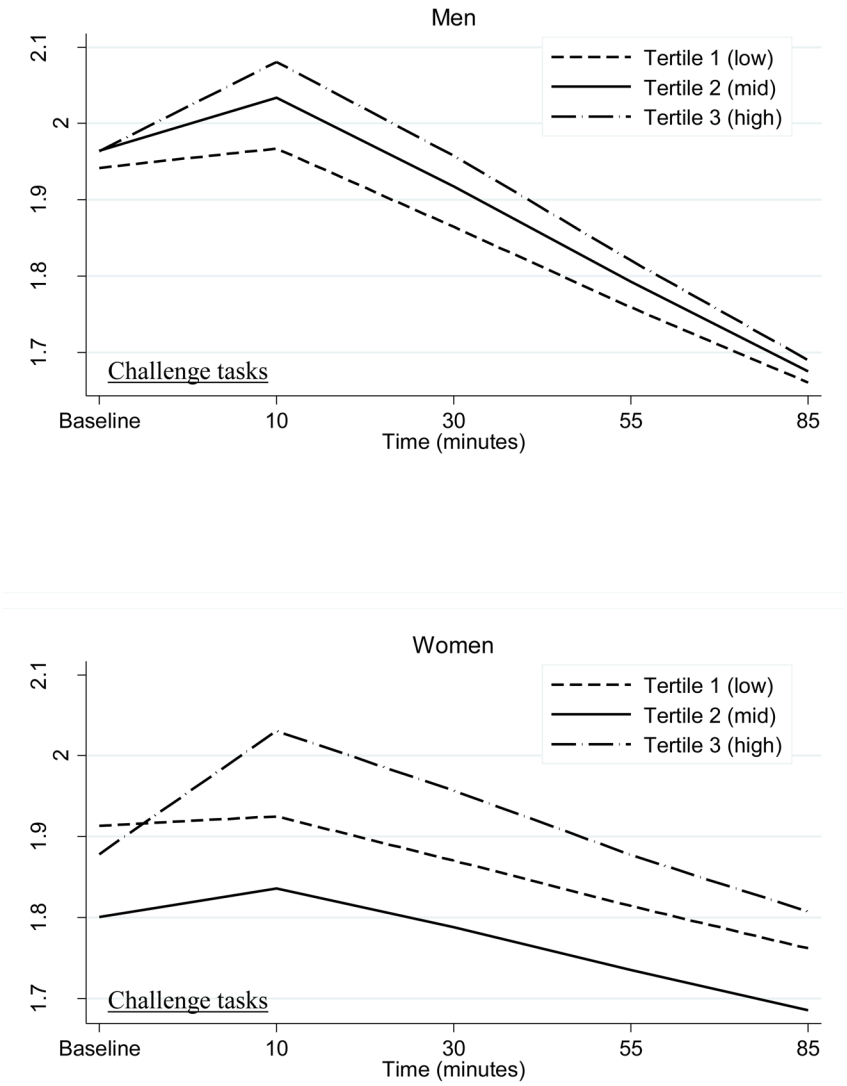

Figure 3.
Predicted cortisol reactivity to acute stressor over time among men and women by tertiles of social control score.

Table 1

Selected characteristics of Heart Scan participants by tertile of neighborhood socioeconomic deprivation score (n=514).

	Tertile of Neighborhood Deprivation Score[a]			P for Trend[b]
	1-Low (n=189)	2-Medium (n=176)	3-High (n=176)	
Afternoon visit (%)	60.6	60.7	56.6	0.10
Mean (SD) baseline cortisol, nmol/L	6.7 (4.8)	6.3 (3.8)	7.1 (5.0)	0.99
Mean (SD) task stress rating	4.0 (1.5)	4.3 (1.4)	4.1 (1.3)	0.19
Mean (SD) age, years	62.9 (5.7)	63.0 (5.9)	62.6 (5.6)	0.48
Female (%)	37.2	46.4	52.4	<0.0001
Employment status (%)				<0.0001
Low (grades 7 to 1)	48.9	38.7	32.5	
Intermediate (e.g. higher executive office)	39.4	41.1	39.2	
High (e.g. executive office)	11.7	20.2	28.3	
Household income (%)				<0.0001
<£20,000	12.2	22.0	28.9	
£20,000 to £39,999	43.9	39.3	35.6	
>£40,000	43.9	38.7	35.5	
Mean (SD) neighborhood residence, years	23.1 (12.1)	21.8 (14.1)	24.5 (14.9)	0.19
Mean (SD) perceived neighborhood factors				
Fear of crime[c]	2.5 (1.7)	2.8 (1.6)	2.9 (1.6)	<0.0001
	IQR: 1–3	IQR: 2–3	IQR: 2–3	
Social control[d]	12.1 (4.7)	12.0 (4.6)	10.9 (4.7)	<0.0001
	IQR: 10–15	IQR: 10–15	IQR: 8–14	

[a] Neighborhood socioeconomic deprivation based on the IMD 2007 income and employment deprivation rates within a lower super output area (LSOA)

[b] P values by non-parametric test for trend across ordered tertiles of neighborhood deprivation

[c] Fear of crime score range: 0–9

[d] Social control score range: 0–20

Table 2

Piecewise growth-curve models of log cortisol.

	Model 1			Model 2			Model 3			Model 4		
	Est[a]	SE	p[b]	Est[a]	SE	p[b]	Est[a]	SE	p[b]	Est[a]	SE	p[b]
Intercept (baseline)	1.65	0.23		1.60	0.24		1.67	0.24		1.68	0.24	
Reactivity (slope, per minute)	0.07	0.02	<0.0001	0.10	0.03	0.001	−0.04	0.04	0.28	−0.03	0.04	0.38
Recovery (slope, per minute)	−0.09	0.01	<0.0001	−0.09	0.01	<0.0001	−0.07	0.02	<0.0001	−0.06	0.02	<0.0001
Afternoon visit	−0.21	0.03	<0.0001	−0.20	0.04	<0.0001	−0.21	0.04	<0.0001	−0.21	0.04	<0.0001
Task stress rating	0.01	0.01	0.28	0.02	0.01	0.16	0.01	0.01	0.36	0.01	0.01	0.39
Age (years)	0.01	0.003	0.03	0.01	0.003	0.03	0.01	0.003	0.03	0.01	0.003	0.04
Female	−0.001	0.03	0.97	−0.003	0.04	0.93	−0.01	0.03	0.79	−0.002	0.03	0.95
Employment status [d]	0.03	0.12	0.005	0.03	0.01	0.01	0.03	0.01	0.02	0.03	0.01	0.007
Household income (£)	−0.01	0.03	0.62	−0.02	0.03	0.55	−0.01	0.03	0.74	−0.01	0.03	0.62
Neighborhood tenure (years)	0.001	0.001	0.27	0.002	0.001	0.23	0.001	0.001	0.41	0.001	0.001	0.35
Neighborhood deprivation (NDEP)[c]	−0.02	0.02	0.45							−0.02	0.02	0.48
NDEP x reactivity	−0.03	0.02	0.08							−0.03	0.02	0.08
NDEP x recovery	−0.004	0.01	0.60							−0.003	0.01	0.65
Fear of Crime (FOC)				0.01	0.01	0.54						
FOC x reactivity				−0.01	0.01	0.31						
FOC x recovery				0.00	0.004	0.94						
Social control							0.00	0.004	0.99	0.00	0.004	0.98
Social control x reactivity							0.01	0.003	0.003	0.01	0.003	0.006
Social control x recovery							−0.002	0.001	0.11	−0.002	0.001	0.99
Random- effects parameters												
Between neighborhood												
Variances												
Intercept	0.004			0.007			0.002			0.002		
Reactivity	0.02			0.03			0.02			0.02		
Recovery	0.002			0.002			0.002			0.002		
Covariances												
Intercept/reactivity	−0.01			−0.01			−0.01			−0.01		

	Model 1			Model 2			Model 3			Model 4		
	Est[a]	SE	p[b]	Est[a]	SE	p[b]	Est[a]	SE	p[b]	Est[a]	SE	p[b]
Intercept/recovery	0.0005			0.0009			−0.0002			−0.001		
Reactivity/recovery	−0.0006			−0.001			0.0004			0.0001		
Between Person												
Variances												
Intercept	0.16			0.16			0.16			0.16		
Reactivity	0.03			0.03			0.03			0.03		
Recovery	0.01			0.01			0.01			0.01		
Covariances												
Intercept/reactivity	0.004			0.009			0.002			0.001		
Intercept/recovery	−0.03			−0.03			−0.02			−0.03		
Reactivity/recovery	−0.002			−0.002			−0.001			−0.001		
	129			137			122			122		
AIC	0.82			5.27			8.67			7.36		

[a]Beta coefficients calculated using multilevel piecewise growth curve modeling assuming exchangeable correlation

[b]Wald test

[c]Neighborhood socioeconomic deprivation based on the IMD 2007 income and employment deprivation rates within a lower layer super output area (LSOA)

[d]Coded from low to high status