Socioeconomic Status and Blood Pressure Reactivity in Healthy Black Adolescents

Dawn K. Wilson, Wendy Kliwer, Laura Plybon, Domenic A. Sica

Abstract—Adolescents in low-socioeconomic-status environments are more susceptible to illnesses, such as hypertension and cardiovascular diseases. This study examined the influence of both neighborhood- and family-level socioeconomic status (SES) on blood pressure (BP) reactivity in a healthy sample of 76 black adolescents. It was hypothesized that a higher level of parental education and/or income would reduce the elevated BP reactivity associated with living in poorer neighborhoods. Census-derived data were obtained using each participant’s address. Neighborhood level of SES was based on percentage of households below the poverty line, female-headed households, owner-occupied housing, percentage vacant housing, and average number of persons per household. Family level of SES was based on self-reported level of parental education and annual family income. Adolescents participated in a competitive video game to establish their BP reactivity scores. As predicted, adolescents who lived in poorer neighborhoods had lower diastolic BPs if their parents were more (versus less) educated (P<0.05; 7±8 versus 13±6 mm Hg). Adolescents who lived in poorer neighborhoods also had significantly lower diastolic BP reactivity (P<0.05) if their family had a higher (versus lower) annual income (7±7 versus 12±8 mm Hg). These data are the first to demonstrate the buffering effect of family SES on the negative health consequences of living in low-SES neighborhoods in healthy black adolescents.

Key Words: cardiovascular reactivity ■ social economic status ■ education ■ adolescents

Neighborhoods affect individuals’ physical health, in part because communities vary in the prevalence and intensity of stressors and resources. Environmental stressors such as noise, overcrowding, and violence, or economic stressors such as chronic poverty, may abound in inner-city neighborhoods, which may in turn influence essential hypertension (EH) and related health outcomes in children and youth.1,2 Anderson et al3 have proposed a contextual model of EH and laboratory stressors. In contrast, Jackson and colleagues4 found that black adolescents living in higher-SES neighborhoods showed greater BP reactivity to mental stressors than black adolescents living in lower-SES neighborhoods. These disparate findings may reflect a lack of attention to the interaction of family-level resources with neighborhood SES. Youths who reside in neighborhoods that are more disadvantaged may be buffered from negative health effects because of family-level resources. Parental education and/or income, in particular, may protect children from the negative health consequences of living in low-SES neighborhoods. The purpose of the present study was to examine the influence of both neighborhood- and family-level SES on BP reactivity in a healthy sample of black adolescents. Specifically, it was predicted that a higher level of parental education and/or income would reduce the elevated BP reactivity associated with living in poorer neighborhoods in a sample of healthy black adolescents.

Methods

Subjects
The study protocol was approved by the institutional review boards of the Medical College of Virginia of Virginia Commonwealth University and the University of Tennessee, Memphis, and LeBonheur Children’s Medical Center. Written informed consent was obtained from the parents and the adolescents before participation.
The procedures followed were in accordance with institutional guidelines. Black adolescents, aged 13 to 16 years, were recruited from schools and churches and through local recreation centers. Each child participated in a health screening conducted by a trained nurse. The screening included a BP assessment, a urine specimen (to rule out hematuria, glucosuria, or proteinuria), and the measurement of height (in centimeters) and weight (in kilograms). Only normotensive adolescents who did not have preexisting cardiovascular or chronic disease and who were not currently taking medications (including oral contraceptives) were allowed to participate in the study. The definition of high BP in the present study was 136/86 mm Hg for 13- to 15-year-olds and 142/92 mm Hg for 16-year-olds. All participants were within 25% of ideal weight for their height. A total of 76 healthy adolescents participated in the study. There were 35 males and 41 females in the study sample. Table 1 provides demographic and baseline information for the entire sample.

### Procedures

Subjects arrived at the Clinical Research Center, where they participated in the health screening described above. Next, the parent and adolescent participants completed demographic questionnaires. Each participant’s casual BP was measured by a trained technician with a Dinamap BP apparatus (Critikon Inc), as outlined by the Second Task Force on Blood Pressure Control in Children. During the BP assessments, subjects were seated in a relaxed position with their legs uncrossed, and the proper cuff size was selected for each subject. For all participants, the BP cuff was placed on the nondominant arm throughout the BP testing. Before BP assessment, 1 BP measurement was used as the casual BP value for the data analyses.

### Demographic and Background Information

The parents provided information on family history of EH and related illnesses. Parents indicated in a yes/no format whether anyone in the child’s immediate family (father, mother, brother, sister, grandparents, uncles, and aunts) had hypertension, had died of a stroke or heart attack before the age of 50 years, or had died suddenly because of natural causes. To assess parental level of education, respondents indicated the highest level of education that the head of the household (the person who financially supported the family) had completed, as follows: 1, <eighth grade; 2, eighth grade; 3, some high school; 4, high school graduate; 5, some college; 6, college graduate; and 7, professional or graduate school. The parents also indicated their total annual family income on a scale ranging from 1 to 7: 1, <$10 000; 2, $10 000 to $19 999; 3, $20 000 to $29 999; 4, $30 000 to $39 999; 5, $40 000 to $49 999; 6, $50 000 to $59 999; and 7, >$60 000. Parents also provided information on whether they were currently married, separated/divorced, or widowed.

### Calculation of Neighborhood SES

Census-derived data were obtained by use of the participants’ address and corresponding census track. In this study population, 43 census tracks from the Memphis, Tenn, and Richmond, Va, metropolitan areas were represented. For the census track of each participant, the following data were included: the percentage of households below the poverty line, the percentage of female-headed households with children aged <18 years, the percentage of owner-occupied housing, the percentage of vacant housing, and the average number of persons per household. Median household income was not used because it correlated highly with the percentage of households below the poverty line and the percentage of female-headed households with children aged <18 years. The indicators selected in the present study are consistent with those used in other studies of neighborhood effects.

A cluster analysis procedure was used with the above 5 indicators to derive neighborhood SES types. The advantage of using a cluster approach rather than treating neighborhood factors individually is that the combined contextual effects of these factors may be captured more effectively. All 76 cases were used in the cluster analysis. A hierarchical agglomerative method (Ward’s method) with squared euclidean distance as the distance measure was used to cluster participants on the basis of the qualities of their neighborhood. SPSS-X (SPSS, Inc) was used for this analysis. Ward’s method is designed to optimize the minimum variance within the clusters. Based on inspection of the dendrogram and the coefficients in the agglomeration schedule, a 2-group solution was identified (low-versus high-SES neighborhoods).

### Calculation of Family SES

A median split on parental education was used to determine a low and a high category. The low parental education category consisted of response of 1 to 4, which reflected having obtained less than an eighth grade education through having finished high school. The

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low SES, Low EDU</th>
<th>Low SES, Hi EDU</th>
<th>Hi SES, Low EDU</th>
<th>Hi SES, Hi EDU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size, n</td>
<td>11</td>
<td>12</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>6/5</td>
<td>6/6</td>
<td>8/14</td>
<td>15/16</td>
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<tr>
<td>Parents married, %</td>
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<td>27</td>
<td>13</td>
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<tr>
<td>History EH+, %</td>
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<td>83</td>
<td>90</td>
<td>68</td>
</tr>
<tr>
<td>Parent education*</td>
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<td>6±1</td>
<td>4±1</td>
<td>6±1</td>
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<tr>
<td>Annual income*</td>
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<td>4±2</td>
<td>3±2</td>
<td>5±2</td>
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<tr>
<td>Height, cm</td>
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<td>161±7</td>
<td>165±8</td>
</tr>
<tr>
<td>Quetelet, kg/m²</td>
<td>21±3</td>
<td>21±2</td>
<td>22±3</td>
<td>22±3</td>
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<tr>
<td>SBP, mm Hg</td>
<td>99±7</td>
<td>99±13</td>
<td>102±10</td>
<td>104±10</td>
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<td>DBP, mm Hg</td>
<td>54±6</td>
<td>54±5</td>
<td>55±6</td>
<td>55±5</td>
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<tr>
<td>HR, bpm</td>
<td>75±9</td>
<td>78±14</td>
<td>76±11</td>
<td>75±10</td>
</tr>
</tbody>
</table>

Values are expressed as mean±SD unless otherwise specified. *P<0.001 (main effect for EDU).

Table 1. Baseline and Demographic Measures for the Entire Sample
TABLE 2. Census Track Descriptive Information for Neighborhood SES Classifications

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low-SES Neighborhood</th>
<th>High-SES Neighborhood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size, n</td>
<td>23</td>
<td>53</td>
</tr>
<tr>
<td>Vacant housing units,* %</td>
<td>14±4</td>
<td>6±2</td>
</tr>
<tr>
<td>Owner-occupied housing,* %</td>
<td>31±12</td>
<td>65±15</td>
</tr>
<tr>
<td>Average ≥3 persons in house</td>
<td>3±1</td>
<td>3±1</td>
</tr>
<tr>
<td>Households below poverty level,* %</td>
<td>36±18</td>
<td>11±6</td>
</tr>
<tr>
<td>Female-headed houses,* %</td>
<td>22±12</td>
<td>10±5</td>
</tr>
</tbody>
</table>

Values are expressed as mean±SD unless otherwise specified. *P<0.001.

high parental education category consisted of a response of 5 to 7, which reflected having obtained some college education through having a profession or a graduate degree. A median split on annual family income was determined to derive a low and high category. The low annual income category consisted of a response of 1 to 3, which reflected an income of <$30 000 per year. The high annual income category consisted of a response of 4 to 7, which reflected an income of ≥$30 000 per year.

BP Reactivity Testing
The competitive video game procedure has been previously described in detail.15–17 Each participant was seated in front of a 25-inch color television monitor. Next, 4 resting SBP, DBP, and HR readings were taken by a trained technician. The television monitor was turned on and the subject was given standard instructions for the Atari game “Breakout.” Each participant was provided with a brief practice session to allow familiarization with the game. In game 1 (personal challenge), participants were told to see how well they could do. In game 2 (experimenter challenge), they were told they did pretty well in game 1 but to try harder this time. In game 3 (monetary incentive), they were told they could earn some money if they beat their higher score obtained in games 1 and 2. Participants were not told how much money they could earn, but were paid 5 cents to 5 dollars, depending on their performance. During each game, 1 measurement each of SBP, DBP, and HR was taken 30 seconds after the participant began playing the game. A 5-minute recovery followed the video game task; however, no other rest period was provided for the participants during the entire reactivity task. Average resting and stress BP and HR values were calculated across the 3 games. BP and HR reactivity scores were determined by calculating baseline-stress change scores.

Results
Subject Characteristics
Table 1 presents demographic and baseline characteristics for the sample. There were no significant group differences on demographic or baseline measures. As expected, there were significant effects for both education and annual income of family-level SES variables (P<0.001 for both).

Neighborhood SES Census Data
Table 2 displays the means for each SES neighborhood group (high versus low) on the 5 variables composing the analysis. As seen in Table 2, the low-SES neighborhood group had an average of 3 times as many households living below the poverty line, more than twice the percentage of female-headed households with minor children, half as many owner-occupied housing units, and nearly 3 times the number of vacant housing units relative to the high-SES neighborhood group. The average number of persons per household was not significantly different across the 2 neighborhood types.

To provide evidence for the validity of the cluster solution, the clusters were compared on variables not used to create the clusters, as recommended by Aldenderfer and Blashfield.14 These variables included median household income (census level) and annual family income (household level). The census-level household incomes of participants living in the lower-SES neighborhoods were roughly half those of participants living in the higher-SES neighborhoods ($28 175±$7185 versus $14 763±$5069, P<0.001). Annual family income (household level) was also significantly lower in the lower- (versus higher-) SES neighborhood (P<0.05). Fifty-nine percent of families in the lower-SES neighborhoods versus 37% of families in higher-SES neighborhoods had annual incomes of <$30 000 (P<0.05).

Cardiovascular Reactivity Measures
A series of ANCOVAs, controlling for Quetelet Index and family history of EH, were performed to determine the impact of neighborhood SES and parental education on BP reactivity. The independent variables were neighborhood SES (high versus low) and parental education level (high versus low). The 2×2 ANCOVA indicated a significant interaction effect for DBP reactivity (P<0.05; Figure 1). As predicted, adolescents who lived in lower-SES neighborhoods had lower DBP reactivity if their parents were more (versus less) educated. There were no significant effects for SBP reactivity (low SES, low education (EDU): 14±9 mm Hg; low SES, high EDU: 9±7 mm Hg; high SES, low EDU: 9±8 mm Hg; high SES, high EDU: 11±7 mm Hg) or HR reactivity (low SES, low EDU: 10±9 bpm; low SES, high EDU: 4±10 bpm; high SES, low EDU: 3±7 bpm; high SES, high EDU: 5±8 bpm).

A series of ANCOVAs controlling for Quetelet Index and family history of EH were also performed to determine the impact of neighborhood SES and annual family income on BP reactivity. The independent variables were neighborhood SES (high versus low) and annual family income (high versus low). The 2×2 ANCOVA indicated a significant interaction effect for DBP reactivity (P<0.05; Figure 2). Adolescents who lived lower-SES neighborhoods had significantly lower DBP reactivity if their family had a higher (versus lower) family income. There were no significant effects for SBP reactivity (low SES, low income (INC): 11±9 mm Hg; low SES, high INC: 11±9 mm Hg; high SES, low INC: 11±9 mm Hg; high SES, high INC: 11±9 mm Hg).
Figure 2. DBP reactivity change scores separated by level of neighborhood SES and annual family income.

9±9 mm Hg; high SES, high INC: 11±6 mm Hg) or HR reactivity (low SES, low INC: 8±9 bpm; low SES, high INC: 7±12 bpm; high SES, low INC: 1±8 bpm; high SES, high INC: 6±7 bpm).

Discussion

The present study demonstrates that adolescents in lower-SES neighborhoods had lower DBP reactivity if their parents had a higher education level (at least some college) rather than lower educational level (high school graduate or less). Adolescents who lived in lower-SES neighborhoods also had lower DBP reactivity if their annual family income was higher (≥$30 000) rather than lower (<$30 000). These data are the first to demonstrate the protective effect of family SES factors on the negative health consequences (elevated BP reactivity) of living in low-SES neighborhoods in a sample of healthy black adolescents.

The findings in the present study are consistent with other studies which have demonstrated that higher parental education is associated with better mental health outcomes in children and higher levels of family support. Kliwer and colleagues\(^\text{18}\) examined the influence of maternal education on psychological symptoms among 99 families from low-income, high-violence areas in Richmond, Va. Their study demonstrated that higher (versus lower) maternal education was associated with lower levels of depression and anxiety and a greater feeling of availability to talk with parents about stressful life events. Kliwer and Kung\(^\text{19}\) also reported that higher maternal education was associated with greater levels of family cohesion (ie, support, emotional availability). Additional studies\(^\text{20,21}\) provide evidence for the direct effects of low parental education on behavioral problems in children. Overall, these studies suggest that parents with higher education levels, as in the present study, may have provided their children with encouragement that helped them to better cope with the stresses associated with living in lower-SES neighborhoods.

Another potential explanation for the protective effect of family SES factors on the negative health consequences of living in low-SES neighborhoods may be in part due to greater health awareness and positive health behaviors among the families of higher educated parents. Consistent with this interpretation, previous studies have demonstrated that higher family-level SES was associated with more positive health behaviors, such as improved diet,\(^\text{22}\) better fitness, and lower prevalence of tobacco smoking among adolescents.\(^\text{2}\) Further research is needed to determine whether this association between family-level SES and positive health behaviors mediates BP reactivity in children who live in lower-SES neighborhoods.

The present study also indicates that adolescents in low-SES neighborhoods with fewer (versus more) family SES resources had higher levels of DBP reactivity. These findings are consistent with other studies which have shown that children are adversely affected by chronic environmental stressors.\(^\text{23}\) Anderson et al\(^\text{1}\) have proposed a contextual model for investigating stress-induced BP reactivity in blacks. The model suggests that the exaggerated peripheral vascular reactivity observed in many blacks is a function of a wider array of chronic stressors than those seen in their white counterparts. These chronic stressors (such as low-SES neighborhoods) interact with biological, behavioral, and psychological risk factors to increase sympathetic nervous system activity. Over time, the repeated stressor-induced episodes of vascular reactivity may lead to structural changes in the vascular wall, and subsequent development of EH. In support of this model, previous research has demonstrated that chronic social and environmental stressors (eg, low SES) are associated with an increased rate of EH among blacks.\(^\text{24,25}\) Research from animal and human laboratory studies has also demonstrated that exposure to uncontrollable stress may augment resting sympathetic nervous system tone; enhance sympathetic reactivity to acute, novel stressors; and elevate plasma levels of catecholamines.\(^\text{26–30}\) Taken together, the above studies suggest that adolescents in lower-SES neighborhoods with few family SES resources may be at particularly high risk for developing EH and other cardiovascular complications in early adulthood.

In the present study the observation that the effects of neighborhood- and family-level SES variables were more reliable for DBP than SBP reactivity may not be surprising. Previous studies have demonstrated that elevated vascular reactivity (ie, DBP reactivity and vascular resistance) is more prevalent among blacks than whites.\(^\text{3,31–34}\) Furthermore, it has been demonstrated that total peripheral resistance and norepinephrine responses to stress are greater in offspring of hypertensive than normotensive individuals.\(^\text{35,36}\) These studies suggest that the presence of preclinical changes in vascular reactivity are most likely linked to heightened sympathetic nervous system activity. Although the present study did not assess plasma hormones, adolescents in low-SES neighborhoods may have elevated DBP reactivity in response to heightened sympathetic nervous system activation and elevated peripheral resistance.

There are several limitations to the present study. First, the study is based on cross-sectional data rather than longitudinal data. Thus, no direct causal interpretations can be made. Further research is needed to determine the causal relationships between neighborhood SES, family SES, and BP reactivity. A second limitation of the present study is the small sample size used, which limits the generalizability of the study. Although these data represent only 2 inner-city locations in the southern United States, further research is...
needed to see whether other similar demographic locations would reproduce similar findings.

In conclusion, this study is the first to demonstrate the buffering effect of family SES factors on the negative health consequences (elevated BP reactivity) of living in low-SES neighborhoods in a sample of healthy black adolescents. Early environmental life experiences impact BP reactivity in normotensive black adolescents and may be critical determinants for the expression of the hypertension phenotype. Because of the long-term health implications of chronic environmental stressors, understanding how community and family factors may affect children’s BP responses should be a major focus of future research.

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References

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