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Are Socioeconomic Status, School Environment, Body Mass Index, and Blood Pressure Related in an Ethnically Diverse Sample of Adolescents? A Multilevel Approach

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This study investigated how individual-level health behaviors as well as school-level socioeconomic status (SES) and school climate impact adolescent health outcomes. Most of the research supporting an association between adolescent health and social contextual factors has been conducted at the neighborhood-level. However, schools are also influential contexts in adolescents' lives and their consideration in studies of adolescent health outcomes is warranted. The present research expands upon the existing literature in the area of school contextual effects on health, as it addresses these issues in an ethnically diverse sample of 84,165 adolescents using multilevel techniques to properly account for the nested nature of these data. Student-level demographic and health behavior data were collected from 10^{th}-grade students attending traditional public senior high schools in Miami-Dade County during school-based blood pressure (BP) screenings for six academic years, beginning in 1999-2000 and ending in 2004-05. School-level demographic, achievement, and climate data were derived from a publicly available database of Florida School Indicators. Separate hierarchical linear models for boys and

girls were used to investigate the contribution of school-cohort effects to the overall variance in adolescents' BMI, systolic BP (SBP), and diastolic BP (DBP).

In support of study hypotheses, it was found that several school-level environmental factors, including student-teacher ratio, SES, and safety of the school, were associated with BMI and SBP, particularly in girls. As predicted, lower school-level SES was associated with increased BMI in both boys and girls, such that boys in lower-SES school cohorts have higher average BMIs by 0.010 kg/m^2, while girls in such school cohorts have higher average BMIs by 0.014 kg/m^2, adjusting for student-teacher ratio, total student enrollment, and additional school cohort-level variables. However, this relationship was not found for either blood pressure outcome. As hypothesized, student-teacher ratio, a proxy for neighborhood overcrowding, was directly associated with BMI for both boys ($\gamma = 0.046$, $p < 0.01$) and girls ($\gamma = 0.049$, $p < 0.01$). However, this relationship was again not found for SBP or DBP. As predicted, FCAT passing rate, a measure of school achievement, was inversely associated with BMI, but only in girls ($\gamma = -0.015$, $p < 0.01$), while school safety rating was inversely associated with SBP, again only in girls ($\gamma = -0.719$, $p < 0.01$). Other positive school indicators were not significantly associated with any of the study outcomes. None of the school cohort-level factors were associated with DBP for either gender. In support of Hypothesis 3, more school cohort-level factors appear to influence girls' health outcomes compared to those of boys, but differences in the effects of these predictors did not reach statistical significance.

A number of student-level factors, including age, ethnicity, and health behaviors, were associated with the 3 study outcomes, BMI, SBP, and DBP as well. Findings suggest that, in addition to an adolescent's health behaviors, where the adolescent attends school is relevant in terms of health outcomes and cardiovascular risk. Poor weight status and elevated blood pressure may result, in part, from school contextual influences beyond the adolescent's control and not solely individual action. Thus, policy changes to impact school environments on a larger scale, rather than focusing on individual behavior change, may help students more effectively maintain healthy weights and blood pressures. As the present study found associations between adversity at the school level and health outcomes, future work may include identifying those adolescents at highest risk of poor health outcomes as a result of school environment.

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Chapter 1: Review and Related Literature

The rates of obesity, cardiovascular disease (CVD), and associated chronic conditions in America have reached unprecedented heights largely due to unhealthy lifestyle factors, such as poor diet and physical inactivity. Chronic illness and, accordingly, these modifiable risk factors, are responsible for the majority of deaths worldwide (World Health Organization (WHO), 2005). Epidemiological data reveal that the prevalence of adult obesity has doubled, while the prevalence of obesity in youth 6 – 19 years of age has tripled since 1980 (Ogden et al., 2006). Overweight and obesity in adolescence has been found to track into adulthood, contributing to the burden of chronic disease later in life (Gordon-Larsen, The, & Adair, 2010; Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008). Consequently, even children and adolescents exhibit markers of increased CVD risk, including hypertension and other components of the metabolic syndrome (Srinivasan, Bao, Wattigney, & Berenson, 1996). Similarly, health habits established during adolescence are often carried into adulthood, indicating a need to intervene early in life to prevent premature morbidity and mortality (Gordon-Larsen, Nelson, & Popkin, 2004; Mikkilä, Räsänen, Raitakari, Pietinen, & Viikari, 2005). Furthermore, some subgroups of the population are at higher risk of early mortality and, thus, may benefit more from early intervention.

Many studies point to a greater burden of early mortality, CVD, and associated risk factors among low-socioeconomic status (SES) and ethnic minority adults (Kaplan & Keil, 1993). In the U.S., ethnic minority status and SES are inextricably linked in most studies of SES and health, as poverty is disproportionately prevalent in African-American and Hispanic populations (U.S. Census Bureau, 2010). Across a variety of physical health conditions, individuals of lower SES, whether SES is operationalized as years of education, level of income, or professional prestige, appear to have elevated risk of adverse outcomes (Adler et al., 1994; Schreier & Chen, 2013).

The interplay of environmental and psychosocial factors associated with low SES is thought to give rise to this relationship through several pathways. Low SES has been related to greater exposure to chronic, uncontrollable stressors, including noise, overcrowding, crime/violence, which may lead to altered physiological responses to stress and, in turn, poorer health status. Alternatively, as suggested by the reserve capacity model, higher SES may confer additional protective resources, such as perceived control over life's stressors and social support, which buffer the effects of stress in these individuals (Gallo & Matthews, 2003). The pathway from lower SES to adverse health outcomes could also be behavioral, as individuals living in unsafe areas or without easy access to healthy foods may be less physically active and eat poorer diets (Diez Roux & Mair, 2010). Either pathway is consistent with the Social Ecological model of health behavior, which emphasizes that health behaviors (and thus, outcomes) are influenced by factors at multiple levels (e.g., intrapersonal, interpersonal, community, governmental) and thus, multi-level interventions will be most successful in changing behavior (Sallis, Owen, & Fisher, 2008).

The present study expands upon existing literature linking social contexts and health in youth by examining relationships between school-level SES and environmental factors and body mass index (BMI) and blood pressure (BP), controlling for individual-level health behaviors. Specifically, this study will use hierarchical linear modeling (HLM) to: 1) examine whether school-level SES is associated with adolescent BMI and

BP, 2) examine whether school contextual factors, such as student-teacher ratio and school safety, are associated with adolescent BMI and BP, and 3) determine whether girls are more adversely impacted by lower SES and more stressful environments than boys. Considering existing evidence that environmental contexts may differentially impact girls and boys, analyses were done separately for boys and girls.

The literature review below will discuss previous research linking childhood SES and physical health outcomes, as well as how to best measure SES and utilize this construct in studies of health. To date, much of the research supporting an association between adolescent health and social contextual factors has been conducted at the neighborhood-level and is reviewed below. However, schools are also influential contexts in adolescents' lives and should be considered in studies of adolescent health outcomes. The few studies addressing school influences on adolescent health are reviewed below, as well as gaps in the current literature. Finally, studies examining gender differences in relationships between SES and health outcomes will also be addressed.

Associations between Childhood SES and Physical Health

Not only are the mechanisms through which SES impacts health debated, but the relevance of the timing of exposure to low SES is controversial as well. Much of the research to date has been conducted within the context of an accumulation model, in which the impact of exposure to low SES and its associated stressors is additive over time, regardless of the point at which exposure occurred (Matthews & Gallo, 2011). Recently, however, a "critical period" model has also been postulated, suggesting that the experience of low SES early in life places individuals at particularly elevated risk of poor physical health later in life (Cohen, Janicki-Deverts, Chen, & Matthews, 2010). Evans and Kim (2007) suggest that early exposure to cumulative environmental stressors associated with poverty may chronically dysregulate hypothalamic-pituitary-adrenal (HPA) axis activity, compromising the body's adaptive response to future stressors. In the short term, the HPA axis and nervous, cardiovascular, endocrine, and immune systems work together to protect the body from the detrimental effects of stress. However, prolonged dysregulation of this response creates "wear and tear" on many organ systems, known as allostatic load (McEwen, 1998). This accumulation of physiological strain in lower SES groups is of concern, as Lupien, King, Meaney, and McEwen (2000) found that the stress hormone levels of lower SES children are elevated relative to that of their higher SES peers as early as 6 years of age.

Furthermore, while low SES has also been associated with health outcomes during childhood and adolescence, the evidence for detrimental effects of low SES across health outcomes in youth is mixed (Chen, Matthews, & Boyce, 2002). In youth, SES is often operationalized as parental education, household income, or parental occupational status. Lower SES youth have higher all-cause mortality, greater likelihood of death from chronic conditions, lower parental rating of health status, and more functional impairment due to illness (Montgomery, Kiely, & Pappas, 1996; Pamuk, Makuc, Heck, Reuben, & Lochner, 1998). Also, as family income decreases, children's prevalence of both acute and chronic conditions, visits to the emergency rooms to treat these conditions, and missed days of school due to illness increase (Egbuonu & Starfield, 1982).

More specifically, the relationship between low SES and cardiovascular risk factors has also been studied in youth. First, lower SES appears to be related to increased rates of smoking in youth, as well as greater risk of second-hand smoke exposure (Chen, Matthews, & Boyce, 2002; Harrell, Bangdiwala, Deng, Webb, & Bradley, 1998). Additionally, elevated blood pressure (BP) in childhood has been linked to high BP in adulthood, with lower childhood individual-level SES associated with elevations in BP in both childhood and adulthood (Kivimäki et al., 2006; Poulton et al., 2002). This traditional SES effect on BP is observed in children under 13 years of age, but appears to diminish in adolescence (Chen, Matthews, & Boyce, 2002). Some studies found an inverse association between BP and individual SES (Kivimäki et al., 2006; Whincup, Cook, Papacosta, Walker, & Perry, 1994; Wright, Treiber, Davis, Bunch, & Strong, 1998), but others have found no or very weak associations (Chen & Paterson, 2006; Cornoni-Huntley, Harlan, & Leaverton, 1979; Hunter, Frerichs, Webber, & Berenson, 1979; McGrath, Matthews, & Brady, 2006), supporting what Chen, Matthews, and Boyce (2002) call a "childhood-limited pattern." This pattern might be explained by the homogeneity of the school environment, which is more greatly emphasized during adolescence, such that the BP difference across SES groups observed during childhood disappears. McGrath et al. (2006) suggest that neighborhood-level measures of SES may be of particular importance during adolescence, as neighborhood SES was inversely associated with systolic BP.

Lowry, Kann, Collins, and Kolbe (1996) found that lower SES was associated with several health risk behaviors in adolescents, including physical inactivity. In Lowry et al.'s representative sample of U.S. adolescents from the 1992 Youth Risk Behavior Survey (YRBS), youth aged 12 -17 were less likely to have a sedentary lifestyle as both their family's income and educational level increased. McMurray et al. (2000) found that lower SES adolescents had higher rates of overweight or obesity, while also spending more hours watching television or playing video games than their higher SES peers. The U.S. Surgeon General's Report on Physical Activity and Health agreed that the prevalence of sedentary behavior increases with decreasing SES (USDHHS, 1996). Furthermore, Hanson and Chen (2007b) found that frequency of sedentary behavior mediated an association between lower SES and higher body mass index (BMI) in a racially diverse sample of high school students. In this sample, lower SES students reported less physical activity and spent more time in sedentary pursuits than higher SES students.

Finally, as in adults, the relationship between SES and overweight and obesity has been widely studied in youth. Children and adolescents 6 to 17 years of age from low-income families have higher rates of obesity and central obesity, in addition to sedentary behavior and tobacco exposure as reviewed above, than those from families above the poverty line (Ali et al., 2011). However, another study has suggested that the prevalence of adolescent overweight differs by family poverty only in older adolescents aged 15 – 17 years (Miech et al., 2006). Increases in both family income and education level of the head of household have been associated with decreased prevalence of childhood obesity in the U.S., but these associations are somewhat inconsistent across ethnic groups (Ogden, Lamb, Carroll, & Flegal, 2010). Interestingly, since the late 1980's, rates of childhood obesity have increased at all levels of household income and education.

In a review of the pediatric literature since 1990, Shrewsbury and Wardle (2008) reported that predominantly inverse associations between parental social class and childhood adiposity have been found in studies conducted in developed countries. When parental education was used to measure SES, Shrewsbury and Wardle (2008) found inverse SES-adiposity associations in 75% of the studies reviewed, suggesting differential influences of various measures of SES. Of note, even after controlling for adulthood SES, inverse associations between adult BMI and childhood SES have been found to remain (Poulton et al., 2002). Additionally, Goodman, Slap, and Huang (2003) analyzed data from the large National Longitudinal Study of Adolescent Health (Add Health) to determine the population-level impact of SES on adolescent obesity and also found a graded relationship between individual SES and obesity. Goodman et al. (2003) also determined that lower family income and education level accounted for a large proportion of the population-level burden of obesity. Importantly, Chen and Paterson (2006) published one of the first studies to examine the influence of neighborhood-level SES on adolescent physical health outcomes, including obesity. Some neighborhood-level measures of SES were found to predict adolescent BMI above and beyond family-level measures. However, both individual- and neighborhood-level SES were found to influence adolescent obesity. Potential mechanisms for this dual influence are worthy of exploration.

Wang and Zhang's (2006) analysis of data from the National Health and Nutrition Examination Survey (NHANES), however, suggests that not all low-SES youth are at greater risk of obesity, as there are significant group differences due to interactions between SES, race/ethnicity, gender, and age. In this study, the traditional inverse SES effect appeared in white children and white adolescent girls, but was not consistently observed in Black children and adolescents.

In conclusion, inverse associations between SES and health habits and outcomes have been predominantly found in the literature; however, findings relating SES and BP have been mixed. Also, fewer studies have investigated the effects of neighborhood-level (or other social context-level) SES on health, both in addition to and apart from individual-level SES. Taken together, these findings indicate a need to examine the independent influences of individual-level and neighborhood-level SES on adolescent health outcomes, including BP, physical inactivity, and obesity. It appears that sociodemographic variables, such as gender and race/ethnicity, may also influence relationships between SES and health outcomes.

Measuring SES and Modeling SES-Health Relationships

Socioeconomic status (SES) is a complex, multidimensional construct, which can be cumbersome, yet very important, to use in studies of health and well-being. The term "socioeconomic status" itself refers only to one component of this construct, as only "prestige-based measures" of SES represent an individual's status in a social hierarchy (Krieger, Williams, & Moss, 1997). Such prestige-based indicators include educational attainment, employment status, and occupational group. These are commonly used as indices of SES, but resource-based measures, or a combination of these, may be a more accurate representation of one's social class. Resource-based measures include income, material goods, home or car ownership, and assets. In youth, individual- or family-level SES is often operationalized as years of parental education, household income, or parental occupational status.

Chen and Paterson (2006) found that neighborhood-level prestige-based measures of SES predicted adolescent BMI above and beyond family prestige-related SES measures, such as education and occupation. However, measures of family resources, such as income and assets, did contribute to BMI beyond the influence of neighborhood resources, implying that both individual and neighborhood-level factors influence adolescent obesity.

However, in both adults and youth, a number of neighborhood-level socioeconomic factors may contribute to an individual's health status and thus, have been used in research studies of health. Such neighborhood-level measures of SES are often obtained from U.S. Census data or other large, publicly available datasets. These variables may include the percentage of residents below the poverty threshold, median household income, the average number of people living in a household, the percentage of residents who rent versus own their homes, as well as rates of unemployment, single parenthood, or use of public assistance. Further, poverty and its associated neighborhood-level effects may not provide a full picture of the chronically stressful environment experienced by youth living in poor neighborhoods or attending poor schools. As such, researchers should consider other variables such as level of noise, availability of fresh produce, and crime rates at the neighborhood level. At the school level, such variables may include safety ratings of the school, poor academic achievement, overcrowding of classrooms, availability of educational resources, percentage of students receiving free or reduced-price lunch, and percentage of students rating the school's climate as positive and conducive to learning.

The use of multiple measures of SES may be problematic, as investigators may over-control at the individual level in multilevel analyses and multiple measures of SES at either level of analysis may be highly collinear (Sellström & Bremberg, 2006b).

Additionally, because SES is such a complex construct, using only one measure of SES likely taps into only one dimension of SES, which leads to the loss of important information about SES-health pathways.

Individual-level health outcomes and behaviors are determined by both individual-level and environmental factors and thus, both should be taken into account (VonKorff, Koepsell, Curry, & Diehr, 1992). Multilevel techniques, such as HLM, allow researchers to elucidate both student and school effects on student outcomes (Saab & Klinger, 2010). Student-level indicators are modeled at level 1 and school-level characteristics, or those of another social context, are modeled at level 2. Another important feature of multilevel methods is the modeling of cross-level interactions, which can offer useful information about how social contexts may differentially influence individual outcomes (Sellström & Bremberg, 2006a). Modeling health behaviors within a multilevel framework may be particularly beneficial, as epidemiological studies of health are intended to be studies of health at the group level. However, behaviors and the experience of stress are often viewed as individual phenomena. Thus, the resulting poor health outcomes are often attributed to individual responsibility, when they are, in reality, heavily influenced by context (Diez Roux, 1998; Sellström & Bremberg, 2006b; Torsheim & Wold, 2001).

Neighborhoods and Health

Like low SES, neighborhoods and other social contexts may also affect adolescents' health through limitation or enrichment of opportunities to engage in healthy behaviors, as well as through increased exposure to stressors (Diez Roux & Mair, 2010). Lower SES neighborhoods may have less availability of healthy foods, fewer safe places to exercise and may also expose residents to more environmental risks, such as air pollution, toxins, noise, poor housing quality, overcrowding, and violence (Lovasi, Hutson, Guerra, & Neckerman, 2009). In adult samples, beneficial effects of the greater availability of supermarkets in higher SES neighborhoods on weight status have not been consistently demonstrated (Morland, Diez Roux, & Wing, 2006; Wang, Kim, Gonzalez, MacLeod, & Winkleby, 2007). One of the few studies on the food environment and adolescents' weight status showed that BMI and prevalence of overweight in a neighborhood decreased as availability of supermarkets increased (Powell, Auld, Chaloupka, O'Malley, & Johnston, 2007).

In accordance with social ecological theory, environmental characteristics of a neighborhood also impact physical activity levels of its residents. For instance, in a multilevel study of Chicago neighborhoods, Molnar, Gortmaker, Bull, and Buka (2004) found that lower perceived safety of the neighborhood and greater "social disorder" were associated with less leisure-time physical activity in youth aged 11-16 years, controlling for demographics, including individual-level SES. Gordon-Larsen, McMurray, and Popkin (2000) also found that living in a neighborhood with high levels of crime decreases the likelihood that an adolescent participates in moderate-to-vigorous physical activity five or more times per week.

An association between physical activity and the neighborhood context has not been reliably found. Lee and Cubbin (2002) examined whether neighborhood characteristics are associated with adolescents' cardiovascular health behaviors independent of their family's SES. Neighborhood context variables included measures of both socioeconomic status and social disorganization. Measures of SES collected included median family income, proportion of residents below poverty level, proportion of residents who did not earn a high school diploma, housing value, household density, and proportion of residents employed in blue-collar occupations. Indicators of social disorganization included rates of mobility, unemployment, and divorce, as well as the proportion of female-headed households and proportion of residents who rent their homes. Data on the racial/ethnic minority composition and urbanicity of the neighborhoods were collected as well. The authors found that low neighborhood-level SES (i.e., low income, high poverty, low education, low housing values, and more blue-collar workers) and greater social disorganization (i.e., higher mobility and more female-headed poor households) were associated with poorer dietary habits, but not physical activity, independent of individual-level SES or other demographics.

Evidence suggests that living in a lower SES neighborhood with high levels of crime and social disorganization may constitute a model of chronic stress. Living in an underprivileged neighborhood has been associated with higher levels of allostatic load in adults, regardless of one's individual SES (Bird et al., 2010). To investigate the neighborhood effects on physiological stress in adolescents, Theall, Drury, and Shirtcliff (2012) used multilevel modeling to examine the cumulative impact of stressful experiences in the social context, termed "cumulative risk," on allostatic load in a nationally representative sample of adolescents from the NHANES study. A summary score based on levels of biomarkers collected in NHANES, such as waist circumference, C-reactive protein, lipid concentrations, fasting glucose, and presence of hypertension, was used to quantify allostatic load. Sociodemographic data and information about adolescents' dietary and physical activity habits were collected to aid in identifying potential moderators of the neighborhood-allostatic load relationship. Individual-level (or, household-level) measures of SES were taken, including poverty-to-income ratio, parental education level, parental marital status, time spent living in the neighborhood, and household density. Neighborhood-level measures of SES, such as proportion of residents living below the poverty level, proportion of female-headed households, and proportion of adults with at least a college education, were derived from the 2000 U.S. Census.

Theall et al. (2012) operationalized “cumulative neighborhood risk” using some of the neighborhood-level indicators of SES, as well as other neighborhood characteristics, such as total crime risk, density of liquor stores and alcohol-serving businesses, low grocery store density, number of unhealthy fast-food outlets, and low density of gyms and related facilities. Results indicated that male and older adolescents, ethnic minority youth, adolescents who did not meet physical activity recommendations, and those living below poverty level exhibited greater allostatic load. Clustering of allostatic load appeared at both the household and neighborhood levels, such that individuals residing in the same neighborhood are more likely to have similar degrees of allostatic load compared to those living in a different neighborhood. Expanding upon previous results reported in adults, Theall et al. (2012) found that higher levels of “cumulative neighborhood risk” were associated with a higher degree of allostatic load in adolescents, above and beyond exposure to household-level stressors. In fact, neighborhood-level SES has been found to predict health outcomes above and beyond individual-level SES (Pickett & Pearl, 2001).

Attributes of a neighborhood may be linked to other social systems within it, such as schools, via Mayer and Jencks' (1989) "contagion model of neighborhood effects." This theory posits that a neighborhood's socioeconomic environment may determine the type of social and behavioral norms that are shared between peer groups living in the neighborhood (Saab & Klinger, 2010). By virtue of the shared struggles of living in lower SES neighborhoods, individuals from the same underprivileged area may experience a similar degree of stress, which in turn, predisposes them to adverse behavioral and physiological consequences. Overall, studies point to neighborhood characteristics influencing individual health behaviors and some health outcomes, including BMI and BP. However, studies tend to disagree on the most crucial neighborhood-level variables to consider and which health behaviors are most greatly impacted by neighborhood context.

School Influences on Adolescent Health

Youth's exposure to stressful environments extends beyond the home, to their neighborhood and their school, where they spend a great deal of time. Thus, studies of youth's stress exposure may be well served by incorporating both school- or neighborhood-level variables, in addition to parental SES and the family environment. In fact, for adolescents, schools may function as the most important social context in which these youth participate.

Adolescents spend a significant proportion of their time at school and may even attend a school outside of their neighborhood social context. Thus, it is important to consider the major role of the school in shaping adolescents' behaviors, habits, and social networks. In fact, peer influences on adolescent behavior, including health habits and health-risk behaviors, may be greater than that of families during adolescence (Biddle, Bank, & Marlin, 1980; Prinstein, Boergers, & Spirito, 2001; Wilks, 1986). Prior evidence supports that there are significant peer effects on adolescent BMI, particularly in adolescent girls and youth that are overweight or obese (Trogdon, Nonnemaker, & Pais, 2008). Several mechanisms explaining this effect have been suggested, one of which is that students' dietary and activity patterns, and thus, their BMI may mirror those of their peers. In fact, Leatherdale and Papadakis (2011) found that a ninth- or tenth-grade student's odds of being overweight or obese increased with every 1% increase in school-level prevalence of overweight and obesity in eleventh- and twelfth-grade students.

Relatively few studies have investigated how school contextual factors influence adolescent health behaviors and specific health outcomes, such as BMI and BP. In one study of obesity-related health behaviors, Maes and Lievens (2003) used multilevel modeling to examine aspects of the school context that may influence adolescent health and risk behaviors. Several school-level variables were available for inclusion in statistical models, including school size, class size, quality of relationships between teachers and pupils or other teachers, health education awareness and concern, and school policy-related variables. Potential outcome variables included smoking habits, alcohol consumption, "healthy nutrition behavior" (daily consumption of fruit, vegetables, whole grains, and skim or low-fat milk), "unhealthy nutrition behavior" (daily consumption of soft drinks, sweets, peanuts, potato chips, hamburgers, or hot dogs), weekly hours of vigorous physical activity, and medication use for common ailments.

Ultimately, healthy nutrition behavior and physical activity did not vary enough between schools to justify the use of multilevel modeling in the Maes and Lievens (2003) study. The gender of the school administrator, the gender ratio of teachers in the school, and teacher workload were all found to significantly predict habitual alcohol consumption, tooth brushing, and smoking behavior, but the authors suspect these may be spurious associations. Instead, they suggest that student SES may better explain differences in student health behaviors between schools, but SES was not measured in this study at either level of analysis.

Studies that do evaluate how the SES of a school may influence students' health have focused solely on students' weight status as an outcome. One such study provided support that poor school environments may both directly and indirectly influence adolescents' weight status (Martin, Frisco, Nau, and Burnett, 2012). Students attending poorer schools may have more restricted access to healthy foods at lunchtime and physical activity programs.

In turn, poor schools may also foster environments that regularly activate the stress response due to higher levels of disorder and chaos, thereby contributing to greater abdominal obesity. Martin et al. (2012) argued that poverty and level of parental education at both the individual and school levels may differentially contribute to adolescent overweight. Ultimately, they found that family education, but not income, is associated with adolescent overweight. But, at the school level, the proportion of students at or below poverty level, but not the average level of parental education in the school, is associated with overweight. Similarly, Richmond and Subramanian (2008) found that, in girls, higher maternal education and individual-level household income were both associated with lower BMI. These measures of individual-level SES were not associated with BMI in boys; however, school-level median household income was significantly associated with BMI in both genders. Further, results of Lee, Harris, and Lee's (2013) multilevel analysis of data from the Add Health study also indicated that family-level socioeconomic deprivation was only associated with obesity in young women, whereas school-level deprivation was associated with adolescent obesity in both boys and girls.

O'Malley, Johnston, Delva, Bachman, and Schulenberg (2007) assessed whether rates of student overweight/obesity vary between secondary schools and if student overweight/obesity clusters by particular attributes of a school using a nationally representative sample of 8th, 10th, and 12th grade students from the Monitoring the Future study. In this study, data were collected from approximately 400 schools per year for a 14-year period. In bivariate analyses, O'Malley et al. (2007) found that school type (e.g., public, parochial, or private) was significantly associated with BMI and proportion of students at or above the 85th BMI percentile such that rates of overweight/obesity were greater in students attending a public school. School size was only significantly associated with BMI and percent at or above the 85th percentile in the 8th grade cohort, such that those attending medium-sized schools had poorer outcomes. Racial/ethnic distribution of the school and population density of the surrounding area were also significantly associated with BMI and proportion of overweight for most of the sample. Schools with a majority of Hispanic or African-American students had higher rates of overweight/obesity in all three grade cohorts. Students attending rural schools exhibited significantly higher rates of overweight/obesity in the 8th and 10th grades. School SES, measured as the school mean level of parental education, was a very significant predictor of overweight/obesity, as lower-SES schools had much greater proportions of overweight or obese students.

In multivariate analyses, O'Malley et al. (2007) found that school type and school size were no longer significant predictors of BMI or obesity rate after accounting for SES in the model. With individual SES and race/ethnicity included in the model, school SES still significantly predicted overweight/obesity, but this association was greatly diminished. Racial/ethnic composition of the school and population density did not remain significant predictors of overweight/obesity in nearly all of the multivariate analyses. Thus, this study provides further evidence that some aspect of the experience of attending a lower-SES school contributes to obesity above and beyond the contributions of one's individual SES. However, an important limitation of this study is that the authors did not employ hierarchical linear modeling (HLM) in their analyses, despite collecting nested data.

The majority of studies linking school-level characteristics to student health outcomes while also using HLM have used surveys about emotional well-being or somatic symptom checklists as outcome measures, rather than hard endpoints like BMI and BP. For instance, Låftman and Modin (2012) found that students reported fewer subjective health complaints if they were in classes in which the majority of students reported experiencing a positive environment in terms of teacher support, achievement motivation, and above average grades. Torsheim and Wold (2001) also explored the relationship between the psychosocial atmosphere of a school, including academic stress, level of noise disturbance in class, and perceived support from teachers and fellow classmates, and self-reported subjective health complaints. Stressors at both the individual level and the aggregate school level, such as academic demands and noise in class, were associated with more subjective health complaints.

While individual-level predictors explained much of the variance in health complaints, main effects of shared environmental factors were also found. One study assessed the relationship between socioeconomic indicators at the student and school levels and students' self-rated health, emotional wellbeing, and psychosomatic health complaints (Saab & Klinger, 2010). Saab and Klinger (2010) found that self-rated health was higher and the number of health complaints was lower when students had better perceptions of their neighborhood, when they lived with both parents, and when their family wealth and the student's academic achievement were greater. Students reported fewer health complaints in schools with a higher socioeconomic position, but reported more in schools with higher levels of student aggression (i.e., schools with a more tense and stressful climate). Generally, more stressful school environments with more disorder and poorer student achievement were associated with more health complaints.

In summary, a few studies have considered the importance of the school as the social context in which adolescents spend most of their time and the implications of the school's context for their weight status. These studies have largely found that school-level socioeconomic deprivation predicts higher BMI, often above and beyond individual-level measures of SES. No study has evaluated the relationship between school contextual factors and BP. Further, many of the studies that have utilized HLM have used subjective health ratings as their primary outcome. Additionally, most studies linking school context and students' health reviewed above have been conducted in homogeneous student samples from Europe and Canada, but not the United States.

Together, these indicate a need for exploring the relationship between school contextual factors and meaningful clinical outcomes, such as BMI and BP, in a more diverse population of American students using HLM.

Gender and the SES-Health Relationship

Gender disparities exist for many of the health-related outcomes in the studies reviewed above and there is also evidence that social and environmental contexts may differentially affect boys and girls. As a result, it is likely that gender may influence the relationship between SES and health outcomes. This may be especially true in youth, as differences between the genders in many life domains tend to emerge during adolescence.

CVD risk factors, which are highly prevalent in diverse adult populations, are present at an early age (Fardy et al., 1994). In some studies, associations between SES and unhealthy lifestyle factors and outcomes, such as consumption of high-fat foods (Lowry et al., 1996), more subjective health complaints (Låftman & Modin, 2012), and increased BMI (Winkleby et al., 1999), have been strongest or have only appeared in young girls. In fact, Bergstrom et al. (1996) reported that overweight, low aerobic fitness, and current smoker status often cluster together in adolescent girls of lower SES, but not in adolescent boys. Further, Ali et al. (2011) observed that while both girls and boys in the lowest poverty-income ratio category were more likely to be obese, the difference in abdominal obesity was significantly more evident in adolescent girls than boys. The findings of McMurray et al. (2000) also suggest that low SES, rather than lack of physical activity or other behavioral factors, contributes more greatly to overweight in adolescent girls.

Gender differences in physical activity level and, thus, fitness may be an important distinction between the genders that perhaps drives a steeper SES-health gradient in girls. Girls' participation in physical activity declines much more steeply than in boys during adolescence, which may be due to social contextual influences related to body image, gender role expectations, and a host of other factors (Kimm et al., 2002). Voorhees et al. (2009) did not find an association between individual or neighborhood SES and objectively measured physical activity in the TAAG sample. However, another study using a mixed-gender sample found no association between SES and physical activity in boys, but did find that lower-SES girls were less active than their higher-SES counterparts (Brodersen et al., 2007). Together, these findings suggest the association between SES and activity could vary by gender, but more research needs to be conducted to determine the directionality of this relationship.

Girls may be more susceptible to adverse neighborhood and environmental conditions compared to boys. Lee and Cubbin (2002) suggest that girls are socialized to depend more on familial and other contextual influences when choosing behaviors in which to engage. The negative association found between neighborhood SES and dietary habits in this study appears to have been driven by findings in girls, as when the final models were stratified by gender, the resulting associations were weaker in boys, but stronger in girls. Three European studies reviewed in this paper suggest that difficult school environments may more negatively impact health and other outcomes in girls relative to boys. The first of these, Gillander-Gådin and Hammarström (2003), found that lack of control over an unfavorable school climate was more strongly associated with increased somatic complaints and poorer mental health in girls than in boys. The findings of Ravens-Sieberer et al. (2009) also indicate more pronounced decrements in girls' perceived health resulting from a poorer school climate. School-performance indicators, such as intensity of academic demands and feelings of incompetence, were more strongly associated with subjective health complaints in girls, despite girls reporting more motivation in and enjoyment of school in a 2012 study by Låftman and Modin. Further, though conducted in a strictly African-American sample, a recent study reported that the relationship between neighborhood-level poverty and cortisol reactivity to stress varies by gender, such that boys were found to be more vulnerable to community disadvantage, as they responded to stressors with increased reactivity (Hackman, Betancourt, Brodsky, Hurt, & Farah, 2012). The authors argue that since boys may be given more freedom to spend more time in the surrounding neighborhood, they may be more easily influenced by its characteristics. However, in Winzer (2004), findings again suggested that girls are more sensitive to social environmental factors at the school level, whether positive or negative, particularly in terms of effects on obesity.

Taken together, these studies indicate sensitivity to impoverished or otherwise stressful environments and, thus, SES-health disparities, may vary by gender, but further research is needed to determine which gender is most greatly affected.

Conclusion

In summary, support for a relationship between lower SES and poorer health outcomes has been established across the lifespan. Understanding more about SES-health disparities is critical to effective cardiovascular risk prevention and intervention. For some outcomes, SES-health gradients, which have been found in children and adults, have not been found in adolescent samples, encouraging some researchers to argue that adolescents may be buffered against adverse influences of individual SES on health. However, some evidence suggests that adverse environmental and neighborhood context and, thus, lower neighborhood-level SES, may have a more potent impact on health outcomes in adolescents and that this relationship may vary by gender. Only a limited number of studies have utilized multilevel modeling techniques to examine how both individual and neighborhood factors may interact to affect health outcomes in youth.

Chapter 2: Rationale and Hypotheses

In recent decades, unhealthy lifestyle behaviors have contributed to an unprecedented rise in obesity and its consequences across the lifespan. Researchers have examined whether particular subgroups of the population are at greater risk of becoming overweight and obese and developing obesity-related complications. Lower SES has generally been found to confer increased risk of overweight and obesity and other adverse health outcomes, regardless of how SES is operationalized (Adler et al., 1994). Socioeconomic disadvantage is thought to contribute to poorer health outcomes in a number of possible ways. First, individuals of lower SES may face chronic, uncontrollable stress because of their social position, such as exposure to noise, overcrowding, and violence and other crime. Exposure to chronic stress and the accompanying elevations in cortisol, over time, may lead to changes in one's physiological response to stress. Behaviorally, lower SES and living in underprivileged neighborhoods may limit access to healthy food and safe places to be physically active (Diez Roux & Mair, 2010).

Experiencing low SES early in life is believed to be particularly detrimental to health later in life. However, some studies have failed to identify SES-health gradients in adolescents and have argued that attending school and spending more time with peers may wash out these differences during this developmental stage (West, 1997; West & Sweeting, 2004). Other studies have found that adolescent SES-health behavior gradients do exist, but only when neighborhood-level SES is considered (Janssen et al., 2006). This is an important distinction, as family-level measures, such as parental education or income, may not be as accurate in depicting adolescents' social position once they begin spending more time away from home and may have their own part-time jobs (Hanson &

Chen, 2007a). During adolescence, schools become the center of youth's social, emotional, and even physical well-being. Measuring SES at the school-level, as in the present study, may better capture the socioeconomic gradient in adolescent health behaviors and outcomes compared to individual- or neighborhood-level measures. Socioeconomic status (SES) can be measured in this way by averaging individual-level measures of SES taken from students or may be operationalized as the percentage of students attending the school who are eligible for free or reduced-price lunch, as in the present study and in Voorhees et al. (2009). However, measuring poverty alone may be neglecting other important school environmental factors that contribute to a chronically stressful experience for lower-SES adolescents.

For most adolescents, exposure to chronic and potentially damaging stress likely also occurs outside the home in their neighborhoods and schools (Slopen et al., 2013). Psychosocial stressors at the school level may include lack of peer relationships, bullying, academic stress, high rates of crime and conflict in school, overcrowded classrooms, and other concerns. Most studies examining school context and student-level outcomes have focused on academic achievement and other school-related outcomes. Those that have looked at how school-level factors affect health outcomes often considered mental health outcomes or the frequency of general physical symptoms, rather than behavioral or objectively measured clinical endpoints. The small number of studies that have investigated the relationship between school context and adolescent health behaviors and outcomes were conducted primarily in Europe and Canada, in rather homogeneous samples (Låftman & Modin, 2012; Maes & Lievens, 2003; Saab & Klinger, 2010; Torsheim & Wold, 2001). Studies conducted in the United States on school context and health have only utilized weight status or BMI as an outcome (Martin et al., 2012; O'Malley et al., 2007). The present study will fill an important gap in this literature by examining the relationship between school contextual factors and meaningful clinical outcomes, such as BMI and BP, as well as health behaviors, in a diverse sample of American 10th grade students.

The present study further aimed to evaluate the role of gender in the relationship between SES and health behaviors and outcomes. Several studies have suggested that girls may be more dramatically influenced by their surrounding social context (Gillander-Gådin and Hammarström, 2003; Låftman and Modin, 2012; Lee and Cubbin, 2002; Ravens-Sieberer et al., 2009; Wang and Zhang, 2006). This suggests that boys of lower SES may not necessarily be at greater risk of adverse health outcomes. Because adolescence is a tumultuous developmental phase in which the genders become differentiated in a number of ways, the role of gender may be especially important to consider in studies of adolescent health.

Finally, a limitation of several studies examining the associations between health outcomes and both neighborhood or school context and individual-level factors is the use of traditional multiple regression analyses, rather than multilevel modeling. Conventional single-level techniques, such as ordinary least squares regression, fail to account for the implicit nested nature of data collected from individuals within organizations and other social contexts (Lee, 2000; Raudenbush & Bryk, 2002). Data collected from students attending different schools are considered "nested" because students attending the same school (or those from the same neighborhood, family, etc.) have more in common than a random sample of students. For instance, students attending the same school are often drawn from the residential areas surrounding the school and, therefore, may have similar racial/ethnic backgrounds, SES, and formative experiences by virtue of living in the same area. Within the school environment, these youth may also have shared experiences, including exposure to the same curricula, same teachers, similar peer group influences, and other features of the school environment. As such, observations obtained from these students cannot be considered independent, which violates the standard assumption of many statistical techniques, including ordinary least squares regression.

In the present study, HLM was used to model how individual-level health behaviors (Level 1), as well as school-level SES and school contextual factors (Level 2), impact adolescent health outcomes, such as BMI and BP. School SES will be operationalized using the percentage of students eligible for receiving free or reduced-price lunch during the school day. Potentially stressful social-environmental factors at the school-level, such as larger student-teacher ratio and lower safety grades assigned to the school, will also be considered. These school-level factors were chosen as proxies of neighborhood-level characteristics, such as residential overcrowding and higher crime rates, which have been associated with health behaviors and outcomes in other samples. Only a limited number of extant studies have investigated the effects of school-level environmental and socioeconomic factors on adolescent health outcomes, with even fewer using diverse adolescent samples and the appropriate multilevel techniques to account for the non-independence of these data. The hypotheses below will be examined using HLM to analyze data collected from a large, diverse sample of adolescents attending Miami-Dade County Public Schools.

Hypothesis 1. Lower school-level SES (or greater percentage of students eligible for free or reduced-price lunch) will be associated with higher BMI and BP.

Hypothesis 2. (a) Student-teacher ratio and school enrollment will be directly associated with BMI and BP, while (b) school safety rating and other positive school indicators (e.g., educational resources, positive climate ratings, and achievement) will be inversely associated with these outcomes.

Hypothesis 3. Girls will be more adversely impacted by lower SES and more stressful school environments than boys.

Chapter 3: Method

Participants

The archival sample used in the present study consists of approximately 88,936 10th grade students attending senior high, vocational, and alternative schools in the Miami-Dade County public school system (MDCPS) for six academic years, beginning in 1999-2000 and ending in 2004-05. These students comprised a total of 227 school cohorts. Students participated in a BP screening program conducted by University of Miami Behavioral Medicine Research Program staff as a service to the school district. Due to logistical factors, variation in the number of contracted schools, and scheduling issues, the number of schools screened varied over the 6-year period, as did the number of students screened each year (see Table 1). A core group of 32 schools participated in the screenings for each of the 6 academic years (see Table 2). In accordance with MDCPS' policies regarding parental consent for noninvasive health procedures, parents were notified via letter of the scheduled BP screening and if they did not want their child to participate, they were asked to return a form to the school indicating such. The final sample used in the present study excluded students attending non-traditional senior high schools (N = 4,152 students) and schools for which complete sets of Florida School Indicators could not be located for at least one of the years in the 6-year study period (N = 619 students).

Measures

Student information form. Students were asked to complete the Project Adolescent Cardiovascular Evaluation (ACE) Adolescent Blood Pressure Screening

Form prior to their BP assessment (see Appendices A-D). This form requested demographic and behavioral data about the student and his or her family.

Demographic information. Students indicated their age, gender, ethnic background, and the primary language spoken in their home on the screening form. The response options for student ethnic background included: White non-Hispanic, American Indian, Asian, White Hispanic, African-American, Black Hispanic, Caribbean Black, and other ethnic background. Students were also asked to indicate whether their family spoke primarily English, Spanish, Creole, or another language at home.

Personal health information. Students reported their height in feet and inches and their weight in pounds. If a student was unaware of his or her height, researchers measured the student's height and recorded this height on the screening form. Students also reported personal and family history of hypertension, heart disease, heart attack, and diabetes. Students selected from "not at all," "some," or "very" to indicate their levels of perceived stress both in and outside of school and the degree to which they consider themselves to be "fat around the waist."

Health behavior information. These items were drawn from the 1999 Youth Risk Behavior Survey (YRBS) and showed at least moderate reliability over time in a large, representative sample of high school students (Brener et al., 2002). The screening form asked about the number of days in the past week on which the students used tobacco or alcohol and participated in vigorous physical activity for at least 20 minutes. The number of days on which students lifted weights was requested on only some versions of the form over the 6-year data collection period. Students also selected one of five response options (less than 1 hour, 1 hour, 2-3 hours, 4-5 hours, or more than 5 hours) to quantify the degree to which they typically engage in sedentary behavior (hours spent watching television, playing video games, or using a computer) on a daily basis. Students also reported their typical daily consumption of fruits, vegetables, salty foods, fatty meats, sweet foods, and regular soft drinks, using the response options “no,” “once,” or “twice or more.”

Of note, 4 slightly different versions of the form were used over the 6-year data collection period. However, only three of the items relating to physical activity and dietary habits were affected. The 1999-2000 version of this form (see Appendix A) did not ask for information regarding students’ participation in strength training during the past week or about consumption of regular soda on a typical day. Additionally, this version of the form inquired about consumption of vegetables and tossed salad as two separate items. The 2000-2001 and 2001-2002 versions of the screening forms are identical (see Appendix B) and included the following additional items, “During the past 7 days, how many days did you lift weights (strength train)?” and “On a typical day, do you drink regular (non-diet) soda?” Tossed salad and vegetable consumption are now included in the same item: “On a typical day, do you eat tossed salad and/or vegetables?” On the 2002-2003 version of the screening form, two separate items are again used to inquire about consumption of tossed salad and vegetables (see Appendix C). The final version of the screening form, used in the 2003-2004 and 2004-2005 academic years, included the strength training and soda consumption items and also inquired about tossed salad and vegetable consumption in the same item (see Appendix D).

Florida School Indicators. The Florida Department of Education (FLDOE) collects these data on school status and performance each year for all public schools. For

Miami-Dade County Public Schools, these data are made publicly available at http://oada.dadeschools.net/SchoolPerformanceData/SchoolPerformanceData.asp.

Student-teacher ratio. The student-teacher ratio is computed by dividing the total number of students enrolled in regular ("mainstream") programs by the total number of classroom teachers allocated to that school.

Total number of students. The total number of students is reported as the number of students enrolled in a given school in grades 9 – 12.

Florida Comprehensive Assessment Test (FCAT) reading passing rate. The 10^{th} grade FCAT reading test results are reported as the percentage of students scoring at each of 5 achievement levels. Students who reach Levels 3, 4, or 5 are considered to have passed and to be on a trajectory toward college or career success.

Instructional computer rate. This indicator refers to the number of instructional computers available for use in a school divided by the total student enrollment of the school.

Free/Reduced-price lunch. This indicator refers to the percentage of students eligible to receive free or reduced-price lunch due to family SES.

Positive climate. In the present study, this variable is computed by taking the average of the percentage of parents, students, and staff who agree with the following statement, "The overall climate at this school is positive and helps students learn," as reported in the annual School Climate Survey.

Safety rating. Records are also kept regarding the frequency of incidents of crime and violence occurring at school or at school-sponsored activities. Incidents of crime and violence include both violent and nonviolent acts, such as fighting, harassment, possession of weapons, possession of alcohol, tobacco, or other substances, destruction of property, and disorderly conduct. The total number of incidents is divided by the total school enrollment to calculate crime rate. Based on the crime rate calculated, schools are assigned a "safety grade" (A – E), which was coded on a 5-point scale from 0 – 4 with higher scores indicative of safer schools.

In the present study, the percentage of students eligible for free or reduced-price lunch was used to operationalize school-level SES. This approach to operationalizing SES has been used in other studies (Voorhees et al., 2009). The instructional computer rate was included as an index of educational resources available to the school. Additionally, student-teacher ratio and safety rating will be used as proxies for household density and neighborhood crime, which are often used to represent chronic stressors in studies of lower-SES neighborhoods and health (Carter & Dubois, 2010; Johnston-Brooks, Lewis, Evans, & Whalen, 1998).

Procedures

Students turned in their completed Project ACE screening forms prior to the BP screening. A team of trained assessors, including graduate and undergraduate research assistants, took resting BP measurements using a Baumanometer mercury sphygmomanometer and an appropriately sized cuff on the student's right arm. Participants were instructed to remain quiet for 5 minutes with their right arm resting on a table at heart level and their feet flat on the floor, remaining awake but relaxed. Researchers inflated the cuff to 180 mmHg, and then recorded the value at which the first Korotkoff sound was heard (Phase I) as the systolic BP and the value at which Korotkoff sounds ceased (Phase V) as the diastolic BP. If either systolic or diastolic BP was elevated based on National High Blood Pressure Education Program Working Group criteria, (90^{th} percentile or above for age, gender, and height), the student's BP was taken again after sitting quietly (USDHHS, 2005). If the average of the 2 readings remained above the 90^{th} percentile cutoff, the student's BP was assessed again after 1 month. Students with elevated BP at the screening were also given informational materials about living a healthy lifestyle and reducing their BP. On the day of the screening, all students were given feedback forms with their BP results to take home to their parents. If a student's BP remained elevated after the re-check, researchers mailed letters to the student's parents to inform them of their child's elevated BP status and to provide lifestyle recommendations.

Statistical Analyses

Data reduction. Items from the screening form measuring variables of interest were scored in order for these variables to be entered as predictors into model equations. "Healthy food consumption" (i.e., fruit and vegetable consumption) was scored based on relevant items found in the dietary habits portion of the screening form. Items included "On a typical day, do you eat fruit or drink fruit juice?" and "On a typical day, do you eat tossed salad and/or vegetables?" Response options for these items were coded as follows to yield a total score representing the number of times daily fruit and vegetables were consumed: "no" = 0, "once" = 1, and "twice or more" = 2. These response options do not allow the determination of whether students met the recommendations for fruit and vegetable consumption because students' responses only indicate whether they ate fruit and vegetables 0, 1, 2, 3, or 4 times on a typical day, rather than the expected 7-9 servings for adolescents (U.S. Department of Agriculture (USDA), 2010). No information regarding serving sizes of fruit and vegetables consumed was collected.

Students' "unhealthy food consumption scores" were also calculated based on the following screening items: "On a typical day, do you eat salty foods or add salt to your food?"; "On a typical day, do you eat fatty meats (hamburgers, hot dogs, or red meat)?" ; "On a typical day, do you eat French fries or high fat chips (potato chips, corn chips, cheese puffs?; "On a typical day, do you eat cookies, doughnuts, pie, cake, or other sweets or candies?" Again, the response options were coded 0 ("no"), 1, ("once"), or 2, ("twice or more") to generate a possible "unhealthy food consumption" score from 0 to 8. Higher scores indicated poorer diets (likely calorie-dense but nutrient-poor).

Next, items related to activity level were scored to quantify the degrees to which students are both physically active and sedentary. Vigorous-intensity aerobic physical activity was assessed using the following item: "During the past week, how many days did you exercise or participate in sports activities for at least 20 minutes that made you sweat and breathe hard, such as basketball, jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities?" Of note, answers to this item did not provide sufficient information to determine whether students met physical activity guidelines for youth, as it is recommended that adolescents participate in the equivalent of 60 minutes of moderate-intensity activity (30 minutes of vigorous-intensity activity) each day (Centers for Disease Control and Prevention (CDC), 2011). Sedentary behavior was assessed using the following item: "On a typical weekday, how many hours do you spend watching TV, playing video games, or using a computer?" The response options provided did not allow for the continuous measurement of this variable ("Less than one hour," "1 hour," "2-3 hours," "4-5 hours," and "more than 5 hours"); however, for the purpose of the present analyses, this ordinal variable was treated as continuous because previous research suggests that normally distributed ordinal variables with 5 or more categories treated as continuous are unlikely to have much functional impact on results (Dolan, 1994; Johnson & Creech, 1983).

Additionally, one of the primary study outcomes, BMI, was calculated using self-reported weight and height (or measured height if the student was unaware of his or her height). Weight in pounds was converted to kilograms and then divided by height (converted from inches to meters) squared to calculate BMI. Of note, self-reported values of height and weight have been found to compare favorably (i.e., with 96% agreement) with objectively measured height and weight in a large, representative sample of adolescents in the Add Health study (Goodman, Hinden, & Khandelwal, 2000).

Data screening. Before beginning hypothesis testing, data were screened to verify that normality assumptions had not been violated using PROC UNIVARIATE in Statistical Analysis Systems (SAS) version 9.2. Variables of interest with outliers, kurtosis values greater than or equal to an absolute value of 10, and/or skewness values greater than or equal to an absolute value of 3 were screened more closely. Extreme outliers (>1.5 IQR) and nonsensical values found in the dataset were coded as missing. Pearson correlations were calculated between available Florida School Indicators thought to contribute to a stressful school environment unconducive to learning and planned study outcomes to aid in selection of Level 2 predictors. The issue of possible multicollinearity between both the Level 1 covariates (healthy and unhealthy food consumption scores, stress rating, physical activity, and sedentary behavior) and Level 2 predictors (free and reduced lunch rate, student-teacher ratio, positive climate ratings of students, staff, and parents, school safety rating, FCAT reading passing rate, total student enrollment, number of instructional computers available) was also addressed. Positive climate ratings of students, staff, and parents were highly correlated and thus, were averaged in order to be entered into the final model. Similarly, student-teacher ratio was selected rather than average class size, as it was more strongly correlated with the study outcomes. Further, a possible Level 2 predictor, mobility (the rate at which students leave or enter the school system), was removed from the model due to a high proportion of missingness.

Unit of analysis at Level 2. Although the data used in the present study were collected over a 6-year period, there were not multiple observations for each participant. Tenth-grade students were the only students screened for hypertension each of the 6 years and therefore, a different subsample of students were screened each year. However, each school participated in the screening program at least two times from 1999-2005 (see Table 2). While meaningful large-scale changes in the sociodemographics of the participating schools over the 6-year period were not expected, the year in which a student attends a particular school is thought to contribute to a unique social context within the school. Thus, school cohort was chosen as the unit of analysis, as controlling for year would partial out variance that might reflect important neighborhood or school change, which contribute to the students' learning environment. Standard errors of parameter estimates did not appreciably change whether or not year was controlled for in the models.

Preliminary analyses. Using SAS version 9.2, descriptive statistics will be calculated for all relevant variables at both the student and school levels. Given prior evidence of gender differences in health behaviors (Courtenay, McCreary, & Merighi, 2002), independent sample *t*-tests were conducted to examine differences in reported health behaviors and health outcomes between boys and girls.

Primary analyses. Mplus version 6.0 (Muthén & Muthén, 2010) was used to analyze all models to account for missing data using full information maximum likelihood (FIML) estimation. Due to the hierarchical nature and, thus, the nonindependence of the data used in the present study, hierarchical linear modeling (HLM) was used to test study hypotheses. Adolescents in the sample were students attending various public high schools in Miami-Dade County and thus, data collected from this sample are nested by school. Separate multilevel models for boys and girls were used to investigate the contribution of school-cohort effects to the overall variance in adolescents' BMI, systolic BP (SBP), and diastolic BP (DBP). Analysis at the individual level will estimate the intercept and slope coefficients describing relationships between behavioral and other student-level covariates and health outcomes within each school. These parameters become outcomes at Level 2, at which variables reflecting the socioeconomic status and school climate were added to the model. Separate HLM models were evaluated for boys and girls for each outcome variable: BMI, SBP, and DBP.

Because the effects of Level 2 predictors are of primary interest in the study hypotheses, continuous Level 1 covariates (and those treated as continuous) were centered around the grand mean in order to produce scores that will remain correlated with variables at both levels of the model. Grand-mean centering is the "method of choice for assessing the impact of cluster-level variables, controlling for Level 1 covariates" (Enders & Tofighi, 2007).

The first step in model specification was to estimate a null (or unconditional) model with no predictors at either level, which allowed for partitioning of the variance in the dependent variable into its two components: within-school and between-school. Then, the degree to which the data are non-independent was determined by calculating the intra-class correlation (ICC), which is the unconditional school cohort-level variance divided by the sum of unconditional student-level and school cohort-level variances in the outcome. For instance, using BMI as the outcome, this model is as follows:

$$BMI_{ij} = \beta_{0j} + r_{ij}$$
$$\beta_{0j} = \gamma_{00} + u_{0j}$$

where BMI_{ij} = the observed BMI for the *i*th student in the *j*th school cohort

β_{0j} = mean BMI in the *j*th school cohort

γ_{00} = grand mean BMI across all school cohorts

r_{ij} = unique effect of the *i*th student on BMI in the *j*th school cohort

u_{0j} = unique effect of *j*th school cohort on BMI

Next, Level 1 variables known to influence BMI were included primarily as control variables, and Level 2 predictors were added to test study aims. To investigate how the influence of school cohort-level factors on health outcomes differed by gender, males and females were modeled separately. Due to the large sample size in the present study, a more conservative significance level was selected to decrease the likelihood of making a Type I error. Thus, model results will only be considered statistically significant if $p < 0.01$. All variables were centered around the grand mean because the primary interest of the research questions is the effect of Level 2 predictors. This yielded the following model:

$$
\begin{aligned}
BMI_{ij} = \beta_{0j} &+ \beta_{1j}(AGE_{ij} - \bar{x}_{AGE}) + \beta_{2j}HISPANIC_{ij} + \beta_{3j}(STRESS_{ij} - \bar{x}_{STRESS}) \\
&+ \beta_{4j}(AEROPA_{ij} - \bar{x}_{AEROPA}) + \beta_{5j}(SEDTIME_{ij} - \bar{x}_{SEDTIME}) \\
&+ \beta_{6j}(HEALTHYFOOD_{ij} - \bar{x}_{HEALTHYFOOD}) \\
&+ \beta_{7j}(UNHEALTHYFOOD_{ij} - \bar{x}_{UNHEALTHYFOOD}) + r_{ij}
\end{aligned}
$$

$$
\begin{aligned}
\beta_{0j} = \gamma_{00} &+ \gamma_{01}(STRATIO_j - \bar{x}_{STRATIO}) + \gamma_{02}(TOTALSTU_j - \bar{x}_{TOTALSTU}) \\
&+ \gamma_{03}(NUMCOMPR_j - \bar{x}_{NUMCOMPR}) + \gamma_{04}(PCTFRPL_j - \bar{x}_{PCTFRPL}) \\
&+ \gamma_{05}(FCATRDG_j - \bar{x}_{FCATRDG}) + \gamma_{06}(POSITIVE_j - \bar{x}_{POSITIVE}) \\
&+ \gamma_{07}(SAFETY_j - \bar{x}_{SAFETY}) + \gamma_{08}(AGEM_j - \bar{x}_{AGEM}) \\
&+ \gamma_{09}(AEROPAM_j - \bar{x}_{AEROPAM}) + \gamma_{010}(SEDTIMEM_j - \bar{x}_{SEDTIMEM}) \\
&+ \gamma_{011}(HEALTHYFOODM_j - \bar{x}_{HEALTHYFOODM}) \\
&+ \gamma_{012}(UNHEALTHYFOODM_j - \bar{x}_{UNHEALTHYFOODM}) \\
&+ \gamma_{013}(STRESSM_j - \bar{x}_{STRESSM}) + u_{0j}
\end{aligned}
$$

$$\beta_{1j} = \gamma_{10}$$

$$\beta_{2j} = \gamma_{20}$$

$$\beta_{3j} = \gamma_{30}$$

$$\beta_{4j} = \gamma_{40}$$

$$\beta_{5j} = \gamma_{50}$$

$$\beta_{6j} = \gamma_{60}$$

$$\beta_{7j} = \gamma_{70}$$

where β_{0j} = mean BMI in the jth school cohort

γ_{00} = grand mean BMI across all school cohorts

γ_{01} = mean effect of student-teacher ratio (STRATIO) on mean BMI across all school cohorts

γ_{02} = mean effect of total student enrollment (TOTALSTU) on mean BMI across all school cohorts

γ_{03} = mean effect of instructional computer rate (NUMCOMPR) on mean BMI across all school cohorts

γ_{04} = mean effect of free/reduced-price lunch percentage (PCTFRPL) on mean BMI across all school cohorts

γ_{05} = mean effect of FCAT reading test passing rate (FCATRDG) on mean BMI across all school cohorts

γ_{06} = mean effect of positive climate rating (POSITIVE) on mean BMI across all school cohorts

γ_{07} = mean effect of safety grade (SAFETY) on mean BMI across all school cohorts

γ_{08} = mean effect of average age of school cohort (AGEM) on mean BMI across all school cohorts

γ_{09} = mean effect of cohort average number of days physically active (AEROPAM) on mean BMI across all school cohorts

γ_{010} = mean effect of cohort average amount of sedentary time (SEDTIMEM) on mean BMI across all school cohorts

γ_{011} = mean effect of cohort average healthy food consumption score (HEALTHYFOODM) on mean BMI across all school cohorts

γ_{012} = mean effect of cohort average unhealthy food consumption score (UNHEALTHYFOODM) on mean BMI across all school cohorts

γ_{013} = mean effect of cohort average stress rating (STRESSM) on mean BMI across all school cohorts

β_{1j} = the average effect of AGE on BMI, controlling for Hispanic ethnicity (HISPANIC), stress rating (STRESS), days > 20 minutes of aerobic activity (AEROPA), sedentary time (SEDTIME), healthy food consumption score (HEALTHYFOOD), and unhealthy food consumption score (UNHEALTHY FOOD) (γ_{10} has the same interpretation because these gammas are all fixed effects)

β_{2j} = difference between BMI of a Hispanic student and a non-Hispanic student, controlling for AGE, STRESS, AEROPA, SEDTIME, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{20} has the same interpretation because these gammas are all fixed effects)

β_{3j} = the average effect of STRESS on BMI, controlling for AGE, HISPANIC, AEROPA, SEDTIME, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{30} has the same interpretation because these gammas are all fixed effects)

β_{4j} = the average effect of AEROPA on BMI, controlling for AGE, HISPANIC, STRESS, SEDTIME, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{40} has the same interpretation because these gammas are all fixed effects)

β_{5j} = the average effect of SEDTIME on BMI , controlling for AGE, HISPANIC, STRESS, AEROPA, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{50} has the same interpretation because these gammas are all fixed effects)

β_{6j} = the average effect of HEALTHYFOOD on BMI, controlling for AGE, HISPANIC, STRESS, AEROPA, SEDTIME, and UNHEALTHY FOOD (γ_{60} has the same interpretation because these gammas are all fixed effects)

β_{7j} = the average effect of UNHEALTHYFOOD on BMI, controlling for AGE, HISPANIC, STRESS, AEROPA, SEDTIME, and HEALTHY FOOD (γ_{70} has the same interpretation because these gammas are all fixed effects)

For both boys and girls, similar models will be used to predict the SBP and DBP outcome variables, as shown in Appendix E.

Chapter 4: Results

Sample Characteristics

The study sample consisted of 84,165 tenth grade students attending 33 traditional senior high schools in the Miami-Dade County public school system (MDCPS) over six academic years, beginning in 1999-2000 and ending in 2004-05. These students comprised 192 school cohorts out of a total of 227 school cohorts included in the original screening. The average age was 15.6 years and 49.2% of these students were boys. With respect to ethnic background, 61.8% of the sample self-identified as Hispanic, with 41.6% reporting Spanish as the primary language spoken at home. On average, the sample was of normal weight with a mean BMI of 22.9 kg/m^2. The mean recorded casual BP was 118/69, which does not exceed the 90th percentiles for systolic and diastolic BP adjusted for adolescent age, gender, and height. Demographic characteristics of the sample as well as means and standard deviations of study variables are presented in Tables 3 - 5. Bivariate correlations among student -level variables and among school cohort-level variables are shown in Tables 6 and 7.

Preliminary Analyses

Given previous research indicating gender differences in adolescent health behaviors (Courtenay et al., 2002; Sallis, Zakarian, Hovell, & Hofstetter, 1996), preliminary analyses were conducted to clarify the magnitude of such differences in the present sample. Significant differences were found in both reported health behaviors and health outcomes by gender, independent of the students' school contexts. Boys' self-reported stress ratings were significantly lower (M = 3.50; SD = 1.21) than those of girls (M = 3.97; SD = 1.22), t (83395) = -56.49, p < 0.0001, but both boys and girls reported moderate levels of stress on average. Boys also reported slightly longer time spent in sedentary behavior ($M = 3.11$; $SD = 1.19$) compared to girls ($M = 3.03$; $SD = 1.19$), $t\ (83197) = 8.96$, $p < 0.0001$. On average, both boys and girls reported exceeding the recommended 2-hour limit on screen time per day. However, boys reported being physically active for at least 20 minutes on more days each week ($M = 3.54$ days; $SD = 2.30$) than girls ($M = 2.57$ days; $SD = 2.09$), $t\ (80466) = 62.62$, $p < 0.0001$. While boys reported significantly more activity than girls, it does not appear that boys or girls on average met recommended physical activity guidelines.

With respect to eating behavior, on a typical day, boys consumed healthy food slightly less frequently ($M = 2.29$ times/day; $SD = 1.09$) compared to girls ($M = 2.46$ times/day; $SD = 1.10$) on average ($t\ (83815) = -23.64$, $p < 0.0001$), but boys also reported consuming unhealthy food less frequently on a typical day ($M = 3.48$ times/day; $SD = 1.89$) than girls ($M = 3.67$ times/day; $SD = 2.00$), $t\ (83796) = -14.37$, $p < 0.0001$. As the dietary intake measure used in the present study asked for only the number of times a food was consumed "on a typical day," the amount of fruits, vegetables, and other types of foods consumed at each sitting cannot be determined. However, if we assume that a one-half cup serving of fruit or vegetables was consumed at each sitting, neither boys nor girls appear to be meeting daily recommendations for fruit and vegetable consumption on average. However, both boys and girls on average consume fatty meats, high-fat snacks, sweets, or salty foods on at least 3 occasions on a typical day.

Furthermore, boys had higher average BMI ($M = 23.37$ kg/m^2; $SD = 4.54$) compared to girls ($M = 22.48$ kg/m^2; $SD = 4.19$), $t\ (80840) = 29.13$, $p < 0.0001$. Boys also had significantly higher SBP ($M = 122.26$ mmHg; $SD = 12.61$) and DBP ($M = 69.79$

mmHg; *SD* =10.56) relative to girls (SBP *M* = 114.23 mmHg; *SD* = 11.30; DBP *M* = 68.35 mmHg; *SD* = 9.64), t_{SBP} (83764) = 97.03, $p < 0.0001$; t_{DBP} (83654) = 20.63, $p < 0.0001$.

Student- and School Cohort-Level Factors Associated with Health Outcomes

Hierarchical linear models (HLM) were used to analyze the effects of student-level and school cohort-level variables on student BMI, SBP, and DBP. Specifically, school cohort-level SES, as indicated by percentage of students receiving free or reduced-price lunch, was hypothesized to be inversely associated with BMI, SBP, and DBP (Hypothesis 1). Indicators of school environments unconducive to learning, such as student-teacher ratio and total student enrollment, were expected to be directly associated with poorer outcomes (Hypothesis 2a). Conversely, indicators of educational resources and achievement (instructional computers available per student and FCAT reading passing rate), safety grade assigned to the school, and average percentage of staff, students, and parents rating the school's climate as "positive" were hypothesized to be associated with better health outcomes, such as lower BMI, SBP, and DBP (Hypothesis 2b). Finally, Hypothesis 3 stated that girls would be more adversely impacted by lower SES and more stressful school environments compared to boys.

To investigate whether the influence of school cohort-level factors on health outcomes differed by gender, girls and boys were modeled separately. For each outcome, a null model was first estimated to determine the proportion of variance accounted for at each level and to obtain the intraclass correlation. Next, student-level covariates were entered into the model primarily as control variables, as well as school cohort-level variables to test study aims. As mentioned earlier, due to the large sample size in the present study, model results will only be considered statistically significant if $p < 0.01$.

Body mass index.

Girls. The results for girls from two models—a null (or empty variance component) model (Model 1) and a variance component model with individual- and school cohort-level variables included (Model 2)—are shown in Table 6. In the null (or unconditional) model, the variance of the random effects of school cohorts was significantly different from zero ($\sigma^2_{u0} = 0.583$, $p < 0.001$). The intraclass correlation coefficient was 0.033, indicating that the school-level variance contributed approximately 3.3% to the overall variance in BMI. After adding both student- and school cohort-level variables, approximately 1.4% of the student-level variance and 73.6% of the school-cohort level variance were explained by Model 2, as calculated using Raudenbush and Bryk's (2002) formula, 1 – [variance (conditional) / variance (unconditional)].

Student-level factors. All but one of the student-level variables were found to be significantly associated with BMI. Student age was positively associated with BMI, such that as girls age one additional year, their BMIs increase by 0.262 kg/m^2 ($\beta = 0.262$, $p < 0.001$). Girls self-identifying as Hispanic were noted to have a BMI 0.342 kg/m^2 lower than that of their non-Hispanic peers ($\beta = -0.342$, $p < 0.001$), after adjusting for other student-level variables. Higher self-reported stress ratings were found to be associated with an increase of 0.072 kg/m^2 in BMI ($\beta = 0.072$, $p < 0.001$), controlling for other student-level variables. Again, following adjustment for other individual-level factors, increased time spent in sedentary behavior was associated with an increase of 0.069 kg/m^2 in BMI ($\beta = 0.069$, $p = 0.001$). However, for girls, BMI was not significantly associated with a change in number of days per week physically active for at least 20 minutes ($\beta = 0.015$, $p > .05$). Contrary to expectations, the associations of healthy and unhealthy food consumption with BMI were in unexpected directions. With a one-unit increase in healthy food consumption score, BMI was found to increase by 0.175 kg/m^2 ($\beta = 0.175$, $p < 0.001$), after adjusting for other student-level factors. Finally, BMI was found to decrease by 0.222 kg/m^2 with a one-unit increase in unhealthy food consumption score ($\beta = -0.222$, $p < 0.001$).

School cohort-level factors. After adding variables reflecting the socioeconomic status and school climate, the variance at the school level was reduced, but remained significantly different from zero ($\sigma^2_{u0} = 0.154$, $p < 0.001$).

Several of the school-cohort level variables were found to be significantly associated with BMI in girls. As predicted, the percentage of students receiving free or reduced-price lunch was directly associated with BMI such that girls in school-cohorts with higher rates of free/reduced-price lunch have higher average BMIs by 0.014 kg/m^2, adjusting for student-teacher ratio, total student enrollment, and additional school cohort-level variables. Next, student-teacher ratio was directly associated with BMI ($\gamma = 0.049$, $p < 0.01$). Thus, girls in school-cohorts with higher student-teacher ratios have higher average BMIs by 0.049 kg/m^2, after controlling for total number of students enrolled, instructional computer rate, percentage of students receiving free/reduced price lunch, FCAT reading passing rate, positive climate, safety grade, mean age, mean physical activity, mean sedentary time, mean stress rating, and mean healthy and unhealthy food consumption scores. Contrary to Hypothesis 2a, girls in school-cohorts with higher student enrollment have lower average BMIs by 0.018 kg/m^2, after adjusting for student-teacher ratio and the remaining factors listed above ($\gamma = -0.018$, $p < 0.001$).

As predicted, girls in school-cohorts with higher FCAT reading test passing rates have lower average BMIs ($\gamma = -0.015$, $p < 0.01$), adjusting for all other school cohort-level factors. However, other positive school indicators (e.g., number of instructional computers available per student, average positive climate rating, safety grade assigned to school) were not found to be associated with BMI in girls. Furthermore, girls in school cohorts with higher mean consumption of unhealthy food have higher average BMIs as well ($\gamma = 0.404$, $p < 0.001$). However, results unexpectedly indicated that girls in school cohorts with higher mean reported stress ratings have significantly lower BMIs ($\gamma = -0.962$, $p < 0.001$). Finally, mean age, mean days physically active for 20 minutes or longer, mean sedentary time, and mean consumption of healthy food were not found to be associated with BMI (most *p*'s > 0.05).

Boys. The results for boys from two models—a null model (Model 1) and a variance component model with individual- and school cohort-level variables included (Model 2)—are shown in Table 6. In the null model, the variance of the random effects of school cohorts was significantly different from zero ($\sigma^2_{u0} = 0.188$, $p < 0.001$). The intraclass correlation coefficient was 0.01, indicating that the school-level variance contributed only about 1% to the overall variance in BMI. After adding both student- and school cohort-level variables, approximately 1.5% of the student-level variance and 66.0% of the school-cohort level variance were explained by Model 2.

Student-level factors. In boys, all but one of the student-level variables were found to be significantly associated with BMI at $\alpha = 0.01$. With few differences, the directions of the associations between individual-level factors and BMI were similar to those for girls. Student age was positively associated with BMI, such that as boys age one additional year, their BMIs increase by 0.3 kg/m^2 (β = 0.300, $p < 0.001$). Unlike for Hispanic girls, the BMIs of boys self-identifying as Hispanic were found to be 0.255 kg/m^2 higher than those of their non-Hispanic peers (β = 0.255, $p < 0.001$), after adjusting for other student-level variables. Similar to girls, higher self-reported stress ratings were found to be associated with an increase of 0.076 kg/m^2 in BMI (β = 0.076, $p < 0.001$), controlling for other student-level variables. Again, following adjustment for other individual-level factors, with increased time spent in sedentary behavior, boys' BMIs increased by 0.124 kg/m^2 (β = 0.124, $p = 0.001$). As in girls, BMI was not significantly associated with a change in number of days per week physically active for at least 20 minutes (β = -0.023, $p > .01$). Finally, similar to the results for girls, BMI was unexpectedly found to increase by 0.140 kg/m^2 (β = 0.140, $p < 0.001$) with a one-unit increase in healthy food consumption score. BMI was also found to decrease by 0.261 kg/m^2 with a one-unit increase in unhealthy food consumption score (β = -0.261, $p < 0.001$).

School-cohort level factors. Fewer of the school-cohort level variables were found to be significantly associated with BMI in boys compared to girls. In keeping with Hypothesis 1, the percentage of students receiving free or reduced-price lunch was again directly associated with BMI (γ = 0.010, $p < 0.001$). Boys in school cohorts with higher rates of free/reduced-price lunch have higher average BMIs by 0.010 kg/m^2, adjusting for student-teacher ratio, total student enrollment, and additional school cohort-level variables. Next, student-teacher ratio was again directly associated with BMI (γ = 0.046,

$p < 0.01$). Thus, boys in school-cohorts with higher student-teacher ratios have higher average BMIs by 0.046 kg/m^2, after controlling for total number of students enrolled, instructional computer rate, percentage of students receiving free/reduced price lunch, FCAT reading passing rate, positive climate, crime grade, mean age, mean physical activity, mean sedentary time, mean stress rating, and mean healthy and unhealthy food consumption scores. Of note, total student enrollment and positive school indicators (e.g., number of instructional computers available per student, FCAT reading passing rate, average positive climate rating, safety grade assigned to school) were not associated with BMI in boys.

As in girls, boys in school cohorts with higher mean consumption of unhealthy food have higher average BMIs as well ($\gamma = 0.425$, $p < 0.001$). Finally, like in girls, mean age, mean days physically active for 20 minutes or longer, mean sedentary time, mean consumption of healthy food, and, unlike in girls, mean self-reported stress rating were not found to be associated with BMI in boys (p's > 0.01).

Systolic blood pressure.

Girls. Model results for girls for both a null model (Model 1) and a variance component model with individual- and school cohort-level variables included (Model 2) are shown in Table 7. In the null model, the variance of the random effects of school cohorts was significantly different from zero ($\sigma^2_{u0} = 5.261$, $p < 0.001$). The intraclass correlation coefficient was 0.041, indicating that the school-level variance contributed approximately 4.1% to the overall variance in SBP. After adding both student- and school cohort-level variables, approximately 0.4% of the student-level variance and 28.2% of the school-cohort level variance were explained by Model 2.

Student-level factors. All but one of the student-level variables were found to be significantly associated with SBP. Student age was not found to be significantly associated with SBP ($p > 0.05$). Similar to the effect of girls' ethnicity on BMI, girls self-identifying as Hispanic were noted to have an SBP 0.798 mmHg lower than that of their non-Hispanic peers ($\beta = -0.798$, $p < 0.001$), after adjusting for other student-level variables. Contrary to what would be expected, higher self-reported stress ratings were found to be associated with a decrease of 0.275 mmHg in SBP ($\beta = -0.275$, $p < 0.001$), controlling for other student-level variables. Both increased time in sedentary behavior and an increase in the number of days physically active for at least 20 minutes were significantly related to girls' SBP in the expected directions. Increased time spent in sedentary behavior was associated with an increase of 0.2 mmHg in SBP ($\beta = 0.200$, $p < 0.001$), while a one-day increase of the number of days being physically active for at least 20 minutes was associated with a decrease of 0.093 mmHg in SBP ($\beta = -0.093$, $p < 0.001$). As with BMI, healthy and unhealthy food consumption scores were significantly related to SBP, but not in the expected directions. For instance, with a one-unit increase in healthy food consumption score, SBP was found to increase by 0.184 mmHg ($\beta = 0.184$, $p = 0.001$), after adjusting for other student-level factors. Finally, SBP was found to decrease by 0.258 mmHg with a one-unit increase in unhealthy food consumption score ($\beta = -0.258$, $p < 0.001$).

School cohort-level factors. As with BMI, school-level SES, as measured by greater percentage of students receiving free or reduced-price lunch, was expected to be inversely associated with higher student SBP (Hypothesis 1). Similarly, it was hypothesized that indicators of a stressful school environment would also be associated with higher student SBP. In particular, the public health literature on effects of the neighborhood on health suggests that crime rate is often associated with increases in blood pressure. Thus, the "safety grade" assigned by the school district to each school cohort was expected to be inversely associated with SBP, as higher grades were assigned to schools reporting fewer crimes and other incidents and thus, those deemed to be safer. Again, to test Hypotheses 1 and 2, variables reflecting the socioeconomic status and school climate, including safety grade, were added to the model at Level 2. The variance at the school cohort level was reduced, but remained significantly different from zero ($\sigma^2_{u0} = 3.779$, $p < 0.001$).

As compared to results of the BMI model, fewer of the school cohort-level variables were found to be significantly associated with SBP, after controlling for all other school cohort-level factors. Contrary to Hypothesis 1, the percentage of students receiving free or reduced-price lunch was inversely associated with SBP, such that girls in school cohorts with higher rates of free/reduced-price lunch have lower average SBP by 0.045 mmHg ($\gamma = -0.045$, $p < 0.001$). As predicted, girls in school cohorts with higher safety grades (i.e., fewer reports of crimes and other offenses) were noted to have lower average SBP by 0.719 mmHg ($\gamma = -0.719$, $p < 0.01$). However, other positive school indicators (e.g., number of instructional computers available per student, FCAT reading passing rate, average positive climate rating), student-teacher ratio, and total student enrollment were not associated with SBP in girls (p's > 0.05). Finally, mean age, mean days physically active for 20 minutes or longer, mean sedentary time, mean self-reported stress rating, and mean scores for consumption of healthy and unhealthy foods were not found to be associated with SBP (p's > 0.05).

Boys. Model results for boys for both a null model (Model 1) and a variance component model with individual- and school cohort-level variables (Model 2) are shown in Table 7. In the null model, the variance of the random effects of school cohorts was significantly different from zero ($\sigma^2_{u0} = 3.916$, $p < 0.001$). The intraclass correlation coefficient was 0.025, indicating that the school-level variance contributed only about 2.5% to the overall variance in SBP. After adding both student- and school cohort-level variables, approximately 0.5% of the student-level variance and 15.8% of the school-cohort level variance were explained by Model 2.

Student-level factors. All but one of the student-level variables were found to be significantly associated with SBP at $\alpha = 0.01$ for boys. Unlike in girls, student age was positively associated with SBP, such that as boys age one additional year, their SBPs increase by 0.411 mmHg ($\beta = 0.411$, $p < 0.001$). As in the model results for BMI, the SBPs of boys self-identifying as Hispanic were found to be 0.482 mmHg higher than those of their non-Hispanic peers ($\beta = 0.482$, $p < 0.001$), after adjusting for other student-level variables. Similar to the SBP model results for girls, higher self-reported stress ratings in boys were unexpectedly found to be associated with a decrease of 0.274 mmHg in SBP ($\beta = -0.274$, $p < 0.001$), controlling for other student-level variables. For boys, a one-day increase in number of days per week physically active for at least 20 minutes was associated with a decrease in SBP of 0.081 mmHg ($\beta = -0.081$, $p < 0.01$), following adjustment for other individual-level variables. As boys' time spent in sedentary behavior increased by one unit, their SBP also increased 0.264 mmHg ($\beta = -0.274$, $p < 0.001$). Finally, similar to the results for girls and contrary to expectation, SBP was found to decrease by 0.384 mmHg ($\beta = -0.384$, $p < 0.001$) with a one-unit increase in unhealthy food consumption score. SBP was not significantly associated with healthy food consumption score in boys ($p > 0.01$).

School cohort-level factors. Only one of the variables reflecting the socioeconomic status and school climate at the school cohort level were found to be significantly associated with SBP in boys. After adjusting for student-teacher ratio, total student enrollment, instructional computer rate, the percentage of students receiving free/reduced price lunch, positive climate, safety grade, and cluster means of student-level variables, only FCAT reading passing rate (i.e., school achievement) was significantly associated with a change in SBP, but not in the expected direction. Boys in school cohorts with higher FCAT reading passing rates were found to have higher average SBP by 0.052 mmHg ($\gamma = 0.052$, $p < 0.01$). Contrary to hypotheses, percentage of students receiving free/reduced-price lunch, student-teacher ratio, total student enrollment, number of instructional computers available per student, average positive climate rating, safety grade assigned to school, mean age, mean days physically active for 20 minutes or longer, mean sedentary time, mean consumption of healthy and unhealthy food scores, and mean self-reported stress rating were not found to be associated with SBP in boys (p's > 0.01).

Diastolic blood pressure.

Girls. Results for girls from both a null model (Model 1) and a variance component model with individual- and school cohort-level variables (Model 2) are shown in Table 8. In the null or unconditional model, the variance of the random effects of school cohorts was significantly different from zero ($\sigma^2_{u0} = 4.995$, $p < 0.001$). The intraclass correlation coefficient was 0.054, indicating that the school-level variance contributed approximately 5.4% to the overall variance in DBP. After adding both student- and school cohort-level variables, approximately 0.3% of the student-level variance and 17.3% of the school-cohort level variance were explained by Model 2.

Student-level factors. A number of the student-level variables were found to be significantly associated with DBP. Girls self-identifying as Hispanic were noted to have DBP values 0.941 mmHg lower than that of their non-Hispanic peers ($\beta = -0.941$, $p < 0.001$), after adjusting for other student-level variables. Contrary to expectation, increases of one point in self-reported stress ratings were associated with a 0.142 mmHg decrease in DBP, controlling for other student-level variables ($\beta = -0.142$, $p < 0.001$). As expected, following adjustment for other individual-level factors, increased time spent in sedentary behavior was associated with an increase of 0.123 mmHg in DBP ($\beta = 0.123$, $p < 0.01$). Similarly, a one-day increase in number of days per week physically active for at least 20 minutes was associated with a reduction of 0.096 mmHg in DBP ($\beta = -0.096$, $p < 0.001$). A one-unit increase in unhealthy food consumption score was unexpectedly associated with a reduction of 0.112 mmHg in DBP ($\beta = -0.112$, $p < 0.001$). Student age and healthy food consumption score were not associated with DBP in girls (p's > 0.01).

School cohort-level factors. With the addition of student and school cohort-level variables, the variance of random effects of Level 2 was slightly reduced, but remained significantly different from zero ($\sigma^2_{u0} = 4.132$, $p < 0.001$). However, contrary to hypotheses, unlike in BMI and SBP, none of the variables reflecting the socioeconomic status and school climate were significantly associated with DBP in girls.

Boys. Results for boys from both a null model (Model 1) and a variance component model with individual- and school cohort-level variables (Model 2) are shown in Table 8. In the null model, the variance of the random effects of school cohorts was significantly different from zero (σ^2_{u0} = 5.566, $p < 0.001$). The intraclass correlation coefficient was 0.050, indicating that the school-level variance contributed approximately 5% to the overall variance in DBP. After adding both student- and school cohort-level variables, approximately 0.6% of the student-level variance and 18.3% of the school-cohort level variance were explained by Model 2.

Student-level factors. A number of the student-level variables were found to be significantly associated with DBP, including student age, Hispanic ethnic group membership, days per week with at least 20 minutes of physical activity, sedentary time, and unhealthy food consumption score. Unlike in girls, student age was associated with DBP, such that as boys age one year, their DBP increases by 0.834 mmHg (β = 0.834, $p < 0.001$). Like girls, boys self-identifying as Hispanic had DBP values 0.524 mmHg lower than those of their non-Hispanic peers (β = −0.524, $p < 0.001$). As anticipated, controlling for other student-level factors, increased time spent in sedentary behavior was associated with an increase of 0.198 mmHg in DBP (β = 0.198, $p < 0.01$) for boys. Accordingly, a one-day increase in number of days per week physically active for at least 20 minutes was associated with a reduction of 0.162 mmHg in DBP (β = -0.162, $p < 0.001$). Contrary to expectation, a one-point increase in unhealthy food consumption score was associated with a reduction of 0.116 mmHg in DBP (β = -0.116, $p < 0.001$). As in girls, healthy food consumption scores were not associated with DBP ($p > 0.05$). However, unlike in girls, self-reported stress ratings were not associated with DBP in boys ($p > 0.05$).

School cohort-level factors. Again, it was expected that lower school-level SES, as indicated by greater percentage of students receiving free or reduced-price lunch, would be associated with higher student DBP. Accordingly, indicators of an overcrowded, underachieving school environment were also hypothesized to be associated with higher student DBP. As found for girls, none of the variables reflecting the socioeconomic status and school climate were significantly associated with DBP in boys.

Did the School-level Factors Influence Girls More than Boys?

To investigate whether school-level factors influenced boys and girls differently, boys and girls were modeled separately and the results were reported above. The 95% confidence intervals of parameter estimates for significant predictors were compared. In general, the school cohort level only accounted for a small portion of variance in the health outcomes for both girls and boys, but these variance components were larger for girls. For significant Level 2 predictors of all 3 health outcomes, all 95% confidence intervals of estimated coefficients overlapped between the girls' and boys' models. Thus, it cannot be concluded that the effects of these predictors were significantly different in girls, as compared to boys. However, in the models for both BMI and SBP, more Level 2 predictors were significant for girls than for boys. For instance, the safety grade assigned to a school was a significant predictor of SBP for girls, but not for boys. Of note, at Level 1, self-identifying as Hispanic did appear to have differential effects on students' BMI, as confidence intervals for these coefficients were not overlapping. Hispanic girls had lower BMIs compared to non-Hispanic girls. Conversely, Hispanic boys had higher BMIs than non-Hispanic boys.

Summary of Results

As visually depicted in Table 11, several student-level variables were significantly associated with BMI in both girls and boys with few differences, including age, reported stress level, amount of time spent sedentary, and healthy and unhealthy food consumption scores. For both boys and girls, amount of physical activity was not associated with BMI. However, for both genders, amount of time spent sedentary and unhealthy food consumption score, as well as amount of physical activity, were significantly associated with SBP and DBP. Reported stress levels were also associated with SBP in both boys and girls, but not in the expected direction. Hispanic ethnicity appeared to have differential effects on BMI and SBP across genders.

School-cohort level predictors appeared to have a greater effect on BMI as compared to the blood pressure outcomes and were more often associated with health outcomes in girls rather than boys (see Table 12). For instance, the proportion of students receiving free or reduced-price lunch, student-teacher ratio, and mean unhealthy food consumption score were directly associated with BMI in both girls and boys, while 3 additional predictors were associated with BMI in girls, though not always in the expected directions. However, only one predictor, school safety rating, was associated with SBP in the expected direction and only in girls. Unexpectedly, free and reduced-price lunch rate was weakly inversely associated with SBP in girls and FCAT passing rate was weakly directly associated with SBP in boys. None of the school cohort-level variables significantly predicted DBP in either gender.

With respect to study hypotheses, as predicted in Hypothesis 1, lower school-level SES was associated with increased BMI in both boys and girls. However, this relationship was not found for either blood pressure outcome. In fact, for girls, school-level SES appeared weakly directly associated with SBP. As stated in Hypothesis 2a, student-teacher ratio was directly associated with BMI for both boys and girls. However, this relationship was again not found for SBP or DBP. Total student enrollment was largely unassociated with study outcomes, with one exception. Total student enrollment was inversely associated with girls' BMI, contrary to Hypothesis 2a. As predicted in Hypothesis 2b, FCAT passing rate was inversely associated with BMI, but only in girls, while school safety rating was inversely associated with SBP, again only in girls. FCAT passing rate was directly associated with SBP in boys, contrary to Hypothesis 2b. Other positive school indicators were not significantly associated with any of the study outcomes. In support of Hypothesis 3, more school cohort-level factors appear to influence girls' health outcomes compared to those of boys, but differences in the effects of these predictors did not reach statistical significance.

Chapter 5: Discussion

This study investigated how individual-level health behaviors as well as school-level SES and school climate impact adolescent health outcomes. The research expands upon the existing literature in the area of school contextual effects on health, as it addresses these issues in a large, ethnically diverse sample of adolescents using multilevel techniques to properly account for the nested nature of these data. In support of study hypotheses, it was found that several school-level environmental factors, including student-teacher ratio, SES, and safety of the school, are associated with adolescent BMI and SBP, particularly in girls. Findings suggest that, in addition to an adolescent's health behaviors, where the adolescent attends school is relevant in terms of health outcomes and cardiovascular risk. A number of student-level factors, including age, ethnicity, and health behaviors, were found to be associated with the 3 study outcomes, BMI, SBP, and DBP. Significant findings related to covariates at the student level will be described first for each health outcome, followed by significant findings at the school cohort level.

Student-Level Factors and BMI

First, in both girls and boys, it was found that BMI was directly associated with student age. Such an association is expected to some degree due to natural pubertal development; however, it may also be related to existing evidence that physical activity declines and sedentary behavior increases as individuals progress through adolescence (Kimm et al., 2002; Must & Tybor, 2005). Self-identifying as Hispanic appeared to have different effects on student BMI, as Hispanic girls were found to have lower BMIs than their non-Hispanic peers, while Hispanic boys' BMIs were found to be higher than those of non-Hispanic boys. In fact, Flegal et al. (2010) found evidence of racial/ethnic BMI disparities in Hispanic boys as well, such that Hispanic boys tended to have higher BMIs than their non-Hispanic peers. Similar to the findings in the present study, Flegal et al. (2010) also found that Hispanic girls had lower BMIs than their non-Hispanic Black peers but found no difference between BMIs of Hispanic and non-Hispanic White girls. While the non-Hispanic group in the present study consisted of both non-Hispanic Blacks and Whites, there were relatively few Whites in the study sample due to the racial/ethnic distribution of students in the Miami-Dade County Public Schools. It is well known that Miami has a high prevalence of Hispanics, and in particular individuals of Cuban background. Research focusing on the racial/ethnic differences in the trajectory of BMI from adolescence to adulthood found that Cuban males have greater BMI increases over this time period, while there are not significant differences in the BMI trajectory between Cuban females and their non-Hispanic White counterparts (Albrecht & Gordon-Larsen, 2013). Taken together, the findings of the present study related to Hispanic boys are consistent with previously reported evidence of ethnic disparities in BMI, but the literature pertaining to ethnic differences in BMI for girls is mixed.

Student health behaviors were found to predict BMI in a comparable fashion between girls and boys. As expected, higher self-reported ratings of stress both in and outside of school were associated with increased BMI for all students. Chronic stress has been known to lead to overweight and obesity through both biological and behavioral pathways (McEwen, 1998b). Chronically stressed individuals may make behavioral changes, including reduced physical activity and poor dietary habits, which adversely impact weight status (Hamer, Molloy, & Stamatakis, 2008; Oliver & Wardle, 1998;

Torres & Nowson, 2007). As anticipated, sedentary behavior was directly associated with increases in BMI for both girls and boys; however, in this sample, physical activity frequency was not related to BMI for either gender. As discussed in McMurray et al. (2000), controversy exists in the literature as to whether physical activity is related to adolescent body weight. Several studies have found that overweight adolescents are more sedentary and less active than their normal-weight counterparts (Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998; Must & Tybor, 2005; Treuth et al., 2007). However, other studies have not consistently found a relationship between physical activity and weight status, suggesting instead that dietary habits play a larger role in body weight (McMurray et al., 2000; Must & Tybor, 2005). In the present study, both healthy and unhealthy food consumption were significantly related to BMI in both genders, but not in the expected directions. A lack of validated dietary intake measures in the present study may explain this aberrant finding, as 7 questions with limited response options were used to assess food intake on "a typical day." Research has shown that brief measures of dietary intake are prone to underreporting and other biases, particularly in children and adolescents, and that prolonged recordkeeping of foods eaten provides the best nutritional data (Livingstone, Robson, & Wallace, 2004). Also, dietary habits may be more variable than BMI over time and thus, the measure of dietary habits used may not have adequately captured the true relationship between the students' diet and their weight status.

Overall, a number of individual-level behavioral factors significantly predicted BMI, including stress and sedentary behavior, in a similar fashion across gender. Despite using an imprecise measure of self-reported stress, the present study linked increased stress levels to increased BMI in both boys and girls. This relationship should be explored in future studies using a validated measure of perceived stress.

Student-Level Factors and Blood Pressure

Similarly, several demographic and behavioral factors were also predictive of student blood pressure. Student age was directly associated with SBP, but only in boys. In terms of ethnicity, as with BMI, Hispanic ethnic background impacted SBP differently depending on gender. Hispanic girls were found to have lower SBP compared to their non-Hispanic peers, while Hispanic ethnicity in boys was associated with increased SBP. Similarly, Rosner et al. (2009) reported, after controlling for BMI, Hispanic boys had significantly higher rates of elevated SBP compared to non-Hispanics; however, no ethnic differences in prevalence of elevated SBP remained for girls after adjusting for BMI.

In both girls and boys, both physical activity frequency and time spent in sedentary behavior were significant predictors of SBP in the expected directions. An increase in the number of days physically active for at least 20 minutes per week was associated with decreased SBP. This finding is supported by a large body of literature suggesting that physical activity is preventive against hypertension across the lifespan and even reduces blood pressure in individuals with hypertension (Cornelissen & Smart, 2013; Janssen & LeBlanc, 2010; USDHHS, 1996; Whelton, Chin, Xin, & He, 2002). Again, in both girls and boys, sedentary time predicted increased SBP. Not only does time spent in front of a screen (e.g., computer, video games, television) detract from time in which an adolescent could be engaging in physical activity, but such inactive time could encourage increased snacking on unhealthy foods, including those with a high sodium content. Together, these contribute to an increased risk of obesity as well as elevated BP (White House Task Force on Childhood Obesity, 2010).

The remaining health behaviors that significantly predicted SBP did so in unexpected directions. For instance, in both girls and boys, self-reported stress ratings were inversely associated with SBP. This finding is not consistent with the literature, as chronic stress is a well-established contributor to elevated BP (Rozanski, Blumenthal, & Kaplan, 1999). However, several possible explanations for this finding exist in the present study. First, a validated measure of perceived stress, such as the Perceived Stress Scale, was not utilized in the present study. Additionally, as these data were collected during a brief BP screening procedure, students were only asked to report their current stress levels on one occasion, using a limited range of response options. It is possible that these students are not stressed to the extent necessary to elevate their SBP. A literature exists that suggests that chronic exposure to stress may contribute to the development of hypertension. Through the "fight or flight" response of the hypothalamic-pituitary-adrenal (HPA) axis, acute stressors result in adaptive changes within the cardiovascular system to manage the threat, including increased BP, followed by recovery. However, when this stress response is chronically activated, the BP response is sustained and lasting changes to the vasculature occur, resulting in elevated resting BP and even plaque formation (McEwen, 1998b; Selye, 1956).

It remains unclear why perceived stress was not associated in the expected direction with SBP, but was directly associated with BMI in both boys and girls. However, it is speculated that the self-reported stress ratings collected during the BP screening were more indicative of acute stressors, which are not consistently found to produce long-term effects on BP (Sparrenberger et al., 2009). Instead, it may be that the school cohort-level measures of stressors in the school environment are better proxies for chronic stress. In fact, the adolescent's inability to change environmental circumstances at school may be most stressful, as there is evidence that the controllability of stressors may determine the course of the stress response (Schneiderman, Ironson, & Siegel, 2005). One might speculate that the adolescent's perception of stress, however, may be sufficient to produce dietary and other behavioral changes that lead to increases in BMI.

Finally, as with BMI, both healthy and unhealthy food consumption were significantly associated with SBP for girls in this sample, but not in the anticipated directions. Only unhealthy food consumption was associated with SBP for boys, but again, not in the expected direction. This may be due to the use of a measure of dietary intake insufficient to capture true eating behavior.

In recent years, systolic BP has emerged as a more potent predictor of cardiovascular risk compared to diastolic BP. Thus, most recent studies of behavioral risk factors and blood pressure concentrate on SBP as an outcome (Kannel, 2000; Kivimaki et al., 2006). However, as medical professionals still recommend considering both SBP and DBP when determining cardiovascular risk, both measures were included in the present study. As observed for SBP, student age was again directly associated with DBP, but only in boys. This increase with age will likely taper off, as in adulthood, SBP is known to increase with age, but DBP begins to fall in later life (Franklin et al., 1997). Unlike in SBP, Hispanic ethnicity was associated with decreased DBP in both girls and boys. This finding was unexpected, but not entirely contradictory to the literature, as evidence of ethnic disparities in adolescent blood pressure has been inconsistently found, especially after controlling for overweight and obesity (Park, Menard, & Yuan, 2001; Sorof, Lai, Turner, Poffenbarger, & Portman, 2004). As with SBP, both increased sedentary time and reduced physical activity were predictive of increased DBP in both girls and boys. Again, unexpectedly, stress was found to be inversely associated with DBP, but only in girls, while unhealthy food consumption was associated with decreased DBP for both genders. As mentioned above, these unanticipated findings may be attributable to weaknesses in how these predictors were measured in the present study or, in the case of stress, may be due to insufficient intensity and duration to elevate BP.

In sum, a number of health behaviors were found to be associated with both SBP and DBP; however, these associations were not always in the expected directions. Compared to its relationship with BMI, it appears that physical activity has more influence on blood pressure in adolescents. Thus, programs to increase students' physical activity may be beneficial in reducing cardiovascular risk by improving blood pressure management.

School Cohort-Level Factors and BMI

Many multilevel studies investigating school-contextual influences on health, including school-level SES, have not utilized actual clinical endpoints as outcomes, instead opting for self-reported psychosomatic symptoms (Låftman and Modin, 2012; Torsheim and Wold, 2001; Saab and Klinger, 2010). However, a few recent studies in this area have used weight status or BMI as primary outcomes (Lee et al., 2013; Martin et al., 2012; Richmond, Milliren, Walls, & Kawachi, 2014; Richmond and Subramanian, 2008). Whenever possible, the results of the present study will be compared to these—

with an important caveat, as individual-level SES was not available to be used in the present study due to school district constraints on data collection.

In the present study, school cohort-level SES, as indexed by the percentage of students eligible for the free or reduced-price lunch program, was significantly associated with BMI in both girls and boys. Hypothesis 1 was partially supported, as a higher percentage of students qualifying for free or reduced-price lunch predicted increased average BMI. Several previous studies have also suggested that school-level SES is associated with students' weight status (Lee et al., 2012; Martin et al, 2012; O'Malley et al., 2008; Richmond and Subramanian, 2008) and have found this association even after controlling for individual-level SES. Various mechanisms by which a school's average SES may impact the weight status of its student body have been posited. First, behaviorally speaking, school-level SES may affect the resources available to the school to provide healthy food options and adequate, safe opportunities to engage in physical activity. Further, the nutritional value of the free/reduced-price lunches provided may not be adequate, spurring overeating later in the day. Also, lower-SES schools have been found more likely to have chaotic classrooms and incidents of violence (Mrug, Loosier, & Windle, 2008), potentially leading to persistent activation of students' stress response and triggering a hormonal cascade which may promote weight gain over time.

In addition, larger student-teacher ratio in schools was conceptualized as a proxy for population density, which has often been used as a predictor in multilevel studies of neighborhood effects on health. As predicted in Hypothesis 2a, in both girls and boys, increased student-teacher ratio was predictive of increased average BMI. Some studies have conceptualized overcrowding as a model of chronic stress (Johnston-Brooks et al., 1998; Lee and Cubbin, 2002) and have found that overcrowding—at the neighborhood level—predicts physical illness, but not cardiovascular health behaviors, in youth. At the school level, both class size and student-teacher ratio have been used to represent crowded conditions (Maes & Lievens, 2003; Saab & Klinger, 2010). In the present sample, class size was not correlated with other study variables and thus, student-teacher ratio was used. Unlike in the present study, other school-based studies have failed to detect an association between classroom overcrowding and health outcomes (Maes & Lievens, 2003; Nygren, Bergstrom, Janlert, & Nygren, 2013).

Finally, higher school-cohort mean consumption of unhealthy food also predicted increased average BMI in both girls and boys. This finding is consistent with prior research suggesting that obesity spreads through social networks (Christakis & Fowler, 2007). It may be important to consider peer effects in studies of dietary habits and weight status, as unhealthy eating patterns and other detrimental health behaviors may be transmitted through social connections (Pachucki, Jacques, & Christakis, 2011). In this way, the school context and social norms around eating within a school may greatly influence students' BMIs. As reported earlier, students' self-reported unhealthy food consumption did not predict increased BMI as expected at the student level. This may be explained by Livingstone and colleagues' (2004) conclusion that available measures of dietary intake are better able to provide unbiased estimates of food consumption at the group level for children and younger adolescents, but remain prone to bias at the individual level.

Additional school cohort-level factors were found to be significantly associated with BMI in only girls; however, only one of these associations was in the expected direction. First, as anticipated in Hypothesis 2b, girls in school cohorts with lower passing rates on the FCAT reading test had higher average BMIs. School-level achievement may be indirectly linked to students' health status. Schools with poorer achievement may be pressured to cut extracurricular activities and physical education programs in favor of a focus on remedial academic courses. Such cuts may have a greater effect on girls, who are less likely than boys to engage in physical activity outside of school (Sallis et al., 1996; Treuth et al., 2007). Total student enrollment was also associated with BMI, but not in the expected direction. Girls in school cohorts with lower student enrollment were found to have higher average BMIs, although this difference was very slight and unlikely to be clinically meaningful. Also unexpectedly, higher school-cohort mean stress ratings were associated with lower BMI, but only in girls. Perhaps the female tendency to "tend-and-befriend" to cope with stress is more protective against weight gain in peer networks reporting higher levels of stress (Taylor et al., 2000).

Overall, the findings suggest that, in addition to an adolescent's health behaviors, the adolescent's school setting and resources may contribute to their weight status. Thus, overweight and obesity are not strictly the result of individual action, but also products of environmental factors beyond the adolescent's control.

School Cohort-Level Factors and Blood Pressure

Stressful environments have often been studied as predictors of SBP. These studies have largely been conducted at the neighborhood level (Cubbin, Hadden, & Winkleby, 2001; Harburg et al., 1973; Harburg, Gleibermann, Roeper, Schork, & Schull, 1978; McGrath et al., 2006; Mujahid et al., 2008). Despite schools often being settings in which youth's blood pressures are screened (Miller & Shekelle, 1976), studies to date have not investigated relationships between school characteristics and blood pressure. In contrast to Hypothesis 1, school-level SES was not found to be associated with SBP in boys. A weak association was found in girls, but not in the expected direction, as decreased student eligibility for free/reduced-price lunch (i.e., higher SES) was associated with higher average SBP. It is possible that, for girls, being more affluent is associated with higher stress and more health consequences; however, this remains unclear, as individual-level SES was not available to investigators in the present study. Studies like Miller and Shekelle's school-based screening (1976) have found weak inverse associations between blood pressure and individual-level SES. Several studies have failed to find an association between SES and adolescent blood pressure (Cornoni-Huntley et al., 1979; Hunter et al., 1979; Whincup et al., 1994) or have found minimal associations (Chen & Paterson, 2006). Further, Chen, Matthews, and Boyce (2002) posit that the traditionally inverse relationship between BP and SES found in children and adults may not hold in adolescents, as it has not been consistently found in the literature.

Hypothesis 2b was partially supported in relation to BP, as girls in school cohorts with lower assigned safety grades (i.e., more violent and non-violent offenses reported at school) were found to have higher average SBP. As stated previously, lower-SES schools have been found to be more chaotic environments with more reports of violent incidents (Mrug et al., 2008). The present finding is consistent with the classic Harburg studies conducted in Detroit, Michigan, which found adult residents' blood pressures were higher in "high stress" areas within the city (Harburg et al., 1973; Harburg et al., 1978). One of the components of "stress scores" assigned to each Census tract was the degree of "neighborhood threat," which included subjective ratings of safety in the area, likelihood of robbery or assault if out at night, knowledge of violent crimes in the area, and also the responsiveness of law enforcement to complaints. Greater neighborhood safety ratings (i.e., lower crime rates) have since been linked to decreased prevalence of hypertension in adults as well (Mujahid et al., 2008). Additional work by Wilson and colleagues (2004) suggests that youth's exposure to community violence leads to pre-clinical changes in cardiovascular reactivity, particularly elevated nighttime BP. However, typically boys respond more negatively to overt aggression than girls, who are more likely to have increased physiological reactivity to interpersonal stress (e.g., relational aggression) (Ewart, Jorgensen, & Kolodner, 1998). Thus, the absence of this finding in boys is surprising.

In boys, only one school-level factor, FCAT reading passing rate, was related to increased SBP, but not in the expected direction. Boys in school cohorts with higher FCAT reading passing rates were found to have higher average SBP. While unexpected, it may be that higher-achieving schools place more academic stress on students, which has a greater adverse effect on boys rather than girls. Thus, overall, Hypotheses 1 and 2a were not supported in terms of SBP.

Finally, none of the school-level factors were associated with DBP in this sample and thus, none of the study hypotheses were supported in relation to DBP. Diastolic BP has not often been considered as an outcome in studies of socioeconomic or environmental factors on health, with researchers often opting for the presence of hypertension as a dichotomous outcome or systolic BP alone as primary outcomes. This may be due to a lack of significant findings in regard to DBP, as in the present study.

Of note, a BP-SES gradient has not been consistently found in adolescent populations (Chen et al., 2002), which may explain why fewer school climate factors were associated with BP as compared with BMI in the present study. Furthermore, blood pressure measurements are more variable and sensitive to situational stress (e.g., white coat hypertension) than BMI, which is a more stable measure. As such, relationships between chronic stressors, such as school-level SES and unsupportive school climate, and BMI may be more reliably found, as in the present study. As noted above, school cohort-level factors may be more likely to produce elevated BP, compared to student-level perceived stress, as they constitute a model of chronic stress. Results suggest that different school-level factors may chronically activate the stress response in boys versus girls, as FCAT passing rate (proxy of academic demands) was significantly associated with SBP in boys, while school safety was significantly associated with SBP in girls. These findings appear to map onto traditional gender roles, as males may feel more pressure to achieve academically to ensure future financial success, while females may have a need to feel safe and protected from harm when outside of the home (Brannon, 2010).

These findings suggest that stressful school environments, not only neighborhoods, have deleterious effects on adolescent SBP. Thus, school-based hypertension prevention efforts may maximize benefit by targeting schools known to be stressful, either due to safety concerns or tremendous academic pressure.

Study Limitations

The present study has a number of limitations that should be mentioned and addressed in future research. First, as these data were collected between 10 and 16 years ago, the findings may not accurately reflect the current relationships between school environments and student health outcomes. Evidence of greater socioeconomic segregation among schools since the early 2000s has surfaced, indicating these findings may actually underestimate the impact of school-level SES on health (Civil Rights Project, 2009). A second and important limitation of the present study is that, due to the school district administration's restrictions on data collection, a measure of individual-level SES, such as parental education or household income, could not be collected. Thus, student SES could not be entered into the models at Level 1, making it impossible to determine the proportion of variance in health outcomes explained by school-level SES versus individual-level SES. While in some contexts, ethnicity might be considered as a proxy for individual SES, in Miami, race/ethnicity and social class do not map well onto each other. As a consequence of this, findings related to Hispanic ethnicity may not generalize to all Hispanic-American adolescents, as Hispanics are not a minority group in Miami-Dade County.

Next, although modeled after questionnaire items used in the 1999 YRBS, the items used to assess dietary intake, physical activity, sedentary behavior, and stress were not ideal to produce continuous variables to be used in linear models. Of note, these ordinal variables were treated as continuous in the present analyses because prior research indicated that normally distributed ordinal variables with 5 or more categories can be treated as continuous without much consequence (Dolan, 1994; Johnson & Creech, 1983). However, in another way, the brief measure used in the present study is also a strength as it allowed for quick assessment of a very large sample of students. As such, the present study also relied on self-reported weight and height to calculate students' BMI. Height was only objectively measured if the student was unaware of his or her height. However, both weight and waist circumference could be measured quickly in a large-scale health screening setting with adequate staffing, as our research group has done in a different study since these data were collected.

Finally, although these data were collected over a six-year period, the study remains cross-sectional in nature because different groups of students (those enrolled in 10^{th} grade) were assessed each year. As such, we are unable to draw conclusions about causality amongst these variables at the individual level.

Study Strengths

A strength of the present study is the availability of a very large, diverse sample of adolescents residing in Miami-Dade County, Florida, which includes ethnic subgroups not widely represented in behavioral research. The present study has a number of additional strengths, which help address gaps in the current literature relating to school-based studies of adolescent health outcomes. The primary contribution of this study to the literature is the use of blood pressure, which was objectively measured by trained staff, as an outcome because blood pressure has not been included in other studies of school climate and SES on adolescent health. This allows school-level environmental factors to be linked to a biomarker for the first time. Further, the present study replicates findings of similar studies of school-level SES and health that have used weight status or BMI as outcomes (Martin et al., 2012; O'Malley et al., 2007; Richmond & Subramanian, 2008).

Another important strength of the present study is the use of HLM to examine associations between adolescent health outcomes and both individual- and school-level factors. Several other studies of health outcomes in a neighborhood or school context use traditional regression methods, rather than multilevel modeling, despite collecting nested data. Students attending the same school are considered more similar than a random sample of students, as they are exposed to similar experiences, curricula, teachers, peer groups, and other school characteristics. Thus, HLM was utilized in the present study to account for the non-independence of these data and allow for the partitioning of variance between the individual and school levels.

Future Directions

Future directions for this line of research fall into two categories: 1) ways upon which the present methods can be improved and 2) additional questions to be investigated that may further elucidate the relationships between school characteristics, SES, and adolescent health. First, future research would benefit from the ability to collect multiple measures of SES at both the individual and school levels, which would be more reliable than one measure alone and could be combined into a latent construct to better represent SES. Future studies may also benefit from utilizing more well-validated measures of health behavior variables, including the Eating Behavior Survey (Fahlman, McCaughtry, Martin, Garn, & Shen, 2012) or a dietary recall method to assess for food intake, accelerometry data to measure physical activity and sedentary behavior, and the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) or Adolescent Perceived Events Scale (Compas, Davis, Forsythe, & Wagner, 1987) to assess life stress. Improved measurement of the health behavior variables may increase consistency in the directionality of relationships between these predictors and the health outcomes.

While the current study was limited by the cross-sectionality of the student-level data, future studies using this dataset may conceptualize these data as longitudinal at the school level. This would enable researchers to look for trends in school-level environmental factors or changes in the average health behaviors or outcomes of 10^{th}-graders over time. Ideally, further study examining relationships between school-level environmental factors and student health outcomes would include follow-ups when the students are young and middle-aged adults to identify any long-term risk incurred by attending a low-income high school with a stressful climate. Alternatively, it may be that only particular subgroups of students are at risk of adverse outcomes as a result of school environment and climate (e.g., those who are clinically distressed, those with past or current exposure to trauma elsewhere, those who attend a school outside of their home district and thus, are more isolated from peers). The measures used in the present study precluded looking at these sorts of relationships; however, as the present study found associations between adversity at the school level and health outcomes, future work may include identifying those adolescents at highest risk of poor health outcomes as a result of school environment.

Clinical and Public Health Implications

The present findings have several clinical and public health implications. The present study found that several school-level environmental factors, including student-teacher ratio, SES, and safety of the school, are associated with adolescent health outcomes, particularly in girls. Poor weight status and elevated blood pressure may result, in part, from influences beyond the adolescent's control and not solely individual action.

Thus, policy changes to impact school environments on a larger scale, rather than focusing on individual behavior change, may help students more effectively maintain healthy weights and blood pressures. Importantly, on average, both boys and girls in this sample did not meet recommended guidelines in terms of fruit and vegetable consumption or physical activity. Since these data were collected, Miami-Dade County Public Schools have made changes to school cafeteria menus, including the introduction of a “School Garden to Cafeteria” program. In order for a meal to be considered in compliance with the National School Lunch Act, a student must take at least one serving of a fruit or a vegetable as one of the meal’s components (MDCPS, 2015). However, if a student receives free breakfast and lunch at school, but does not have access to produce at home, he or she may only be served 2 one-half cup fruit/vegetable servings per day, not meeting the recommended guideline of at least 2.5 cups per day (USDA & USDHHS, 2010). Based on the results of the present study, boys and girls may equally benefit from decreasing sedentary time and increasing time spent participating in physical activity. In particular, schools may make an effort to increase the amount of time students are engaged in aerobic activity for at least 10 minutes during a physical education class.

School policies should seek to effect change in these health behaviors. Schools are an important setting in which to foster these habits, particularly in lower-income neighborhoods where opportunities for safe physical activity and fresh produce (e.g., food deserts) may not be readily available.

Finally, these findings suggest that other changes to school environments may not only improve academic and social outcomes, but physical health outcomes as well, especially when coupled with behavior change. In particular, hiring more teachers to reduce the student-teacher ratio may benefit both boys and girls in terms of weight status. Improving school safety may be beneficial in terms of reducing girls’ blood pressures. Lower school-level SES appears related to increased BMI in both boys and girls. Thus, school district administrators may also wish to target their obesity prevention efforts at schools with more students from lower-income families, which have a higher proportion of students receiving free or reduced-price lunch. While these adjustments are costly in the short-term, such changes could have large payoffs in reducing in the rise of adolescent obesity and arresting the development of long-term health consequences as adolescent health habits track into adulthood.

Conclusions

The results of this study suggest that aspects of an adolescent's school context may contribute to cardiovascular risk factors, above and beyond the influence of his or her individual health behaviors. At the school level, student-teacher ratio, SES, and cohort mean unhealthy food consumption were associated with BMI in both girls and boys, while fewer school-level factors were related to SBP and none to DBP. School safety was inversely associated with SBP in girls, but not significantly associated to SBP in boys. School context and SES may have greater adverse effects on a student's weight status compared to BP or, perhaps, this relationship is more reliably found due to the more variable nature of blood pressure measurements. This study built upon the existing literature in the area of school contextual effects on health outcomes, as it utilized multilevel modeling and included objectively measured blood pressure as an outcome.

Several student-level factors, including age, reported stress level, and sedentary time, were directly associated with BMI for both girls and boys. Physical activity was not related to BMI for either gender. However, sedentary time was directly associated, while time spent in physical activity was inversely associated, with both systolic and diastolic BP in girls and boys. Physical activity habits appear to have a larger influence on adolescents' blood pressure measurements than on weight status. With few exceptions, individual-level factors were similarly related to BMI and BP across gender.

On average, this diverse sample of students did not meet recommended guidelines for physical activity or fruit/vegetable consumption. Secondary schools may be an important venue to cultivate these healthy habits and curb the effects of childhood obesity before students become adults. In addition, school district-level policy changes to decrease overcrowding in school and increase school safety may also have added benefits in terms of adolescents' weight and blood pressure status.

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Table 1

Number of Schools and Students Screened by Year

School Year	Number of Schools Screened (Level 2 units)	Number of Students Screened (Level 1 units)	Number of Students Included in Analyses
1999 - 2000	36	15,522	14,942
2000 - 2001	39	15,707	14,925
2001 – 2002	39	16,147	15,166
2002 – 2003	37	15,144	14,282
2003 – 2004	38	13,389	12,554
2004 – 2005	38	13,027	12,296
Total	--	88,936	84,165

Table 2

Schools Participating in the Blood Pressure Screening by Year

School Name	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005
American	**X**	**X**	**X**	**X**	**X**	**X**
Barbara Goleman	**X**	**X**	**X**	**X**	**X**	**X**
Booker T. Washington		**X**	**X**	**X**	**X**	**X**
Braddock	**X**	**X**	**X**	**X**	**X**	**X**
Carol City	**X**	**X**	**X**	**X**	**X**	**X**
Coral Gables	**X**	**X**	**X**		**X**	**X**
Coral Reef	**X**	**X**	**X**	**X**	**X**	**X**
DASH	**X**	**X**	**X**	**X**	**X**	**X**
Dr. Michael Krop	**X**	**X**	**X**	**X**	**X**	**X**
Felix Varela		**X**	**X**	**X**	**X**	**X**
Hialeah	**X**	**X**	**X**	**X**	**X**	**X**
Hialeah-Miami Lakes		**X**	**X**	**X**	**X**	**X**
Homestead	**X**	**X**	**X**	**X**	**X**	**X**
MAST Academy	**X**	**X**	**X**	**X**	**X**	**X**
McArthur North*	**X**	**X**	**X**	**X**	**X**	**X**
McArthur South*	**X**	**X**	**X**	**X**	**X**	**X**
Miami Beach	**X**	**X**	**X**	**X**	**X**	**X**
Miami Central	**X**	**X**	**X**	**X**	**X**	**X**
Miami Coral Park	**X**	**X**	**X**			**X**

Miami Edison	**X**	**X**	**X**	**X**	**X**	**X**
Miami Jackson	**X**	**X**	**X**	**X**	**X**	**X**
Miami Killian	**X**	**X**	**X**	**X**	**X**	**X**
Miami Lakes Tech Educational Center*	**X**	**X**	**X**	**X**	**X**	**X**
Miami Northwestern	**X**	**X**	**X**	**X**	**X**	**X**
Miami Senior	**X**	**X**	**X**	**X**	**X**	**X**
Miami Springs	**X**	**X**	**X**	**X**	**X**	**X**
Miami Sunset	**X**	**X**	**X**	**X**	**X**	**X**
New World	**X**	**X**	**X**	**X**	**X**	**X**
Norland	**X**	**X**	**X**	**X**	**X**	**X**
North Miami	**X**	**X**	**X**	**X**	**X**	**X**
North Miami Beach	**X**	**X**	**X**	**X**	**X**	**X**
Palmetto	**X**	**X**	**X**	**X**	**X**	**X**
Robert Morgan*	**X**	**X**	**X**	**X**	**X**	
School for Applied Technology*	**X**	**X**	**X**	**X**	**X**	**X**
South Dade	**X**	**X**	**X**	**X**	**X**	**X**
South Miami	**X**	**X**	**X**	**X**	**X**	**X**
Southridge	**X**	**X**	**X**	**X**	**X**	**X**
Southwest Miami	**X**	**X**	**X**	**X**	**X**	**X**
Turner Tech*	**X**	**X**	**X**	**X**	**X**	**X**

*Asterisks reflect school cohorts not included in the present analyses due to the vocational/non-traditional nature of the school.

Table 3

Frequencies and Percentages of Demographic Variables for Overall Sample and by Gender

Demographic variable	Overall sample (N = 84,372)		Boys (N = 41,400)		Girls (N = 42,765)	
	n	%	*n*	%	*n*	%
Gender						
Female	42,765	50.8	0	0.0	42,765	100.0
Male	41,400	49.2	41,400	100.0	0	0.0
Ethnicity						
White	7,468	8.9	3,830	9.3	3,620	8.5
Hispanic	51,615	61.8	25,478	62.1	26,048	61.4
Black	18,699	22.4	8,884	21.7	9,762	23.0
Other	5,826	7.0	2,832	6.9	2,984	7.0
Primary language spoken at home						
English	41,907	51.3	20,568	51.3	21,275	51.4
Spanish	33,939	41.6	16,690	41.6	17,177	41.5
Other	5,830	7.1	2,825	7.1	2,982	7.2

Note. Frequencies not summing to complete N of sample reflect missing data.

Table 4

Means and Standard Deviations of Level 1 Predictors for Overall Sample and by Gender

Level 1 predictor	Overall sample (N = 84,372)				Boys (N = 41,400)				Girls (N = 42,765)			
	M	*SD*	Min	Max	*M*	*SD*	Min	Max	*M*	*SD*	Min	Max
Body mass index (kg/m^2)	22.92	4.39	15.60	64.00	23.37	4.54	15.20	60.40	22.48	4.19	15.60	64.00
Systolic BP (mmHg)	118.18	12.62	94.00	174.00	122.26	12.61	94.00	174.00	114.23	11.30	95.00	170.00
Diastolic BP (mmHg)	69.06	7.13	60.00	118.00	69.79	6.56	60.00	118.00	68.35	7.64	60.00	118.00
Age	15.60	.74	12.00	19.00	15.66	.76	12.00	19.00	15.54	.71	12.00	19.00
Stress rating (0-6)	3.74	1.24	1.00	6.00	3.50	1.21	1.00	6.00	3.97	1.22	1.00	6.00
Physically active time (days > 20 min)	3.05	2.25	.00	7.00	3.54	2.30	.00	7.00	2.57	2.09	.00	7.00
Sedentary time (1-5)	3.07	1.19	1.00	5.00	3.11	1.19	1.00	5.00	3.03	1.19	1.00	5.00
Healthy food score (0-4)	2.38	1.10	.00	4.00	2.29	1.09	.00	4.00	2.46	1.10	.00	4.00
Unhealthy food score (0-8)	3.57	1.95	.00	8.00	3.48	1.89	.00	8.00	3.67	2.00	.00	8.00

Table 5

Means and Standard Deviations of Level 2 Predictors

Level 2 predictor	*N*	*M*	*SD*	Min	Max
Student–teacher ratio (students per teacher)	193	21.93	3.26	12.00	28.00
Total student enrollment (100 students)	193	29.54	10.53	4.57	53.75
Instructional computer rate (computers/student enrollment)	188	.26	.24	.04	2.58
Free or reduced-price lunch (%)	193	40.49	17.04	9.00	79.40
FCAT reading pass rate (%)	193	41.76	16.79	11.00	91.00
Positive school climate percentage (%)	193	70.55	12.92	35.67	95.00
Safety grade (0-4)	193	1.82	1.12	.00	4.00
Age (cluster mean)	193	15.59	.24	15.02	16.47
Physically active time (cluster mean)	193	3.01	.36	2.09	4.36
Sedentary time (cluster mean)	193	3.06	.22	2.04	3.59
Healthy food consumption score (cluster mean)	193	2.40	.24	1.83	3.04
Unhealthy food consumption score (cluster mean)	193	3.66	.81	1.76	5.48
Stress rating (cluster mean)	193	3.73	.22	3.24	4.62

Table 6

Pearson's Correlations among Level 1 Predictors for Overall Sample and by Gender

Level 1 predictors	1	2	3
1. Body mass index (kg/m^2)			
2. Systolic BP (mmHg)			
Overall sample	.309***	—	
Girls	.274***	—	
Boys	.311***	—	
3. Diastolic BP (mmHg)			
Overall sample	.156***	.386 ***	—
Girls	.154***	.427 ***	—
Boys	.147***	.348 ***	—
4. Age			
Overall sample	.057***	.045 ***	.049 ***
Girls	.050***	.008	.016 **
Boys	.049***	.031 ***	.067 ***
5. Stress rating			
Overall sample	-.014***	-.090 ***	-.028 ***
Girls	.001	-.036 ***	-.023 ***
Boys	.011*	-.027 ***	-.007
6. Physically active time			
Overall sample	.018***	.048 ***	-.022 ***
Girls	.006	-.024 ***	-.027 ***
Boys	-.012*	-.021 ***	-.048 ***
7. Sedentary time			
Overall sample	.024***	.032 ***	.024 ***
Girls	.023***	.029 ***	.021 ***
Boys	.019***	.018 ***	.022 ***
8. Healthy food consumption score			
Overall sample	.025***	-.009 **	-.002
Girls	.048***	.023 ***	.010 *
Boys	.021***	.012 *	-.002
9. Unhealthy food consumption score			
Overall sample	-.071***	-.055 ***	-.024 ***
Girls	-.056***	-.030 ***	-.022 ***

Boys	-.077***	-.052 ***	-.019 ***

*p < .05, **p < .01, ***p < .001.

(continued)

Table 6

Pearson's Correlations among Level 1 Predictors for Overall Sample and by Gender

Level 1 predictors	4	5	6
1. Body mass index (kg/m^2)			
2. Systolic BP (mmHg)			
Overall sample			
Girls			
Boys			
3. Diastolic BP (mmHg)			
Overall sample			
Girls			
Boys			
4. Age			
Overall sample	—		
Girls	—		
Boys	—		
5. Stress rating			
Overall sample	.000	—	
Girls	.001	—	
Boys	.031 ***	—	
6. Physically active time			
Overall sample	-.028 ***	-.013 ***	—
Girls	-.041 ***	.049 ***	—
Boys	-.052 ***	.012 *	—
7. Sedentary time			
Overall sample	-.034 ***	.018 ***	-.084 ***
Girls	-.031 ***	.006	-.095 ***
Boys	-.044 ***	.044 ***	-.093 ***
8. Healthy food consumption score			
Overall sample	.020 ***	.009 *	.091 ***
Girls	.028 ***	-.011 *	.118 ***
Boys	.027 ***	-.003	.106 ***
9. Unhealthy food consumption score			
Overall sample	.008 *	.047 ***	-.013 ***
Girls	.004	.034 ***	-.030 ***

Boys	.020 ***	.043 ***	.030 ***

**p* < .05, ***p* < .01, ****p* < .001.

(continued)

Table 6

Pearson's Correlations among Level 1 Predictors for Overall Sample and by Gender

Level 1 predictors	7	8
1. Body mass index (kg/m^2)		
2. Systolic BP (mmHg)		
Overall sample		
Girls		
Boys		
3. Diastolic BP (mmHg)		
Overall sample		
Girls		
Boys		
4. Age		
Overall sample		
Girls		
Boys		
5. Stress rating		
Overall sample		
Girls		
Boys		
6. Physically active time		
Overall sample		
Girls		
Boys		
7. Sedentary time		
Overall sample	—	
Girls	—	
Boys	—	
8. Healthy food consumption score		
Overall sample	-.031 ***	—
Girls	-.029 ***	—
Boys	-.028 ***	—
9. Unhealthy food consumption score		
Overall sample	.111 ***	-.039 ***
Girls	.124 ***	-.066 ***

Boys	.101 ***	-.017 **

*$p < .05$, **$p < .01$, ***$p < .001$.

Table 7

Pearson's Correlations among Level 2 Predictors

Level 2 predictors		1	2	3
1.	Student–teacher ratio	—		
2.	Total student enrollment	.793***	—	
3.	Instructional computer rate	-.493***	-.371***	—
4.	Free or reduced-price lunch	-.062	-.002	.205**
5.	FCAT reading pass rate	-.448***	-.272***	.262***
6.	Positive school climate percentage	-.334***	-.189**	.147*
7.	Safety grade	-.383***	-.242**	.156*
8.	Age (cluster mean)	.299***	.233**	-.256***
9.	Physically active time (cluster mean)	.000	.102	-.010
10.	Sedentary time (cluster mean)	.439***	.337***	-.098
11.	Healthy food consumption score (cluster mean)	-.190**	-.378***	.050
12.	Unhealthy food consumption score (cluster mean)	-.003	.042	.138
13.	Stress rating (cluster mean)	-.251***	-.272***	.005

*$p < .05$, **$p < .01$, ***$p < .001$.

(continued)

Table 7

Pearson's Correlations among Level 2 Predictors

Level 2 predictors		4	5	6
1.	Student–teacher ratio			
2.	Total student enrollment			
3.	Instructional computer rate			
4.	Free or reduced-price lunch	—		
5.	FCAT reading pass rate	-.471***	—	
6.	Positive school climate percentage	-.470***	.698 ***	—
7.	Safety grade	-.599***	.833 ***	.740 ***
8.	Age (cluster mean)	.229**	-.585 ***	-.485 ***
9.	Physically active time (cluster mean)	-.225**	.469 ***	.384 ***
10.	Sedentary time (cluster mean)	.305***	-.637 ***	-.654 ***
11.	Healthy food consumption score (cluster mean)	-.191**	-.007	.017
12.	Unhealthy food consumption score (cluster mean)	.366***	-.082	-.284 ***
13.	Stress rating (cluster mean)	-.440***	.512 ***	.454 ***

*$p < .05$, **$p < .01$, ***$p < .001$.

(continued)

Table 7

Pearson's Correlations among Level 2 Predictors

Level 2 predictors		7	8	9
1.	Student–teacher ratio			
2.	Total student enrollment			
3.	Instructional computer rate			
4.	Free or reduced-price lunch			
5.	FCAT reading pass rate			
6.	Positive school climate percentage			
7.	Safety grade	—		
8.	Age (cluster mean)	-.541***	—	
9.	Physically active time (cluster mean)	.365***	-.292***	—
10.	Sedentary time (cluster mean)	-.618***	.408***	-.486***
11.	Healthy food consumption score (cluster mean)	.100	.093	-.147*
12.	Unhealthy food consumption score (cluster mean)	-.299***	.073	-.008
13.	Stress rating (cluster mean)	.571***	-.292***	.322***

*$p < .05$, **$p < .01$, ***$p < .001$.

(continued)

Table 7

Pearson's Correlations among Level 2 Predictors

Level 2 predictors	10	11	12
1. Student–teacher ratio			
2. Total student enrollment			
3. Instructional computer rate			
4. Free or reduced-price lunch			
5. FCAT reading pass rate			
6. Positive school climate percentage			
7. Safety grade			
8. Age (cluster mean)			
9. Physically active time (cluster mean)			
10. Sedentary time (cluster mean)	—		
11. Healthy food consumption score (cluster mean)	-.008	—	
12. Unhealthy food consumption score (cluster mean)	.222 **	-.505 ***	—
13. Stress rating (cluster mean)	-.545 ***	.236 **	-.368 ***

*p < .05, **p < .01, ***p < .001.

Table 8

Summary of Hierarchical Linear Models Predicting Body Mass Index (kg/m^2) for Girls and Boys

	Girls (*N* = 42,765)								Boys (*N* = 41,400)							
	Model 1				Model 2				Model 1				Model 2			
			95% CI				95% CI				95% CI				95% CI	
	Est.		*LL*	*UL*	Est.		*LL*	*UL*	Est.		*LL*	*UL*	Est.		*LL*	*UL*
Intercept	22.578	***	22.460	22.696	22.697	***	22.601	22.793	23.378	***	23.300	23.456	23.217	***	23.127	23.307
Variance of random effect of Level 2	.583	***	.452	.714	.154	***	.097	.211	.188	***	.123	.253	.064	***	.029	.099
ICC	.033				.009				.009				.003			
Level 1 predictors																
Age					.262	***	.205	.319					.300	***	.235	.365
Hispanic					-.342	***	-.460	-.224					.255	***	.141	.369
Stress rating					.072	***	.037	.107					.076	***	.033	.119
Physically active time					.015		-.007	.037					-.023		-.045	-.001
Sedentary time					.069	**	.030	.108					.124	***	.087	.161
Healthy food score					.175	***	.132	.218					.140	***	.099	.181
Unhealthy food score					-.222	***	-.269	-.175					-.261	***	-.310	-.212

Level 2 predictors								
Student–teacher ratio	.049	**	.014	.084	.046	**	.015	.077
Total student enrollment	-.018	***	-.028	-.008	.002		-.008	.012
Instructional computer rate	.299		-.001	.599	.173		-.299	.645
Free or reduced-price lunch	.014	***	.006	.022	.010	***	.004	.016
FCAT reading pass rate	-.015	**	-.025	-.005	-.003		-.011	.005
Positive school climate percentage	.002		-.008	.012	.001		-.007	.009
Safety grade	.034		-.123	.191	.001		-.105	.107
Age †	-.217		-.568	.134	-.050		-.364	.264
Physically active time †	.034		-.233	.301	.159		-.045	.363
Sedentary time †	.645		.045	1.245	-.087		-.610	.436
Healthy food score †	-.087		-.526	.352	-.202		-.563	.159
Unhealthy food score †	.404	***	.251	.557	.425	***	.309	.541

Stress rating †		-.962	***	-1.395	-.529		-.357	-.704	-.010
AIC	1,148,885	1,148,146				1,129,399	1,128,739		
BIC	1,149,121	1,148,491				1,129,633	1,129,082		

Note. Only estimates smaller than $p < .01$ were flagged for significance. Hispanic was dummy-coded: Hispanic = 1; non-Hispanic = 0.

† Cluster mean.

$**p < .01$, $***p < .001$.

Table 9

Summary of Hierarchical Linear Models Predicting Systolic BP (mmHg) for Girls and Boys

	Girls (*N* = 42,765)								Boys (*N* = 41,400)							
	Model 1				Model 2				Model 1				Model 2			
			95% CI				95% CI				95% CI				95% CI	
	Est.		*LL*	*UL*	Est.		*LL*	*UL*	Est.		*LL*	*UL*	Est.		*LL*	*UL*
Intercept	114.364	***	114.019	114.709	114.771	***	114.444	115.098	122.296	***	121.984	122.608	121.991	***	121.658	122.324
Variance of random effect of Level 2	5.261	***	4.240	6.282	3.779	***	2.991	4.567	3.916	***	3.034	4.798	3.299	***	2.466	4.132
ICC	.041				.030				.025				.021			
Level 1 predictors																
Age					-.083		-.244	.078					.411	***	.250	.572
Hispanic					-.798	***	-1.057	-.539					.482	***	.221	.743
Stress rating					-.275	***	-.361	-.189					-.274	***	-.388	-.160
Physically active time					-.093	**	-.146	-.040					-.081	**	-.132	-.030
Sedentary time					.200	***	.108	.292					.264	***	.144	.384
Healthy food score					.184	**	.080	.288					.137		.010	.264
Unhealthy food score					-.258	***	-.331	-.185					-.384	***	-.484	-.284

Level 2 predictors								
Student–teacher ratio	.004		-.155	.163	-.165		-.322	-.008
Total student enrollment	-.011		-.058	.036	.038		-.007	.083
Instructional computer rate	.350		-.797	1.497	-.117		-1.205	.971
Free or reduced-price lunch	-.045	***	-.070	-.020	-.023		-.047	.001
FCAT reading pass rate	.021		-.012	.054	.052	**	.017	.087
Positive school climate percentage	-.033		-.068	.002	-.029		-.064	.006
Safety grade	-.719	**	-1.266	-.172	-.610		-1.145	-.075
Age †	.579		-1.040	2.198	1.745		.140	3.350
Physically active time †	-.941		-2.043	.161	-.591		-1.708	.526
Sedentary time †	-.053		-2.319	2.213	-.827		-3.116	1.462
Healthy food score †	.647		-1.358	2.652	1.082		-.664	2.828

Unhealthy food score †		.577	.011	1.143		.363	-.176	.902
Stress rating †		.186	-1.737	2.109		-.466	-2.265	1.333
AIC	1,242,947	1,242,746			1,219,874	1,219,672		
BIC	1,243,183	1,243,091			1,220,109	1,220,015		

Note. Only estimates smaller than $p < .01$ were flagged for significance. Hispanic was dummy-coded: Hispanic = 1; non-Hispanic = 0.
† Cluster mean.
$^{**}p < .01$, $^{***}p < .001$.

Table 10

Summary of Hierarchical Linear Models Predicting Diastolic BP (mmHg) for Girls and Boys

	Girls (*N* = 42,765)								Boys (*N* = 41,400)							
	Model 1				Model 2				Model 1				Model 2			
			95% CI				95% CI				95% CI				95% CI	
	Est.		*LL*	*UL*	Est.		*LL*	*UL*	Est.		*LL*	*UL*	Est.		*LL*	*UL*
Intercept	68.376	***	68.045	68.707	68.945	***	68.612	69.278	69.748	***	69.395	70.101	70.147	***	69.786	70.508
Variance of random effect of Level 2	4.995	***	3.903	6.087	4.132	***	3.132	5.132	5.566	***	4.439	6.693	4.547	***	3.479	5.615
ICC	.054				.045				.050				.041			
Level 1 predictors																
Age					.149		.018	.280					.834	***	.681	.987
Hispanic					-.941	***	-1.172	-.710					-.524	***	-.775	-.273
Stress rating					-.142	***	-.220	-.064					-.042		-.120	.036
Physically active time					-.096	***	-.143	-.049					-.162	***	-.207	-.117
Sedentary time					.123	**	.041	.205					.198	***	.110	.286
Healthy food score					.045		-.039	.129					-.028		-.132	.076
Unhealthy food score					-.112	***	-.163	-.061					-.116	***	-.181	-.051

Level 2 predictors						
Student–teacher ratio	.076	-.085	.237	.029	-.153	.211
Total student enrollment	-.018	-.065	.029	.025	-.028	.078
Instructional computer rate	-.834	-2.161	.493	-.855	-2.486	.776
Free or reduced-price lunch	-.024	-.048	.000	-.016	-.043	.011
FCAT reading pass rate	.010	-.025	.045	.014	-.023	.051
Positive school climate percentage	-.028	-.063	.007	-.029	-.068	.010
Safety grade	-.227	-.827	.373	-.074	-.776	.628
Age †	.256	-1.336	1.848	.894	-.823	2.611
Physically active time †	-1.005	-2.003	-.007	-1.198	-2.284	-.112
Sedentary time †	-1.464	-3.896	.968	-2.439	-5.052	.174
Healthy food score †	-.518	-2.304	1.268	.369	-1.636	2.374
Unhealthy food score †	.042	-.552	.636	.100	-.466	.666

Stress rating †		-.860	-2.820	1.100		-1.985	-3.963	-.007
AIC	1,228,466		1,228,344		1,204,161		1,203,917	
BIC	1,228,702		1,228,690		1,204,396		1,204,260	

Note. Only estimates smaller than $p < .01$ were flagged for significance. Hispanic was dummy-coded: Hispanic = 1; non-Hispanic = 0.

† Cluster mean.

$^{**}p < .01$, $^{***}p < .001$.

Table 11

Summary Table of Significant Student-Level Effects by Gender and Outcome

	Girls	Boys
BMI	Age (β= .262)	Age (β= .30)
	Hispanic ethnicity (β= -.342)	Hispanic ethnicity (β= .255)
	Stress (β= .072)	Stress (β= .076)
	Sedentary time (β= .069)	Sedentary time (β= .124)
	Healthy food (β= .175)	Healthy food (β= .140)
	Unhealthy food (β= -.222)	Unhealthy food (β= -.261)
SBP	Hispanic ethnicity (β= -.798)	Hispanic ethnicity (β= .482)
	Stress (β= -.275)	Stress (β= -.274)
	Sedentary time (β= .20)	Sedentary time (β= .264)
	Physical activity (β= -.093)	Physical activity (β=-.081)
	Unhealthy food (β= -.258)	Unhealthy food (β= -.384)
	Healthy food (β= .184)	Age (β= .411)
DBP	Hispanic ethnicity (β= -.941)	Hispanic ethnicity (β= -.524)
	Sedentary time (β= .123)	Sedentary time (β= .198)
	Physical activity (β= -.096)	Physical activity (β= -.162)
	Unhealthy food (β= -.112)	Unhealthy food (β= -.116)
	Stress (β= -.142)	Age (β= .834)

Table 12

Summary Table of Significant School Cohort-Level Effects by Gender and Outcome

	Girls	Boys
BMI	Free/reduced lunch (γ= .014)	Free/reduced lunch (γ= .01)
	Student-teacher ratio (γ= .049)	Student-teacher ratio (γ= .046)
	Mean unhealthy food consumption (γ= .404)	Mean unhealthy food consumption (γ= .425)
	FCAT reading passing rate (γ= -.015)	
	Student enrollment (γ= -.018)	
	Mean stress ratings (γ= -.962)	
SBP	Free/reduced lunch (γ= -.045)	FCAT reading passing rate (γ= .052)
	School safety rating (γ= -.719)	
DBP	None	None

Appendix A

Project ACE Adolescent Blood Pressure Screening Form (1999-2000 academic year)

Adolescent Blood Pressure Screening Form

*ID:*__________

USE #2 PENCIL.

*Date:*__________

*Grade:*_____ *School:* __________

*Name:*__________ *Teacher:* __________

*Home Address:*__________

Parent or Guardian: __________

*Home Phone:*__________ *Parent/Guardian's Business Phone:*__________

*Age:*_____ *Height:*_____*ft.*_____*in.* *Weight:*_____*lbs*

INSTRUCTIONS: This form is two pages (FRONT and BACK). Please fill-in the space that corresponds to your answer. Bring the completed form to your blood pressure screening. MUST use a #2 pencil.

1. What is your gender?	M ① F ②
2. What is your ethnic background?	White, non-Hispanic ① White, Hispanic ② Black, Hispanic ③ American Indian ④ African American ⑤ Caribbean Black ⑥ Asian ⑦ Other ⑧
3. What is the primary language spoken in your home?	English ① Spanish ② Creole ③ Other ④

	Y	N	?
4. Have YOU ever had HIGH BLOOD PRESSURE?	①	②	③
5. If you have HIGH BLOOD PRESSURE, are you taking medication?	①	②	③
6. Has your MOTHER ever had HIGH BLOOD PRESSURE?	①	②	③
7. Has your FATHER ever had HIGH BLOOD PRESSURE?	①	②	③
8. Has a GRANDPARENT ever had HIGH BLOOD PRESSURE?	①	②	③
9. Has your MOTHER ever had HEART DISEASE or had a HEART ATTACK?	①	②	③
10. Has your FATHER ever had HEART DISEASE or had a HEART ATTACK?	①	②	③
11. Has a GRANDPARENT ever had HEART DISEASE or had a HEART ATTACK?	①	②	③
12. Have YOU ever had DIABETES?	①	②	③
13. If you have DIABETES, are you taking medication?	①	②	③
14. Has your MOTHER ever had DIABETES?	①	②	③
15. Has your FATHER ever had DIABETES?	①	②	③
16. Has a GRANDPARENT ever had DIABETES?	①	②	③

CONTINUE ON BACK.

Appendix A, cont.

		Not	Some	Very
7.	Do you consider yourself to be fat around the waist?	1	2	3
8.	In the past week, how stressful was school?	1	2	3
9.	In the past week, how stressful was your life outside school?	1	2	3

		0 days	1day	2 days	3 days	4 days	5 days	6 days	7 days
.0.	On how many of the past 7 days did you smoke cigarettes?	1	2	3	4	5	6	7	8
:1.	On how many of the past 7 days did you drink alcohol?	1	2	3	4	5	6	7	8
.2.	On how many of the past 7 days did you exercise or participate in sports activities for at least 20 minutes that made you SWEAT and BREATHE HARD, such as basketball, jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities?	1	2	3	4	5	6	7	8

		<1 hr	1 hr	2-3 hrs	4-5 hrs	>5 hrs
3.	On a typical weekday, how many hours do you spend watching TV, playing video games, or using a computer?	1	2	3	4	5

		No	Only once	Twice or more
4.	On a typical day do you eat FRUIT or drink FRUIT juice?	1	2	3
5.	On a typical day do you eat TOSSED SALAD?	1	2	3
6.	On a typical day do you eat VEGETABLES?	1	2	3
7.	On a typical day do you eat fatty meats (e.g., HAMBURGERS, HOT DOGS, or RED MEAT)?	1	2	3
8.	On a typical day do you eat FRENCH FRIES or HIGH FAT CHIPS (e.g., potato chips, corn chips, or cheese puffs)?	1	2	3
9.	On a typical day do you eat COOKIES, DOUGHNUTS, PIE, CAKE or other SWEETS or CANDIES?	1	2	3

STOP HERE.

Appendix B

Project ACE Adolescent Blood Pressure Screening Form (2000-01 and 2001-02 academic years)

Project ACE

Adolescent Cardiovascular Evaluation

Project ACE

Adolescent Blood Pressure Screening Form

All the information is confidential and will not be viewed by your parents or teachers.

DO NOT BEND OR FOLD. DO NOT USE PEN.

Instructions: This form is two pages (FRONT & BACK). Please fill and bubble in the space that corresponds to your answer. Bring the completed form to your blood pressure screening.

USE A No. 2 PENCIL

OFFICE USE ONLY

PERSONAL INFORMATION:

Date__________ School__________ Teacher__________

First Name__________ Last Name__________

Address__________ Apt._____ City__________ ST_____ Zip_______

Parent/Guardian First Name__________ Parent/Guardian Last Name__________

Parent/Guardian Home phone__________ Parent/Guardian Work phone__________

Age | Height(F/I) | Weight(lbs.)

Feet=1st column / Inches = last 2 columns

What is your ethnic background?

- White, non-Hispanic
- American Indian
- Asian
- White,Hispanic
- African American
- Black, Hispanic
- Caribbean Black
- Other ethnic background

Grade:

- 9th
- 10th
- 11th

Gender:

- Male
- Female

What is the primary language spoken in your home?

- English
- Spanish
- Creole
- Other Language

	YES	NO	DON'T KNOW
Have you ever had HIGH BLOOD PRESSURE?	○	○	○
If you have HIGH BLOOD PRESSURE, are you taking medication?	○	○	○
Has your MOTHER ever had HIGH BLOOD PRESSURE?	○	○	○
Has your FATHER ever had HIGH BLOOD PRESSURE?	○	○	○
Has a GRANDPARENT ever had HIGH BLOOD PRESSURE?	○	○	○
Has your MOTHER ever had HEART DISEASE or had a HEART ATTACK?	○	○	○
Has your FATHER ever had HEART DISEASE or had a HEART ATTACK?	○	○	○
Has a GRANDPARENT ever had HEART DISEASE or had a HEART ATTACK?	○	○	○
Have YOU ever had DIABETES?	○	○	○
If you have DIABETES, are you taking medication?	○	○	○
Has your MOTHER ever had DIABETES?	○	○	○
Has your FATHER ever had DIABETES?	○	○	○
Has a GRANDPARENT ever had DIABETES?	○	○	○

	NOT AT ALL	SOME	VERY
Do you consider yourself to be fat around the waist?	○	○	○
In the past week, how stressful was school?	○	○	○
In the past week, how stressful was life outside school?	○	○	○

PLEASE CONTINUE ON THE BACK

Appendix B, cont.

Bubble the # of days that correspond to each item:	DAYS **0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
During the past week, how many days did you smoke cigarettes?	○	○	○	○	○	○	○	○
During the past week, how many days did you drink alcohol?	○	○	○	○	○	○	○	○
During the past week, how many days did you exercise or participate in sports activities for at least 20 minutes that made you SWEAT and BREATHE HARD, such as basketball, jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities?	○	○	○	○	○	○	○	○
During the past week, how many days did you lift weights (strength training)?	○	○	○	○	○	○	○	○

	less than 1 hour	**1 hour**	**2-3 hours**	**4-5 hours**	**more than 5 hours**
On a typical WEEKDAY, how many hours do you spend watching TV, playing video games,or using a computer?	○	○	○	○	○

	NO	**ONCE**	**TWICE OR MORE**
On a typical day do you eat FRUIT or drink FRUIT JUICE?	○	○	○
On a typical day do you eat TOSSED SALAD and/or VEGETABLES?	○	○	○
On a typical day do you eat salty foods or add salt to your food?	○	○	○
On a typical day do you eat fatty meats (ex: HAMBURGERS, HOT DOGS, or RED MEAT)?	○	○	○
On a typical day do you eat FRENCH FRIES or HIGH FAT CHIPS (ex: potato chips, corn chips, cheese puffs)?	○	○	○
On a typical day do you eat COOKIES, DOUGHNUTS, PIE, CAKE, or other SWEETS or CANDIES?	○	○	○
On a typical day do you drink REGULAR (non-diet) SODA?	○	○	○

STOP HERE

BP CRITERIA	1ST BP READING	2ND BP READING	3RD BP READING	4TH BP READING	5TH BP READING
0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0
1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1
2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2
3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3
4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4
5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5
6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6
7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7
8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8
9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9
Exp. Initials	*Exp. Initials*	*Exp. Initials*	*Exp. Initials*	*Exp. Initials*	*Exp. Initials*

Appendix C

Project ACE Adolescent Blood Pressure Screening Form (2002-03 academic year)

Project ACE

Adolescent Cardiovascular Evaluation

Project ACE
Adolescent Blood Pressure Screening Form
All the information is confidential and will not be viewed by your parents or teachers.

DO NOT BEND OR FOLD. DO NOT USE PEN.
Instructions: This form is two pages (FRONT & BACK). Please fill and bubble in the space that corresponds to your answer. Bring the completed form to your blood pressure screening.

USE A No. 2 PENCIL

OFFICE USE ONLY

0	0	0	0	0	0
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9

PERSONAL INFORMATION:

Date________ School____________ Teacher__________

First Name____________ Last Name____________

Address________________ Apt.____ City________ ST____ Zip_____

Parent/Guardian First Name____________ Parent/Guardian Last Name____________

Parent/Guardian Home phone____________ Parent/Guardian Work phone____________

Feet=1st column / Inches = last 2 columns

Age		Height(F/I)			Weight(lbs.)		
0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9

What is your ethnic background?
- ○ White, non-Hispanic
- ○ American Indian
- ○ Asian
- ○ White,Hispanic
- ○ African American
- ○ Black, Hispanic
- ○ Caribbean Black
- ○ Other ethnic background

Grade:
- ○ 9th
- ○ 10th
- ○ 11th

Gender:
- ○ Male
- ○ Female

What is the primary language spoken in your home?

○ English ○ Spanish ○ Creole ○ Other Language

	YES	NO	DON'T KNOW
Have you ever had HIGH BLOOD PRESSURE?	○	○	○
If you have HIGH BLOOD PRESSURE, are you taking medication?	○	○	○
Has your MOTHER ever had HIGH BLOOD PRESSURE?	○	○	○
Has your FATHER ever had HIGH BLOOD PRESSURE?	○	○	○
Has a GRANDPARENT ever had HIGH BLOOD PRESSURE?	○	○	○
Has your MOTHER ever had HEART DISEASE or had a HEART ATTACK?	○	○	○
Has your FATHER ever had HEART DISEASE or had a HEART ATTACK?	○	○	○
Has a GRANDPARENT ever had HEART DISEASE or had a HEART ATTACK?	○	○	○
Have YOU ever had DIABETES?	○	○	○
If you have DIABETES, are you taking medication?	○	○	○
Has your MOTHER ever had DIABETES?	○	○	○
Has your FATHER ever had DIABETES?	○	○	○
Has a GRANDPARENT ever had DIABETES?	○	○	○

	NOT AT ALL	SOME	VERY
Do you consider yourself to be fat around the waist?	○	○	○
In the past week, how stressful was school?	○	○	○
In the past week, how stressful was life outside school?	○	○	○

PLEASE CONTINUE ON THE BACK

Appendix C, cont.

Bubble the # of days that correspond to each item:	0	1	2	3	4	5	6	7
During the past week, how many days did you smoke cigarettes?	○	○	○	○	○	○	○	○
During the past week, how many days did you drink alcohol?	○	○	○	○	○	○	○	○
During the past week, how many days did you exercise or participate in sports activities for at least 20 minutes that made you SWEAT and BREATHE HARD, such as basketball, jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities?	○	○	○	○	○	○	○	○
During the past 7 days, how many days did you lift weights (strength train)?	○	○	○	○	○	○	○	○

(DAYS)

	less than 1 hour	1 hour	2-3 hours	4-5 hours	more than 5 hours
On a typical WEEKDAY, how many hours do you spend watching TV, playing video games,or using a computer?	○	○	○	○	○

	NO	ONCE	TWICE OR MORE
On a typical day do you eat FRUIT or drink FRUIT JUICE?	○	○	○
On a typical day do you eat TOSSED SALAD?	○	○	○
On a typical day do you eat VEGETABLES?	○	○	○
On a typical day do you eat fatty meats (ex: HAMBURGERS, HOT DOGS, or RED MEAT)?	○	○	○
On a typical day do you eat FRENCH FRIES or HIGH FAT CHIPS (ex: potato chips, corn chips, cheese puffs)?	○	○	○
On a typical day do you eat COOKIES, DOUGHNUTS, PIE, CAKE, or other SWEETS or CANDIES?	○	○	○
On a typical day do you drink REGULAR (non-diet) SODA?	○	○	○

	YES	NO	DON'T KNOW
Have you ever had ASTHMA?	○	○	○

STOP HERE

BP CRITERIA	1ST BP READING	2ND BP READING	3RD BP READING	4TH BP READING	5TH BP READING
0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0
1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1
2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2
3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3
4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4
5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5
6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6
7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7
8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8
9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9
Exp. Initials	*Exp. Initials*	*Exp. Initials*	*Exp. Initials*	*Exp. Initials*	*Exp. Initials*

Appendix D

Project ACE Adolescent Blood Pressure Screening Form (2003-04 and 2004-05 academic years)

Project ACE

Adolescent Cardiovascular Evaluation

Project ACE
Adolescent Blood Pressure Screening Form
All the information is confidential and will not be viewed by your parents or teachers.

DO NOT BEND OR FOLD. DO NOT USE PEN.
Instructions: This form is two pages (FRONT & BACK). Please fill and bubble in the space that corresponds to your answer. Bring the completed form to your blood pressure screening.

USE A No. 2 PENCIL

OFFICE USE ONLY

PERSONAL INFORMATION:

Date__________ School____________________ Teacher__________

First Name____________________ Last Name____________________

Address____________________ Apt._____ City__________ ST_____ Zip______

Parent/Guardian First Name____________________ Parent/Guardian Last Name____________________

Parent/Guardian Home phone____________________ Parent/Guardian Work phone____________________

Age

Height(F/I)

Feet=1st column / Inches = last 2 columns

Weight(lbs.)

What is your ethnic background?
- ○ White, non-Hispanic
- ○ American Indian
- ○ Asian
- ○ White,Hispanic
- ○ African American
- ○ Black, Hispanic
- ○ Caribbean Black
- ○ Other ethnic background

Grade:
- ○ 9th
- ○ 10th
- ○ 11th

Gender:
- ○ Male
- ○ Female

What is the primary language spoken in your home?

○ English ○ Spanish ○ Creole ○ Other Language

	YES	NO	DON'T KNOW
Have you ever had HIGH BLOOD PRESSURE?	○	○	○
If you have HIGH BLOOD PRESSURE, are you taking medication?	○	○	○
Has your MOTHER ever had HIGH BLOOD PRESSURE?	○	○	○
Has your FATHER ever had HIGH BLOOD PRESSURE?	○	○	○
Has a GRANDPARENT ever had HIGH BLOOD PRESSURE?	○	○	○
Has your MOTHER ever had HEART DISEASE or had a HEART ATTACK?	○	○	○
Has your FATHER ever had HEART DISEASE or had a HEART ATTACK?	○	○	○
Has a GRANDPARENT ever had HEART DISEASE or had a HEART ATTACK?	○	○	○
Have YOU ever had DIABETES?	○	○	○
If you have DIABETES, are you taking medication?	○	○	○
Has your MOTHER ever had DIABETES?	○	○	○
Has your FATHER ever had DIABETES?	○	○	○
Has a GRANDPARENT ever had DIABETES?	○	○	○

	NOT AT ALL	SOME	VERY
Do you consider yourself to be fat around the waist?	○	○	○
In the past week, how stressful was school?	○	○	○
In the past week, how stressful was life outside school?	○	○	○

PLEASE CONTINUE ON THE BACK

Appendix D, cont.

Bubble the # of days that correspond to each item:	**DAYS** 0	1	2	3	4	5	6	7
During the past week, how many days did you smoke cigarettes?	○	○	○	○	○	○	○	○
During the past week, how many days did you drink alcohol?	○	○	○	○	○	○	○	○
During the past week, how many days did you exercise or participate in sports activities for at least 20 minutes that made you SWEAT and BREATHE HARD, such as basketball, jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities?	○	○	○	○	○	○	○	○
During the past 7 days, how many days did you lift weights (strength train)?	○	○	○	○	○	○	○	○

	less than 1 hour	**1 hour**	**2-3 hours**	**4-5 hours**	**more than 5 hours**
On a typical WEEKDAY, how many hours do you spend watching TV, playing video games,or using a computer?	○	○	○	○	○

	NO	**ONCE**	**TWICE OR MORE**
On a typical day do you eat FRUIT or drink FRUIT JUICE?	○	○	○
On a typical day do you eat TOSSED SALAD and/or VEGETABLES?	○	○	○
On a typical day do you eat salty foods or add salt to your food?	○	○	○
On a typical day do you eat fatty meats (ex: HAMBURGERS, HOT DOGS, or RED MEAT)?	○	○	○
On a typical day do you eat FRENCH FRIES or HIGH FAT CHIPS (ex: potato chips, corn chips, cheese puffs)?	○	○	○
On a typical day do you eat COOKIES, DOUGHNUTS, PIE, CAKE, or other SWEETS or CANDIES?	○	○	○
On a typical day do you drink REGULAR (non-diet) SODA?	○	○	○

	YES	**NO**	**DON'T KNOW**
Have you ever had ASTHMA?	○	○	○

STOP HERE

BP CRITERIA	1ST BP READING	2ND BP READING	3RD BP READING	4TH BP READING	5TH BP READING
0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0
1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1
2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2	2 2 2 2 2 2
3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3	3 3 3 3 3 3
4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4	4 4 4 4 4 4
5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5	5 5 5 5 5 5
6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6	6 6 6 6 6 6
7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7	7 7 7 7 7 7
8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8	8 8 8 8 8 8
9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9	9 9 9 9 9 9
Exp. Initials	*Exp. Initials*	*Exp. Initials*	*Exp. Initials*	*Exp. Initials*	*Exp. Initials*

Appendix E

HLM Model Equations

Identical models were used to predict SBP and DBP, as shown below.

Systolic Blood Pressure Models

Null model:

$$SBP_{ij} = \beta_{0j} + \gamma_{ij}$$

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

where SBP_{ij} = the observed SBP for the ith student in the jth school cohort

β_{0j} = mean SBP in the jth school cohort

γ_{00} = grand mean SBP across all school cohorts

r_{ij} = unique effect of the ith student on SBP in the jth school cohort

u_{0j} = unique effect of jth year-school cohort on SBP

Full model:

$$\begin{aligned} SBP_{ij} = \beta_{0j} &+ \beta_{1j}(AGE_{ij} - \bar{x}_{AGE}) + \beta_{2j}HISPANIC_{ij} + \beta_{3j}(STRESS_{ij} - \bar{x}_{STRESS}) \\ &+ \beta_{4j}(AEROPA_{ij} - \bar{x}_{AEROPA}) + \beta_{5j}(SEDTIME_{ij} - \bar{x}_{SEDTIME}) \\ &+ \beta_{6j}(HEALTHYFOOD_{ij} - \bar{x}_{HEALTHYFOOD}) \\ &+ \beta_{7j}(UNHEALTHYFOOD_{ij} - \bar{x}_{UNHEALTHYFOOD}) + r_{ij} \end{aligned}$$

$$\begin{aligned} \beta_{0j} = \gamma_{00} &+ \gamma_{01}(STRATIO_j - \bar{x}_{STRATIO}) + \gamma_{02}(TOTALSTU_j - \bar{x}_{TOTALSTU}) \\ &+ \gamma_{03}(NUMCOMPR_j - \bar{x}_{NUMCOMPR}) + \gamma_{04}(PCTFRPL_j - \bar{x}_{PCTFRPL}) \\ &+ \gamma_{05}(FCATRDG_j - \bar{x}_{FCATRDG}) + \gamma_{06}(POSITIVE_j - \bar{x}_{POSITIVE}) \\ &+ \gamma_{07}(SAFETY_j - \bar{x}_{SAFETY}) + \gamma_{08}(AGEM_j - \bar{x}_{AGEM}) \\ &+ \gamma_{09}(AEROPAM_j - \bar{x}_{AEROPAM}) + \gamma_{010}(SEDTIMEM_j - \bar{x}_{SEDTIMEM}) \\ &+ \gamma_{011}(HEALTHYFOODM_j - \bar{x}_{HEALTHYFOODM}) \\ &+ \gamma_{012}(UNHEALTHYFOODM_j - \bar{x}_{UNHEALTHYFOODM}) \\ &+ \gamma_{013}(STRESSM_j - \bar{x}_{STRESSM}) + u_{0j} \end{aligned}$$

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70}$

where β_{0j} = mean SBP in the *j*th school cohort

γ_{00} = grand mean SBP across all school cohorts

γ_{01} = mean effect of student-teacher ratio (STRATIO) on mean SBP across all school cohorts

γ_{02} = mean effect of total student enrollment (TOTALSTU) on mean SBP across all school cohorts

γ_{03} = mean effect of instructional computer rate (NUMCOMPR) on mean SBP across all school cohorts

γ_{04}= mean effect of free/reduced-price lunch percentage (PCTFRPL) on mean SBP across all school cohorts

γ_{05} = mean effect of FCAT reading test passing rate (FCATRDG) on mean SBP across all school cohorts

γ_{06}= mean effect of positive climate rating (POSITIVE) on mean SBP across all school cohorts

γ_{07}= mean effect of safety grade (SAFETY) on mean SBP across all school cohorts

γ_{08} = mean effect of average age of school cohort (AGEM) on mean SBP across all school cohorts

γ_{09} = mean effect of cohort average number of days physically active (AEROPAM) on mean SBP across all school cohorts

γ_{010} = mean effect of cohort average amount of sedentary time (SEDTIMEM) on mean SBP across all school cohorts

γ_{011} = mean effect of cohort average healthy food consumption score (HEALTHYFOODM) on mean SBP across all school cohorts

γ_{012} = mean effect of cohort average unhealthy food consumption score (UNHEALTHYFOODM) on mean SBP across all school cohorts

γ_{013} = mean effect of cohort average stress rating (STRESSM) on mean SBP across all school cohorts

β_{1j} = the average effect of AGE on SBP, controlling for Hispanic ethnicity (HISPANIC), stress rating (STRESS), days > 20 minutes of aerobic activity (AEROPA), sedentary time (SEDTIME), healthy food consumption score (HEALTHYFOOD), and unhealthy food consumption score (UNHEALTHY FOOD) (γ_{10} has the same interpretation because these gammas are all fixed effects)

β_{2j} = difference between SBP of a Hispanic student and a non-Hispanic student, controlling for AGE, STRESS, AEROPA, SEDTIME, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{20} has the same interpretation because these gammas are all fixed effects)

β_{3j} = the average effect of STRESS on SBP, controlling for AGE, HISPANIC, AEROPA, SEDTIME, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{30} has the same interpretation because these gammas are all fixed effects)

β_{4j} = the average effect of AEROPA on SBP, controlling for AGE, HISPANIC, STRESS, SEDTIME, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{40} has the same interpretation because these gammas are all fixed effects)

β_{5j} = the average effect of SEDTIME on SBP, controlling for AGE, HISPANIC, STRESS, AEROPA, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{50} has the same interpretation because these gammas are all fixed effects)

β_{6j} = the average effect of HEALTHYFOOD on SBP, controlling for AGE, HISPANIC, STRESS, AEROPA, SEDTIME, and UNHEALTHY FOOD (γ_{60} has the same interpretation because these gammas are all fixed effects)

β_{7j} = the average effect of UNHEALTHYFOOD on SBP, controlling for AGE, HISPANIC, STRESS, AEROPA, SEDTIME, and HEALTHY FOOD (γ_{70} has the same interpretation because these gammas are all fixed effects)

Diastolic Blood Pressure Models

Null model:

$$DBP_{ij} = \beta_{0j} + \gamma_{ij}$$

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

where DBP_{ij} = the observed DBP for the *i*th student in the *j*th year-school cohort

β_{0j} = mean DBP in the *j*th year-school cohort

γ_{00} = grand mean DBP across all year-school cohort

r_{ij} = unique effect of the *i*th student on DBP in the *j*th year-school cohort

u_{0j} = unique effect of *j*th year-school cohort on DBP

Full model:

$$DBP_{ij} = \beta_{0j} + \beta_{1j}(AGE_{ij} - \bar{x}_{AGE}) + \beta_{2j}HISPANIC_{ij} + \beta_{3j}(STRESS_{ij} - \bar{x}_{STRESS}) + \beta_{4j}(AEROPA_{ij} - \bar{x}_{AEROPA}) + \beta_{5j}(SEDTIME_{ij} - \bar{x}_{SEDTIME}) + \beta_{6j}(HEALTHYFOOD_{ij} - \bar{x}_{HEALTHYFOOD}) + \beta_{7j}(UNHEALTHYFOOD_{ij} - \bar{x}_{UNHEALTHYFOOD}) + r_{ij}$$

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(STRATIO_j - \bar{x}_{STRATIO}) + \gamma_{02}(TOTALSTU_j - \bar{x}_{TOTALSTU}) + \gamma_{03}(NUMCOMPR_j - \bar{x}_{NUMCOMPR}) + \gamma_{04}(PCTFRPL_j - \bar{x}_{PCTFRPL}) + \gamma_{05}(FCATRDG_j - \bar{x}_{FCATRDG}) + \gamma_{06}(POSITIVE_j - \bar{x}_{POSITIVE}) + \gamma_{07}(SAFETY_j - \bar{x}_{SAFETY}) + \gamma_{08}(AGEM_j - \bar{x}_{AGEM}) + \gamma_{09}(AEROPAM_j - \bar{x}_{AEROPAM}) + \gamma_{010}(SEDTIMEM_j - \bar{x}_{SEDTIMEM}) + \gamma_{011}(HEALTHYFOODM_j - \bar{x}_{HEALTHYFOODM}) + \gamma_{012}(UNHEALTHYFOODM_j - \bar{x}_{UNHEALTHYFOODM}) + \gamma_{013}(STRESSM_j - \bar{x}_{STRESSM}) + u_{0j}$$

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70}$

where β_{0j} = mean DBP in the jth school cohort

γ_{00} = grand mean DBP across all school cohorts

γ_{01} = mean effect of student-teacher ratio (STRATIO) on mean DBP across all school cohorts

γ_{02} = mean effect of total student enrollment (TOTALSTU) on mean DBP across all school cohorts

γ_{03} = mean effect of instructional computer rate (NUMCOMPR) on mean DBP across all school cohorts

γ_{04}= mean effect of free/reduced-price lunch percentage (PCTFRPL) on mean DBP across all school cohorts

γ_{05} = mean effect of FCAT reading test passing rate (FCATRDG) on mean DBP across all school cohorts

γ_{06}= mean effect of positive climate rating (POSITIVE) on mean DBP across all school cohorts

γ_{07}= mean effect of safety grade (SAFETY) on mean DBP across all school cohorts

γ_{08} = mean effect of average age of school cohort (AGEM) on mean DBP across all school cohorts

γ_{09} = mean effect of cohort average number of days physically active (AEROPAM) on mean DBP across all school cohorts

γ_{010} = mean effect of cohort average amount of sedentary time (SEDTIMEM) on mean DBP across all school cohorts

γ_{011} = mean effect of cohort average healthy food consumption score (HEALTHYFOODM) on mean DBP across all school cohorts

γ_{012} = mean effect of cohort average unhealthy food consumption score (UNHEALTHYFOODM) on mean DBP across all school cohorts

γ_{013} = mean effect of cohort average stress rating (STRESSM) on mean DBP across all school cohorts

β_{1j} = the average effect of AGE on DBP, controlling for Hispanic ethnicity (HISPANIC), stress rating (STRESS), days > 20 minutes of aerobic activity

(AEROPA), sedentary time (SEDTIME), healthy food consumption score (HEALTHYFOOD), and unhealthy food consumption score (UNHEALTHY FOOD) (γ_{10} has same interpretation because these gammas are all fixed effects)

β_{2j} = difference between DBP of a Hispanic student and a non-Hispanic student, controlling for AGE, STRESS, AEROPA, SEDTIME, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{20} has the same interpretation because these gammas are all fixed effects)

β_{3j} = the average effect of STRESS on DBP, controlling for AGE, HISPANIC, AEROPA, SEDTIME, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{30} has the same interpretation because these gammas are all fixed effects)

β_{4j} = the average effect of AEROPA on DBP, controlling for AGE, HISPANIC, STRESS, SEDTIME, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{40} has the same interpretation because these gammas are all fixed effects)

β_{5j} = the average effect of SEDTIME on DBP, controlling for AGE, HISPANIC, STRESS, AEROPA, HEALTHYFOOD, and UNHEALTHY FOOD (γ_{50} has the same interpretation because these gammas are all fixed effects)

β_{6j} = the average effect of HEALTHYFOOD on DBP, controlling for AGE, HISPANIC, STRESS, AEROPA, SEDTIME, and UNHEALTHY FOOD (γ_{60} has the same interpretation because these gammas are all fixed effects)

β_{7j} = the average effect of UNHEALTHYFOOD on DBP, controlling for AGE, HISPANIC, STRESS, AEROPA, SEDTIME, and HEALTHY FOOD (γ_{70} has the same interpretation because these gammas are all fixed effects)