The social patterning in a multi-ethnic population: associations of socioeconomic position, neighborhood characteristics and psychosocial stressors with sleep

by

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Dedication

This dissertation is dedicated to my parents, Don and Violester Johnson. I appreciate your continual support. Thank you for being my inspiration.

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Abstract

Although sleep is instrumental for health and well-being, the vast majority of adults have sleep problems at least a few nights a week or more, and 40 million people have a chronic sleep disorder. Poor sleep is associated with chronic diseases such as depression, diabetes, hypertension, obesity, stroke and heart disease that disproportionately affect minority populations. Evidence indicates minority populations are more likely to experience poor sleep than non-Hispanic whites. Recent research suggests that socioeconomic position (SEP), neighborhood characteristics and psychosocial stressors may be novel risk factors for sleep outcomes worthy of further exploration, particularly among minority populations where research is lacking.

This dissertation uses data from two studies, the Stroke Health and Risk Education (SHARE) Project and the Jackson Heart Study (JHS) to investigate the cross-sectional associations of SEP, neighborhood characteristics and psychosocial stressors with sleep outcomes (duration, sleepiness, quality) in Hispanic and African Americans. Multinomial logistic and linear regression models were used to examine the associations of each exposure with sleep duration (short vs. normal, long vs. normal, and continuous sleep duration) and sleep quality after adjustment for demographics, SEP (in models of neighborhood exposures), and risk factors.

In the first analysis, we investigated associations between neighborhood safety, disadvantage and crime and sleep duration and daytime sleepiness among participants in the SHARE project, which recruited a predominantly Hispanic American population. Lower neighborhood safety was associated with a higher daytime sleepiness score after adjustment for confounders. The second analysis using JHS data investigated associations between SEP (measured as categories of education and income), neighborhood characteristics (social cohesion, violence, problems, disadvantage) and sleep outcomes (duration and quality) in a population of African Americans. We found that low individual SEP was associated with long sleep and poor sleep quality; and adverse neighborhood characteristics (high violence, high disorder) were associated with short sleep, longer average sleep duration and poor sleep quality after adjustment for confounders. Lastly, we investigated the associations of psychosocial stressors with sleep outcomes (duration and quality) using data from the JHS. Higher levels of chronic and acute stressors were associated with short sleep, shorter average sleep duration and poorer sleep quality after adjustment for confounders.

The findings of this dissertation improve our understanding of the factors contributing to poor sleep among understudied racial/ethnic groups. Future studies should examine the mechanisms that link low SEP, adverse neighborhoods and psychosocial stressors to poor sleep using prospective cohort data.

Chapter 1 Introduction

Short/long sleep duration, poor sleep quality and daytime sleepiness have been identified as risk factors for numerous adverse health conditions, such as high blood pressure, heart disease, diabetes, stroke, obesity and depression that disproportionately afflict minority populations.[1–6] There are also growing data indicating that minority populations are more likely to experience poorer sleep than non-Hispanic whites.[7,8] Potential contributors to sleep health disparities include individual and environmental (social and physical) risk factors that may both disturb sleep and reduce the efficacy of treatment methods; thus, there is a need to better understand the factors that influence sleep in minority populations.

This dissertation is aimed at understanding the relation between individual socioeconomic position (SEP), neighborhood characteristics and psychosocial stressors with sleep. This dissertation research extends the current knowledge of sleep alterations in the following critical ways using data from the Jackson Hearty Study (JHS) and the Stroke Health and Risk Education (SHARE) Project: (1) by examining the cross-sectional associations of individual SEP, neighborhood characteristics (social cohesion, safety, violence, crime, neighborhood problems, and socioeconomic status (SES)), and psychosocial stressors (chronic and acute) with sleep quality, sleep duration, and daytime sleepiness; and (2) by conducting this research among diverse populations including African Americans and Mexican Americans who tend to experience more sleep alterations and are underrepresented in sleep research.

1.1 Specific Aims

Specific Aim 1. To investigate the cross-sectional associations of neighborhood safety, disadvantage and crime with sleep duration and daytime sleepiness in a predominantly Mexican American population enrolled in the SHARE project.

Hypothesis 2. Higher levels of neighborhood disadvantage and crime and lower levels of self-reported neighborhood safety will be associated with higher odds of abnormal sleep duration (short or long) and a higher daytime sleepiness score, after adjustment for confounders.

Specific Aim 2. To examine the cross-sectional associations of individual socioeconomic position (SEP) and neighborhood characteristics including social cohesion, violence, neighborhood problems and disadvantage (census tract) with sleep duration and sleep quality among African Americans in the JHS.

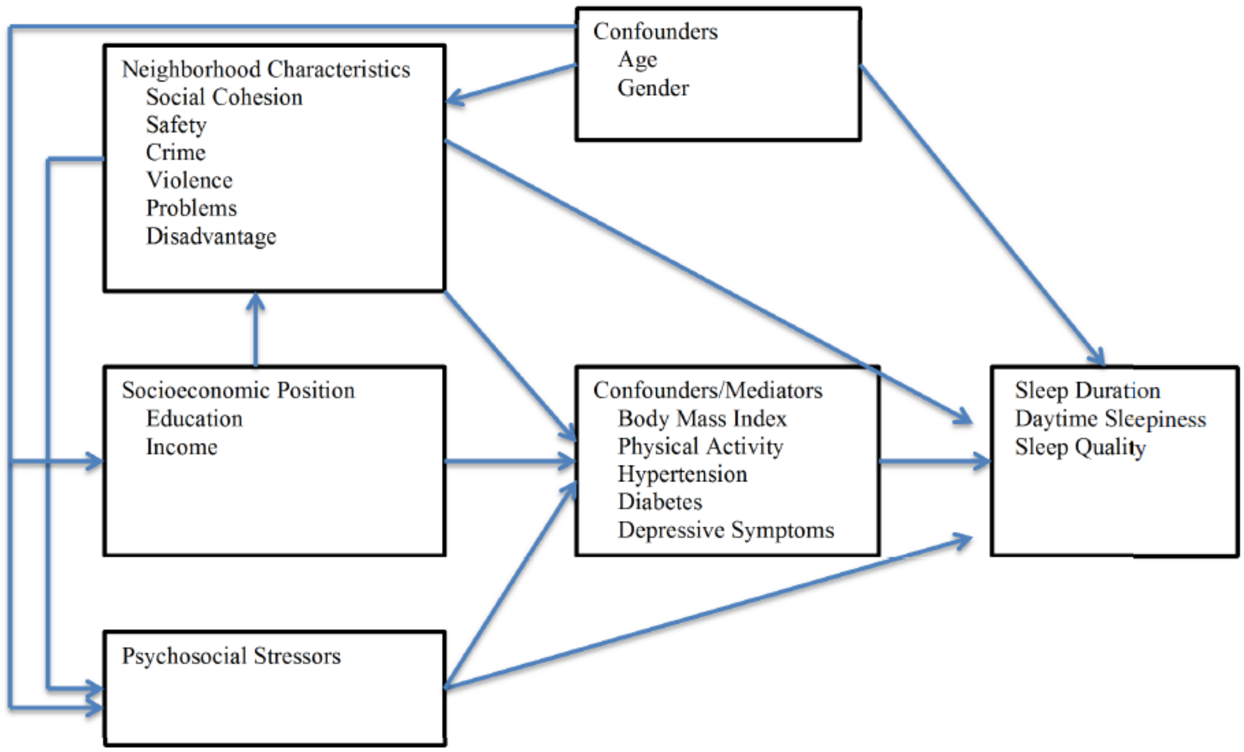
Hypothesis 2: Lower levels of SEP and adverse neighborhood characteristics will be associated with a higher odds of short/long sleep, lower sleep duration and sleep quality after adjustment for confounders.

Specific Aim 3. To investigate the cross-sectional associations of psychosocial stressors (chronic and acute) with sleep duration and sleep quality among African Americans in the JHS.

Hypothesis 3: Higher scores of psychosocial stress will be associated with higher odds of short/long sleep, lower sleep duration and sleep quality after adjustment for confounders.

The conceptual associations underlying the specific aims are presented in Figure 1. These associations guided the development of regression models to identify the relations between SEP, neighborhood characteristics and psychosocial characteristics and sleep outcomes.

Figure 1-1 Conceptual framework of the associations between SEP, neighborhood characteristics and psychosocial stressors with sleep outcomes



1.2 Pathophysiology of Sleep

Individuals sleep for approximately one-third of their life. Sleep can be characterized by rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep which cycles through five sleep stages. Normal sleep is maintained by homeostatic and circadian mechanisms.[10] An internal biological clock regulates sleep onset and awake times.[11,12] This circadian clock located in the suprachiasmatic nucleus (SCN) of the hypothalamus in the brain, cycles for a period of approximately 24 hours.[12] The absence or alteration of sleep/wake cycles has several physiologic consequences.

Physiological processes such as brain activity, heart rate, blood pressure, sympathetic nerve activity, muscle tone, blood flow to brain, respiration, airway resistance, body temperature and sexual arousal change during sleep.[9] In addition to these physiological changes, there are other changes to the body that occur during the sleeping process. The autonomic nervous system activity mainly causes changes to blood pressure and heart rate. Sympathetic-nerve activity decreases as NREM sleep deepens. Other changes include reductions in blood flow and metabolism. Additionally, growth hormone secretion (occurs a few hours after sleep onset), thyroid hormone secretion (occurs in the late evening), and melatonin secretion (induces sleepiness and is influenced by light-dark cycle) are affected by sleep.[12] During sleep loss, commonly referred to as sleep deprivation, increased serum ghrelin levels, increased evening concentrations of cortisol and decreased levels of leptin result.[13] These changes in the body from sleep deprivation affect memory and attention, complex thought, motor responses to stimuli, thermoregulation and increased risk for health problems including metabolic and cardiovascular disease.[12]

1.3 Public Health Significance of Sleep

Sleep disorders are a common phenomenon: a survey conducted by the National Sleep Foundation (NSF) showed that at least 40 million Americans suffer from at least one of over 70 different sleep disorders and 60% of adults have sleep problems a few nights a week or more.[14] In examining levels of sleep duration (defined as the average number of hours slept per night),[6] researchers have shown short sleep ($\leq$6 hours) and long sleep ($\geq$9 hours) to be related to CVD, stroke and overall mortality.[15,16] Additionally, sleep duration, sleep quality and daytime sleepiness are associated with high blood pressure, diabetes, coronary artery disease, obesity, and heart failure.[2,17] Addressing insufficient sleep may potentially aid in reducing the burden of cardiovascular outcomes.

1.4 Mechanisms Linking Sleep to Cardiovascular Disease

There are several proposed mechanisms linking sleep and cardiovascular disease. Sleep deprivation is associated with sympathetic tone which may elevate nocturnal catecholamine levels and contribute to cardiovascular disease.[18] It is hypothesized that sleep deprivation impacts the sympathetic nervous system activity because of a deceased melatonin secretion that occurs with a shorter sleep duration.[18] In a review by Kario et al, the authors suggest that psychological stress or environmental stress leads to brain (hypothalamus) dysregulation which causes a decrease in melatonin excretion, leading to sleep deprivation or arousal thus increasing nocturnal sympathetic nerve activity causing diurnal blood pressure variation disruption resulting in hypertension and coronary heart disease.[18] The effects of the increased nocturnal sympathetic nerve activity also increase insulin resistance causing diabetes mellitus and potentially leading to coronary heart disease. Stressors are also associated with activation of the hypothalamic-pituitary-adrenal (HPA) axis. The dysregulation of the HPA axis and sleep disturbances are interrelated and may be associated with increased risk of CVD.[19] This suggests that sleep could be an important contributor to cardiovascular health for the population. Explorations of the reasons for this high prevalence of inadequate sleep are warranted in efforts to potentially reduce the cardiovascular effects of sleep alterations.[20]

1.5 Racial/ethnic Differences in Sleep

The vast majority of sleep research has been conducted in non-Hispanic white populations, fewer studies in African Americans and to an even lesser extent Hispanic populations.[21] Despite the limited data, emerging evidence suggests racial/ethnic disparities in sleep. For example, research has demonstrated that racial/ethnic minorities are more likely to have poor sleep durations that are associated with increased mortality.[16,22] Krueger and colleagues analyzed data from the

2004-2007 National Health Interview Survey (NHIS) of 110,441 non-institutionalized Americans and found that Mexican American ethnicity was associated with longer sleep hours and non-Hispanic black race/ethnicity was associated with increased odds of both long and short sleep duration relative to non-Hispanic whites.[23] Similarly, Hale et al. found the same associations using data from the National Health Interview Survey (NHIS) and attributed the racial/ethnic disparity to the higher proportion of blacks living in the inner city.[16] Results from the Coronary Artery Risk Development in Young Adults (CARDIA) ancillary study of 669 participants found black men slept on average 82 minutes less per night than white women.[24] The authors hypothesized that the disparity was partially due to time in bed and difficulty falling and staying asleep.[25] Similar evidence exists for race/ethnic disparities in sleep quality.[8] Cross-sectional data of 9,714 participants found that African-Americans and Latinos versus non-Hispanic whites had an increased odds of poor sleep quality.[8]

Contributing factors to race/ethnic differences in sleep

SEP, neighborhoods, and psychosocial stressors are a few of the proposed contributing factors to racial/ethnic disparities in sleep.[16,26] These factors are of particular relevance to minority populations for two reasons; first, these populations have a higher prevalence of these factors; and second, there may be a stronger effect on health outcomes in minority populations.[27]

Evidence demonstrates that Hispanic and African Americans on average have an unfavorable socioeconomic profile.[28,29] For example, the proportion of African Americans that have less than a high school education is higher than that of non-Hispanic whites; and African Americans have a higher proportion of their population at a lower income than non-Hispanic whites.[28] Similarly, Hispanics are disproportionately poor.[27,30] Research also shows that these populations are more likely to live in inner cities.[7,21] This is likely the result of racial residential segregation that may expose these populations to more adverse neighborhood conditions. Additionally, psychosocial stressors are highly prevalent among minority groups. Evidence suggest Hispanics (Mexican Americans) and African Americans are exposed to a greater number of stressors than non-Hispanic whites.[29] Hicken and colleagues suggested racism-related vigilance may be a source of chronic stress that contributes to the higher prevalence of sleep difficulty among Blacks.[31]

The effects of SEP, neighborhoods and psychosocial stressors could differ by race. Research has shown that the associations of SEP with health may differ in African Americans and non-Hispanic Whites.[32] For example, some studies have reported that, in contrast to associations reported in White men and women, among African American men, increases in SEP are sometimes associated with adverse health outcomes.[33–35] Researchers have found employment, education and health status mediate the association between race and sleep quality among lower income individuals.[8] In addition, results indicate a possible differential vulnerability to these factors in lower compared to higher income persons as well as in certain race/ethnic groups.[8] Hispanic and African American populations may be more vulnerable to the adverse sleep consequences of neighborhoods because they may lack the resources necessary to buffer the effects of these environments. Results from a meta-analysis found psychosocial factors may modify differences in sleep continuity and duration.[26] It is likely that the historical experiences of Hispanics and African Americans may be qualitatively different from that of non-Hispanic whites which may make these factors more predictive in these populations. There are major implications to poor sleep among these minority populations and further understanding of the factors driving race-ethnic disparities in sleep is necessary.

1.6 Neighborhood Characteristics and Sleep

Neighborhood characteristics have recently emerged as factors that may affect sleep and contribute to racial/ethnic disparities in sleep.[16] Disadvantaged racial/ethnic groups are disproportionately exposed to detrimental physical and social environments.[16,36] Research by Geronimus indicates certain populations, such as African Americans, are more likely to be exposed to chronic exposure to stressful neighborhood conditions (such as higher crime), which have been shown to affect health.[37] Given the literature, studying the neighborhood environment and particularly the social features may be a promising avenue to better understand predictors of poor sleep among Hispanic and African American populations.

Low SES neighborhoods are often exposed to more neighborhood problems which could impact residents' sleep patterns.[38] The majority of the research has involved analyzing the physical environment and sleep, demonstrating an association between increased noise (most commonly studied) and poor sleep;[39,40] however, the neighborhood social environment has been less frequently studied. A few studies have examined social aspects of the neighborhood in relation to sleep.[41–44] In a study examining neighborhood disorder characterized by cleanliness, noise, and crime, the authors found neighborhood disorder to be associated with worse sleep quality.[45] A separate analysis investigating neighborhood quality measured by crime, graffiti and noise with sleep quality found perceptions of a low neighborhood quality was related to a poor sleep quality.[42] A study conducted by Johnson and colleagues in Baltimore illustrated that respondents with high exposures to neighborhood violence were twice as likely to report poor sleep habits than those with low exposure to neighborhood violence.[44] Additionally, a study conducted in 2008, showed that fear of neighborhood crime is associated with greater sleep problems.[46] Prior studies were limited in that violence/crime was assessed by self-report.

Objective measures of crime or violence may provide a better assessment of the neighborhood, but few studies have aimed to link objective measures of violence or safety with specific sleep outcomes.[44] DeSantis and colleagues have expanded the literature on neighborhoods and sleep by considering multiple dimensions of the social environment (social cohesion, violence, crime, disorder) assessed by aggregated survey measures in a diverse study cohort.[43] The authors found that exposure to adverse social environments was associated with shorter sleep and greater sleepiness.[43] Although this literature is promising, there are limitations of the prior work including small sample size, lack of inclusion of racial/ethnic minorities, and limited measurements of both the neighborhood and sleep outcomes.

1.7 Socioeconomic Position and Sleep

There is an abundance of data that supports SEP as a determinant of health.[47,48] Williams and colleagues have published work indicating differences in SEP across racial groups contribute to health disparities.[33] Researchers have also hypothesized that sleep may mediate the association between SEP and mental and physical health outcomes.[49] In connecting the literature, sleep alterations may contribute to socioeconomic and/or race/ethnic disparities in chronic health conditions; however, little is known about the social determinants of disordered sleep.[8]

Researchers have shown that indicators of SEP are associated with sleep. Individuals that work long hours, shiftwork or night work are more likely to suffer from excessive sleepiness.[50,51] Data from the Behavioral Risk Factor Surveillance System demonstrated lower income and educational attainment were associated with more sleep complaints measured by trouble falling asleep or staying sleep or sleeping too much.[52] The authors also found, in adjusted analyses, the relation between sleep complaints and lower education was stronger in women than men; however, adjusted analyses showed men with lower education levels were more likely to exhibit sleep complaints.[52] Other studies have found that income was associated with sleep quality[49] and less education was associated with short and long sleep.[23,53] Studies conducted outside of the United States have found that higher versus lower grade employees had better sleep assessed by a Japanese version of the Pittsburgh Sleep Quality Index;[54] the odds of reporting mid-range sleep (6.5 – 8.5 hours) decreased with decreasing advantage.[55] These prior studies have varied in the measurement of both SEP and sleep outcomes. To date, the association between SEP and both sleep duration and sleep quality has not been examined in a large population of Hispanic or African Americans. More research is needed to support the association among minority populations that may be more vulnerable to the effects of SEP.

1.8 Psychosocial Stressors and Sleep

Psychosocial stressors are one hypothesized link between social factors and health outcomes. Research suggests that in addition to SEP and neighborhoods, stress is a contributor to health disparities.[56] Research by Warnecke and colleagues suggests some ethnic/racial groups may be more susceptible to the effects of disadvantaged-related stress; however, research on psychosocial stressors and poor sleep has focused primarily on non-Hispanic white populations.[57–62]

Studies have shown that poor sleep is linked to major psychosocial domains including negative emotional states (depression, anger, anxiety, and hostility) and chronic and acute stressors (job stress, negative life events, work stress, financial strain and discrimination), which racial minority populations are more likely to experience.[16,63,64] Results from the Whitehall II study of 240 white middle aged men and women demonstrated that sleep problems were greater among participants who had higher scores of psychosocial adversity and vulnerability independent of covariates.[58] In a separate analysis of 827 men and women participating in the

Whitehall II study, chronic stress measured by financial strain and neighborhood crime was associated with sleep problems.[46] The findings of these analyses illustrate that psychosocial stressors may be associated with poor sleep.

Literature exploring the association of psychosocial stressors with sleep quality is more limited. Few researchers have investigated associations of perceived stress with sleep quality, and the studies that have were limited to working populations[64,65] or consisted of a small sample (n=73) of women, thus, limiting our understanding of the effects of perceived stress on sleep quality in non-working populations or men.[66] Studies that reported short sleep duration to be associated with increasing levels of stress were found among a specific population of police officers,[67] a cohort of men, and women in Scotland.[68] Additionally, many of the previously reported studies measured stress at one time point,[67] considered a narrow range of life domains, or limited the assessment of stress to only daily stressors,[65–67] thus not taking into account stressors from major life events. While some prior studies assessed multiple stressors, they were limited in characterizing sleep.[46,58] To our knowledge, one study by Slopen and colleagues has addressed some of these limitations. The authors assessed multiple psychosocial stressor domains (conditions in the home, workplace, and neighborhood) with sleep duration and sleep difficulties in a diverse cohort.[69] Those with high stressor exposure compared to low had significantly shorter sleep durations and elevated sleep difficulties scores.[69]

1.9 Summary

The dissertation research is unique in investigating social and environmental predictors of poor sleep among large racial/ethnic groups that have not been well studied. Our expansion of the neighborhood social environment and psychosocial stressor measurements are new contributions to the literature. This research could inform factors that may be targeted for interventions to improve sleep health among minority populations.

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Chapter 2
The Association of Neighborhood Characteristics with Sleep Duration and Daytime Sleepiness

2.1 Introduction

Research examining specific features of the neighborhood environment in relation to health outcomes has grown over the years. Neighborhood characteristics, including social, economic, and physical features, have been linked to general health status as well as to specific outcomes including cardiovascular-related endpoints.[1–7] A number of pathways have been posited to explain the associations between neighborhoods and cardiovascular outcomes[8,9] including pathways involving traditional behavioral risk factors as well as traditional medical cardiovascular disease (CVD) risk factors.[10] However, the association of neighborhood features with cardiovascular risks often persists after adjustment for traditional behavioral risk factors and chronic conditions, suggesting that other mediating mechanisms could be involved.[2,11]

Sleep disorders are a common phenomenon. A survey conducted by the National Sleep Foundation (NSF) showed that at least 40 million Americans suffer from at least one of over 70 different sleep disorders, and 60% of adults have sleep problems a few nights a week or more.[12] Sleep duration is important for several reasons; primarily to allow various processes to occur that strengthen or improve cardiovascular function, immune system function, memory, mood, and daily function to name a few.[13] Studies have shown both short ($\leq$6 hours) and long ($\geq$9 hours) sleep duration to be related to total CVD, stroke, and coronary heart disease (CHD) incidence and mortality.[14,11,15,16] Additionally, short sleep duration and daytime sleepiness are associated with high blood pressure, diabetes, coronary artery disease, obesity, and heart failure.[14,17] It has been hypothesized that the altered blood pressure profile resulting from insufficient sleep may induce a persistently higher cardiovascular burden during the night leading to an increased risk for CVD.[18] With the majority of Americans not receiving the recommended 7-9 hours per night,[19] explorations of the reasons for the high prevalence of inadequate sleep are warranted in an effort to potentially reduce the cardiovascular effects of poor sleep quantity.[20] Sleep may be a novel mediating mechanism between neighborhoods and cardiovascular risk, if sleep is patterned by neighborhoods.

Neighborhood characteristics may plausibly affect sleep. There is evidence supporting that residing in disadvantaged neighborhoods increases the risk of poor sleep.[21–23] Low SES neighborhoods are often exposed to more neighborhood problems which could impact residents sleep patterns.[8] Studies have analyzed aspects of the physical environment in relation to sleep, demonstrating an association between increased noise and poor sleep;[24,25] however, the neighborhood social environment has been studied less frequently. Specific features of the neighborhood such as crime and violence have been shown to affect sleep.[21,26] A study conducted by Johnson and colleagues in Baltimore illustrated that respondents with high exposures to neighborhood violence were twice as likely to report poor sleep habits compared to those with low exposure to violence.[26] Additionally, a study conducted in 2008 showed that fear of neighborhood crime is associated with sleep problems.[27] These feelings of fear and being unsafe as a result of neighborhood crime could induce chronic stress and potentially poor sleep habits.[26] Studies often measure violence by self-report, however, objective measures of crime or disorder may be a better assessment of neighborhood violence.

Research on sleep in Hispanic populations is extremely limited. The vast majority of sleep research has been conducted among cohorts of non-Hispanic white populations, thus limiting the generalizability of the results to other populations including Hispanics.[28] It is likely that Hispanics have poor sleep based on the high prevalence of risk factors, such as obesity, diabetes and living in inner cities, which are linked to poor sleep.[29,28] For example, evidence suggest that poor sleep may adversely affect glucose regulation and increase the risk of diabetes; and leptin levels (an appetite stimulating hormones) are lower among those with poor sleep, which promotes appetite and calorie intake leading to obesity.[30,31] In particular, Mexican Americans have a high burden of CVD risk factors and could have poorer sleep health, thus it is important to assess the sleep of this subpopulation.[32] A study conducted by Hale et al. on the ethnic differences in self-report of sleep duration found differences for Mexican Americans and other Hispanic populations. Non-Mexican Hispanics had an increased risk of short sleep compared with non-Hispanic whites;[29] whereas Mexican Americans in the same study had a higher odds of long sleep compared to non-Hispanic Whites (not significant after adjustments for socioeconomic characteristics).[29] Conversely, data from the 2007-2008 NHANES survey showed Mexican Americans were less likely than non-Hispanic Whites to report long sleep.[33] The results for "other" Hispanics/Latinos were consistent with previous reports of an increased odds of short sleep compared to non-Hispanic whites.[34] The 2006 AARP Hispanic Sleep Study was conducted among a nationally representative sample of 487 Hispanic respondents ages 40 and older.[35] Among respondents indicating inadequate sleep, the most frequently reported reason for not getting enough sleep each night was excessive stress, worry or depression.[35] The report of the findings from this study did not include the country of origin for the respondents. There are many within group differences among Hispanics; therefore sleep health could vary among Hispanic subpopulations as evidenced by the results of Hale et al.

Examining predictors of sleep in the Mexican American population is warranted and may inform novel intervention targets to improve sleep duration and sleepiness and subsequent chronic conditions in this population. Using baseline data from the Stroke Health and Risk

Education (SHARE) project, a bi-ethnic behavioral intervention study, we examined the cross-sectional associations of neighborhood characteristics including disadvantage, safety and crime with sleep duration and daytime sleepiness.

2.2 Methods

SHARE is a cluster-randomized, parallel group, church-based behavioral intervention trial designed to reduce stroke risk in Mexican American and non-Hispanic white parishioners in the Corpus Christi, Texas area.[36] Participants in SHARE, N=760, were recruited from one of ten catholic churches selected among those in the Diocese of Corpus Christi. At some churches, participation was encouraged by the Priests at the churches, advertisements were placed in church bulletins and parish liaisons identified potentially eligible participants for enrollment.[36] Participants were encouraged to enroll in friend or family member pairs. A few participants withdrew, prior to baseline, yielding a sample of 760 participants. Of the 760 participants, 738 individuals were enrolled as pairs (22 with no pairing). The recruitment and enrollment of family or friendship pairs[36] allowed the study to exploit the natural social support system to promote behavior change. A baseline assessment was completed during home visits by trained study coordinators in either English or Spanish.[36] Baseline data included behavioral stroke risk factors as well as biological outcome measures collected between May 2011 and November 2012.

Neighborhood Measures

Census tract-level and self-reported measures of the neighborhood were assessed. Each participant's address was geocoded to 2010 US Census tracts, which were used as proxies for neighborhood of residence. If a participant's address could not be identified for geocoding, the zip code was used (11%). Census tracts were then assigned based on where the zip code centroid was located. SHARE participants resided in a total of 79 census tracts. Census tract-level measures included neighborhood disadvantage and per capita violent crime. Neighborhood disadvantage was assessed by an index of objective neighborhood disadvantage using data from the American Community Survey 2011 5-year estimates. This composite measure, developed by Ross and Mirowsky, is derived to characterize the neighborhood socioeconomic environment.[37] The index consisted of the percentage of female-headed households with children, the percentage of households with incomes below the federal poverty threshold in the last 12 months, the percentage of college educated adults, and the percentage of housing units that are owner occupied.[37] Higher scores indicate more disadvantage. Per capita violent crime was assessed as the number of violent crimes (murder, manslaughter, forcible rape, robbery and aggravated assault) in 2009 per census tract with data provided by the Corpus Christi Police Department. Crime data were only available for participants that resided in Corpus Christi, Texas; those outside of the city (22% of sample) were excluded from these analyses. Asking each participant his or her level of agreement with the following statement assessed self-reported safety: "I feel safe walking in my neighborhood day or night." Responses were collected using a likert scale, 1=strongly disagree, 2=disagree, 3=neutral (neither agree nor disagree), 4=agree, 5=agree.

Sleep Measures

We examined sleep duration and daytime sleepiness measured at baseline. Sleep duration in hours was assessed by the question: "How many hours of sleep do you usually get a night (or when you usually sleep)?". Participant responses were recorded in hours and transformed to minutes for the analyses. Daytime sleepiness was measured using the daytime fatigue and sleepiness category of the Berlin Questionnaire:[38] (1) "How often do you feel tired or fatigued after your sleep?, (2) During your wake time, how often do you feel tired, fatigued, or not up to par?, and (3) Have you ever nodded off or fallen asleep while driving a vehicle; if yes how often does this occur". The responses were scored as: 1=nearly every day, 1=3-4 times a week, 0=1-2 times a week, 0=1-2 times a month, 0=never/nearly never. Scores for questions were summed for a total daytime sleepiness score per participant ranging from 0 to 3 with higher scores representing greater daytime sleepiness. We also operationalized daytime sleepiness as a dichotomous variable according to the scoring of the Berlin; high daytime sleepiness was defined as a score of $\geq$2 points.[39]

Demographic Factors and Covariates

Participants self-identified as either Mexican American or non-Hispanic white/European American at enrollment. Education was measured as years of education and ranged from 1 to 19 (no formal education to graduate education). Income was categorized into five groups (less than $10,000, $10,000-$19,999, $20,000-$29,999, $30,000-$49,999, >$50,000). Date of birth and gender were self-reported.

Analyses were adjusted for risk factors for sleep outcomes (body mass index (BMI), hypertension, diabetes, depressive symptoms). These risk factors may operate as both confounders and mediators of the neighborhood and sleep association. Study staff measured height and weight for each participant and BMI was later calculated. While in a seated position, using standard techniques, three consecutive readings of blood pressure were measured in the right arm and the average of the last two were taken.[36] Self-reported hypertension was determined by a response to the following question "Have you ever been told by a doctor, nurse or other health professional that you have high blood pressure or hypertension?". Hypertension was defined as a having a mean systolic blood pressure greater than or equal to 140 mmHg, a mean diastolic blood pressure greater than or equal to 90 mmHg, or a self-reported diagnosis of hypertension. Diabetes was defined by a fasting glucose measurement of greater than or equal to

126 mg/dl or a self-reported diagnosis of diabetes. Diabetes was also self-reported similarly to the hypertension question. The Patient Health Questionnaire (PHQ-2) was used to measure depressive symptoms.[40] The PHQ-2 assesses the frequency of lost interest in doing things and frequency of feeling depressed, 0=not a at all, 1=several days, 2=more than half the days, 3=nearly every day. Responses were summed for a total depressive symptom score, range 0 to 6.

Statistical Analysis

Descriptive statistics were calculated for demographics and risk factors stratified by tertiles of neighborhood disadvantage. Chi-square and analysis of variance tests were used to compare categorical and continuous variables across tertiles of neighborhood disadvantage, respectively. Pearson correlations were calculated to examine the correlations between neighborhood variables and between sleep outcomes. Differences in mean sleep duration and mean daytime sleepiness across tertiles of neighborhood disadvantage, safety, and per capita violent crime were assessed by fitting linear models with adjustment for age and sex. We also compared the distribution of sleep outcomes between Mexican American and non-Hispanic white participants.

We fit linear models to examine the associations between neighborhood characteristics and sleep duration.[41] For models with daytime sleepiness as the outcome, we fit multinominal and binomial logistic regression models due to the ordinal and dichotomous structures of the daytime sleepiness outcomes. Intraclass correlation coefficients (ICC) were calculated to determine clustering within church, pair and census tract. If the responses were clustered within church, pair and/or census tract, a random intercept was included in the model to account for the clustering. The ICC with respect to census tract was zero, therefore a random effect for census tract was not included in any model. We estimated mean differences in the minutes of sleep duration accounting for clustering within churches (ICC=0.06) and pairs (ICC=0.04). Similarly, we estimated mean differences in daytime sleepiness scores accounting for clustering of pair only (ICC=0.07). Each neighborhood characteristic was examined for its relation to each outcome in separate sequential models: model 1 adjusted for age and sex; model 2 adjusted for education and income, in addition to the factors in model 1; model 3 further adjusted for depressive symptoms, BMI, diabetes, and hypertension. Neighborhood characteristics were standardized and modeled continuously for comparisons across the neighborhood measures. All analyses were conducted using SAS software version 9.3 (SAS Institute, Cary, NC). The institutional review board at the University of Michigan approved the study, and all participants gave written informed consent.

2.3 Results

The average age of the study population was 52.9 years, and the population was mostly female (64%); the sample was predominately Mexican American (84%). Approximately 65.5% of the study population lived in the same home as their pair. A total of 751 participants self-reported sleep duration (reports of <4 hours of sleep at night (N=7) and missing values (N=2) were excluded). No exclusions for daytime sleepiness were made; 756 (99%) had complete data. Daytime sleepiness and sleep duration were associated; for a one-unit increase in daytime sleepiness, sleep duration decreased by 16 minutes. Neighborhood disadvantage and crime were positively correlated, 0.70. Neighborhood safety was weakly correlated with neighborhood disadvantage (-0.29) and crime (-0.28).

The distributions of selected study population characteristics across tertiles of neighborhood disadvantage are provided in Table 2-1. The neighborhood disadvantage index ranged from -4.2 to 1.0 (more disadvantage). There were no differences in age, BMI, gender or smoking status across tertiles of neighborhood disadvantage. Persons in the high neighborhood disadvantage tertile were more likely to have a higher mean of depressive symptoms and a lower agreement with perceived neighborhood safety than those in the other neighborhood disadvantage tertiles. Mean violent crime per capita was highest in the upper tertile of neighborhood disadvantage compared to the other tertiles. Hypertension and diabetes were most prevalent in the highest tertile of neighborhood disadvantage. Sleep apnea and history of CVD did not differ across the tertiles of neighborhood disadvantage. Persons within the lower neighborhood disadvantage category had a higher prevalence of short sleep duration compared to the other neighborhood disadvantage categories, P=0.01. Mean hours of sleep duration ranged from 6.5 hours (SD=1.1) in the lowest tertile to 6.8 hours (SD=1.1) in the highest tertile of neighborhood disadvantage, P=0.01. There was no difference in the daytime sleepiness scores across the tertiles of neighborhood disadvantage, 0.7 (SD=0.9) in the lowest tertile to 0.7 (SD=0.8) in the highest tertile.

Approximately 45% of the Mexican American participants slept 6 hours or less each night. The mean sleep duration was similar between Mexican Americans and non-Hispanic whites, 6.7 ± 1.2 and 6.7 ± 1.1, respectively. There was no difference in the prevalence of short sleep duration between Mexican American and non-Hispanic white participants, 45% and 43%, respectively, P=0.84. The mean daytime sleepiness score was similar between the two ethnic groups, 0.70 ± 0.8 for Mexican Americans and 0.67+0.8 for non-Hispanic whites, P=0.70.

Table 2-2 shows mean hours of sleep and mean daytime sleepiness across the tertiles of neighborhood disadvantage, self-reported safety and crime after adjustment for age and sex. Participants in the high neighborhood disadvantage and high neighborhood violent crime per capita had a higher mean sleep duration compared to the other categories of neighborhood disadvantage and crime, *P*<0.01. Higher self-reported neighborhood safety was associated with a higher mean sleep duration, 6.8 hours per night compared to 6.6 and 6.7 for the middle and low self-reported safety neighborhoods respectively, *P*<0.01. Participants living in neighborhoods with higher disadvantage scores and higher crime per capita had lower daytime sleepiness scores compared to those in the middle and low disadvantage and crime neighborhoods, *P*<0.01. Mean daytime sleepiness was lowest among participants in the high self- reported neighborhood safety category compared to the other safety categories, *P*<0.01.

The unadjusted and adjusted mean differences in sleep duration (minutes of sleep at night) and log odds of daytime sleepiness associated with a 1 standard deviation increase in the neighborhood characteristics are displayed in Table 2-3. Neighborhood characteristics were not associated with sleep duration in the unadjusted or adjusted models. Greater neighborhood disadvantage was related to lower daytime sleepiness, although not statistically significant in either of the models (Table 2-3). Neighborhood violent crime was not associated with daytime sleepiness. A one-unit change in self-reported neighborhood safety resulted in a 79% (95% CI: -0.35, -0.07) lower odds of being in a higher daytime sleepiness category. The results were similar after full adjustment. The results modeling daytime sleepiness as an ordinal variable were similar to the results as a dichotomous variable. Higher self-reported neighborhood safety was associated with an 18% lower odds of daytime sleepiness (Table 2-4). The association was attenuated and marginally significant in the fully adjusted model (OR=0.84, 95% CI: 0.70, 1.02).

2.4 Discussion

We found that higher perceived neighborhood safety was associated with a small but statistically significant lower daytime sleepiness level before and after adjustment for demographics and sleep risk factors. Higher levels of neighborhood disadvantage and crime were related to lower daytime sleepiness, although not statistically significant. Perceived neighborhood safety was weakly associated with neighborhood disadvantage and crime. In examining categories of neighborhood characteristics with continuous sleep duration, we found that participants in the highest categories of disadvantage, self-reported safety, and crime had higher mean sleep duration than those in other neighborhood categories with adjustment for demographics; however, we did not observe a linear association between neighborhood characteristics and sleep duration after adjustment for demographics, socioeconomic position and risk factors. Lastly, our study population had a high prevalence of short sleep duration particularly among those in the lowest neighborhood disadvantage category.

These results are significant for several reasons. The vast majority of the literature examining neighborhoods and sleep has focused on the physical environment including noise and traffic.[24,25,42,43] Other studies that have expanded beyond the physical environment have typically focused on the association of one aspect of the neighborhood environment with sleep;[26,42] this study expands the literature by the inclusion of multiple dimensions of the social environment. Our study is also unique in examining both self-reported and objectively measured neighborhood characteristics with sleep. Finally, the study was conducted among a diverse population that included Mexican Americans who are often not included in studies of sleep.

We hypothesized that greater self-reported neighborhood safety would be associated with less daytime sleepiness based on prior reports demonstrating greater neighborhood crime was associated with more sleep problems.[42,22] Our hypothesis was supported by our results; higher perceived neighborhood safety was associated with less daytime sleepiness; however, the magnitude of the association was small. To our knowledge, only one other study has examined perceived neighborhood safety with daytime sleepiness, and the results were not consistent with our finding. In a multi-ethnic sample of 1406 adults aged 45-84 years, greater neighborhood safety measured at the census-tract level was associated with greater sleepiness.[21] This finding was unexpected, and contrary to the authors' hypothesis that lower levels of neighborhood safety would be associated with increased daytime sleepiness.[21] There are a few plausible explanations for the differences in findings across the two studies. First, neighborhood safety was measured differently in the two studies. While the prior study used a census tract-level measure of safety, our study utilized an individual-level measure of perceived neighborhood safety. Perhaps our study confirmed the hypothesis because individual perception of safety has more of an impact on sleep outcomes than an objective measure of safety. Second, our outcome measure, daytime sleepiness, was measured differently from the previous study. Our study measured daytime sleepiness according to the sleepiness category of the Berlin Questionnaire whereas the prior study included daytime sleepiness measured by the Epworth Sleepiness Scale.[21] The Epworth scale measures chances of falling asleep during certain situations commonly encountered in daily life (i.e. while sitting and reading, watching TV), whereas the Berlin's category of daytime sleepiness measures the frequency of feeling tired after sleep and during wake times, and frequency of falling asleep while driving. Thus, the two scales measure daytime sleepiness differently and therefore could have a different meaning in regards to sleep health which could provide a reason for why we were able to detect an association with safety unlike prior studies.

The observed association between greater perceived neighborhood safety and less daytime sleepiness leads one to consider possible explanations. There could be mediating pathways by other neighborhood factors, such as unpleasant walking environments and limited access to healthy foods that lead to decreased physical activity and higher BMI,[44] which are associated with poor sleep outcomes.[45,46] In our study, after adjustment for BMI, the magnitude of the association between perceived neighborhood safety and daytime sleepiness was attenuated, but still statistically significant; additionally, higher BMI was positively associated with daytime sleepiness providing some support for this pathway. Stress is another possible pathway by which neighborhood safety may be associated with sleepiness. Residents that perceive their neighborhoods as unsafe may have increased levels of perceived psychological stress.[47] Evidence suggests that elevated stress is related to increased sleepiness.[48] Stress is known to activate the defense system of the central nervous system including the hypothalamo-pituitary-adrenal (HPA) axis.[49] The HPA axis is involved in regulating the onset and wake time of sleep,[50] potentially disrupting sleep quantity and thus leading to daytime sleepiness.[46] The role of stress as a possible mediator of perceived neighborhood safety and daytime sleepiness association may be a promising direction to explore in future research. Additionally, the cross-sectional design of this work leads us to consider the possibility that people with more sleep may have a better attitude about their neighborhood; future research should try and tease out temporality.

Contrary to our hypothesis that higher neighborhood violent crime would be associated with higher daytime sleepiness, crime was not related to daytime sleepiness. Neighborhood violent crime was measured as a census tract-level variable which may not relate to individual perceptions, evidenced by the weak correlation between crime and perceived safety. The measure of neighborhood crime (a police reported count of violent crimes) in our study may not represent the experience or perceptions of the residents. Residents of the neighborhood may not be aware of the frequency of violent crimes in their neighborhood, or feel personally susceptible to violent crime, and therefore are not vulnerable to the potential negative effects on sleep health. Moreover, researchers have hypothesized that neighborhoods high in crime may interrupt the ability of residents to initiate/maintain sleep;[29,51] however, if these residents exhibit certain stress reducing health behaviors or have social support that combats the feelings of fear, restful sleep may occur. For example, a participant with a high level of social support may feel protected in their neighborhood and therefore has a better sleep quality. In this example, social support could potentially modify the association between neighborhood crime and daytime sleepiness, and this is particularly relevant in our study population of Mexican Americans who tend to have a high level of social support.[52] As a result of this high social support, we may not observe an association; however, in a different population with a lower level of social support, there may be an association between neighborhood crime and daytime sleepiness.

Surprisingly, higher levels of neighborhood disadvantage were associated with lower daytime sleepiness, although this finding was not statistically significant. This unexpected finding was not consistent with our hypothesis that higher neighborhood disadvantage would be associated with higher daytime sleepiness, nor with findings of prior research. DeSantis et al. reported higher neighborhood SES (more advantage) was associated with less daytime sleepiness after adjustment for age and gender.[21] In our study, neighborhood SES was discordant with perceived neighborhood safety; approximately 47% of study participants with higher neighborhood disadvantage perceived their neighborhood as safe. Perceptions of safety may have more of an impact on the sleep of study participants than the SES of the neighborhood.

Regarding our outcome variable of sleep duration, we found no association between neighborhood characteristics (perceived safety, disadvantage and crime) and sleep duration; however, we did find that persons in the lower neighborhood disadvantage group had a higher prevalence of short sleep duration compared to those in the higher neighborhood disadvantage group. Prior research has shown inconsistent reports of associations between neighborhood characteristics and sleep duration.[21,26] Our results were consistent with the findings of Johnson et al. who reported no association between perceived neighborhood safety measured at the individual level and sleep duration. Conversely, DeSantis et al. found an association with group-level neighborhood safety and sleep duration, and also found that the association between neighborhood SES with sleep duration did not become significant until adjustment for sociodemographic variables (race and SES).

In addition to exploring the associations between neighborhood characteristics and sleep, we described the sleep of Mexican Americans in our study sample. This description contributes to the literature by quantifying the prevalence of short sleep duration among a non-immigrant population of Mexican Americans. In our study the prevalence of short sleep duration among Mexican Americans (44.5%) was comparable to that of non-Hispanic whites but higher than recent reports (data from the National Interview Survey) of short sleep duration for blacks (37%) and whites (28%).[53] Identifying determinants of poor sleep among Mexican Americans may potentially inform interventions to reduce the burden of poor mental and physical health outcomes in this population.

Our study has a few limitations. We included self-reported subjective measures of sleep, which can be unreliable; however, studies have found errors in objective measures also, as well as a moderate correlation between objective and subjective measures.[54] Sleep duration and daytime sleepiness were self-reported therefore recall bias or measurement error is probable; however we do not expect that recall differed based on neighborhood status. A reference time period was not included in the measurement of the sleep variables, which may increase susceptibility to error. Our measure of daytime sleepiness was based on the validated Berlin Sleep Questionnaire, which is typically used to assess sleep apnea risk rather than an assessment of the individual sleep dimensions such as daytime sleepiness. Use of different scales across studies makes comparisons challenging. Our study population was predominantly a non-immigrant population of catholic Mexican American church goers that were younger in age, had an existing support system (they enrolled in pairs) and were interested in a CVD risk reduction intervention; therefore, these results may not be representative of the general population with a different ethnic distribution, socioeconomic status, or risk factor profile for sleep outcomes. Our study examined cross-sectional associations and thus is affected by temporal ambiguity, meaning that it is unclear if neighborhoods determine sleep health, sleep health determines neighborhood environment or if there is a causal relation between the two.

Future studies should consider the possible pathways linking neighborhood safety with daytime sleepiness. This predominantly Mexican American study population had a high prevalence of short sleep duration, which may have implications for CVD and other health outcomes in this population. Further research should examine factors related to poor sleep among Mexican Americans.

Table 2-1 Distribution of Selected Study Population Characteristics across Tertiles of Neighborhood Disadvantage Categories. Data are mean±standard deviation or n (%)

	Neighborhood Disadvantage			
	Lowest 1/3 N=250	Middle 1/3 N=258	Upper 1/3 N=250	*p*-value
Age (years)	53.6±13.8	52.7±13.8	52.5±14.6	0.65
BMI (kg/m^2)	32.2±7.6	32.6±7.9	33.0±7.2	0.42
Mexican American	73.1%	91.1%	88.6%	<0.01
Male	37.6%	37.6%	33.2%	0.50
Smoke	6.0%	8.9%	10.0%	0.24
≥Some College	66.8%	55.8%	39.2%	<0.01
>$50,000	37.9%	28.9%	20.2%	<0.01
Short Sleep Duration*	50.0%	45.3%	38.1%	0.01
Sleep Duration	6.5±1.1	6.7 ±1.2	6.8±1.2	0.01
Daytime Sleepiness	0.7±0.9	0.7±0.8	0.7±0.8	0.75
Depressive Symptoms	0.7±1.1	0.9±1.4	1.2±1.6	<0.01
Sleep Apnea	11.6%	11.7%	9.2%	0.60
Hypertension	56.4%	52.7%	58.4%	0.42
Diabetes	24.8%	21.7%	28.4%	0.22
History of CVD^	10.0%	11.0%	11.7%	0.83
Violent Crime per capita*100,000	280.5±199.9	588.2±200.1	998.3±575.8	<0.01
Self-reported Neighborhood Safety				<0.01
Strongly Agree	27.2%	13.2%	10.0%	
Agree	50.0%	45.0%	37.2%	
Neutral	9.2%	15.9%	16.0%	
Disagree	11.2%	19.8%	27.6%	
Strongly Disagree	2.4%	6.2%	9.2%	

*Short sleep duration=<7 hours of sleep per night
^History of CVD= Heart attack, stroke, coronary artery disease, congestive heart failure
BMI, body mass index
Crime=murder, manslaughter, forcible rape, robbery, aggravated assault

Table 2-2 Distribution of Selected Study Population Characteristics across Categories of Sleep Duration and Daytime Sleepiness. Data are mean±standard deviation or n (%)

	<7 hours per night N=334	≥7 hours per night N=417	*P*-value	Low daytime sleepiness N=574	High daytime sleepiness N=186	*P*-value
Age (years)	51.2±13.6	54.3±14.4	<0.01	54.5±13.9	48.1±13.3	<0.01
BMI (kg/m^2)	33.0±7.6	32.3±7.6	0.22	32.2±7.4	34.0±7.9	<0.01
Mexican American	84.3%	83.2%	0.85	83.8%	85.5%	0.59
Male	38.6%	34.0%	0.19	37.6%	31.7%	0.14
Smoke	7.5%	8.6%	0.57	6.3%	14.5%	<0.01
≥Some College	59.9%	49.4%	<0.01	53.3%	55.9%	0.53
>$50,000	35.5%	23.6%	<0.01	29.4%	27.8%	0.67
Depressive Symptoms	1.1±1.5	0.8±1.3	<0.01	0.7±1.2	1.6±1.7	<0.01
Sleep Apnea	12.0%	9.95	0.35	8.2%	18.8%	<0.01
Hypertension	54.2%	57.1%	0.43	57.7%	50.5%	0.09
Diabetes	24.5%	25.9%	0.67	25.4%	23.7%	0.63
History of CVD^	9.0%	12.3%	0.15	11.0%	10.4%	0.83
Neighborhood Disadvantage	-1.4±0.9	-1.4±0.8	0.23	-1.4±0.9	-1.4±0.9	0.52
Violent Crime per capita*100,000	602.2±516.1	614.5±448.0	0.75	612.2±486.6	589.8±450.7	0.62
Self-reported Neighborhood Safety			0.05			0.02
Strongly Agree	13.5%	19.2%		18.8%	10.2%	
Agree	49.4%	39.3%		43.5%	45.2%	
Neutral	14.1%	13.9%		14.3%	12.9%	
Disagree	17.7%	21.1%		17.4%	25.8%	
Strongly Disagree	5.4%	6.5%		5.9%	5.9%	

^History of CVD= Heart attack, stroke, coronary artery disease, congestive heart failure; BMI, body mass index; Crime=murder, manslaughter, forcible rape, robbery, aggravated assault

Table 2-3 Age and sex-adjusted sleep outcomes by levels of neighborhood disadvantage, self-reported safety, and crime

	Hours of Sleep Range: 4-10 (mean)	**Daytime Sleepiness Range: 0-3 (mean)**
Disadvantage		
Low	6.54	0.72
Middle	6.68	0.66
High	6.85	0.70
p-value	<0.01	<0.01
Safety		
Low	6.73	0.79
Middle	6.60	0.69
High	6.84	0.48
p-value	<0.01	<0.01
Crime		
Low	6.58	0.74
Middle	6.67	0.63
High	6.85	0.72
p-value	<0.01	<0.01

*Safety was not correlated with crime or disadvantage

Table 2-4 Adjusted mean differences in minutes of sleep duration and log odds of daytime sleepiness associated with a 1 Standard Deviation increase in neighborhood characteristics

	Model 1		**Model 2**		**Model 3**	
	Difference	**95% Confidence Interval**	**Difference**	**95% Confidence Interval**	**Difference**	**95% Confidence Interval**
Minutes of Sleep						
Neighborhood Disadvantage	2.26	-3.0, 7.5	0.16	-5.4, 5.7	1.03	-4.5, 6.6
Self-reported Safety	2.30	-3.0, 7.6	4.10	-1.2, 9.4	3.55	-1.8, 8.9
Crime	0.84	-4.8, 6.5	-1.32	-7.6, 5.0	-0.29	-6.6, 6.0
Daytime Sleepiness						
Neighborhood Disadvantage	-0.03	-0.2, 0.1	-0.04	-0.2, 0.1	-0.11	-0.3, 0.0
Self-reported Safety	-0.23[a]	-0.4, -0.1	-0.23[a]	-0.4, -0.1	-0.20[a]	-0.3, 0.0
Crime	0.00	-0.1, 0.1	0.03	-0.1, 0.2	-0.04	-0.2, 0.1

Model 1 is adjusted for age and sex. Model 2 is adjusted for education and income, in addition to the factors in adjusted for in model 1. Model 3 is adjusted for depressive symptoms, body mass index, diabetes, and hypertension, in addition to the factors adjusted for in model 2. [a]$P<0.01$

Table 2-5 Associations of neighborhood characteristics with daytime sleepiness

	Model 1		Model 2	
	Unadjusted OR	**95% CI**	**Adjusted OR**	**95% CI**
Daytime Sleepiness				
Neighborhood Disadvantage	0.95	0.8, 1.1	0.85	0.7, 1.0
Self-reported Safety	0.82[a]	0.7, 1.0	0.84[b]	0.7, 1.0
Crime	0.95	0.8, 1.1	0.90	0.7, 1.1

Abbreviations: CI, confidence interval; OR, odds ratio
Model 1 is unadjusted. Model 2 is adjusted age, sex, education, income, depressive symptoms, body mass index, diabetes, and hypertension.
[a]*P*<0.05, [b]*P*<0.10

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Chapter 3
The social patterning of sleep in African Americans: associations of socioeconomic position and neighborhood characteristics with sleep in the Jackson Heart Study

3.1 Introduction

Inadequate sleep is a growing public health concern. The National Sleep Foundation suggests that most adults require 7-8 hours of sleep per night.[1] Short (< 7 hours) or long ($\geq$ 9 hours)[2] sleep duration and a poor quality of sleep can interrupt the health promoting functions that occur during sleep, which can lead to poor health outcomes.[3] Although sleep is essential for physical and emotional well-being,[4] data from large nationally representative samples of United States (US) adults indicate that between 28-37% of adults sleep 6 hours or fewer while approximately 8% sleep 9 hours or more.[5–7] Data from the same studies also show an alarming 35-53% of non-Hispanic blacks sleep 6 hours or less and approximately 10% sleep 9 hours or more.[5–7]

Research has shown that short or long sleep and poor sleep quality are risk factors for several health conditions including high blood pressure, diabetes, stroke, obesity, depression, heart disease and mortality.[4,6,8–10] It has been hypothesized that the altered blood pressure profile resulting from insufficient sleep may lead to cardiovascular damage and increased risk for cardiovascular disease (CVD).[11] Sleep has also been linked to metabolic disturbances related to CVD.[12] Preliminary evidence shows that improving sleep can improve glucose homeostasis and blood pressure.[13,14] With at least a third of Americans sleeping 6 hours or less per night[15] explorations of the reasons for this high prevalence of inadequate sleep are warranted in order to develop appropriate interventions to improve sleep and reduce the downstream cardiovascular consequences, particularly among African Americans who have been infrequently studied.

Growing research indicates that African Americans have poorer sleep quality, lower mean sleep duration, and a higher prevalence of sleep-disordered breathing when compared to non-Hispanic whites.[4,12,16,17] However, the reasons for this racial disparity remain unclear.[18] Individual-level social and environmental factors may contribute to poorer sleep outcomes in African Americans. Socioeconomic position (SEP) may be linked to sleep through occupational characteristics (such as shift work or long hours), behavioral factors patterned by SEP that may affect sleep (like physical activity or dietary behaviors), or exposures to stressors that may affect sleep.[19–21] Several studies have shown shorter sleep and poor quality sleep are associated with lower SEP as indexed by education, family income, poverty, employment status, private insurance, and food security.[20,22–26] However, the majority of work examining associations of SEP with sleep has focused on white populations, and associations may differ for African Americans because they may be more vulnerable to the impact of SEP on sleep.[22,27] For example, some studies have reported that, in contrast to associations reported in White men and women, among African American men increases in SEP are sometimes associated with adverse health outcomes.[27,29,30] Therefore, studying the associations between SEP and sleep outcomes in African Americans is warranted.

In addition to individual measures of SEP, neighborhood characteristics may also affect sleep outcomes. The effects of light, noise, and traffic, which are often patterned by neighborhood, on sleep outcomes are well established.[31–33] Low socioeconomic status (SES) neighborhoods may also have increased exposure to crime and air pollution that could impact residents' sleep patterns.[17,34] The neighborhood social environment (social cohesion, crime, disorder) may impact the initiation or regulation of sleep[35–39] through activation of the stress response process and the release of stress hormones that hinder sleep.[35] Several studies conducted among pediatric populations have shown that living in a socioeconomically disadvantaged neighborhood is associated with sleep problems, inadequate sleep quality, and a short sleep duration.[40–42] Similar evidence linking neighborhood attributes such as neighborhood SES, social cohesion, disorder, and violence to sleep outcomes is emerging for adult populations;[17,36,39,43] however, these studies are limited by small sample size, a lack of racial-ethnic diversity and consideration of single dimensions of the neighborhood environment. Because of the increased exposure of African Americans to adverse neighborhood environments, these factors could contribute to poor sleep outcomes in this population.[38]

Given the limited data on African Americans and sleep, exploring predictors (at the individual and neighborhood levels) of sleep in this population may inform interventions to improve sleep and related chronic conditions in this population. Using data from the Jackson Heart Study (JHS) we studied the cross-sectional associations of individual-level SEP and neighborhood characteristics (social cohesion, violence, problems, SES) with sleep duration and sleep quality in African Americans. We hypothesized that low SEP and adverse neighborhood conditions are associated with short/long sleep duration and a poor sleep quality.

3.2 Methods

The JHS is a large population-based, prospective cohort study designed to examine the etiology of cardiovascular disease in African Americans. The 5,301 participants aged 21-95 were recruited from three counties, Hinds, Madison, and Rankin in the Jackson, Mississippi (MS), metropolitan statistical area (MSA) between September 2000 and March 2004 using four approaches.[44] First, all the Jackson, MS living participants in the Atherosclerosis Risk in Community (ARIC) study within the eligible age range were invited to participate in JHS. Jackson ARIC participants were originally sampled from the city of Jackson residents listed in the Mississippi Driver's License and Identification List.[44] In total, 31% of the JHS participants were recruited from the ARIC study. Second, participants were recruited through random sampling (17% of the total JHS sample) from a commercially available list (AccuData Intergrated Marketing, Fort Myers, FL) of all community residents aged 35-84 years in the tri-county area.[45] The third approach recruited volunteers (30% of the total JHS sample) aged 35-84 years through targeted advertisements: radio, newspaper, local churches, and civic/social organizations.[45] Volunteers were approximately representative of the Jackson MSA African American population in terms of age, sex and socioeconomic characteristics.[46] Lastly, family members of other JHS participants (22% of the total JHS sample) were recruited from enumerated households to permit future genetic studies.[47] Family members were included even if they were under 35 or over 84 years of age. The final study sample has been shown to be geographically representative of the age-eligible African American population in Jackson MSA.[48] The JHS was approved by the institutional review boards of Jackson State University, Tougaloo College and University of Mississippi Medical Center. All participants provided written informed consent.

Of the 5,301 participants enrolled in the JHS study, 5,244 had data on sleep quality and sleep duration. Of these, 19 were missing information on education and were excluded from analyses of individual-level SEP. The 804 participants with missing information on income were coded as missing and retained in analyses. Analyses based on self-reported neighborhood characteristics were further restricted to 3,260 participants who reported this information. Analyses adjusted for sleep risk factors were further restricted to 4,063 participants for individual level SEP and 2,550 participants for self-reported neighborhood characteristics due to missing covariate data. A total of 5,215 participants had information on census tract-level neighborhood characteristics and were included in analyses of census tract SES (n=4,063 for risk factor adjusted analyses) and in sensitivity analyses pooling survey responses within tracts, as described below.

Sleep Measures

Self-reported sleep measures, including sleep duration and sleep quality were collected at baseline between 2000 and 2004. To assess sleep duration, participants responded to the following question: “During the past month, excluding naps, how many hours of actual sleep did you get at night (or day, if you work at night) on average?” Responses were given in hours and transformed into minutes for analysis. Sleep duration was also categorized into short ($\leq$ 6 hours), normal (7 or 8 hours), and long ($\geq$9 hours) sleep.[49,50] The analyses included both continuous (in minutes) and categorized (short, normal, and long) measures of sleep duration. Participants also indicated their level of sleep quality by responding to the following question, “During the past month, how would you rate your sleep quality overall?” Responses were reported on a Likert scale, with 1=excellent, 2=very good, 3=good, 4=fair, 5=poor; coding was reversed for analysis and further categorized as high (excellent, very good, good) and low (fair, poor).

Individual-level Measures of SEP

Individual-level SEP was measured by education and income. Education was reported at baseline as the years of schooling completed (range=0-16+ years) and categorized into four groups: less than high school, high school, greater than high school (HS) but less than a college degree, and college degree or more. Annual family income was reported at baseline in 11 categories ranging from under $5000 to $100,000 or more. Income was then further classified into four categories: low, lower-middle, upper-middle, and affluent which were based upon income, family size, number of children <18 years of age, and the United States Census designated poverty level for the year in which the income information was obtained.[45] Low income was defined as income below the poverty level. Lower-middle income was defined as income at or above the poverty level but below 2.5 times the poverty level.[45] Upper-middle income was defined as income at or above 2.5 times the poverty level, but below four times the poverty level.[45] High income was defined as income at four times the poverty level or more. Participants who did not know their income or refused to respond were classified as "Unknown." A continuous family income variable was also created by taking the interval midpoint of each family income bracket (e.g. the midpoint for $5000-$7999 is $6500).[45] Those who reported total family income of <$5,000 were assigned a value of $2,500 and those with >$100,000 were assigned $112,500 based on the US income distribution.

Neighborhood Measures

JHS participants completed a survey about their neighborhood between 2004 and 2010. Participants were asked questions about their neighborhood defined as the area around where they live, perform routine tasks, such as shopping, going to the park, visiting neighbors, religious or public institutions, or a local business district. Neighborhood social cohesion was measured as the mean of five items with 4 response options from strongly disagree (1) to strongly agree (4). The five items included this is a close knit neighborhood, people are willing to help their neighbors, people in the neighborhood generally don't get along (reverse coded), people in the neighborhood can be trusted, and people in the neighborhood do not share the same values (reverse coded). Neighborhood violence was measured as the mean of five items that assessed the frequency with which acts of violence occurred in the last six months (1=Never to 4=Often): a fight in the neighborhood in which a weapon was used, a violent argument between neighbors, gang fights, a sexual assault or rape, or a robbery or mugging. Neighborhood problems were measured as the mean of six items (1 not really a problem to 4 very serious problem) that assessed aspects of the neighborhood (noise, traffic, trash/litter, availability of health foods, parks, lack of parks and playground).[51,52] Scales were identified a priori (based on the literature) and confirmed via principal component analysis (PCA) of all 17 items. Each neighborhood scale had good internal consistency, with Cronbach's alpha ranging from 0.76-0.80. Main analyses focused on self-reports of neighborhood characteristics. However, in sensitivity analyses we also examined census tract-level neighborhood characteristics created by aggregating responses within a tract over the period 2004-2008 using age and sex adjusted empirical Bayes estimates as in prior work.[51] The use of census tract–level estimates avoids same source bias (and may provide a more valid estimate of "true" neighborhood characteristics) but does not capture an individual's subjective perception, which may be more relevant than "true" characteristics for sleep outcomes.

In addition to the survey based scales, we also investigated a neighborhood SES measure (hence forth referred to as neighborhood disadvantage) developed using data from the 2000 US Census that was based on a score derived from PCA of US census tract-level data.[53] The factor score is a sum of standardized proportions for several socioeconomic indicators for adults in the tracts, including the % with a Bachelor degree, % in managerial occupations, median home value, % with a high school (HS) education, median household income, and % of households with income greater than $50,000. Higher factor scores indicated greater neighborhood disadvantage. In order to investigate trends, all neighborhood characteristics were categorized into tertiles. Dichotomous categories were used when the distribution precluded the creation of tertiles (as for neighborhood violence).

Covariates

Participants self-reported age and sex, which may confound the associations between both individual SEP and neighborhood characteristics with sleep.[39] Risk factors for poor sleep outcomes (short sleep, long sleep and shorter sleep duration and lower sleep quality) including body mass index (BMI), hypertension, diabetes, and physical activity, may confound or mediate the associations between individual SEP, neighborhood characteristics and sleep. For this reason, results are shown before and after adjustment for these covariates. Each of these four risk factors was measured by trained study staff. BMI was calculated in kg/m^2 using measurements of weight and height while participants wore light clothing and no shoes. Seated blood pressure measurements were obtained after 5 minutes of rest. Two resting blood pressure readings were taken 1 minute apart in the seated position and averaged. Hypertension was defined according to Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VII) criteria as a systolic blood pressure $\geq$140 mmHg or a diastolic blood pressure $\geq$90 mmHg, use of antihypertensive medications (self- report and actual) within 2 weeks prior to data collection, or self- reported history of hypertension.[54] Diabetes was defined according to American Diabetes Association, 2004 criteria as fasting glucose $\geq$126 mg/dl, confirmed medication inventory or self-reported use of anti-diabetic medications, or self-reported diabetes diagnosis.[55] Physical activity was measured using the JHS Physical Activity Measurement instrument, a modified version of the Baecke physical activity survey.[56,57] A total physical activity score was calculated based on a summary score of the intensity, frequency, and duration of activities associated with various aspects of life (active living, home life, sport and work).[45]

Statistical Analysis

Descriptive statistics were calculated for demographics and risk factors stratified by categories of sleep duration (short [<7 hours], normal [7-8 hours], and [long ≥9 hours]) and sleep quality (high vs. low). Chi-square and analysis of variance tests were used to compare categorical and continuous variables across categories of sleep duration and sleep quality. Pearson correlations were calculated to examine the correlation between sleep outcome variables.

Multinomial logistic regression was used to examine associations of individual SEP and neighborhood characteristics with categories of sleep duration (short vs. normal, long vs. normal). Linear regression was used to examine associations of individual SEP and neighborhood characteristics with continuous sleep outcomes (sleep duration, sleep quality). Neighborhood models included a random intercept for the census tract. The intraclass correlation coefficient (ICC) was calculated to determine clustering within census tract. Individual education and income as well as each neighborhood characteristic were modeled in separate sequential models as follows: unadjusted, followed by adjustment for age, sex, education and income (neighborhood models only), and further adjusted for BMI, diabetes, hypertension, and physical activity given the potential for these factors to be on the causal pathway. The continuous exposures (individual education and income, neighborhood social cohesion, violence, problems and neighborhood disadvantage) were standardized for ease of interpretation. Tests for trend of the associations between categories of individual SEP and tertiles of neighborhood characteristics and sleep outcomes were performed.

Finally, for significant main effects, we investigated whether the associations of individual SEP and neighborhood characteristics were modified by sex, as previous research has shown sex to modify associations of individual SEP and neighborhood characteristics with health outcomes.[58–60]

Interaction terms between each continuous exposure variable and sex were included in the fully adjusted models. We tested only the continuous exposures in order to reduce the number of statistical tests performed. All analyses were conducted using SAS software version 9.3 (SAS Institute, Cary, NC).

3.3 Results

The study population (n=5215) had a mean age of 54.7 years (Standard Deviation (SD) =12.9) and was 63% female. The mean sleep duration was 6.4±1.5 hours and 54% of the population had a short sleep duration defined as ≤ 6 hours of sleep at night, whereas 5% had a long sleep duration (≥ 9 hours of sleep at night). Approximately 24% of the study population reported "poor sleep." There was a moderate correlation between sleep duration and sleep quality, r=0.45, P<0.01.

Sleep Duration

Respondents who reported long sleep were more likely to be older, female, have a lower physical activity score and a higher prevalence of hypertension and diabetes relative to those in the other sleep categories, P<0.01 (Table 3-1). BMI was higher among respondents who reported short sleep compared to those who reported normal and long sleep, P<0.05 (Table 3-1).

Individuals who reported long sleep were more likely to be of lower education and lower income than those in the other sleep duration categories, P<0.01; but no important differences in education were observed between short and normal sleepers. Persons in the short sleep category reported higher neighborhood violence relative to those in the other sleep categories, P<0.05. Mean scores for census-tract level neighborhood problems and neighborhood disadvantage were highest among long sleepers compared to persons in the normal or short sleep categories, *P*<0.05. There were no differences in mean self-reported or census-tract level neighborhood social cohesion across sleep duration categories (Table 3-2).

Lower income (low and lower middle) and lower education categories (less than HS, HS/General Educational Development (GED) completers, more than HS but less than bachelor degree) were associated with a higher odds of long sleep compared to high income and college educated adults after age and sex adjustment (Table 3-3, *P* for trend <0.01 for income and education). These associations remained after further adjustment for risk factors (Table 3-3). Measures of individual SEP were not associated with short sleep or with continuous sleep duration.

Individuals who reported low neighborhood social cohesion had a 36% (OR=0.64; 95% CI: 0.41, 0.97) lower odds of long sleep duration relative to those who reported high neighborhood social cohesion after adjustment for age, sex, education and income. This association was no longer significant after adjustment for risk factors (Table 3-4). Neighborhood social cohesion was not associated with short sleep or with continuous sleep duration in any model. Persons who reported lower neighborhood violence had a 16% (OR=0.84; 95% CI: 0.71, 0.99) lower odds of short sleep and slept 9.6 minutes (95% CI: 2.71, 16.51) longer on average compared to those who reported higher neighborhood violence after adjustment for age, sex, education and income. Associations were similar after further adjustment for risk factors (Table 3-4). Neighborhood violence was not associated with long sleep in any model (Table 3-4). Individuals in the low and middle categories of neighborhood problems had a 51% (OR=1.51; 95% CI: 0.95, 2.40) and 69% (OR=1.69; 95% CI: 1.07, 2.67) higher odds of long sleep and slept 10.6 minutes (95% CI: 2.64, 18.52) and 7.6 minutes (95% CI: -0.40, 15.64) longer compared to those who reported higher neighborhood problems after adjustment for age, sex, education, and income (*P* for trend <0.01).

The associations remained after further adjustment for risk factors (Table 3-4). Neighborhood problems were not associated with short sleep.

Neighborhood disadvantage was not significantly associated with any of the sleep outcomes (Table 3-4).

Sleep Quality

Persons in the low sleep quality group were younger, more likely to be female, had a higher BMI, lower physical activity score, and a higher prevalence of hypertension and diabetes compared to those in the high sleep quality group, $P<0.01$ (Table 3-1). They were also more likely to be less educated and have lower income, reported lower neighborhood social cohesion, higher neighborhood violence, and more neighborhood problems, and lived in neighborhoods with greater disadvantage relative to persons in the high sleep quality group, $P<0.05$ (Table 3-2).

Lower income and lower education were associated with poorer sleep quality in a graded fashion (Table 3-5) after adjustment for age and sex. The associations remained after further adjustment for risk factors (Table 3-5, P for trend <0.01). Individuals who reported less neighborhood violence and fewer neighborhood problems had higher sleep quality compared to those in the high categories of these factors after adjusting for age, sex, education and income, although the trend was only statistically significant for neighborhood problems ($P<0.01$). These associations remained after further adjustment for risk factors. Neighborhood social cohesion and disadvantage were not associated with sleep quality in any model (Table 3-5).

Effect Modification

The association of neighborhood violence with sleep duration was modified by sex, $P\leq0.05$, such that the association of low neighborhood violence with lower odds of short sleep was observed in males but not females (OR of short sleep for low vs. high neighborhood violence category: OR=1.25; 95% CI: 1.09, 1.44 in men and OR=0.98; 95% CI: 0.87, 1.10 in women). Similarly, higher neighborhood violence was associated with shorter continuous sleep duration in males but not in females (mean difference comparing low to high violence category: -9.2 minutes; 95% CI: -14.33, -4.12 in men and -0.71 minutes; 95% CI: -5.48, 4.06 in women). Sex also modified the association of individual level education with sleep quality, *P*=0.05. Among females, higher education was associated with higher sleep quality (0.08 units of sleep quality (95% CI: 0.05, 0.12)), compared to the null association observed for males (0.03 units of sleep quality (95% CI: -0.02, 0.08)). Tests for effect modification by sex revealed no statistically significant differences in associations of neighborhood problems, social cohesion, or disadvantage and individual-level SEP with sleep duration or sleep quality.

Sensitivity Analysis

The use of aggregate census tract level measures of survey responses for social cohesion, violence, and problems resulted in generally weaker associations: no associations were observed between neighborhood violence and short sleep or sleep quality or between neighborhood problems and continuous sleep or sleep quality (Appendix Tables 3-6 & 3-7).

3.4 Discussion

We found that lower individual SEP was associated with higher odds of long sleep and poorer sleep quality after adjusting for demographics and sleep risk factors. Neighborhood characteristics were also associated with sleep duration and quality. Specifically, lower neighborhood violence and lower neighborhood problems were generally associated with longer sleep duration and better sleep quality, after adjustment for demographics, individual SEP and risk factors. This study is the first to investigate individual SEP and specific features of the neighborhood environment (individual and census tract-level) with sleep duration and quality in a large population of African Americans. The findings have potential implications for the health of African Americans given both short and long sleep are associated with mortality and cardiovascular outcomes.[61]

Although associations between lower SEP (income and education) and sleep (duration and quality) have been documented in non-Hispanic white populations,[22–25,62,63] our study confirmed this finding in a large population of African Americans. There may be specific correlates of SEP that are driving the observed associations with poor sleep. For example, persons with lower SEP are more likely to work long hours, multiple jobs, and shift work and these conditions are also associated with poor sleep quality.[64,65] Other factors including psychosocial factors such as depressive symptoms may also partially explain the association.[66] Researchers have shown that low SEP is associated with depressive symptoms, particularly among African Americans.[67] Interesting, our results show low SEP is associated with a higher odds of long sleep and poorer sleep quality. We would expect that an association with longer sleep duration would also be associated with a better sleep quality. However, it is possible that a person may be in bed longer but is waking more during sleep which may translate to disrupted sleep and thus a poor sleep quality.

Specific features of the neighborhood environment (violence and problems) were associated with sleep duration and quality after adjustment for individual SEP. Our study moved beyond the frequently studied physical environment factors, such as noise and traffic,[31–33] and showed that multiple social features of the neighborhood may be important predictors of sleep outcomes within African Americans. Our results were largely consistent with emerging evidence from a few studies that have shown that aspects of the social environment are associated with sleep.[36,39,43] We built upon this literature by the inclusion of multiple dimensions of the social environment with sleep. Researchers have hypothesized that inadequate or prolonged sleep durations may result from life/psychosocial stressors (working night shifts, multiple jobs) or depression that inhibit falling asleep or maintaining sleep among residents of disadvantaged and urban neighborhoods.[17] Future research should consider the confounding and mediating effects of these factors in longitudinal studies of neighborhoods and sleep.

Our data allowed us to contrast associations observed using individual reports of neighborhood problems and violence (main analyses reported) to associations observed when survey measures were aggregated across tracts. In general, the estimates from the census tract-level results were an attenuation of the self-reported findings. Research has shown length of residence as a significant predictor of observed differences between perceived and objective neighborhood data.[68] The observed difference in our study could be due to time in the neighborhood which was not available. Additionally, there is evidence that indicates neighborhood perceptions and objective neighborhood context are related but also distinct constructs that both contribute to health outcomes with neighborhood perceptions seemingly more proximate to health.[69] Examining the neighborhood environment (census tract-level) provides an avenue to avoid same source bias and to provide a more objective estimate of the neighborhood environment. However, investigating individual reports of the neighborhood environment allows insight into perceptions that may not correlate with the aggregate neighborhood measures but are nonetheless important for health outcomes. We observed longer sleep duration and higher sleep quality when assessing perceptions of the neighborhood but not when assessing the census tract measures; therefore our results suggest that it may be individual perceptions that are more relevant to sleep in this population.

In an exploratory analysis we found that neighborhood violence was associated with sleep duration in men but not women. Prior studies have not shown sex to modify the associations between neighborhood social factors and sleep duration.[39] This difference is likely due to a lack of power to investigate interactions in the prior study.[39] It is plausible that we observed an association in men only as research has shown African American men to be more vulnerable to the effects of violence.[70] In our study, it could be likely that lower violence was associated with better sleep outcomes because there was a sense of social trust or safety among residents thus lowering stress levels. In contrast to the neighborhood measures, we found that education was associated with better sleep quality among females but not males. This finding is consistent with prior research showing higher education is associated with increased sleep efficiency among women.[66] Given the research that has shown poorer health outcomes are associated with higher SEP in African American men, this may be why we do not observe the same associations as observed with the women in this study. Again, this was an exploratory analysis and our results should be interpreted with caution.

Although we measured two sleep outcomes, sleep duration and sleep quality, these are subjective sleep measures, which may correlate poorly with objective measures of sleep.[71] Research has shown that sleep duration is often underreported, especially among African Americans, and therefore our effect estimates could be biased towards the null.[72] Our study was cross-sectional in design, limiting causal inference. Specifically, it is difficult to determine if the exposure to low SEP or adverse neighborhood conditions preceded poor sleep; data on how long participants lived in the neighborhood were not available. Lastly, residual confounding is possible if there were unmeasured covariates at the individual and/or neighborhood level that were not accounted for in the statistical models. We controlled for demographics, individual SEP as well as risk factors. It is likely that depression or other medical illnesses may confound or mediate the explored associations. It is likely that those that have existing medical conditions (including sleep conditions) might be more likely to be disadvantaged[73] and more likely to have abnormal sleep duration.[74]

In conclusion, our study provides insight into determinants of sleep among African Americans, a group at increased risk for a variety of health conditions linked to poor sleep. Individual SEP as well as specific features of the neighborhood were associated both sleep duration and sleep quality. These findings suggest social and environmental characteristics may contribute to adverse sleep outcomes in African Americans.

Table 3-1 Sample characteristics by categories of sleep duration and sleep quality, The Jackson Heart Study, 2000-2004

		Sleep Duration*				**Sleep Quality^**		
	Full sample N`	**Short Mean (SE) or %**	**Normal Mean (SE) or %**	**Long Mean (SE) or %**	**P**	**Low Mean (SE) or %**	**High Mean (SE) or %**	**P**
Proportion of sample n (%)	5215	2828 (54.2)	2100 (40.3)	287 (5.5)	<0.01	1800 (34.5)	3415 (65.5)	<0.01
Age (y, mean)	54.7±12.8	53.9±12.5	55.2±13.0	59.0±13.9	<0.01	53.4±12.8	55.4±12.8	<0.01
Sex (%)					<0.01			<0.01
Female	63.3	61.6	64.9	69.0		66.1	61.9	
Body Mass Index	31.8±7.2	32.0±7.4	31.5±7.1	31.1±6.9	0.02	32.6±7.6	31.3±7.0	<0.01
Physical Activity	8.3±2.6	8.4±2.6	8.4±2.6	7.5±2.8	<0.01	8.2±2.6	8.4±2.6	<0.01
Hypertension	63.0	62.9	62.0	71.6	<0.01	66.2	61.3	<0.01
Diabetes	18.8	18.8	18.0	25.5	0.01	20.3	18.0	0.05

Sleep duration category differences were calculated using chi=squared distributions (categorical variables) and analysis of variance (continuous variables).
SE, standard error.
*Short sleep duration (<7 h), normal sleep duration (≥7 and <9 h), long sleep duration (≥9 h)
^Low sleep quality (fair, poor), high sleep quality (good, very good, excellent)
`Sample size: 5215 except: BMI=5208, physical activity=4929, hypertension=5176, diabetes=5094

Table 3-2 Individual-level socioeconomic position (SEP) and neighborhood characteristics by categories of sleep duration and sleep quality, The Jackson Heart Study, 2000-2004

		Sleep Duration*				**Sleep Quality^**		
	Full Sample	**Short Mean (SE) or %**	**Normal Mean (SE) or %**	**Long Mean (SE) or %**	**P**	**Low Mean (SE) or %**	**High Mean (SE) or %**	**P**
Individual SEP								
Education					<0.01			<0.01
Less than HS+	18.3	17.4	17.9	29.6		20.3	17.2	
HS	20.1	19.4	20.8	22.6		20.6	19.8	
>HS but <college	28.9	29.7	27.7	30.3		31.6	27.5	
College	32.7	33.5	33.6	17.4		27.4	35.4	
Income (dollars)	42752.5± 31307.9	43677.1± 31253.2	43283.9± 31591.0	29808.2± 26706.5	<0.01	38057.2± 29754.4	45207.5± 31820.5	<0.01
Income Status					<0.01			<0.01
Low	15.6	15.0	15.1	24.6		19.5	13.5	
Lower Middle	25.2	24.8	24.0	37.3		28.2	23.6	
Upper Middle	29.6	29.8	30.7	19.7		30.0	29.4	
Affluent	29.7	30.5	30.1	18.4		22.3	33.5	
Neighborhood Factors								
Self-reported								
Social Cohesion	3.10±0.56	3.09±0.56	3.11±0.56	3.16±0.56	0.34	3.05±0.58	3.12±0.55	<0.01
Violence	1.22±0.42	1.23±0.44	1.20±0.40	1.17±0.33	0.03	1.26±0.47	1.19±0.39	<0.01
Problems	1.50±0.59	1.51±0.61	1.47±0.58	1.42±0.51	0.06	1.56±0.63	1.46±0.57	<0.01
Census-tract								
Social Cohesion	3.01+0.12	3.01+0.12	3.01+0.12	3.00+0.13	0.27	3.00+0.12	3.01+0.12	0.01
Violence	1.26+0.12	1.26+0.12	1.26+0.13	1.28+0.12	0.11	1.27+0.13	1.26+0.12	0.02
Problems	1.57+0.19	1.56+0.19	1.57+0.19	1.59+0.17	0.04	1.57+0.19	1.56+0.18	0.02
Census-derived Neighborhood Disadvantage	0.63±0.65	0.62±0.66	0.63±0.64	0.76±0.58	<0.01	0.66±0.65	0.62±0.65	0.04

Sleep duration category differences were calculated using chi=squared distributions (categorical variables) and analysis of variance (continuous variables). SE, standard error; *Short sleep duration (≤6 h), normal sleep duration (7 or 8 h), long sleep duration (≥9 h); ^Low sleep quality (fair, poor), high sleep quality (good, very good, excellent); +HS, high school; `Full sample size=5215 except: income (dollars) =4433; income status=4411; self-reported neighborhood factors=3260

Table 3-3 Adjusted associations of individual-level socioeconomic position with sleep duration, The Jackson Heart Study, 2000-2004

	Model 1*			Model 2^		
	OR of short sleep (vs. normal)	**OR of long sleep (vs. normal)**	**Mean difference in minutes of sleep**	**OR of short sleep (vs. normal)**	**OR of long sleep (vs. normal)**	**Mean difference in minutes of sleep**
Income						
Low	1.01 (0.83, 1.23)	2.46 (1.61, 3.74)[a]	2.62 (-5.92, 11.16)	0.95 (0.77, 1.17)	2.18 (1.39, 3.40)[a]	3.89 (-5.08, 12.87)
Lower Middle	1.07 (0.90, 1.27)	2.29 (1.56, 3.36)[a]	1.27 (-6.16, 8.69)	1.01 (0.85, 1.21)	2.10 (1.40, 3.15)[a]	2.26 (-5.50, 10.03)
Upper Middle	0.96 (0.82, 1.13)	1.05 (0.68, 1.60)	-1.82 (-8.82, 5.18)	0.94 (0.80, 1.11)	0.96 (0.61, 1.50)	-2.17 (-9.42, 5.08)
High	REF	REF	REF	REF	REF	REF
***P*-trend**	0.63	<0.01	0.46	0.83	<0.01	0.29
Education						
<HS	1.07 (0.90, 1.28)	2.59 (1.75, 3.84)[a]	1.25 (-6.48, 8.98)	0.99 (0.82, 1.20)	2.35 (1.53, 3.60)[a]	3.12 (-5.05, 11.28)
HS/GED	0.96 (0.82, 1.12)	1.99 (1.35, 2.93)[a]	2.28 (-4.79, 9.36)	0.94 (0.79, 1.11)	2.09 (1.38, 3.18)[a]	3.44 (-3.97, 10.85)
>HS but <Bachelor Degree	1.05 (0.91, 1.21)	2.23 (1.55, 3.22)[a]	1.70 (-4.64, 8.05)	1.02 (0.88, 1.19)	2.45 (1.66, 3.63)[a]	3.37 (-3.20, 9.93)
College degree +	REF	REF	REF	REF	REF	REF
***P*-trend**	0.71	<0.01	0.64	0.72	<0.01	0.37

Model 1 adjusted for age and sex

Model 2 adjusted for age, sex, physical activity, body mass index, diabetes, and hypertension

[a]*P*<0.01, [b]*P*<0.05

*Model 1 sample size: income=4411; education=5215

^Model 2 sample size: income=4063; education=4806

Table 3-4 Adjusted associations of neighborhood characteristics with sleep duration, The Jackson Heart Study, 2000-2004

	Model 1*			Model 2^		
	OR of short sleep (vs. normal)	**OR of long sleep (vs. normal)**	**Mean difference in minutes of sleep**	**OR of short sleep (vs. normal)**	**OR of long sleep (vs. normal)**	**Mean difference in minutes of sleep**
Social cohesion						
Low	0.89	0.64	-1.48	0.86	0.68	-0.06
	(0.74, 1.07)	(0.41, 0.97)[b]	(-9.18, 6.21)	(0.70, 1.04)	(0.43, 1.08)	(-8.03, 7.91)
Middle	0.93	0.73	0.65	0.96	0.82	0.02
	(0.77, 1.13)	(0.47, 1.14)	(-7.30, 8.60)	(0.78, 1.17)	(0.51, 1.31)	(-8.12, 8.17)
High	REF	REF	REF	REF	REF	REF
***P*-trend**	0.21	0.03	0.72	0.12	0.10	0.99
Violence						
Low	0.84	1.02	9.61	0.84	1.03	10.43
	(0.71, 0.99)[b]	(0.69, 1.51)	(2.71, 16.51)[a]	(0.71, 1.01)[c]	(0.68, 1.56)	(3.61, 17.25)[a]
High	REF	REF	REF	REF	REF	REF
***P*-trend**	----	----	----	----	----	----
Problems						
Low	0.86	1.51	10.58	0.86	1.51	11.48
	(0.71, 1.04)	(0.95, 2.40)[c]	(2.64, 18.52)[a]	(0.70, 1.04)	(0.92, 2.49)	(4.22, 18.74)[a]
Middle	0.97	1.69	7.62	0.98	1.80	9.83
	(0.79, 1.17)	(1.07, 2.67)[b]	(-0.40, 15.64)[c]	(0.80, 1.20)	(1.10, 2.94)[b]	(2.67, 16.99)[a]
High	REF	REF	REF	REF	REF	REF
***P*-trend**	0.12	0.10	<0.01	0.12	0.13	<0.01
Census-derived Neighborhood Disadvantage						
Low	1.00	0.82	-1.71	0.99	0.72	-2.72
	(0.85, 1.17)	(0.58, 1.17)	(-9.83, 6.41)	(0.84, 1.17)	(0.49, 1.05)[c]	(-10.97, 5.52)
Middle	1.04	0.90	-2.91	1.02	0.85	-2.69
	(0.89, 1.21)	(0.65, 1.24)	(-11.00, 5.17)	(0.87, 1.20)	(0.60, 1.19)	(-10.88, 5.49)
High	REF	REF	REF	REF	REF	REF
***P*-trend**	0.97	0.27	0.65	0.90	0.08	0.49

Neighborhood cohesion, violence and problems are based on each individual's report.
Model 1 adjusted for age, sex, education, income
Model 2 adjusted for age, sex, physical activity, body mass index, diabetes, and hypertension
[a]$P<0.01$, [b]$P<0.05$, [c]$P<0.10$
*Model 1 sample size=2749 except: neighborhood disadvantage=4411
^Model 2 sample size=2550 except: neighborhood disadvantage=4063

Table 3-5 Adjusted associations of individual socioeconomic position, neighborhood characteristics with sleep quality, The Jackson Heart Study, 2000-2004

	Mean difference in sleep quality	
	Model 1`	**Model 2[+]**
Individual SEP		
Income		
Low	-0.39 (-0.49, -0.29)[a]	-0.34 (-0.44, -0.23)[a]
Lower-Middle	-0.25 (-0.34, -0.16)[a]	-0.22 (-0.31, -0.13)[a]
Upper- Middle	-0.19 (-0.27, -0.10)[a]	-0.18 (-0.27, -0.09)[a]
High	REF	REF
***P*-trend**	<0.01	<0.01
Education		
<HS	-0.25 (-0.34, -0.16)[a]	-0.19 (-0.29, -0.09)[a]
HS/GED	-0.19 (-0.28, -0.10)[a]	-0.15 (-0.24, -0.06)[a]
>HS but <Bachelor degree	-0.19 (-0.27, -0.11)[a]	-0.16 (-0.24, -0.08)[a]
College degree +	REF	REF
***P*-trend**	<0.01	<0.01
Neighborhood Factors		
Social cohesion*		
Low	-0.05 (-0.15, 0.04)	-0.03 (-0.13, 0.07)
Middle	-0.05 (-0.15, 0.05)	-0.08 (-0.18, 0.02)
High	REF	REF
***P*-trend**	0.26	0.49
Violence*		
Low	0.11 (0.02, 0.20)[a]	0.11 (0.02, 0.20)[b]
High	REF	REF
***P*-trend**	----	----
Problems*		
Low	0.16 (0.06, 0.26)[a]	0.15 (0.05, 0.26)[a]
Middle	0.09 (-0.01, 0.19)[c]	0.07 (-0.03, 0.18)
High	REF	REF
***P*-trend**	<0.01	<0.01
Census-derived Neighborhood Disadvantage^		
Low	-0.02 (-0.10, 0.07)	-0.01 (-0.10, 0.07)
Middle	0.03 (-0.05, 0.11)	0.02 (-0.06, 0.11)
High	REF	REF
***P*-trend**	0.71	0.77

Model 1 adjusted for age and sex for SEP models
Model 1 adjusted for age, sex, education and income for neighborhood characteristic models
Model 2 adjusted for age, sex, physical activity, body mass index, diabetes, and hypertension
[a]$P \leq 0.01$, [b]$P<0.05$, [c]$P<0.05$ *Self-reported neighborhood characteristic, ^Census tract-level neighborhood characteristic
`Model 1 sample size=5215 except: income status=4411; self-reported neighborhood characteristics = 2749, neighborhood disadvantage=4411
[+]Model 2 sample size=4806 except: income status=4063; self-reported neighborhood characteristics = 2550, neighborhood disadvantage=4063

3.5 Appendix.

Table 3-6 Adjusted associations of census tract-level neighborhood characteristics with sleep duration and sleep quality, The Jackson Heart Study, 2000-2004

	Model 1			**Model 2**		
	OR of short sleep (vs. normal)	**OR of long sleep (vs. normal)**	**Mean difference in minutes of sleep**	**OR of short sleep (vs. normal)**	**OR of long sleep (vs. normal)**	**Mean difference in minutes of sleep**
Social cohesion						
Low	0.95 (0.81, 1.10)	0.81 (0.58, 1.14)	-2.03 (-10.06, 6.01)	0.95 (0.80, 1.11)	0.79 (0.55, 1.12)	-2.60 (-10.78, 5.57)
Middle	0.87 (0.74, 1.01)[c]	0.70 (0.50, 0.99)[b]	-0.12 (-8.24, 8.00)	0.86 (0.74, 1.01)[c]	0.71 (0.49, 1.02)[c]	0.41 (-7.81, 8.64)
High	REF	REF	REF	REF	REF	REF
***P*-trend**	0.51	0.27	0.60	0.52	0.22	0.50
Violence						
Low	1.00 (0.85, 1.17)	1.22 (0.84, 1.78)	4.32 (-3.42, 12.07)	0.99 (0.84, 1.17)	1.24 (0.83, 1.83)	4.76 (-3.26, 12.78)
Middle	0.96 (0.82, 1.12)	1.43 (1.04, 1.98)[b]	7.49 (-0.02, 15.00)[b]	0.96 (0.82, 1.12)	1.40 (1.00, 1.97)[b]	6.87 (-0.93, 14.67)[c]
High	REF	REF	REF	REF	REF	REF
***P*-trend**	0.99	0.20	0.25	0.91	0.21	0.23
Problems						
Low	0.99 (0.84, 1.16)	1.04 (0.72, 1.51)	2.98 (-4.99, 10.96)	0.99 (0.84, 1.17)	1.02 (0.69, 1.50)	2.92 (-5.33, 11.18)
Middle	1.04 (0.89, 1.21)	1.31 (0.95, 1.80)[c]	2.17 (-5.82, 10.16)	1.06 (0.90, 1.24)	1.26 (0.90, 1.76)	1.41 (-6.83, 9.66)
High	REF	REF	REF	REF	REF	REF
***P*-trend**	0.90	0.65	0.45	0.94	0.78	0.48

Model 1 adjusted for age, sex, education and income

Model 2 adjusted for age, sex, education, income, physical activity, body mass index, diabetes, and hypertension

[a]$P \leq 0.01$, [b]$P \leq 0.05$, [c]$P \leq 0.10$

*Model 1 sample size=4411

^Model 2 sample size=4063

Table 3-7 Adjusted associations of census tract-level neighborhood characteristics with sleep duration and sleep quality, The Jackson Heart Study, 2000-2004

	Mean difference in sleep quality	
	Model 1	**Model 1**
Social cohesion*		
Low	-0.02 (-0.10, 0.07)	-0.02 (-0.11, 0.06)
Middle	-0.02 (-0.10, 0.07)	-0.02 (-0.10, 0.06)
High	REF	REF
***P*-trend**	0.67	0.59
Violence*		
Low	0.03 (-0.06, 0.11)	0.04 (-0.05, 0.13)
Middle	0.03 (-0.05, 0.11)	0.03 (-0.06, 0.11)
High	REF	REF
***P*-trend**	0.53	0.40
Problems*		
Low	0.06 (-0.02, 0.14)	0.06 (-0.03, 0.14)
Middle	0.06 (-0.02, 0.14)	0.06 (-0.02, 0.14)
High	REF	REF
***P*-trend**	0.15	0.20

Model 1 adjusted for age and sex
Model 2 adjusted for age, sex, physical activity, body mass index, diabetes, and hypertension
[a] $P \leq 0.01$, [b] $P \leq 0.05$
*Model 1 sample size=4411
^Model 2 sample size=4063

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Chapter 4
The contribution of chronic and acute psychosocial stressors to sleep among African Americans in the Jackson Heart Study

4.1 Introduction

Approximately 50-70 million adults in the United States have a sleep or wakefulness disorder.[1] Short (<7 hours) or long ($\geq$9 hours)[2] sleep duration and a poor quality of sleep can interrupt the health promoting functions that occur during sleep, leading to poor health outcomes.[1] Large scale observational studies and experimental research have linked high blood pressure, heart disease, diabetes, stroke, obesity and depression to poor sleep.[3–8]

Although most research on sleep has been conducted in white populations, growing research indicates that African Americans have poorer sleep quality, lower mean sleep duration, and a higher prevalence of sleep-disordered breathing when compared to non-Hispanic whites.[9,10] Research in non-Hispanic white populations has linked poor sleep to psychosocial stressors including negative life events, work stress and financial strain.[11–15] For example, results from the British Whitehall II study of 240 white middle-aged men and women demonstrated that sleep problems were greater among participants who had higher scores of psychosocial adversity and vulnerability independent of covariates.[12] In a separate analysis of 827 white men and women in the Whitehall II study, exposure to chronic stress measured by financial strain and neighborhood crime was associated with sleep problems.[11] Other studies have reported short sleep duration to be associated with high levels of stress in a population of police officers[16] and a cohort of men and women in Scotland.[17] Additionally, researchers have found higher perceived stress was associated with poor sleep quality, but the studies were limited to working populations[16,18] or consisted of a small sample (n=73) of women.[19] Although these findings support that psychosocial stressors are associated with poor sleep, similar studies in African Americans are lacking.

It is important to investigate these associations among African Americans for two reasons; (1) this population has a high prevalence of stress; and (2) this population may have a differential vulnerability to stressors relative to non-Hispanic whites.[20] African Americans have been shown to have more frequent exposures to certain stressors over the life course because of their social and economic circumstances.[20–27] For example, research has indicated that African Americans report experiencing greater cumulative exposures to stressors (chronic and acute) than non-Hispanic whites.[25–29] Additionally, stressful experiences, such as discrimination due to race, can produce psychosocial distress which can result in alterations in physiological processes that can impair sleep.[21,28] Workplace stressors may also be more common in African Americans than in whites.[21] In addition to the higher prevalence of stressors, the consequences of these stressors for sleep may be different in African Americans than in whites. For example, African Americans may be less likely to have access to resources and support mechanisms that buffer the adverse health effects of stressors, or these stressors may interact with other exposures (such as adverse neighborhood environments) resulting in stronger effects. It is therefore important to examine associations of psychosocial stressors with sleep in African American samples.

We used a large population based study, the Jackson Health Study (JHS) to examine the cross-sectional associations of psychosocial stress (global, weekly, major life events) with sleep duration and quality in African Americans. We hypothesized that higher chronic and acute stress is associated with poor sleep quality and short sleep duration.

4.2 Methods

The JHS is a large population-based, prospective cohort study designed to examine the etiology of cardiovascular disease in African Americans. The 5,301 participants aged 21-95 were recruited from three counties, Hinds, Madison, and Rankin in the Jackson, Mississippi (MS), metropolitan statistical area (MSA) between September 2000 and March 2004 using four approaches.[30] First, all the Jackson, MS living participants in the Atherosclerosis Risk in Community (ARIC) study within the eligible age range were invited to participate in JHS. Jackson ARIC participants were originally sampled from the city of Jackson residents listed in the Mississippi Driver's License and Identification List.[30] In total, 31% of the JHS participants were recruited from the ARIC study. Second, participants were recruited through random sampling (17% of the total JHS sample) from a commercially available list (AccuData Intergrated Marketing, Fort Myers, FL) of all community residents aged 35-84 years in the tri-county area.[24] The third approach recruited volunteers (30% of the total JHS sample) aged 35-84 years through targeted advertisements: radio, newspaper, local churches, and civic/social organizations.[24] Volunteers were approximately representative of the Jackson MSA African American population in terms of age, sex and socioeconomic characteristics.[31] Lastly, family members of other JHS participants (22% of the total JHS sample) were recruited from enumerated household to permit future genetic studies.[32] Family members were included even if they were under 35 or over 84 years of age. The final study sample has been shown to be geographically representative of the age-eligible African American population in Jackson MSA.[33] The JHS was approved by the institutional review boards of Jackson State University, Tougaloo College and University of Mississippi Medical Center. All participants provided written informed consent.

Psychosocial Stressors (Exposures)

Three measures of psychosocial stress were included: the Global Perceived Stress Scale (GPSS) was administered as part of the baseline examination; Major Life Events (MLE) were assessed by telephone interview during the annual follow-up; and the Weekly Stress Inventory (WSI) was given to study participants at the conclusion of the baseline with instruction to complete at home and mail back to the JHS Coordinating Center.[24]

The GPSS is a 8-tiem questionnaire that measured the perception of the severity of chronic stress experienced over a prior period of 12 months in eight domains including employment, relationships, related to one's neighborhood, caring for others, legal problems, medical problems, racism and discrimination, and meeting basic needs.[34] Participants rated stress severity for each domain on a 4-point scale ranging from "not stressful" to "very stressful" (0-3). Of 5,301 JHS participants, 5,279 completed the GPSS survey. Of these participants, 99.55% (N=5,255) had complete GPSS data; 0.38% (N=20) had missing responses for 1 out of the 8 questionnaire items.

The MLE survey measured 11 items based on participant reports of major life events (chronic stress) that had occurred in the last 12 months by answering "yes" or "no."[35] The items included: (1) experiencing serious personal illness; (2) being a victim of physical assault; (3) being a victim of a robbery or home burglary; (4) losing a loved one due to violence; (5) experiencing gunfire at home/neighborhood; (6) having a close friend/relative die; (7) having a close friend/relative experience major illness/injury; (8) moving to a worse residence/ neighborhood; (9) losing a job; (10) being forced to retire when didn't want to; (11) experiencing divorce/separation from spouse. Yes responses were coded as 1 and no responses as 0. Of the JHS participants, 5,085 completed the MLE survey. Of these participants (N=5,085), 81.07%

(N=4,867) had responses on all items; 1.28% (N=65) had missing responses in 1 out of the 11 items.

The WSI consisted of an 87-item questionnaire that assessed minor discrete experiences of stress (acute stress) across a broad range of life domains (over the past week) including, work tasks, relationships, finances, transportation, household tasks and responsibilities, leisure time activities, and others.[36] Participants were asked to assess the severity of the daily irritants during the past week on a 7-point scale with levels defined as follows: 0=did not happen; 1=not stressful; 2=slightly stressful; 3=mildly stressful; 4=moderately stressful; 5=stressful; 6=very stressful; 7=extremely stressful. Of the JHS participants, 3,602 returned the WSI survey. Of these participants, 81.07% (N=2,920) had all responses on all items; 13.24% (N=477) had missing responses in less than or equal to 9 out of 87 questionnaire items.

For statistical analyses, we used an average score for the GPSS, MLE and WSI. If the number of missing responses were equal to 1 (GPSS and MLE) or less than or equal to 9 (WSI), the missing response(s) were imputed as the average of the other complete responses for the participant. The average score was then calculated as the average of all responses after imputation. If the number of missing items was more than 1 for the GPSS and MLE or more than 9 for the WSI then the overall score was set to missing. Higher average scores indicate more stress on all scales.

Sleep Measures (Outcome)

Self-reported sleep duration and sleep quality were collected at baseline between 2000 and 2004. To assess sleep duration, participants responded to the following question: “During the past month, excluding naps, how many hours of actual sleep did you get at night (or day, if you work at night) on average?” Responses were given in hours and transformed into minutes for analysis. Sleep duration was also categorized into short ($\leq$ 6 hours), normal (7 or 8 hours), and long ($\geq$9 hours) sleep.[37,38] The analyses included both continuous (in minutes) and categorized (short, normal, and long) measures of sleep duration. Participants also indicated their level of sleep quality by responding to the following question, "During the past month, how would you rate your sleep quality overall?" Responses were reported on a Likert scale, with 1=excellent, 2=very good, 3=good, 4=fair, 5=poor; coding was reversed for analysis and further categorized as high (excellent, very good, good) and low (fair, poor).

Covariates

Data for covariates were collected at baseline. Participants self-reported age, gender, education and income, which may confound the association of psychosocial stressors and sleep. Education was reported as the years of schooling completed (range=0-16+ years) and further categorized into four groups: less than high school, high school, greater than high school but less than a college degree and greater than a college degree. Annual family income was reported during baseline. Income was self-reported into 11 categories ranging from under $5000 to $100,000 or more and further classified into four categories: low, lower-middle, upper-middle, and affluent which were based upon on income, family size, number of children <18 years of age, and the United States Census designated poverty level for the year in which the income information was obtained.[24] Low income was defined as income below the poverty level. Lower-middle income was defined as income at or above the poverty level but below 2.5 times the poverty level. Upper-middle income was defined as income at or above 2.5 times the poverty level, but below four times the poverty level. High income was defined as income of four times the poverty level or more. Participants who did not know their income or refused to respond were classified as "Unknown." A continuous family income was also calculated by taking the interval midpoint of each family income bracket (e.g. the midpoint for $5000-$7999 is $6500).[24] Those who reported total family income of <$5,000 were assigned a value of $2,500 and those with >$100,000 were assigned $112,500 based on the US income distribution.

Risk factors, i.e. BMI, hypertension, diabetes, physical activity, may confound the associations between psychosocial stress measures and sleep. However, some of these risk factors may also operate as mediators as psychosocial stress can impact the occurrence of these factors thus leading to poor sleep. For this reason results are shown before and after adjustment for these covariates. Trained study staff measured each of these four risk factors. BMI was calculated in kg/m^2 using measurements of weight and height while participants wore light clothing and no shoes. Seated blood pressure measurements were obtained after 5 minutes of rest. Two resting blood pressure readings were taken 1 minute apart in the seated position and averaged. Hypertension was defined according to Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VII) criteria as a systolic blood pressure ≥140 mmHg or a diastolic blood pressure ≥90 mmHg, use of antihypertensive medications (self- report and actual) within 2 weeks prior to data collection, or self- reported history of hypertension.[37] Diabetes was defined according to American Diabetes Association, 2004 criteria as fasting glucose ≥126 mg/dl, confirmed medication inventory or self-reported use of anti-diabetic medications, or self-reported diabetes diagnosis.[38] Physical activity was measured using the JHS Physical Activity Measurement instrument, a modified version of the Baecke physical activity survey.[39,40] A total physical activity score was calculated based on a summary score of the intensity, frequency, and duration of activities associated with various aspects of life (active living, home life, sport and work).[24]

To address the dual nature of these sleep risk factors, these variables will be accounted for in the fully adjusted models only; in order to assess the association with and without these variables.

Statistical Analysis

Only participants with complete data on the psychosocial stress measures and sleep measures were included in the analyses. After excluding missing data for sleep and psychosocial stress measures, we performed analyses on two analytic datasets: the first included participants with complete data on the GPSS and MLE measures, n=4,863; and the second included a subset of participants who had complete data on the WSI measure, n=3,177.

Descriptive statistics for demographics and risk factors were calculated for the two analytic datasets and stratified by sex due to prior literature showing differences between the association of stress and sleep by sex.[41] Pearson correlations were calculated to examine the correlation between psychosocial stress measures and between sleep outcome variables (sleep duration and sleep quality). Differences in mean sleep duration and mean sleep quality across quartiles of psychosocial stress measures stratified by sex were assessed by fitting linear models with adjustment for age.

Multinomial logistic regression was used to examine the association of each psychosocial stress measure (modeled as indicator variables based on quartiles of the distribution with the highest quartile as the referent) with categories of sleep duration (short vs. normal, long vs. normal). Linear regression was used to examine the association of each psychosocial stress measure with continuous sleep outcomes (sleep duration and sleep quality). Psychosocial stress measures were modeled in separate sequential models as follows: unadjusted, followed by adjustment for age, sex, education, and income, and further adjusted for BMI, diabetes, hypertension, and physical activity. We also tested for linear trend across quartiles of psychosocial stress measures.

Finally, we investigated whether associations of psychosocial stress measures with the sleep outcomes were modified by sex. Interaction terms between each psychosocial stress measure and sex were included in the fully adjusted models; p-values <0.05 for interaction terms were considered evidence of effect modification. All analyses were conducted using SAS software version 9.3 (SAS Institute, Cary, NC).

4.3 Results

Comparisons of the GPSS/MLE sample and the WSI sample showed some differences; the WSI sample was younger, more likely to be women, more likely to be of higher education and higher income, had a higher mean physical activity score, and a lower prevalence of hypertension and diabetes than the GPSS/MLE sample. The GPSS was weakly correlated with the MLE (r=0.25) and WSI (r=0.37); MLE and WSI were also weakly correlated (r=0.16). Sleep duration and sleep quality were moderately correlated (r=0.46).

In the GPSS/MLE sample, women were older, had a lower family income, a lower physical activity score, a higher BMI, and a higher prevalence of hypertension and diabetes compared to men (Table 4-1). Similar patterns were observed for the WSI sample. Women had higher stress scores (GPSS, MLE and WSI) than men (Table 4-1). Mean sleep duration was higher for women than men, but men had a higher sleep quality score than women in both analytic samples (Table 4-1).

The age-adjusted sleep duration and sleep quality by quartiles of the psychosocial stress measures by sex are reported in Table 4-2. For both women and men, lower chronic and acute stressors were associated with longer sleep duration and better sleep quality, *P* for trend <0.01 for all.

Overall, persons who reported lower scores on the GPSS, MLE, and WSI had lower odds of short sleep relative to those in the highest quartile of GPSS, MLE and WSI after age, sex, education and income adjustment (Table 4-3, *P* for trend <0.01 for all). The associations remained after further adjustment for risk factors (Table 4-3). In general, psychosocial stress measures were not associated with long sleep (Table 4-3). There was a graded association such that the minutes of sleep duration was lower with each higher quartile of the GPSS, MLE and WSI after adjustment for age, sex, education and income (*P* for tend <0.01). The associations remained after further adjustment for risk factors (Table 4-3).

Persons who reported lower scores on the GPSS, MLE and WSI reported a better sleep quality relative to those in the highest quartile of GPSS, MLE and WSI after adjusting for age, sex, education and income (Table 4-4). All psychosocial stress measures had significant tests for trend, such that higher categories of the psychosocial stress measures were associated with lower sleep quality scores, *P*<0.01 for all. The associations remained after further adjustment for risk factors (Table 4-4).

Tests of effect modification according to sex revealed no statistically significant differences in associations of psychosocial stress measures with sleep duration or sleep quality.

4.4 Discussion

Sleep problems are prevalent among African Americans but the factors associated with poor sleep in this population are understudied. We investigated predictors of poor sleep among African Americans. Lower levels of reported chronic and acute stressors were associated with lower odds of short sleep, longer sleep duration on average, and a higher sleep quality score after adjustment for demographics, socioeconomic status and risk factors. We found graded associations such that higher levels of stress related to shorter sleep durations. These findings indicate that psychosocial stressors may contribute to sleep outcomes among African Americans. These results have potential implications for the health of African Americans who have an increased prevalence of psychosocial stressors and poor sleep, which are associated with a host of poor health outcomes including mortality and cardiovascular disease.[44,45]

Our study extends the current literature by examining multiple psychosocial stressors as predictors of sleep outcomes within a large population of African Americans. Additionally, we contributed to the literature by demonstrating a graded association of lower sleep duration with higher levels of stress. Another major contribution is our comprehensive measurement of psychosocial stress. Existing studies have measured stress within one time frame, included a narrow range of life domains or limited the assessment of stress to daily stressors.[16,18,19] We expanded the assessments of stress across various life domains. To our knowledge, only one other study examined associations of multiple psychosocial stressor domains with sleep duration in a population of 2,983 black, Hispanic and white adults. In the prior study they found multiple psychosocial stressors (acute life events, financial stress, community stress, employment stressors, childhood adversity, relationship stress) were associated with short sleep duration; our findings were consistent.[46] Although our psychosocial stressor domains were similar to those measures in the prior study, we further extended their research to a large sample of African Americans and expanded associations to a sleep outcome (sleep quality) that was not studied. Sleep quality is known to be associated with increased risk of total cardiovascular disease and coronary heart disease incidence, and therefore it is necessary to study correlates of poor sleep quality.[5]

Researchers have hypothesized that inadequate sleep among racial minorities may be due to an abundance of life stressors;[9] our results support this hypothesis. We found that both, chronic and acute stressors were associated with the sleep outcomes. Across different studies, researchers have found that chronic stressors have the largest impact on health outcomes;[47,48] however, this was not supported by our data. In our study of older African Americans, not only did we find strong associations between psychosocial stressors and sleep, we also found similar associations for both chronic and acute stressors with sleep outcomes which were examined in separate models. Although our psychosocial measures were weakly correlated, our results suggest that chronic and acute stressors have similar implications for poor sleep. Examining several sources or the accumulation of stress may be necessary to comprehensively capture the impact of stress on sleep among African Americans.

There are plausible mechanisms by which psychosocial stressors may contribute to poor sleep. Stress consists of increased psychological and physiological activation which triggers the stress response system.[49,50] Arousal of the stress response system activates both the sympathetic nervous system (triggers fight-or-flight response) and the hypothalamo-pituitary-adrenal (HPA) axis.[51] The result of this activation can delay sleep onset and lead to longer sleep, potentially contributing to poor sleep quality and disrupting sleep duration.[49,52,53] Furthermore, psychosocial stressors may affect sleep indirectly through unhealthy behaviors such as poor diet or lack of physical activity or other risk factors (medical conditions).[54,55] We adjusted for physical activity, and the results were slightly attenuated indicating physical activity may explain some of the association but further tests of mediation are needed to confirm.

Women in our study had higher mean psychosocial stressor scores compared to men which was consistent with previous reports, but we did not find that sex modified the associations between psychosocial stress measures and sleep duration or quality in our population.[16] A prior study on the associations of perceived stress with sleep duration and sleep quality among police officers found strong associations among men but not women.[16] It is possible that there is something unique regarding being a police officer that may result in differences by sex that we would not observe in a general population. Other studies examining the association between psychosocial stress (depression) and sleep found sex to be an effect modifier; specifically depression was a significant predictor of sleepiness in men.[56] Similarly, Burgard and colleagues found an association between being bothered/upset at work and poor sleep quality to be stronger in men. These prior studies used different measures of psychosocial stressors. Our psychosocial stress measures were broad and included a wide array of experiences that were not gender specific. However, more specific measures of psychosocial stressors (as measured in these previous studies), may be more relevant to capturing the different experiences of men and women. Until there is further research with consistent measures of psychosocial stressors across studies, we should be cautious in concluding that sex is modifies the association of psychosocial stressors and sleep.

Although our findings provide novel insight into the association of psychosocial stressors with sleep duration and sleep quality among African Americans, there are limitations that warrant discussion. Despite our measurement of two sleep outcomes, sleep duration and sleep quality, these are subjective sleep measures, which may correlate poorly with objective measures of sleep.[57] Research has shown that sleep duration is often underreported, especially among African Americans, therefore our effect estimates could be biased towards the null if nondifferential by stress levels.[58] Measurement error is also of concern as a result of our self-reported psychosocial stress measures, which may not reflect the most relevant experiences of this population.[24] The cross-sectional design of our study limits the ability to infer causation. More specifically, we cannot determine whether experiences of psychosocial stress occurred prior to the sleep problems or the reverse. As with many epidemiologic studies, residual confounding is a limitation if there were unmeasured covariates that were not accounted for in the analyses. Lastly, our study consisted of African Americans in Jackson MS, therefore our results may not generalize to other populations or regions, with different risk profiles that those in our study.

In conclusion, we found higher stress was associated with poor sleep duration and sleep quality. Psychosocial stressors may be a point of intervention among African Americans for the improvement of sleep and downstream health outcomes.

Table 4-1 Sample Characteristics by gender and analytic sample, Jackson Heart Study, 2000-2004

Characteristics	Women		Men	
	GPSS/MLE	WSI	GPSS/MLE	WSI
N (% of sample)	3106 (63.9)	2071 (65.2)	1757 (36.1)	1106 (34.8)
Age (years), mean (SE)	55.2 (12.6)	54.1 (12.4)	53.6 $\pm$ 12.9	52.4 (12.6)
Education (%)				
< HS	17.3	12.6	17.7	13.1
HS/GED	20.4	19.4	19.0	18.1
>HS but Bachelor degree	28.6	30.9	30.0	29.8
College degree+	33.6	37.1	33.3	39.0
Income (dollars), mean (SE)	38560 (29345)	40880 (29749)	51670 (32663)	53984 (32876)
Income (%)				
Low	17.8	15.5	9.7	9.3
Lower-Middle	27.0	25.4	21.5	18.3
Upper-Middle	29.6	30.6	30.8	31.8
Affluent	25.7	28.4	38.0	40.6
Body Mass Index	32.8 (7.5)	32.8 (7.5)	29.8 (6.1)	29.9 (6.1)
Physical Activity, mean (SE)	8.2 (2.6)	8.4 (2.5)	8.7 (2.6)	8.9 (2.5)
Hypertension (%)	64.7	62.4	59.3	56.0
Diabetes (%)	19.4	18.0	16.8	14.7
Stress Measures				
GPSS, mean (range)	0.69 (0-3.0)	----	0.56 (0-2.6)	----
MLE, mean (range)	0.13 (0-.0.7)	----	0.11 (0-0.5)	----
WSI, mean (range)	----	1.0 (0-5.5)	----	0.94 (0-6.2)
Sleep Duration, mean (SE)	6.5 (1.5)	6.5 (1.5)	6.3 (1.5)	6.3 (1.4)
Sleep Quality, mean (SE)	2.9 (1.1)	2.9 (1.1)	3.0 (1.1)	3.0 (1.1)

GPSS=global perceived stress scale; NLE= negative life events; WSI= weekly stress inventory; HS=High School; Sample size GPSS/MLE=4863 except: education=4852, income (dollars) =4134, income (categorical) =4114, BMI=4856, physical activity=4597, hypertension=4829, diabetes=4756; Sample size WSI=3177 except: education=3174, income (dollars) =2736, income (categorical) =2723, BMI=3173, physical activity=3008, hypertension=3157, diabetes=3107

Table 4-2 Age-adjusted* sleep duration and sleep quality by stress quartiles among women and men in the Jackson Heart Study, 2000-2004

	Women[a]		Men[a]	
	Sleep Duration (range 1-16 hours)	Sleep Quality (range: 1 poor -5 excellent)	Sleep Duration (range 1-16 hours)	Sleep Quality (range: 1 poor -5 excellent)
GPSS				
Q1	6.78 (0.06)	3.25 (0.04)	6.58 (0.06)	3.31 (0.05)
Q2	6.59 (0.05)	3.09 (0.04)	6.44 (0.06)	3.11 (0.05)
Q3	6.45 (0.06)	2.92 (004)	6.29 (0.08)	2.95 (0.06)
Q4	6.20 (0.05)	2.54 (0.04)	5.96 (0.07)	2.68 (0.05)
P for trend	<0.01	<0.01	<0.01	<0.01
MLE				
Q1	6.68 (0.05)	3.08 (0.04)	6.50 (0.06)	3.16 (0.04)
Q2	6.44 (0.05)	2.96 (0.04)	6.36 (0.06)	3.11 (0.05)
Q3	6.49 (0.05)	2.91 (0.04)	6.28 (0.07)	2.96 (0.05)
Q4	6.24 (0.06)	2.63 (0.05)	6.11 (0.09)	2.80 (0.07)
P for trend	<0.01	<0.01	<0.01	<0.01
WSI				
Q1	6.69 (0.07)	3.21 (0.05)	6.61 (0.08)	3.27 (0.06)
Q2	6.67 (0.06)	3.10 (0.05)	6.27 (0.08)	3.15 (0.06)
Q3	6.38 (0.06)	2.91 (0.05)	6.31 (0.09)	2.95 (0.07)
Q4	6.26 (0.06)	2.58 (0.05)	6.08 (0.09)	2.83 (0.07)
P for trend	<0.01	<0.01	<0.01	<0.01

GPSS=global perceived stress scale; NLE= negative life events; WSI= weekly stress inventory; HS=High School; [a]N = GPSS/MLE: women: 3106 , men: 1757; WSI: women: 2071, men:1106. The N values for GPSS & MLE and for WSI are given separately because of the variations in sample size.
*adjusted to the mean age.

Table 4-3 Odds ratio (95% CI) of short and long sleep duration and mean differences in sleep duration associated with psychosocial stress, The Jackson Heart Study, 2000-2004

	Model 1*			**Model 2+**		
	OR of short sleep (vs. normal)	**OR of long sleep (vs. normal)**	**Mean difference in minutes of sleep**	**OR of short sleep (vs. normal)**	**OR of long sleep (vs. normal)**	**Mean difference in minutes of sleep**
GPSS						
Q1	0.52 (0.43, 0.63)[a]	1.22 (0.80, 1.84)	35.4 (27.5, 43.3)[a]	0.53 (0.43, 0.64)[a]	1.18 (0.75, 1.86)	33.6 (25.4, 41.8)[a]
Q2	0.64 (0.53, 0.76)[a]	1.02 (0.67, 1.56)	25.5 (18.0, 32.9)[a]	0.63 (0.53, 0.76)[a]	1.11 (0.71, 1.75)	26.3 (18.6, 34.0)[a]
Q3	0.77 (0.64, 0.93)[a]	1.10 (0.70, 1.72)	15.7 (7.8, 23.5)[a]	0.79 (0.65, 0.96)[b]	1.10 (0.68, 1.80)	13.5 (5.4, 21.6)[a]
Q4	REF	REF	REF	REF	REF	REF
***P*-trend**	<0.01	0.41	<0.01	<0.01	0.49	<0.01
MLE						
Q1	0.60 (0.49, 0.73)[a]	1.06 (0.70, 1.61)	26.6 (18.1, 35.0)[a]	0.62 (0.50, 0.76)[a]	1.07 (0.69, 1.67)	27.2 (18.4, 35.9)[a]
Q2	0.72 (0.60, 0.88)[a]	0.60 (0.38, 0.94)[b]	13.4 (5.0, 21.8)[a]	0.73 (0.59, 0.91)[a]	0.56 (0.35, 0.91)[b]	13.2 (4.5, 21.9)[a]
Q3	0.74 (0.60, 0.91)[a]	0.72 (0.45, 1.14)	13.7 (4.8, 22.4)[a]	0.75 (0.60, 0.93)[a]	0.69 (0.42, 1.12)	14.9 (5.9, 23.9)[a]
Q4	REF	REF	REF	REF	REF	REF
***P*-trend**	<0.01	0.45	<0.01	<0.01	0.40	<0.01
WSI						
Q1	0.50 (0.40, 0.63)[a]	0.74 (0.45, 1.22)	30.2 (20.7, 39.8)[a]	0.51 (0.40, 0.65)[a]	0.60 (0.36, 1.02)[c]	28.5 (18.6, 38.4)[a]
Q2	0.63 (0.50, 0.79)[a]	0.77 (0.46, 1.28)	21.8 (12.4, 31.2)[a]	0.63 (0.50, 0.80)[a]	0.72 (0.43, 1.21)	22.1 (12.4, 31.8)[a]
Q3	0.81 (0.64, 1.02)[c]	0.75 (0.45, 1.26)	9.1 (-0.2, 18.4)[b]	0.82 (0.65, 1.04)	0.66 (0.39, 1.13)	8.3 (-1.3, 17.9)[c]
Q4	REF	REF	REF	REF	REF	REF
***P*-trend**	<0.01	0.29	<0.01	<0.01	0.09	<0.01

Model 1 adjusted for age, gender, education, income

Model 2 adjusted for age, gender, education, income, physical activity, body mass index, diabetes, and hypertension

[a]$P \leq 0.01$, [b]$P \leq 0.05$, [c]$P \leq 0.10$; *Sample size GPSS/MLE=4125; WSI=2734, +Sample size GPSS/MLE=3799; WSI=2531

Table 4-4 Adjusted mean differences in sleep quality scores associated with psychosocial stress, The Jackson Heart Study, 2000-2004

	Mean difference in sleep quality	
	Model 1[*]	Model 2[+]
	Beta estimate (95% CI)	**Beta estimate (95% CI)**
GPSS		
Q1	0.72 (0.62, 0.82)[a]	0.73 (0.63, 0.83)[a]
Q2	0.47 (0.38, 0.57)[a]	0.49 (0.40, 0.58)[a]
Q3	0.31 (0.22, 0.41)[a]	0.30 (0.20, 0.40)[a]
Q4	REF	REF
***P*-trend**	<0.01	<0.01
MLE		
Q1	0.37 (0.27, 0.48)[a]	0.38 (0.27, 0.49)[a]
Q2	0.28 (0.18, 0.39)[a]	0.28 (0.17, 0.38)[a]
Q3	0.19 (0.09, 0.30)[a]	0.18 (0.07, 0.29)[a]
Q4	REF	REF
***P*-trend**	<0.01	<0.01
WSI		
Q1	0.52 (0.40, 0.64)[a]	0.52 (0.40, 0.65)[a]
Q2	0.40 (0.29, 0.52)[a]	0.42 (0.29, 0.54)[a]
Q3	0.21 (0.09, 0.32)[a]	0.21 (0.09, 0.33)[a]
Q4	REF	REF
***P*-trend**	<0.01	<0.01

Model 1 adjusted for age, gender, education, income
Model 2 adjusted for age, gender, education, income, physical activity, body mass index, diabetes, and hypertension
[a]$P \leq 0.01$, [b]$P \leq 0.05$
[*]Sample size GPSS/MLE=4125; WSI=2734
[+]Sample size GPSS/MLE=3799; WSI=2531

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Chapter 5
Discussion

5.1 Overall Summary of Research

This dissertation improves our understanding of the factors contributing to poor sleep among understudied racial/ethnic groups. The findings of this dissertation suggest that both individual and neighborhood level factors have implications for sleep health. In Aim 1 (Chapter 2), lower neighborhood safety was associated with a higher daytime sleepiness score after adjustment for confounders in a predominately Mexican American study population. Contrary to our hypotheses, higher levels of neighborhood disadvantage and crime were related to lower daytime sleepiness; these associations were not statistically significant. We also found that participants in the highest categories of disadvantage, self-reported safety, and crime had a higher mean sleep duration than those in the lowest neighborhood categories; however, the associations between the neighborhood measures and sleep duration were not linear. In Aim 2, (Chapter 3) we found that low individual socioeconomic position (SEP) measured by self-reported education and income was associated with higher odds of long sleep and poor sleep quality; and adverse neighborhood characteristics (high violence and disorder) were for the most part associated with shorter average sleep duration and poor sleep quality after adjustment for confounders in a large population of African American. In Aim 3 (Chapter 4), we found higher levels of psychosocial stressors (overall stress, major life events, and weekly stress) were associated with short sleep, shorter average sleep duration and poorer sleep quality after adjustment for confounders in a large African American study population; and we observed graded associations such that with each higher level of stress, sleep duration was shorter. The results of this dissertation could inform interventions to improve sleep health in minority populations and ultimately reduce cardiovascular burden and other health outcomes linked to poor sleep.

5.2 Contributions to the literature

Neighborhood Characteristics and Sleep (Aims 1 and 2)

This research contributed to the literature by 1) focusing on understudied minority populations of Hispanic and African Americans that tend to have increased exposure to adverse neighborhoods[1] and have poorer sleep outcomes,[2–4] 2) studying multiple dimensions of the neighborhood social environment and 3) assessing several sleep outcomes.

The vast majority of the literature examining neighborhoods and sleep has focused on the physical environment including noise and traffic.[5–8] Only a few studies to date have focused on associations between the social neighborhood environment and sleep, and these studies have typically considered only one dimension of the social environment, with only one study considering multiple social dimensions of neighborhoods.[9–12] These prior studies examined either neighborhood violence, disorder or living in an inner city as one dimension of the social environment with sleep.[10,11,13] DeSantis and colleagues extended this literature to study several dimensions of the social environment. The authors found that an adverse social environment characterized as high disorder and low safety and social cohesion measured at the census-tract level was associated with shorter sleep duration and greater sleepiness.[9] We further extended this research to examine perceptions of multiple dimensions of the social neighborhood with an additional sleep outcome (quality) that was not previously explored. Therefore, this dissertation is one of the first to study multiple dimensions of the social neighborhood environment using validated measures[14] (Aim 2) with multiple sleep outcomes including sleep duration, quality and daytime sleepiness among large populations of understudied racial/ethnic groups that have not been well studied. An additional unique aspect of this research is that these neighborhood dimensions were examined at different levels, including objective (police reported violent crime), self-reported and aggregated survey measures to the census tract level. Investigating these different levels is an important step to determining which factors are most related to poor sleep health. Our findings suggest that individual perceptions of the social environment may be more relevant to sleep health in this population and more research in this area should be done.

Lastly, the investigation of individual and neighborhood factors with several sleep outcomes (duration, quality, daytime sleepiness) extends the literature. This is an important contribution because our research suggests that neighborhoods are related to multiple dimensions of sleep. These different dimensions of sleep are associated with numerous adverse health conditions, such as high blood pressure, heart disease, diabetes, stroke, obesity and depression that disproportionately afflict minority populations.[36–41]

Socioeconomic Position and Sleep (Aim 2)

In this Aim we made several unique contributions to the literature including: 1) considering the gradient of SEP with sleep outcomes, 2) investigating long sleep as an outcome, and 3) establishing associations between SEP and sleep in an understudied population of African Americans.

Researchers have demonstrated shorter sleep and poor sleep are associated with lower SEP in predominately non-Hispanic white populations.[21–27] These prior studies included various measures of SEP including education, family income, poverty, employment status, private insurance, and food security, that were typically dichotomized.[21–27] For example, research by Piccolo and colleagues found lower SES (standardized levels of education and income categorized such that ¼ of the sample was lower, ½ middle, and 1/4 upper SES) men were more likely to report shorter sleep duration compared to men of higher SES.[27] Additionally Grandner et al. found different dimensions of SEP (poverty, education, access to private health insurance, and food security) were generally associated with poor sleep symptoms.[23] These studies were limited in assessing SEP with sleep outcomes including sleep quality and the possible graded association between SEP and sleep. We extended the current literature with our assessment of SEP with multiple sleep outcomes among African Americans who may be more vulnerable to the impact of low SEP on sleep possibly due to limited resources to buffer the effects.[19,20] Our measure of income contained four levels, low, lower-middle, upper-middle, and affluent. This categorized assessment of income allowed us to investigate whether the association between income and sleep was graded. Typically, research on SEP has examined effects of lower versus higher SEP (i.e., no high school versus high school), despite evidence of a graded association of SEP with health outcomes.[22] Our results suggested a graded association between SEP and long sleep; however, SEP was not associated with short or continuous sleep duration. These findings suggest that higher SEP may be protective for long sleep, but the effect is not the same for short and continuous sleep duration.

In contrast to other studies, we investigated the association of SEP with long sleep duration. Long sleep is not as frequently studied as short sleep duration, but the health effects are comparable.[30] Research has shown long sleep to be associated with morbidity and mortality.[30] The reasons for these associations are unclear; however, research is emerging. Patel and colleagues have explored correlates of long sleep and found measures of socioeconomic status (lack of employment, low household income, or low perceived societal status) were strongly associated with long sleep;[30] consistent with the findings of this dissertation. Future studies should aim to understand the associations between SEP and long sleep as well as understand the link between long sleep and mortality. Although this dissertation provides new evidence into factors contributing to long sleep among African Americans, more research is needed to confirm these findings with longitudinal data.

Lastly, this investigation into the association between SEP and sleep may contribute to the understanding of the relation between SEP and other health outcomes. Researchers have hypothesized that sleep may mediate the association between SEP and health outcomes (physical and mental).[16] Our research demonstrates a link between SEP and sleep (duration and quality) supporting this hypothesis in African Americans. Based on our evidence of an association between SEP and sleep, future research should test sleep as a mediator between SEP and health outcomes.

Psychosocial Stressors and Sleep (Aim 3)

Aim 3 contributed to the literature in several ways including: 1) demonstrating an association between psychosocial stressors and sleep among African Americans, 2) considering multiple dimensions of psychosocial stressors across the life course, and 3) expanding the sleep outcomes considered in relation to psychosocial stressors.

Our research found an association between psychosocial stressors and sleep which is important due to the high prevalence of stress among minority populations. Researchers have shown that African Americans have an increased prevalence of psychosocial stressors,[30–34] often resulting from job demands. Research by Jackson et al. found sleep duration was related to professional roles for African Americans, and hypothesized that the association may be attributed to stress.[35] Our finding that stress is related to sleep duration among African Americans provides some evidence in support of their hypothesis. Additionally, the results from Aim 2 show an association between SEP and sleep. In connecting Jackson and colleagues research and the results of this dissertation, it is plausible that psychosocial stressors my mediate the association between SEP and sleep. This should be examined in future research.

A major contributor of our research to the literature is our comprehensive assessment of psychosocial stressors in a general population of African Americans. This dissertation measured stress across different time frames and considered both chronic and acute stress from weekly stressors and major life events. These dimensions assessed a variety of domains including finances, discrimination, divorce, death, employment, and assault to name a few. Researchers have demonstrated that psychosocial stressors including negative life events, work stress and financial strain are associated with sleep problems in non-Hispanic white populations.[38–42] Few studies have extended the literature to show associations between higher perceived stress and shorter sleep duration and poor sleep quality.[43–46] These prior studies were limited to an occupation-specific cohort, included a general measure of stress, or a small sample of women.[43,45,46] To our knowledge, only one other study has investigated multiple psychosocial stressors with sleep; and our results were consistent.[29] Research by Slopen and colleagues found psychosocial stressors (acute life events, financial stress, community stress, childhood adversity, and relationship stress) were associated with shorter sleep duration and sleep difficulties. We built upon the prior study by demonstrating similar associations with sleep quality among a large understudied population of African Americans.

5.3 Increased Vulnerability to Risk Factors for Poor Sleep

This dissertation focused on the differential vulnerability to risk factors for poor sleep by specifically studying the risk factors in minority populations. Although comparisons to other studies were difficult given the limited research in this area and differences in study designs and measurements, we were able to determine that most of the associations presented in this dissertation were stronger than those reported among non-Hispanic white populations. Table 5-1 illustrates the findings of other studies with similar exposures and outcomes (sleep duration, quality or daytime sleepiness). For the neighborhood measures, we observed stronger associations in African Americans than those presented in the literature except for associations with social cohesion. Our association of neighborhood safety and daytime sleepiness among Mexican Americans was also stronger than existing data; however, safety was not associated with sleep duration which other researchers have found. Associations with neighborhood SES and sleep were consistent with the literature. Our association for SEP and sleep quality was stronger, but the associations between SEP and sleep duration were slightly weaker than those reported in the literature. Overall associations with psychosocial stress and sleep were much stronger in our cohort than in the literature aside from the findings of one occupation-specific cohort of police offers who found stronger associations than ours, but their study sample consisted of potentially higher stess individuals. Our findings demonstrate that minority populations may be more vulnerable to the influence of SEP, neighborhood characteristics and psychosocial stressors on sleep and this may be one reason why these populations have a greater prevalence of poor sleep outcomes.

5.4 Limitations

Although our study had several key strengths as highlighted above, there are also limitations that should be considered. This dissertation examined cross-sectional associations, which limits our ability to infer causation. Specifically, it is unclear if the predictors (SEP, neighborhood characteristics or psychosocial stressors) preceded the onset of poor sleep or the reverse. Also, the cross-sectional design of this work leads us to consider the possibility that people with more sleep may have a better attitude about their neighborhoods. Next, there could be measurement error. We included self-reported measures of sleep, which may correlate poorly with objective measures of sleep.[34] Research has shown that sleep duration is often underreported, especially among African Americans, and therefore our effect estimates could be biased towards the null.[35] However, although our measure of daytime sleepiness in Aim 1 was self-reported, it was based on a modified validated scale, the Berlin questionnaire.[44] Measurement error could also apply to our exposures, if those included were not measuring what was expected. Additionally, these exposure measures, for example stress, may be under- or overestimates based on individual experiences. Meaning, those that may not have coped with some of the major life events could be in denial and thus underestimate their stress levels. As with many epidemiologic studies, residual confounding is possible if there were unmeasured covariates at the individual and/or neighborhood level that were not accounted for in the statistical models. We controlled for demographics, individual SEP as well as risk factors. However, it is likely that depression, occupation or other medical illnesses may confound or mediate the explored associations. Additionally, the included measures in this study may not capture relevant constructs. The neighborhood measures or psychosocial stressors analyzed may not capture the experiences of these populations, and therefore may not be most relevant to the sleep health of Hispanic or African Americans.[46] Lastly, the findings of this dissertation may not be generalizable. Participants in SHARE and JHS are not representative samples; JHS is racially homogenous. There is evidence that some of these associations may be different in non-Hispanic white populations, therefore these findings may not apply to those that are not Hispanic or African American. Additionally, most of the participants in SHARE are Mexican American. There may be heterogeneity in the associations within Hispanic subgroups and this warrants further study. SHARE participants were also church goers that were enrolled in a trial with a partner, thus suggesting some degree of social support. The JHS population was older, the average age was 54 years. Research shows that as people age they typically have a harder time initiating sleep and difficulties remaining asleep.[47] Our study population may have more sleep difficulties than a younger adult population.

5.5 Future directions

This research contributes evidence regarding factors that relate to sleep health among understudied minority populations. However, future research should address some of the limitations of this dissertation in order to conduct studies that provide more understanding into the associations of these exposures with sleep as well as translate the findings into interventions to improve sleep health and ultimately reduce health disparities.

Measurement error was a highlighted limitation of this work. Given the evidence showing African Americans may underreport sleep duration and the lack of evidence regarding sleep among Hispanic populations, future studies should evaluate the correlations of subjective sleep measures with objectively measured sleep collected via actigraphy. Actigraphy will provide 24-hour data regarding sleep/wake behavior and other sleep related information. This method is more cost-effective and is minimally invasive compared to a polysomnography in a clinic where patients' sleep may not mimic their sleep at home. Large epidemiological studies including the Multi-Ethnic Study of Atherosclerosis (MESA), the Coronary Artery Risk

Development in Young Adults (CARDIA) and recently the JHS have collected objective sleep measures. These studies also contain social factors (those included in this dissertation) that could be used to replicate this work with objective sleep measures (sleep duration and quality). Replicating this research with more objective measures could confirm these findings thus avoiding the idea that our results were due to bias. However, it should be noted that these objective measures may measure something different than the self-reported measures. It may be necessary to consider both measures to have a complete picture of factors related to different dimensions of sleep health (perceptions and objective). Understanding these objective and subjective measures may also provide an understanding of sleep quality, which may represent a variety of sleep outcomes including sleep duration and daytime sleepiness. Future research should understand the concept of sleep quality, particularly among minority populations who report a poor quality.[3] Data on sleep in minority populations are lacking; therefore race/ethnicity should be considered in sleep research. In addition, normative data on sleep (subjective and objective) in minority populations should be established.[3] Moving research in this direction may potentially improve diagnosis and treatment of sleep disturbances in minority populations. Overall, there is a need to extend sleep research (measures) in minorities in efforts to improve sleep and subsequent disorders.

Further consideration of different environments could be an asset to the literature. Research has demonstrated that home environments, as assessed by socioeconomic status, family size, noise, and cleanliness, are associated with sleep disorders and unhealthy sleep duration; however, this remains understudied among Hispanics and African American adults.[48–50] The home environment may be especially important among certain racial/ethnic groups, given the evidence showing socioeconomically disadvantaged populations are more likely to sleep in less than optimal environments.[51] Home environments may also be a more feasible target for intervention than neighborhoods. Studies have shown that those with a television in the bedroom went to bed later and slept less than those without a television.[57] Interventions that aim to make the home or bedroom (i.e. reducing noise, removing electronics) more conducive to sleep may improve sleep.

In addition to the neighborhood measures, it may be productive to further assess psychosocial factors, particularly by sex. There are abundant data from non-Hispanic white populations that women have stronger associations of anxiety and depression with sleep disorders than men.[52,53] Similar data from African American men and women are lacking. Future research should consider these other stressors, anxiety, depression, and trait-hostility, to contribute new knowledge on the association of psychosocial stressors with sleep. Additionally, these stressors may be good targets for diagnosis and treatment. These factors are available in the JHS for exploration.

The temporal relation of the exposures with sleep was highlighted as a limitation. To address the issue of temporality longitudinal studies are needed. Future research should consider analyzing data from longitudinal epidemiologic studies including the MESA, CARDIA and JHS which have similar measures as those included in this dissertation. A longitudinal study would allow for more insight into causation. This is important for determining whether the exposures examined in this dissertation are predictors of poor sleep and thus would be good candidates to intervene on to reduce poor sleep outcomes. Should these longitudinal studies confirm the findings of this dissertation, mechanistic work can be done to understand the pathways linking these exposures with sleep outcomes. Formal tests of mediation could be done to determine the causal relations of individual, neighborhood and psychosocial factors with sleep. In this dissertation we a priori identified body mass index (BMI), hypertension, physical activity, depressive symptoms, and diabetes as both confounders and mediators and adjusted from them in analyses. Our results were often attenuated after the inclusion of these variables, which supports that these variables may explain some of the associations; however formal test of mediation were not conducted. Future research should consider these factors and others that may be on the causal pathway to poor sleep as well as effect modifiers that may negate the adverse effects of these exposures on sleep using longitudinal data.

Finally, sleep patterns may contribute to health disparities. There are growing data indicating that minority populations are more likely to experience short sleep, poor sleep quality and sleep-disordered breathing (SDB) than non-Hispanic whites.[20,54] Empirical research that investigates the contribution of these different factors explored in this dissertation to racial/ethnic differences in sleep is needed. Specifically, researchers should investigate the relation of race and poor sleep while accounting for neighborhood characteristics, SEP or psychosocial stressors to determine their influence on the association. This research question can be addressed using data from MESA because of the diversity in the sample. The findings of such research could inform interventions that target sleep health to provide novel approaches for reducing health disparities for a wide range of disorders.

5.6 Intervention and Policy Implications

Insufficient sleep is a public health problem. The prevalence of insufficient sleep has grown; people are sleeping less in the 21st Century than previously.[55] It has been estimated that the annual cost to United States (US) employers in lost productivity due to sleep problems is approximately $18 billion.[56] With 40 million people in the US suffering from a chronic sleep disorder, it is imperative to develop interventions and policies to improve sleep. By addressing poor sleep we could reduce the public health and cost burden.

This dissertation found a high prevalence of short sleep in both SHARE and JHS. As a result, there is a need to educate individuals and particularly minority populations on sleep and the importance of sleep in efforts to improve sleep duration. Although there are interventions to improve sleep (medications (sleeping pills), cognitive/behavioral therapies, continuous positive airway pressure (sleep-disordered breathing treatment)), research is limited in examining the effectiveness of these therapies in minority populations.[3] The high prevalence of short sleep found in this dissertation suggests such research should be a high priority. Social and environmental factors may also reduce the efficacy of treatment methods, so future research is needed to understand the influence of these factors on sleep treatments in minority populations.

Should future research determine the causal relation of these factors neighborhood characteristics, SEP or psychosocial stressors to poor sleep, treatment methods could include addressing these upstream factors (including social) that are influencinging poor sleep. For example, this dissertation suggests that individual and neighborhood level factors may be possible targets for intervention to improve sleep. Although we are cautious in suggesting interventions given the cross-sectional design of our study, should these findings be confirmed, then interventions to reduce stress and/or to improve neighborhood characteristics may be promising. The associations between psychosocial stressors and sleep were strongest in this dissertation and may be a good point of intervention and most optimal among those experiencing higher exposures to stress. Potentially, health care providers could identify higher stress individuals or materials could be developed to help individuals recognize chronic or acute stress, and thus information could be developed and provided regarding healthy coping mechanisms. Lastly, interventions that utilize social support or network theories could potentially help a high stress group to lower stress or better cope with stress and thus improve sleep. These potential interventions should be evaluated for effectiveness in determing whether reducing stress improves sleep. A randomized trial assigning participants to either a stress reduction or control group that assesses sleep at baseline and follow-up could provide data on the effectivess of reducing stress to improve sleep. Although these interventions seem promising, more research is needed to determine if an intervention of this nature would be beneficial.

One of the strengths of our dissertation was in identifying specific features of the neighborhood that affect sleep. The results indicated that in general, neighborhood problems, violence and low safety may be contributors to poor sleep; therefore with more research these neighborhood characteristics may be points of intervention to improve sleep. Our measure of neighborhood problems was an assessment of aspects of the neighborhood including noise, traffic, trash/litter, availability of health foods, lack of parks and playgrounds, which might be targeted to improve health endpoints including sleep. Specifically, traffic in the neighborhood could translate to more pollution which researchers have shown affects sleep.[58] Further study of the pathway linking neighborhood traffic and sleep may be promising. Also, addressing neighborhood crime/violence by increasing police response to crime, may potentially lower neighborhood violence and increase neighborhood safety thus improving sleep, although more research is needed to determine the temporal relation of neighborhood characteristics and sleep. If the relation is further established then specifically examining the influence of reducing crime on improving sleep should be explored. Neighborhood safety may also be a point of intervention. Individual concerns regarding safety can affect involvement in physical activity. Researchers have found women in lower-income and African-American and Latino neighborhoods feel unsafe more and therefore spend less time outdoors; these women walked 20% less than those who self-reported their neighborhoods as safe.[59] Evidence shows physical activity impacts sleep quality.[60] Policies to improve safety (reduce crime and violence) may encourage residents to engage in more outdoor activities and likely reduce poor sleep. With further research, it could be advantageous to develop policy or increase efforts to enforce existing policy that regulates neighborhood disorder to improve sleep if these associations are truly causal.

5.7 Conclusion

This dissertation contributed to the understanding of the social patterning of sleep among understudied populations of Hispanic and African Americans. Our findings demonstrate that both individual and neighborhood level factors are important to sleep health. This evidence can be used to improve sleep and potentially reduce the subsequent cardiovascular burden resulting from poor sleep.

Table 5-1 Summary of Existing Evidence

Author	Year	Analytic Sample	Exposure	Covariates	Outcome	MOA*
DeSantis (et al.)	2013	1,412 non-Hispanic white, non-Hispanic Black/African American, Chinese and Hispanic/Latino from the Multi-Ethnic population	Neighborhood: Disorder Safety Social cohesion Socioeconomic status	Age, sex, race/ethnicity, education, income-wealth, depressive symptoms, BMI, diabetes, hypertension	Sleep duration (hours) Daytime Sleepiness	Difference (95% CI) -0.11 (-0.21, -0.01) 0.12 (0.03, 0.20) 0.08 (-0.01, 0.17) 0.01 (-0.06, 0.08) 0.06 (-0.00, 0.13) -0.05 (-0.10, 0.01) -0.07 (-0.13, -0.00) -0.06 (-0.11, -0.01)
Johnson (et al.)	2009	392 Baltimore City mothers	Neighborhood: Exposure to violence (high vs. low) Perceived safety (low vs. high)	Age, child's age, martial status, race, education, household crowding	Sleep duration (short vs. normal)	OR (95% CI) 2.06 (1.50-2.62) 1.28 (0.57–1.99)
Hill (et al.)	2009	1444 non-Hispanic white, black, Mexican and other race or ethnicity in the 2004 Survey of Texas Adults	Neighborhood: Disorder	Age, gender, race/ethnicity, non-citizen, spanish interview, education, employed family income, income missing, fiancial strain, married, number of children, health and lifestyle factors	Sleep quality	Standardized coefficient (SE) -0.05 (0.04)
Hale (et al.)	2013	1298 Survey of the Health of Wisconsin	Neighborhood: Neighborhood quality	Race, education, income, marital	Sleep quality	OR (95% CI) 1.42 (1.07, 1.87)

				status, smoking history, BMI		
Moore (et al.)	2002	1139 whites, African Americans, asian, Native American, or Hispanic ethnicity from the 1995 Detroit Area Study (DAS)	SEP: Income Education	Age, gender, ethnicity, prior health status, sleep quantity (sleep quality models)	Sleep Duration Sleep Quality	Standardized regression coefficients (*P*-value) Not associated (estimate not given) -0.04 (p<0.001) (income) no association with education (estimate not given)
Patel (et al.)	2010	9,533 non-Latino white, African American, Latino, and other from a community survey by the Philadelphia Health Management Corporation	SEP: Education (post college vs. <HS grad (ref))	Race, employment, marital status, general health, mental illness, BMI, stress levels, alcohol use, smoking	Sleep quality (poor vs. good)	OR (95% CI) 0.57 (0.40, 0.81)
Patel (et al.)	2006	60,028 women from the Nurses	SEP: Income (<30,000 vs. >100,000 (ref))	Binomial	Long sleep	OR (95% CI) 3.07 (2.65, 3.55)
Slopen (et al.)	2014	2,983 black, Hispanic, and white adults from the Chicago Community Adult Health Study	Psychosocial stressors: Acute events Financial strain Community disadvantage Employment stress Childhood adversity Relationship stress	Age, sex, race/ethnicity, socioeconomic status (education, income, employment status)	Sleep duration (hours, short vs. normal, long vs. normal)	Difference (SE) / Short OR (95% CI) / Long OR (95% CI) -0.18 (0.04) / 1.32 (1.20, 1.46) / 1.13 (0.94, 1.36) -0.19 (0.04) / 1.29 (1.16, 1.44) / 0.93 (0.74, 1.15) -0.11 (0.03) / 1.11 (1.01, 1.22) / 0.90 (0.75, 1.08) -0.10 (0.05) / 1.26 (1.08, 1.47) / 1.09 (0.76, 1.56) -0.10 (0.03) / 1.14 (1.03, 1.25) / 0.92 (0.76, 1.11) -0.20 (0.04) / 1.30 (1.17, 1.46) / 1.06 (0.82, 1.39)
Hall (et al.)	2009	370 Caucasian, African American and Chinese	Psychosocial stress: Finacial strain	Age, menopausal status, vasomotor	Sleep quality	Regression coefficient (*P*-value) 0.15 (p<0.01)

		participants from the Study of Women's Health across the Nation		symptoms, BMI symptoms of depression, perceived health, and use of medications		
Charles (et al.)	2010	430 police offers in the Buffalo Cardio-metabolic Occupational Police Stress Study	Psychosocial stress Perceived stress (high vs low (ref)	Social support, physical activity, and shift work status	Sleep quality	OR (95% CI) 3.72 (1.14-12.13) women 5.94 (2.50-14.13) men
Burgard (et al.)	2009	1,101 adults from the American's Changing lives	Psychosocial stress Bothered/upset at work	Age, race, marital status, education, income	Sleep quality (poor vs. good)	OR (95% CI) 1.35 (1.089, 1.676)

MOA=Measure of association
BMI=Body Mass Index
CI=Confidence Interval
OR=Odds ratio

5.8 References

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