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**What Makes for a Good Night's Sleep?
A Multilevel Investigation of Individual and Neighborhood Influences on Sleep Disparities**

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Introduction

Sleep is a “biological imperative” which has a significant impact on daily functioning, quality of life, health, and longevity (Knutson 2012:1; Strine and Chapman 2004; Colten and Altevogt 2006). Humans spend approximately one third of their lives asleep (Lauderdale et al. 2006; Hall 2010), and approximately 50-70 million Americans experience sleep-related problems (Colten and Altevogt 2006). There are four important dimensions of sleep – duration, continuity, architecture, and quality; yet sleep duration and quality are among the most widely studied measures of sleep (Hall 2010). Previous studies indicate that sleep quality and duration varies across social, cultural, and demographic characteristics, and it varies across the life course. That is, sleep duration decreases linearly with age, as infants biologically require more sleep than adults (Ohayon et al. 2004). In addition to age, sleep disparities also exist across race, gender, marital status, socioeconomic status; and such disparities in sleep quality and duration are associated with a variety of health indicators and personal health behaviors, including self-reported health (Knutson 2012).

Previous studies have found that sleep affects a host of physical health outcomes such as physical functioning and immune suppression (Hall 2010). For example, sleep deficiency is linked to an increased risk of cardiometabolic diseases, which are among the leading causes of morbidity and mortality in the United States (Knutson 2012; Mokdad et al, 2004). In fact, self-reported sleep duration is associated with mortality. There is a curvilinear relationship between self-reported sleep duration and all-cause mortality (Kripke et al. 2002; Gallicchio and Kalesan 2009); and this relationship persists after controlling for social and demographic characteristics, personal health behaviors, and other covariates (Kripke et al. 2002). It is reported that women who report sleep duration of 6 to 7 hours have a lower mortality risk than women who report short or long sleep duration (Patel et al. 2004). Short sleep duration is also associated with hypertension (Gangwisch et al. 2006), and it also affects glucose and insulin levels, which are known risk factors for diabetes (Speigel et al. 2004; Buxton et al. 2004; Stumakis and Punjabi 2010). Furthermore, restricted sleep duration is also associated with obesity (Teheri 2006), as sleep deprived individuals are more likely to consume more calories, while not simultaneously increasing energy expenditures (Nedeltcheva et al. 2009).

The effects of sleep go beyond physical health; and sleep is also strongly associated with various dimensions of psychological well-being, including depression and anxiety. Individuals that experience persistent sleep deficiency are more likely to report stress, depression, and anxiety (Taylor et al. 2005; Knudsen et al. 2007; Frazen and Buysse 2008; Gregory et al. 2005). Sleep is also associated with brain function in which sleep loss can impair cognitive functioning and alertness. Such impair in cognitive functioning and alertness can have serious consequences for individuals. For example, impair in cognitive functioning related to sleep loss can increase the risk of accidents for individuals. A study shows that approximately 20% of traffic accidents are associated with inadequate sleep (Colten and Altevogt 2006).

While there is growing interest in the role of sleep on individual health and well-being in the population health and social science literature (Allshire and Burgard 2012; Patel 2007), limited research has investigated the existing disparities in sleep and its contributing factors. Most existing studies investigating such sleep disparities have primarily focused on various individual factors. For example, previous studies show that socioeconomic background is significantly associated with restricted sleep after controlling for age, gender, obesity, tobacco and alcohol use, and physical activity (Stranges et al. 2008). Race and ethnicity also plays an important role in understanding sleep disparities, yet empirical findings on the relationship between race/ethnicity and sleep quality is somewhat mixed and inconclusive. For example, Patel and colleagues (2010) have found that African-Americans and Latinos have higher odds of reporting poor sleep quality than Whites. However, the relationship between sleep quality and race was moderated by socioeconomic position. Furthermore, poor Whites actually reported higher odds of poor sleep after adjusting for the education, employment, marital status, and personal health attributes and behaviors (Patel et al. 2010). On the other hand, Hale and Do (2007) have found that African-Americans are more likely to report sleep duration that is either too short (< 6 hours) or too long (\geq 9 hours) compared to Whites, while Mexican Americans report sleep duration that is similar to Whites (Hale and Do 2007).

A few studies have moved beyond investigating the individual factors for sleep disparity by extending its scope to include environmental factors. For instance, McLaughlin and colleagues (2005) have examined the relationship between residential context and sleep quality among adolescents and infants. Empirical studies show that children who live in low income ZIP code areas have shorter sleep durations and more excessive daytime sleepiness than children who live in high income ZIP code areas. In another study, Bottino and colleagues (2012) find that infants who live in more urban environments experience restricted sleep duration. Hale and Do (2007) also find that for adults, living in more urban environments is associated with increased risk of short sleep duration and a reduced risk of long sleep duration compared to living in non-urban environments.

Despite these studies, research on environmental influences on sleep disparities remains largely unexplored. Furthermore, the environmental measures in previous studies are not comprehensive and coherent. To better understand the influence of environment factors in racial and ethnic sleep disparities, this study aims to use multilevel modeling to investigate racial and ethnic sleep disparities among adults, and to examine how such differences in sleep quality and duration are mediated by neighborhood context. We are not aware of any study to date that has used multilevel modeling to examine these relationships. A deeper understanding of how environmental influences on sleep behaviors will undoubtedly help elucidate disparities across a myriad of health outcomes.

Analytic Strategy

Data and Methodology

This study will use data from the Philadelphia Health Management Corporation's (PHMC) 2008 Household Survey to create all individual-level variables. PHMC is a non-profit institution that promotes community health in a 5-county area in southeast Pennsylvania (PHMC, 2008). PHMC employs a random-digit dialing methodology to administer interviews of residents of Bucks, Chester, Delaware, Montgomery, and Philadelphia counties from June through October 2008. About 15 percent of respondents completed the survey via cell phone; therefore, sample weights were constructed to account for differences in cell phone users by socio-economic and demographic characteristics (PHMC, 2008). The response rate was 25 percent. Despite the relatively low response rate, the PHMC sample mirrors the demographic and socioeconomic composition of the American Community Survey 2006-2008 3-year estimates and resembles the 2008 Behavioral Risk Factor Surveillance Survey (PHMC, 2008). We use survey weights in our analyses to adjust for non-response and sampling bias.

There are two dependent variables of interest in this analysis: self-reported sleep quality and the general number of hours of sleep a respondent gets at night. Sleep quality is measured on a 5-point scale (1= restless and 5= restful). This study will include four categories of level-1 independent variables: demographic, socioeconomic, health indicators and a neighborhood scale of social cohesion. The focal independent variable in this analysis is individual racial/ethnic membership. Other demographic variables will include age, sex, and marital status, and if a child is present in the household. Socioeconomic variables include measures of poverty status, education, and employment status. Health indicators will include measures of self-reported health status, mental health status, body mass index (BMI), tobacco use, and physical activity. Similar to Mulvey-Day et al. (2007), an additive scale of neighborhood social cohesion will be measured using the following item responses: (1) participation in community organizations, (2) neighbors' willingness to help with routine activities such as picking up trash or removing snow, (3) neighbors' willingness to work together to improve the neighborhood, (4) neighborhood attachment, and (5) perceived trustworthiness of neighbors.

This study will also use contextual-level measures from a variety of secondary data sources. Each of the contextual measures uses tract-level data for the 5-county area surrounding the Philadelphia metropolitan area. Traffic data from the Pennsylvania Department of Transportation will be used to measure traffic volume. Following Yang and Matthews (2010), traffic volume is measured by daily vehicle miles traveled, which is estimated by multiplying the length of road traveled by the average daily traffic on the road. Violent crime and

property crime data will come from the Philadelphia Police Department crime statistics. In this analysis violent crime includes robberies and aggravated assaults, and the property crime includes residential and commercial burglaries, arson, theft, and auto theft. Racial composition and a scale of neighborhood disadvantage and neighborhood affluence will be used to measure the demographic and social context of the environment (Sampson et al. 1997). Neighborhood disadvantage index is measured by the following: the percentage of households with a resident/room ratio greater than one, percentage of female-headed households, the unemployment rate, poverty rate, and the percentage of people receiving public assistance. The neighborhood affluence scale is measured by percentage of residents ages 25 or over with a bachelor's degree or higher, percentage of the civilian population ages 16 years or over employed in professional or managerial occupations, and the percentage of the population with annual incomes over \$75,000 (Sampson et al. 1997).

Preliminary Results

Preliminary analysis examines the relationship between sleep quality, sleep duration, and the focal independent variable. Poor sleep quality is determined by a self-report of sleep quality ≤ 2 on a 5 point scale (Patel et al. 2010). Short sleep duration is measured by respondents who report ≤ 5 hours of sleep per night, and long sleep duration is measure by respondents who report ≥ 9 hours of sleep per night. Survey weights and sophisticated missing data techniques (i.e., list wise deletion was used to account for missing data) are not used in this preliminary analysis the results are not expected to vary substantially from what is reported here, but future data analysis will use survey weights and multiple imputation to account for missing data. Table 1 reports that non-Hispanic Blacks and Hispanics are significantly more likely to report poor sleep quality than non-Hispanic Whites. Blacks are 23% more likely to report poor sleep quality and Hispanics are 49% more likely to report poor sleep quality than non-Hispanic Whites. Other race groups are not significantly more likely to report poor sleep compared to whites.

Multinomial logistic regression results are reported in Table 2 and show that non-Hispanic Blacks are almost 2 times more likely to experience short sleep duration as opposed to the recommended hours of sleep than their non- Hispanic white counterparts; similarly The relative risk of short sleep duration among Hispanics is 96% higher than the odds of reporting that they achieved the recommend hours of sleep at night compared to non- Hispanic whites. There is no significant difference in reporting long sleep duration as opposed to the recommended sleep duration by racial groups classified as other; however they are significantly less likely to report short sleep duration.

Future Analysis

Future analysis will further investigate racial and ethnic differences in sleep quality and duration reported in the preliminary analysis by employing multivariate logistic modeling to determine how socioeconomic position, health status, and social cohesion mediates the relationship between race/ethnicity and sleep disparities. Furthermore, since individual level analysis fails to account for contextual influences on variations in sleep quality and sleep duration, we will employ hierarchical linear modeling to account for the nested nature of the data. A failure to account for the multilevel feature of the data could potentially lead to two statistical problems: misspecification error, and biased parameter estimates. The misspecification error would aggregate the context effect into a single error term, and consequently masking the effect of the environment on the outcome variable. In addition, traditional regression methods assume that the errors terms are uncorrelated. However, respondents nested in the same context have correlated error terms, thus violating the assumptions of individual-level regression models (Bryk and Raudenbush 2001). While a few studies have examined how residential context shape sleep patterns (Hale and Do 2007; Bottino et al. 2012; McLaughlin et al. 2005), the authors are not aware of any study to date that has used multilevel modeling to control for environmental influences on sleep quality and duration to examine group differences. Therefore, using the unique set of contextual variable discussed previously will add a dimension to the analysis that has not been widely examined in the sleep disparities literature. Demographic research in sleep disparities research is long overdue (Knutson 2012); this study will fill a void in health disparities literature by examining a neglected and an imperative determinant of general health and individual well-being.

Table 1 Logit model predicting Racial Disparities in Self-reported Sleep Quality (poor sleep =1) (Unadjusted)

	Odds Ratio	95% CI
Intercept	0.22***	(0.21, 0.23)
Race		
Non-Hispanic White (reference)		
Non-Hispanic Black	1.23***	(1.10, 1.39)
Hispanic	1.48***	(1.19, 1.83)
Other	0.76	(0.47, 1.22)
N	9,730.00	
-2 log-likelihood test	-4,722.56	

*p≤0.05; ** p≤ 0.01; ***p≤ 0.001

Table 2 Relative Risk Ratio for Self-reported Sleep Duration across Race/Ethnicity (Unadjusted)

	Restricted Sleep Duration vs. Recommended Sleep Duration	95% CI	Long Sleep Duration vs. Recommended Sleep Duration	95% CI
Intercept	0.21***	(0.19, 0.22)	0.05***	(0.81, 1.41)
Race				
Non-Hispanic White (reference)				
Non-Hispanic Black	2.06***	(1.84, 2.30)	1.13	(0.89, 1.43)
Hispanic	1.96***	(1.59, 2.42)	1.48	(0.99, 2.24)
Other	0.92***	(0.57, 1.47)	1.49	(0.75, 2.98)
N	9,739.00			
-2 log-likelihood test	-6405.39			

*p≤0.05; ** p≤ 0.01; ***p≤ 0.001

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