

Neighborhood Characteristics and Sleep Behavior in the NHANES

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STATEMENT OF RESEARCH INTEREST

My core research interests focus on understanding both the health effects and environmental determinants of sleep behavior. Sleep deficiency is an important risk factor for a wide range of adverse health outcomes, including cardiometabolic diseases, mental disorders, cancer, and all-cause mortality.¹⁻⁴ The American Academy of Sleep Medicine and the National Sleep Foundation have each issued consensus statements recommending a minimum of 7 hours of sleep for healthy adults.^{5,6} However, despite the well-established evidence supporting an important role of sleep in maintaining good health, about one third of the US population fail to meet this guideline.⁷⁻⁹ Given the health implications of sleep, it is important to identify factors that are associated with unhealthy sleep patterns, including insufficient and excessive sleep duration, poor sleep quality, and sleep disorders.

Like many other health behaviors such as diet and physical activity, sleep is shaped not only by biological and individual factors, but also by macroenvironmental characteristics.¹⁰ Recent studies have found that physical and social aspects of the neighborhood environment are associated with sleep deficiency. For example, exposure to ambient light and noise at night have an adverse effect on sleep.^{11,12} In addition, neighborhood disadvantage, including low social cohesion, poor safety and high poverty, is also associated with sleep deficiency.¹³⁻²² In one of our recent studies of a large US cohort, we found that people who lived in neighborhoods in the lowest quintile of socioeconomic status (SES) measured by census variables were 72% more likely to report insufficient sleep (<6 hr) at night compared to those who lived in the highest quintile of neighborhood SES (manuscript in press).

Although findings from previous research are intriguing, several limitations exist in the current literature. First, the participants in earlier studies were predominantly white, and little is known about the relationship between neighborhood environment and sleep in minority populations. Second, most of the studies only examined sleep duration, while sleep is a complex behavior and more comprehensive evaluation of sleep is needed to fully understand the impact of neighborhood conditions on sleep. Finally, all the previous studies focused on either the physical (light and noise) or social environment, and therefore were unable to assess their relative contribution to and combined effect on sleep behavior.

The National Health and Nutrition Examination Survey (NHANES) offers a unique opportunity to address the current limitations. The NHANES is a nationally representative sample that over-sampled racial/ethnic minorities. Between 2005 and 2008, the NHANES included a 24-item sleep questionnaire which obtained information on sleep duration, sleep quality, sleep disorders and daytime sleepiness. During the same period, NHANES participants also reported residential addresses, which were geocoded and linked with the 2000 Census ID. Both geographic coordinates and census ID are part of the restricted data that can be obtained through the NCHS Research Data Center. To better understand the relationship between neighborhood attributes and sleep, I propose to develop a protocol to merge the NHANES data with three key environmental variables: 1) light at night (LAN) estimated using satellite imagery, 2) noise exposure derived from a geospatial model of environmental sound levels,²³ and 3) neighborhood SES measured using the 2000 Census.

Our research protocol will allow for a comprehensive examination of various attributes of neighborhood environment in relation to multiple aspects of sleep, which in itself will undoubtedly result in high quality publications. Moreover, it will also produce preliminary data for future grant application. We have a particular interest in testing the hypothesis that sleep deficiency contributes to cardiometabolic health disparities across different populations with various SES background and neighborhood conditions. We believe that once the linkage is completed, the detailed environmental data combined with the rich information on sleep, disease histories, biomarkers, and sociodemographic factors in the NHANES will provide an ideal opportunity for developing future studies to examine our research hypothesis.

I believe our team is well prepared for the proposed study. I have extensive experience in conducting epidemiological studies using large populations and have published multiple studies on neighborhood environment, sleep, and other risk factors for chronic diseases. I have worked with NHANES before and published a study on sleep and obesity using NHANES (2005-2008) data. Moreover, my current postdoctoral fellow Dr Zhang Dong, who earned a PhD in human development and family studies and a MS in statistics in Iowa State University, is experienced in statistical analysis and familiar with using census variables to assess neighborhood SES. He has led a study on neighborhood socioeconomic deprivation and colorectal cancer risk in a large cohort of 500,000 men and women in the US. Finally, my collaborator Dr Peter James at Harvard University is an expert in environmental health and has authored numerous papers on LAN and noise exposure. Taken together, we are well positioned to complete the proposed tasks and our study has the potential to advance our understanding of the impact of macroenvironmental factors on health.

RESEARCH TASKS

The end product we anticipate to produce during the funding period will be a protocol that include a set of datasets with LAN, noise, and neighborhood SES variables, as well as R and SAS code to merge with the NHANES (2005-2008).

Light at night (LAN)

Annual outdoor LAN will be derived from satellite imagery data from the US Defense Meteorological Satellite Program's Operational Linescan System (OLS), maintained by the National Oceanic and Atmospheric Administration's Earth Observation Group. Because previous studies reported that low-dynamic range data OLS do not have the spatial resolution to differentiate and characterize LAN exposure in urban areas, we will use the high-dynamic range data, which are available as annual composites at a 1km resolution. Dr Peter James is the lead author on a recent study that examined the relationship between LAN exposure using high-dynamic satellite data and breast cancer in the Nurse's Health Study II.²⁴ He has generously agreed to collaborate with us on the current study and will provide the LAN data as well as R code to facilitate the linkage to the NHANES. The LAN variables will be linked to the NHANES through geographic coordinates.

Noise

Exposure to noise will be based on a previously published geospatial model of environmental sound levels. Expected noise exposure is modeled using empirical acoustical data (natural data from the National Park Service and urban data from a collection of measurements from airport noise monitoring system and 14 urbanized areas where the National Park Service conducts acoustic measurements) and geospatial features such as topography, climate, hydrology and anthropogenic activity. Cross-validation procedures have been used to evaluate model performance and identify variables with predictive power. Using this method, a previous study reported substantial racial/ethnic and socioeconomic differences in model-based estimates of noise exposure at the block group level in the US.²³ Dr Peter James is the senior author on this paper, and again, Dr James has agreed to provide noise data and R code to facilitate linkage to the NHANES. Noise data will be linked to the NHANES through FIPS/Census codes at the block group level.

Neighborhood SES

Because the NHANES geocoding data has been linked to the 2000 Census ID, we will use 2000 Census data to characterize neighborhood SES. In our previous work in a large cohort of 500,000 participants and ~18,000 census tracts, we applied the method developed by Messer et al.²⁵ to generate an empirical neighborhood socioeconomic deprivation index at the census tract level using 2000 Census variables.²⁶ In brief, we selected 19 variables that were related to seven components of the neighborhood environment (housing characteristics, residential stability, poverty, employment, occupation, racial composition, and education). We performed principal component analysis (PCA) on these variables, stratified by state, and retained ten variables with consistent high loadings. The deprivation index was constructed for each census tract by summarizing the PCA scores of these ten variables. We have conducted multiple studies using this deprivation index to study the relationship between neighborhood SES and various health behaviors and outcomes, including self-reported health,²⁷ weight change,²⁸ physical activity and sedentary behaviors,²⁹ sleep (in press), mortality (unpublished data), and colorectal cancer risk (unpublished data). Using the same method, we are now planning to generate a national ranking system to assign a deprivation score to all the census tracts in the US using publicly available data. Once completed, we will be able to link the deprivation ranking score with NHANES participants. Neighborhood SES data will be linked with NHANES through FIPS/Census codes at the census tract level.

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