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Zachary Oberholtzer Date

Accumulation of Daily Life Stress and Its Effect on Sleep Quality

By

Zachary W. Oberholtzer
Master of Public Health

Department of Epidemiology

_____

Dayna Johnson
Committee Chair

Accumulation of Daily Life Stress and Its Effect on Sleep Quality

By

Zachary W. Oberholtzer

B.S., University of Georgia, 2019
B.A., University of Georgia, 2019

Thesis Committee Chair: Dayna Johnson, PhD, MPH, MSW, MS

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Abstract

Accumulation of Daily Life Stress and Its Effect on Sleep Quality
By Zachary W. Oberholtzer, MPH Candidate

Introduction: Sleep quality is important for overall health. Poor sleep quality is associated with adverse health outcomes such as cardiovascular disease, obesity, and type 2 diabetes. Evidence shows that stress is associated with poor sleep quality, but there has been little work examining the accumulation of stress in relation to sleep quality. The goal of this study is to examine the frequency of daily life stress and the frequency of specific stressors on sleep quality among adults in the United States.
Methods: Participants (N=673) from the Midlife in the United States study were surveyed between 2004-2009. Frequency of daily stress, number of days with stress, and frequency of specific stressors were measured using daily questionnaires collected over 8-days. Sleep quality was assessed based on a modified version of the Pittsburgh Sleep Quality Index (PSQI), with higher scores indicating worse sleep quality. A PSQI score >5 defined poor sleep quality. Linear and Poisson regression models with robust variance were fit to test associations between accumulation of stress defined as the number of stress encounters, number of days with stress or frequency of stressors (e.g., arguments/disagreements, work or school stress, home stress, stressful events happening to friends/family, or discrimination) with sleep quality (categorical and continuous).
Results: The analytic sample had an average age of 56.3 years (SD: 11.8), was 41.5% male, and was 86.5% white. Poor sleep quality was common, with 44.7% of the sample having a PSQI score above 5. On average, participants experienced 4.3 (SD: 3.3) stress occurrences across the 8 days on average (range: 0-40). A unit increase in the number of stress encounters, was associated with a higher prevalence of poor sleep quality [PR=1.05, 95% CI (1.03, 1.08)] and a higher PSQI score [β=0.17, 95% CI (0.08, 0.24)]. As the number of days with stress increased, there was a lower prevalence of poor sleep quality [PR=0.92, 95% CI (0.88, 0.96)] and a lower PSQI score [β =-0.27, 95% CI (-0.40, -0.13)]. As the number of occurrences of stressful events happening to others and arguments increased, there was a higher PSQI score, [β =0.40, 95% CI (0.05, 0.76)] and [β =0.25, 95% CI (0.01, 0.49)], respectively. As the number of occurrences of home life stress and arguments increased, there was a higher prevalence of poor sleep quality, [PR=1.08, 95% CI (1.01, 1.17)] and [PR=1.09, 95% CI (1.01, 1.17)] respectively. The number of occurrences of work/school stress and discrimination were not associated with poor sleep quality after adjustment for covariates.
Discussion: The results suggests that frequent exposure to stress (across a week) is associated with poor sleep quality. Frequent occurrences of arguments/disagreements, home life stress, and stressful events happening to others were associated with poor sleep quality. Intervening on stress may help to improve sleep quality. Future research should test these associations with a more diverse study population with a prospective design.

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Table of Contents

Introduction

Sleep is an essential part of human function and is vitally important for overall health. Sleep is a physiological process that consists of a number of neurobiological regulation functions including memory consolidation and emotional regulation.[1] Sleep is also important for regulating metabolism and cardiovascular function.[2,3] The sleep period consists of four stages, three of which are considered non-rapid eye movement (REM) sleep and the fourth being REM sleep.[4] As one moves through NREM sleep, the sleep gets progressively deeper and it becomes progressively more difficult to wake the person. Stage 1 is the transition between wakefulness and sleep, and is a short stage of light sleep where brain waves begin to slow compared to during wakefulness.[5] Stage 2 is signified by muscle relaxation, eye movement stopping, body temperature dropping, and the onset of delta waves.[5] Stage 3 is a period of deep sleep signified by the increase of delta waves; this stage is also called "slow wave sleep".[4] REM sleep is a distinctive stage and is associated with dreaming. During REM, skeletal muscles are unable to move, breathing becomes irregular, and heart rate often increases.[4] Healthy sleep is defined by a number of dimensions, including subjective satisfaction with one's sleep, timing of sleep in the 24-hour day, sleeping for 7-9 hours per night (for adults), ease of falling and staying asleep, and being able to maintain attentive wakefulness after sleep.[6] Poor sleep is caused by disruption to any or all of these dimensions of sleep. Growing research indicates poor sleep is negatively associated with numerous health indicators at all ages, such as higher body mass index,[7] elevated risk of type 2 diabetes,[8] increased prevalence of hypertension,[9] and greater risk of all-cause mortality[10]. Sleep is a critical target for public health intervention due to the numerous downstream health outcomes that are associated with poor sleep. To reduce the burden of poor health outcomes, sleep should be considered an intervention target. Thus, to improve sleep, it is important to identify the determinants of poor sleep quality.

Chronic and acute stress are associated with poor sleep quality.[11–13] Chronic stress can be defined in multiple ways: frequent exposure to stressors, an inability to habituate to the same stressor or set of stressors over time, or the stress response not ending after the removal of the stressor.[14] Whereas acute stress is a result of life events such as accidents, emotional disturbances, or other major life events.[15] There are a few pathways by which stress may be associated with poor sleep quality. Acute stress can lead to changes in heart rate variability that is linked to sleep disturbances.[13] Stress is also coupled with activation of the hypothalamic–pituitary–adrenal (HPA) axis that leads to increased cortisol levels and disturbances in sleep.[16] Chronic stress in particular can increase inflammation that exacerbates cardiovascular disease and can create alterations in the brain that can potentially cause cognitive, emotional, and behavioral dysfunction.[12] Prolonged exposure to stress can have negative effects on health outcomes. Continual exposure to chronic stressors and prolonged stress reactions can subsequently increase vulnerability to the negative effects of stress.[17,18] This cycle of exacerbating the stress reaction due to continued exposure is called stress reactivity.[19] There is a clear pathophysiologic process linking stress and sleep, yet few studies have examined the association between the accumulation of stress and sleep quality.

There are epidemiologic data supporting that stress is associated with poor sleep quality. In a review of sleep assessed by polysomnography, stress, including experimentally induced stress and stress stemming from trauma was shown to be associated with poor sleep defined as frequent sleep disturbances, increased body movement during sleep, and reduced slow-wave sleep.[11] Retrospective assessments of perceived stress, which are subject to recall bias have been shown to be negatively associated with lower sleep quality in normal sleepers,[20] as well as in a cohort of American women[21]. This body research is limited by single assessments of stress,

cross-sectional data, and general assessments of stress or only considering one stressor. Long-term exposure to stressors can exacerbate the effects that stress has on health outcomes like sleep. For example, in a cross-sectional study of Chicago households, it was shown that as stress exposure accumulates over time, the impact of stress on sleep duration and sleep difficulties was amplified.[22] The prior study supports the need to understand the frequency of stress occurrence on sleep. Additionally, it is unknown which stressors that are experienced frequently may affect sleep quality.

There are studies that have identified specific stressors that are associated with poor sleep. Stress from one's occupation has been shown to be a major stressor and is associated with an increased likelihood of poor sleep quality in adults.[23] Family and home life stressors, including conflicts with loved ones, has been shown to be associated with poor sleep quality in adult populations.[24] Interpersonal conflict as a stressor is also associated with poor sleep quality.[25] Social relationships, especially close relationships, have been shown to be associated with sleep quality, with supportive relationships having an association with better sleep quality and negative relationships having an association with worsened sleep quality.[26] Another stressor that has shown to affect sleep quality is racial and socioeconomic discrimination.[22,27,28] The majority of these studies examined occurrence of the stressor but not how the frequency of the occurrence over time may affect sleep. Studying the frequency allows us to better understand the effect of chronic stress exposure over time on sleep quality and allow us to focus on interventions that reduce stress. Another limitation of the literature is the focus on a single dimension of sleep. Assessing these associations in regarding a global dimension of sleep is needed.

Given the effects of stress on sleep quality are independent of sleep duration, there is a need to understand how stress over time affects sleep quality. While some studies use more holistic measurements of sleep such as the Pittsburgh Sleep Quality Index (PSQI), the majority of the research conducted focuses on either sleep duration or sleep disorders such as insomnia. Moving beyond these measures will allow for a shift toward a more complete and holistic measure of healthy sleep.[6]

Among a subset of participants from a nationally representative sample, the Midlife in the United States (MIDUS) study, we examined the association between the accumulation of stress and frequency of various stressors with sleep quality =across a week. We hypothesize that prolonged exposure to daily life stress is associated with poor sleep quality. We also hypothesized individuals who reported more days with stress have poor sleep quality. The results of this research may provide evidence for health interventions that target stressors. Targeting stress, to improve sleep quality may improve numerous health indicators and conditions.

Methods

Study Design/Participants

This study utilizes data from the Midlife in the United States (MIDUS) study. The MIDUS study is a longitudinal cohort study that sought to investigate age variations in behavioral, psychological, and social factors and their influence on physical and mental health.[29] The current study uses data from the MIDUS Daily Stress Project and the MIDUS Biomarker Project, collected as part of MIDUS 2 (2004-2009). MIDUS began with a sample of 7,108 non-institutionalized, English-speaking adults within the continental United States who were selected for participation using random digit dialing (RDD) of telephone numbers. A list of all household

members ages 25-74 from each household contacted using RDD was generated, and a random respondent was chosen from these lists. Researchers oversampled older individuals and men by varying the probability of carrying out an interview based on a function of the age and gender of the randomly selected participant.[30] Participants considered for the current analysis were sampled from MIDUS 2, a longitudinal follow-up study of the initial MIDUS sample. This project successfully enrolled 4,963 into at least the initial phone interview, with a retention rate of 70%. Demographic and socioeconomic data for participants were collected from this interview. The main MIDUS 2 sample ranged from ages 34 to 84, was 48% male, and had 66% of participants completed at least 12 years of education. A further subset of these 4,963 participants were enrolled in the Daily Stress Project (n=2022), the Biomarkers Project (n=1255), or both projects.[30] Any participant that was enrolled in the main MIDUS 2 study was asked to participate in either or both of these sub-studies. The participants considered for this project were restricted to those who enrolled in both previously mentioned projects and had data for the daily stress variables as well as the sleep quality variables (n=673). This project was not deemed human subjects research and an IRB waiver was granted by Emory University.

Sleep Quality

Sleep quality was assessed as a part of the MIDUS 2 Biomarkers Project using the Pittsburgh Sleep Quality Index (PSQI) questionnaire. The PSQI is a commonly-used validated instrument that measures sleep quality using 19 questions to generate seven component scores for subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping meds, and daytime dysfunction.[31] These 7 component scores are then aggregated to form a global PSQI score, ranging from 0-21, with a score above 5 indicating poor sleep quality.[31] This measure has been hugely important in the field of sleep epidemiology

because of its ability to measure sleep quality and because it has created a standardized measurement that can be widely used and the results can be compared across studies and fields[31]. For analytic purposes, sleep quality was analyzed categorically to define occurrence of poor sleep quality (PSQI > 5), and continuously to assess severity of poor sleep quality (higher scores indicate worse sleep quality).

Daily Stress.

Daily stressors were assessed via the MIDUS Daily Stress Project. Semi-structured interviews were conducted with participants, using a version of the Daily Inventory of Stressful Experiences survey. Participants were called daily and asked about the events of their day on eight consecutive days. The interviews consisted of a series of stem questions asking whether certain types of events had occurred in the past 24 hours along with a set of guidelines for probing affirmative responses.[32,33] This method involved subjects keeping a daily diary of all experiences that the subject considered stressful. At the end of each of the 8 days of observation, participants were asked via telephone survey about all stressful experiences in the previous 24 hours. Research assistants recorded whether any type of stress was reported for that day of observation, responses included: yes: a stress encountered occurred or no: a stress encounter did not occur. Participants were also asked about the specific stressors that occurred, including (1) arguments or disagreements, (2) home life stress, (3) work or school stress, (4) someone in their social network experiencing a stressor, and (5) discrimination. The participants indicated whether they experienced (yes or no) each of the 5 stressors each day across the 8-day study period. For the current paper, we assessed 3 stress exposures: frequency of daily stress, number of days experiencing stress, and frequency of the occurrence of specific stressors. (1) Frequency of daily stress was defined as the sum of the total number of stress encounters experienced across

the 8-day study period, with values ranging from 0 to 40. (2) The number of days experiencing stress was defined by summing the number of days where any one of the stressors were reported, with values ranging from 0 to 8. (3) The frequency of the occurrence of specific stressors was defined as the total number of days the specific stressor occurred over the 8-day study period, range for each of the five stressors was 0 to 8.

Covariates

Based on the previous literature, we identified a number of possible confounders that were accounted for in the models. Covariates selected *a priori* include age, race, gender, sexual orientation, depression, anxiety disorder, marital status, parental status, education level, and employment status. Gender, race, and sexual orientation were included due to their effect on one's stress level and sleep.[28,34–36] Socioeconomic status, which is linked to stress levels and sleep quality[23,37], was measured according to education and employment status. Marital status and parental status have also been linked to both stress and sleep quality[24] and were included as possible confounders. Mental health indicators also have links to both stress levels and sleep.[38] All demographic and socioeconomic covariates were self-reported when enrolled in the main MIDUS study. Depressive episodes and Generalized Anxiety Disorder (GAD) were assessed using a series of questions during the main MIDUS 2 interviews. These mental health covariates were assessed using structured assessments adapted from the World Mental Health Organization's Composite International Diagnostic Interview Short Form.[39] Participants were asked questions used to ascertain depressed affect and anhedonia. Depressed affect was assessed by asking if participants felt sad, blue, or depressed, and asking questions about what they felt when they were sad, including losing interest in most things, feeling more tired than usual, losing appetite, trouble falling asleep, trouble concentrating, feeling down on yourself, and thinking

about death. If participants felt sad all or most of the day every day or almost every day, and answered yes to 4 out of 7 of the other questions, they were coded as having depressed affect. Anhedonia was assessed by asking if participants lost interest in most things and what happened when they lost interest, including feeling more tired than usual, losing appetite, trouble falling asleep, trouble concentrating, feeling down on yourself, and thinking about death. If participants lost interest in most things all or most of the day every day or almost every day and answered yes to 4 out of 6 of the other questions, they were coded as having anhedonia. Those that were coded to have depressed affect or anhedonia were coded as having depression. For anxiety disorder, a series of ten questions about symptoms over the past 12 months were asked, including if they were restless because of worry, if they were keyed up or on edge, if they were irritable because of worry, if they had trouble falling asleep, if they had trouble staying asleep, if they had trouble keeping their mind of what they were doing, if they had trouble remembering things because of worry, if they were low energy, if they tire easily due to worry, or if they had sore/aching muscles due to tension. Participants were coded to have the presence of anxiety disorder symptoms if they answered that they experienced three or more of the symptoms most days.

Data Analysis

Descriptive statistics were calculated using SAS 9.4. Linear regression and Poisson models with robust error variance were fit to test associations. Poisson regression with robust error variance was used for analysis of dichotomous sleep quality instead of logistic regression analysis because the outcome was common.[40] Both beta coefficients and prevalence ratios with 95% confidence intervals were calculated in separate models for the associations with frequency of daily stress encounters, number of days encountering stress, the frequency of occurrence of specific stressors. A sequential modeling approach was used. In total, 18 models were created,

with three iterative models used for each exposure-outcome pair. The first model in each series analyzed the crude association between the stress exposure and the sleep quality outcome. The second model included demographic and socioeconomic covariates, including age, gender, sexual orientation, race, employment status, education level, marital status, and parental status. The third model added mental health covariates, including depression symptoms and anxiety disorder symptoms.

Results

Participants (n=673) completed both surveys and met our inclusion criteria. There were 338 MIDUS participants excluded due to missing either exposure or outcome data. Table 1 presents descriptive data for selective characteristics of the analytic sample. Overall, our sample was 86.5% white, 41.5% male, and had a mean age of 56.3 years (SD=11.8 years) at baseline. The majority of our sample was employed (59.6%), married (67.3%), and had at least one child (79.2%). The average PSQI Global score across the entire sample was 5.9 (SD=3.41). Poor sleep was common, 44.7% had a PSQI > 5. Among the entire sample, the most common poor sleep quality indicator was sleep disturbance, with 96.9% of the analytic sample reporting at least one sleep disturbance on an average night.

Overall, 93.5% of participants reported at least one stress encounter a day across the 8-days, and the average participant experienced 4.3 stressors over the observation period of 8 days, as seen in Table 1. The average number of days with at least one stress exposure was 4.4. Figure 1 shows the percent of participants that experienced each stressor at least once over the survey period. Stress stemming from an argument or disagreement was the most frequently reported stressor with 44.6% of participants reporting it occurred at least once during the survey period, as seen in Figure 1.

Table 2 shows the crude and adjusted associations between the stress exposures and continuous sleep quality. A unit increase in the number of stressors experienced over the week was associated with worse sleep quality (β=0.17, 95% CI= 0.10, 0.25). This association persisted in the fully adjusted model (β=0.17, 95% CI=0.08, 0.24). A unit increase in the number of days with a stress encounter was associated with a better sleep quality score (β=-0.26, 95% CI= -0.38, -0.13). This association remained constant in the fully adjusted model (β=-0.27, 95% CI=-0.40, -0.13). Table 2 also shows the associations between the frequency of occurrence of each stressor with sleep quality. An increase in the number of occurrences of a stressful event happening to friends or family was associated with a higher PSQI global score (β=0.48, 95% CI=0.12, 0.83). This association remained significant after adjustment for covariates. An increase in the number of experiences of discrimination was associated with a higher PSQI global score (β=1.67, 95% CI=0.67, 2.67). However, the association was attenuated and no longer significant in the adjusted model. An increase in the number of occurrences of arguments/disagreements was associated with a higher PSQI global score (β=0.31, 95% CI=0.08, 0.54). The association persisted after adjustment for confounders. The number of occurrences of work or school stress was associated with better sleep quality (β=-0.09, 95% CI=-0.32, 0.15). The association persisted with adjustment for confounders. The number of occurrences of home life stressors was not associated with the PSQI global score.

Table 3 shows the associations between the stress exposure variables with poor sleep quality (PSQI>5). The associations were consistent with Table 2. A unit increase in the number of stressors experienced over the week was associated with worse sleep quality (PR=1.05, 95% CI=1.02, 1.07). This association remained constant in the fully adjusted model (PR=1.05, 95% CI=1.03, 1.08). For the number of days with at least one stressor, a unit increase in the number of

days with a stress exposure was associated with better sleep quality (PR=0.93, 95% CI=0.90, 0.97). This association remained constant in fully adjusted models. An increase in the number of occurrences of stressful events happening to friends or family was associated with higher prevalence of poor sleep quality (PR=1.14, 95% CI=1.03, 1.26). The association did not remain significant after adjustment for covariates. An increase in the number of occurrences of discrimination was associated with a higher prevalence of poor sleep quality (PR=1.31, 95% CI=1.11, 1.55) in the unadjusted models. The association was attenuated and no longer significant after in the adjusted models. Frequent occurrences of arguments/disagreements were associated with a higher prevalence of poor sleep quality (PR=1.08, 95% CI=1.02, 1.15). This association did not persist after adjustment for confounders. An increase in the occurrences of home life stressors was associated with higher prevalence of poor sleep quality (PR=1.08, 95% CI=1.01, 1.16) in the unadjusted models. The association persisted with adjustment for confounders. The number of occurrences of work or school stress was not found to be associated with poor sleep quality in either the unadjusted or adjusted models.

Discussion

Using data from a nationwide sample of adults in the Midlife in the United States study, we found that frequent encounters with daily stressors were associated with poor sleep quality. Specifically, frequent encounters with arguments and home life stressors were associated with poor sleep quality after adjustment for confounders. Stressful events happening to friends/loved ones and instances of discrimination were significantly associated with sleep quality in the unadjusted models, but these relationships were attenuated when adjusting for covariates. Unexpectedly, the number of days with stress exposure was associated with better sleep quality. This study contributed to the literature by providing evidence that occurrences of stress are

associated with poor sleep quality and highlighted the stressors (arguments and home life stress) that could be key intervention targets.

Overall, there was a high prevalence of poor sleep quality (44.7%) in the sample, with an average PSQI global score of 5.9. This is consistent with the prevalence of poor sleep quality shown in the literature assessing sleep quality as either the exposure or outcome of interest. Among a sample of 1220 middle-age men, as part of the Vietnam Era Twin Study of Aging, the average PSQI global score was 5.6.[41] Among a sample of 2232 young adults, as part of the Environmental Risk (E-Risk) Longitudinal Twin Study, the average PSQI was 5.4.[42] Among a cohort of 175 middle-aged and older adults in a study designed to assess the effects of social relationships on sleep quality, the average PSQI global score was 6.15.[26] Understanding more about the determinants of sleep quality is vitally important for public health due to the numerous health consequences from poor sleep quality.

We found frequency of stress to be an important determinant of poor sleep quality. Individuals who reported more stress encounters across the week had higher prevalence of poor sleep quality. This was consistent with our hypothesis and the literature on stress and sleep quality.[20–25,37,45,46] Data from multiple cohorts have shown that stress is associated with poor sleep quality.[20,25,46] For example, in a cross-sectional cohort of 467 undergraduate students, an increase in life stress was correlated with the five facets of sleep quality (going to bed, falling asleep, maintaining sleep, reinitiating sleep, and waking).[25] Another study of 66 undergraduate students recorded daily sleep and stress diaries for two weeks of observations; Pearson's correlations were calculated and poor sleep quality was found to be highly correlated with an increase in the Perceives Stress Scale.[20] Another cohort of 330 middle-aged women enrolled in the Study of Women's Health Across the Nation, collected prospective data over 9 years about

chronic stress and sleep quality.[46] Women with higher levels of chronic stress were more likely to report lower subjective sleep quality, insomnia symptoms, and increased polysomnography-assessed wake after sleep onset.[46] The current analysis builds upon prior studies by assessing chronic stress via the daily diary method in a larger cohort of middle-aged adults. In the current study we assessed frequency of the occurrence of stressors extending beyond only occurrence.

The number of days with stressor exposure was associated with a better sleep quality score. This was unexpected, as we hypothesized that number of days experiencing a stressor would be associated with worse sleep quality. Few studies have analyzed the number of days encountering stress and sleep quality. Other studies using the MIDUS cohort have analyzed the number of days with stress, but not in the context of sleep quality. These studies analyzed the relationship between number of days of stress and positive/negative affect.[47,48] There is literature showing that the accumulation of stress has an effect on health outcomes,[49] but previous work on this relationship have assessed exposure using methods similar to our method of assessing overall stressor frequency. It is possible that our use of number of days with stress may not capture accumulation in the current study.

We examined the frequency of the occurrence of specific stressors including arguments/disagreements, home life stress, work/school stress, stressful events happening to others, and discrimination, with sleep quality and found mixed results. Home stress and arguments/disagreements were significantly associated with poor sleep quality in the adjusted models. This is consistent with literature. Arguments, with loved ones, coworkers, or others, have been shown to be a stressor that can affect sleep quality.[26,50] Antagonistic interactions and adversarial relationships have shown to be significant sources of stress, which then can affect sleep quality.[26,51] While this study does not specify who these arguments are with, the evidence

from our analysis supports the fact that arguments may impact sleep quality. Studies have shown that home life and family stress is associated with poor sleep.[24] A previous sample of the MIDUS 1 (1995) cohort, assessed family strain as a score of negative interactions with family members and found that an increase in family strain was associated with trouble sleeping assessed by a Likert scale question.[24] Marital stress specifically has also been shown to have an effect on sleep quality; a sample of 2148 middle-aged women from the Study of Women's Health Across the Nation found that lower marital happiness was associated with an increase in sleep disturbances.[44] Our study builds upon this literature by utilizing repeated measurements to incorporate an aspect of temporality in the exposure measurement.

Work or school stress was not associated with sleep quality, which was surprising and s unexpected, given the literature shows associations between job stress and poor sleep quality.[23,52] One cross-sectional study, conducted in a probability sample of the National Employee Survey (NES), used negative binomial regression to analyze associations between work stressor frequency and poor sleep quality.[23] Researchers found that the frequency of each indicator of work stress (work overload, role conflict, repetitive tasks, and lack of job autonomy) were negatively associated with poor sleep quality indications (difficulty initiating sleep, difficulty maintaining sleep, and non-restorative sleep).[23] Another cross-sectional study using a sample of 5720 workers from the WOLF study, conducted multiple logistic regression and found that work stressors (high work demands and physical effort at work) were risk indicators for disturbed sleep assessed using the Karolinska Sleep Questionnaire.[52] These studies were conducted in more heterogenous samples than the one used for the current analysis. Given the relatively high education level of the sample used for the current analysis, it may be that these participants have lower stress jobs compared to those assessed elsewhere in the literature. The

participants in the NES had a lower education level (73% completing more than a high school degree) and the study conducted using participants in the WOLF study was made up of 45% blue collar workers. These sample differences, of SES, may account for the differences in results. Future studies should seek to be more representative of different SES categories.

Frequent occurrences of discrimination were associated with poor sleep quality in the unadjusted models. However, this relationship was attenuated and not significant in the adjusted models. These findings are inconsistent with the literature. Discrimination has been identified as a severe stressor that can negatively impact outcomes such as sleep quality/duration.[30] The insignificant results in the adjusted models may be due to the low rates of reported discrimination and/or the lack of diversity in the sample. Prior longitudinal studies have shown an association between discrimination and sleep. Results from a cohort of 368 women from the Study of Women's Health Across the Nation (SWAN) showed that chronic occurrence of discrimination was associated with more subjective sleep complaints and poorer sleep continuity.[53] The SWAN study consisted of 37.5% African-American, 16% Chinese, and 46.5% white women;[53] thus the diversity of the sample may have provided more of a range in discrimination scores, given the inclusion of minorities who often face discrimination. Another study, a cross-sectional analysis of discrimination and self-reported sleep duration/difficulties in an adult population, showed that discrimination was associated with likelihood of poor sleep outcomes.[22] This effect was shown among a sample comprised of 39.7% African-American, 25.9% Hispanic, and 34.4% white. Discrimination, especially on the basis of race, was not identified as a source of stress in our majority white sample; thus, future studies should explore other sources of discrimination such as SES that may be related to poor sleep in this sample.

The current study showed inconsistent associations between stressful events happening to others and sleep quality. A study among a sample of 175 middle-aged and older adults showed that social relationships, categorized as supportive, aversive, ambivalent, and indifferent, had varying effects on sleep quality.[26] An increase in the number of supportive social ties was associated with better sleep quality, an increase in the number of aversive social ties was associated with worsening sleep quality, and ambivalent/indifferent ties had no effect.[26] Based on this work and others, we expected to observe an association between stress happening to others and sleep quality. It is possible that stressful events happening to others, also known as vicarious experiences, may not be as seen as a source of stress in this study population. Prior studies have shown that vicarious experiences and trauma are associated with health, including mental health issues,[54,55] so it is somewhat surprising that this type of stress was not associated with sleep quality. However, we did observe an association in the unadjusted models, but once we adjusted for the socioeconomic and mental health covariates the association was attenuated, thus suggesting some of these factors likely explain the association.

This study has several strengths. Strengths of this study include the use of a validated measure of sleep quality, the incorporation of repeated measurement of experiences with stress, and the examination of frequency of occurrence with specific stressors. The main implication of this study is that stress is an important determinant of sleep quality. Our results suggest focusing on home life stressors and arguments may be important. These types of stressors show promise as intervention targets to improve the downstream health effects associated with sleep quality. Future studies should seek to better understand the sources of home stress or arguments in order to refine interventions and allow them to be more effective. While discrimination was not seen to

be associated with poor sleep quality in this population, future studies could examine sources of discrimination that are applicable to this population.

While our study is well designed to capture the effect of stress exposure on sleep quality, there are limitations in the study design that may have affected the results. First, due to limitations imposed by the dataset, sleep quality was assessed at only one time point. Therefore, we cannot ascribe causality to the relationships found by this analysis. There is also potential for selection bias due to the data collection involving two separate studies. Data were collected from two projects under MIDUS, the Daily Stress Project and the Biomarkers Project, and it is unclear if there are reasons why those who participated in both projects did so. These reasons may impact reported daily life stress and/or sleep quality. For example, it is possible that those with higher levels of stress may not have participated in both projects due to work, childcare, or other stress. This would bias our results toward the null as high-exposure level individuals would be excluded from our study. The inclusion of the mental health covariates could bias our results (adjusted analyses) as trouble sleeping was an item to assess the depression covariate. Another limitation is that the sample is homogenous. As stated in the results section, the majority of the analytic sample was white (86.5%), heterosexual (87.4%), married (67.3%), and a parent (79.2%). This sample is not truly representative of the United States population and this may limit the generalizability of the results. Additionally, some of the results of the study could have been affected by measurement error. As discussed previously, using days with stress exposure may not be an appropriate proxy for accumulation of stress. Further refinement in capturing this facet of stress exposure is needed to truly understand if an increase in the number of days experiencing stress can affect sleep quality. An additional limitation of this study has to do with the analysis method chosen. An analysis using multilevel methods would have been better suited

to account for the within-person variation stemming from repeated measurement of stress exposure for each subject.

Our findings indicate that frequency of exposure to stressors is associated with poor sleep quality. Additionally, we have found that arguments and home life stress specifically are associated with poor sleep quality. These finding are important because they provide evidence for stress intervention targets. Future studies that incorporate a prospective design, account for repeated measurement in the analysis, and utilize a more representative sample would provide additional evidence about this relationship.

Appendix A: Tables and Figures

Table 1: Selected Characteristics of the Sample, Midlife in the United States Study (N=673)

Variable	**N = 673**
Age, years	56.30 ± 11.79
Male	41.5%
White	86.5%
Heterosexual	87.4%
Married	67.3%
Completed at least high school	87.2%
Parent	79.2%
Employed (Full- or part-time)	59.6%
Depression symptoms	7.6%
Anxiety disorder symptoms	1.5%
Mean number of stressors	4.27 ± 3.28
Mean number of days with stress	4.36 ± 2.10
Had any stressors	93.5%
Poor sleep quality	44.7%
Mean Pittsburgh Sleep Quality Index Global Score	5.89 ± 3.41

MIDUS 2, 2004-2009; Numbers in the table are either mean ± SD or percentage.

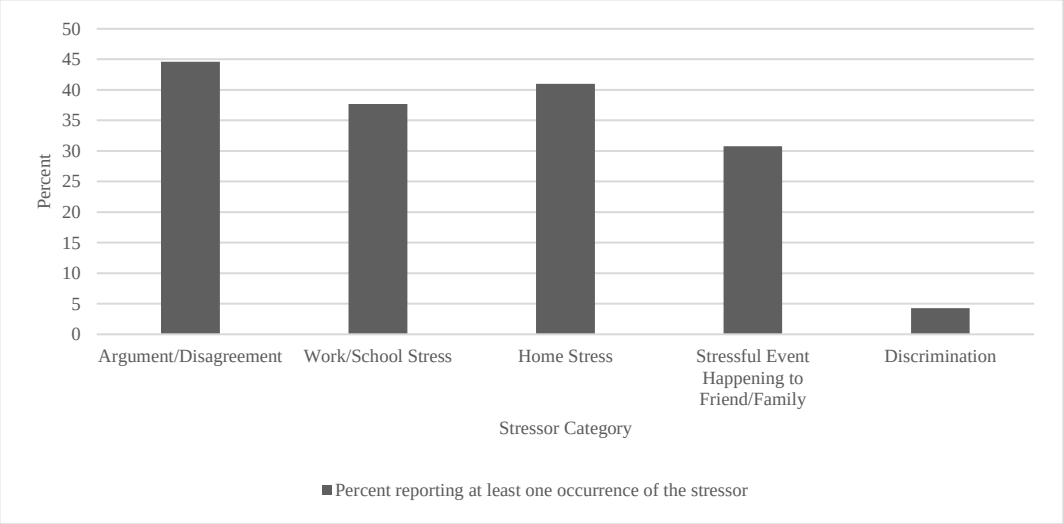

Figure 1: Proportion of Study Participants that Experienced Stressor Categories at Least Once during Observation; MIDUS 2, 2004-2009;

Table 2: Crude and Adjusted Associations between Frequency of Stress Occurrences and the PSQI Global Score

	Model 1		Model 2		Model 3	
Exposure Variable	β (SE)	95% CI	β (SE)	95% CI	β (SE)	95% CI
Number of stressors	0.17 (0.04)*	0.1, 0.25	0.17 (0.04)*	0.09, 0.25	0.17 (0.04)*	0.08, 0.24
Number of days with stress	-0.26 (0.07)*	-0.38, -0.13	-0.28 (0.069)*	-0.41, -0.14	-0.27 (0.068)*	-0.40, -0.13
Argument/Disagreement	0.31 (0.12)*	0.08, 0.54	0.25 (0.12)*	0.01, 0.49	0.25 (0.12)*	0.01, 0.49
Home Stress	0.23 (0.12)	-0.01, 0.47	0.22 (0.12)	-0.03, 0.47	0.21 (0.12)	-0.03, 0.46
Work/School Stress	-0.09 (0.12)	-0.32, 0.15	0.02 (0.13)	-0.23, 0.27	0.02 (0.13)	-0.23, 0.27
Something stressful happening to a friend/loved one	0.48 (0.18)*	0.12, 0.83	0.41 (0.19)*	0.05, 0.77	0.40 (0.18)*	0.05, 0.76
Discrimination	1.67 (0.51)*	0.67, 2.67	0.93 (0.57)	-0.18, 2.04	0.59 (0.56)	-0.51, 1.70

N = 673; PSQI: Pittsburgh Sleep Quality Index; Higher PSQI scores equate to worse sleep quality; Overall stressor frequency, number of days with stress, stressor category frequency were included in separate model series. Each model series followed the same Model 1-3 pattern. Model 1 is the unadjusted model relating the stress exposure and the sleep quality outcome. Model 2 includes all demographic and socioeconomic covariates described previously. Model 3 includes demographic, socioeconomic, and mental health covariates. *: Statistically significant at $\alpha = 0.05$

Table 3: Crude and Adjusted Associations between Frequency of Stressor Occurrences and Poor Sleep Quality (PSQI Score > 5)

	Model 1		Model 2		Model 3	
Exposure Variable	PR	95% CI	PR	95% CI	PR	95% CI
Number of stressors	1.05*	1.02, 1.07	1.05*	1.03, 1.08	1.05*	1.03, 1.08
Number of days with stress	0.93*	0.90, 0.97	0.92*	0.88, 0.96	0.92*	0.88, 0.96
Argument/Disagreement	1.08*	1.02, 1.15	1.08*	1.01, 1.16	1.09*	1.01, 1.17
Home Stress	1.08*	1.01, 1.16	1.09*	1.01, 1.17	1.08*	1.01, 1.17
Work/School Stress	0.96	0.88, 1.04	1.00	0.92, 1.10	1.00	0.92, 1.10
Something stressful happening to a friend/loved one	1.14*	1.03, 1.26	1.10	0.98, 1.23	1.11	0.99, 1.24
Discrimination	1.31*	1.11, 1.55	1.29*	1.05, 1.59	1.19	0.95, 1.49

N =673; PSQI: Pittsburgh Sleep Quality Index; PR: Prevalence Ratio; Overall stressor frequency, number of days with stress, and stressor category frequency were included in separate model series. Each model series followed the same Model 1-3 pattern. Model 1 is the unadjusted model relating the stress exposure and the sleep quality outcome. Model 2 includes all demographic and socioeconomic covariates described previously. Model 3 includes demographic, socioeconomic, and mental health covariates; *: Statistically significant at $\alpha = 0.05$

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