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The Moderating Role of Gender in Social Determinants of Sleep

THESIS

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by

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ABSTRACT OF THE THESIS

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by

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Master of Arts in Social Ecology

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Objective: To determine whether the association between perceived social support or strain in close relationships and sleep outcomes varies by gender.

Methods: Participants were selected from the Biomarker projects of either the MIDUS II or MIDUS Refresher study if they were in a married-or married-like relationship and shared a bed with their partner (*N*=989). A subsample also participated in a seven-day sleep study (*n*=282). Perceived social support and strain from partner, family, and friends were examined by self-report questionnaires. We used the Pittsburgh Sleep Quality Index, sleep daily diary, and actigraphy to measure both subjective and objective sleep.

Results: Social support and strain were both associated with sleep outcomes. Specifically, higher social support was associated with fewer daily reports of light sleep and feeling more rested in the morning, while higher social strain was associated with higher clinical sleep disturbance. For women, but not men, social support was significantly associated with lower daily sleep disturbance while perceived social strain was significantly associated with higher daily sleep disturbance, lighter sleep, feeling less rested in the morning, lower sleep efficiency, and longer sleep onset latency.

Conclusions: Mainly among women, social support and strain are associated with an important transdiagnostic health outcome -- sleep -- which may have implications for a wide range of health disparities. Interpersonal stressors may increase health risks differently for women compared to men and one mechanism that may link social relationships to long-term health outcomes is sleep.

Keywords: sleep, social support, social strain, health psychology, objective sleep outcomes, subjective sleep outcomes

Introduction

Social connection and the quality of social relationships are important determinants of mental and physical health (Holt-Lunstad et al., 2010, 2018; Uchino, 2006). In particular, a more diverse network of social relationships, higher frequency of social contact, and higher quality of social relationships are significantly related to better physical health outcomes (Holt-Lunstad, 2018). Social support refers to an individual's perception of care, value, affection, and help from other persons or networks (Taylor, 2011). Higher social support is a robust protective factor, predicting lower risk for mortality even after controlling for standard risk factors such as age, obesity, and health status, and the strength of the association between social support and mortality risk is as large as risk factors such as obesity and physical inactivity (Holt-Lunstad et al., 2010). In contrast, social strain is related to chronic illness and higher mortality rates (De Vogli, 2007; Kiecolt-Glaser & Wilson, 2017). An increase in the number of social relationships or frequency of social contact may have unintended negative effects if conflict or strain is present. Yet our understanding of how social relationship quality, such as support and strain, impacts physical and mental health remains limited and would benefit from the elucidation of underlying processes. Identifying such mechanisms would allow researchers to refine current treatment protocols and develop more effective interventions.

Social relationships may contribute to physical and mental health via sleep (e.g. Troxel et al., 2007). Sleep is a robust, transdiagnostic risk factor for a wide range of physical and mental health problems such as metabolic diseases, cardiovascular disease, cancer, post-traumatic stress disorder (PTSD), and ADHD (Harvey, 2008; Irwin, 2015); it also contributes to all-cause mortality (Irwin, 2015). Identifying modifiable determinants of sleep is essential to reducing the burden of physical and mental illness. Previous research has mainly focused on identifying

individual risk factors for sleep disturbance such as biomedical or psychological risk factors (Espie, 2002). However, many different contextual and social factors such as ethnicity (e.g. Yip et al., 2019), SES (e.g. Mezick et al., 2008), and social relationships (e.g. Troxel et al., 2007) may contribute to sleep outcomes.

Sleep requires feeling physically and emotionally safe, which serves to down-regulate awareness and vigilance to the external world. Social relationships have an evolutionarily adaptive function of providing such a context (Dahl, 1996; Dahl & El-Sheikh, 2007; Troxel et al., 2009). Interpersonal security contributes to psychophysiological responses that could impact sleep onset and quality (Palagini et al., 2018). For instance, partner responsiveness, as a characteristic of interpersonal security, predicts lower arousal and consequently contributes to better sleep outcomes (Selcuk et al., 2017). Additionally, for most adults, sleep is a dyadic behavior. Seventy percent of American adults regularly sleep with a bed partner (National Sleep Foundation, 2013), making this a critical relationship context in which to explore social processes that affect sleep. Sleep behaviors are usually concordant among couples with parallel bed timing, wake timing, and number of wakings (Meadows et al., 2009). Additionally, social interactions may impact sleep through their contribution to the emotion or mood states that one experiences (Troxel et al., 2007). Therefore, understanding the contribution of social relationships to sleep may help researchers better understand how social relationships impact health outcomes in order to identify and isolate potential intervention targets to reduce the burden of physical and mental illness.

Compared to men, women are more likely to have disabling conditions such as arthritis, and depression (Crimmins et al., 2011). Women also report lower levels of self-rated health and more chronic health problems than men (Denton et al., 2004). Health risks may emerge through different pathways for women compared to men. Interpersonal stressors may increase health risks

differently for women compared to men (Kiecolt-Glaser & Wilson, 2017). Compared to men, women have more sensitive physiological responses (e.g. blood pressure, cortisol levels) to relationship interactions (Kiecolt-Glaser & Newton, 2001). Similarly, the association between social relationships and sleep may differ for men and women. Yet with a few exceptions (El-Sheikh et al., 2015; Kane et al., 2014), the role of gender in the association between social relationships and sleep outcomes remains unexamined. Women report better sleep quality and have higher sleep efficiency, and longer duration of sleep on days they have engaged in more self-disclosure to their partners (Kane et al., 2014). Additionally, quality of interaction with partner is associated with following night sleep quality, sleep efficiency and sleep onset latency among women, but not men (Hasler & Troxel, 2010). Although these findings suggest that compared to men, women's sleep may be more susceptible to social interactions with partner, more research is needed to confirm this among other sources of social relationships (e.g. family and friends).

Perceived social support may contribute to more favorable sleep outcomes. Perceived social support is associated with lower clinical sleep disturbance (Chung, 2017; Kent et al., 2015; Liu et al., 2016; Stafford et al., 2017), better subjectively measured sleep outcomes (Ailshire & Burgard, 2012; Chung, 2017; Gosling et al., 2014), and better objectively measured sleep parameters (Chen et al., 2015; Troxel et al., 2010). The role of social relationships in sleep outcomes varies depending on the extent to which support and strain from a partner are included (Chen et al., 2015; Chung, 2017; El-Sheikh et al., 2015; Stafford et al., 2017). For example, a seven-day sleep study from the Midlife in the United States II (MIDUS II) study found that perceived social support from family (excluding spouse/partner) and friends predicted subjective sleep outcomes but not when sleep was measured objectively (e.g., via actigraphy) (Chung, 2017). In contrast, perceived support from one's partner (Chen et al., 2015) and total social

network, including partner, family, and friends (Troxel et al., 2010) is linked with actigraphy-measured sleep characteristics but not with subjectively measured sleep outcomes such as daily sleep disturbance (Chen et al., 2015; Troxel et al., 2010). The inconsistencies linking social support and sleep outcomes may reflect the different potential sources of social support (i.e. partner vs. friends and family).

A smaller but growing literature shows that social strain is negatively associated with sleep outcomes, indicating that relationship strain may negatively contribute to sleep outcomes. Social strain such as relationship stress, social threats, and conflicts could contribute to emotional arousal, increase individuals' vigilance, interfere with sleep onset, and negatively impact sleep outcomes (Ailshire & Burgard, 2012; Chen et al., 2015; El-Sheikh et al., 2013, 2015; Kent et al., 2015; Meadows & Arber, 2015; Rauer et al., 2010). Individuals with medium to high relationship distress with their partner experience poorer sleep compared to individuals with low distress (Meadows & Arber, 2015). Several previous studies examining the link between negative aspects of social relationships and sleep outcomes have focused on relationship aggression or intimate partner violence (El-Sheikh et al., 2013, 2015; Rauer et al., 2010). Higher aggression and violence in marital relationships predict more sleep disturbance (El-Sheikh et al., 2013, 2015; Rauer et al., 2010). Even mildly strained and demanding relationships could increase psychological distress (Durden et al., 2007) and consequently contribute to adverse sleep outcomes (Ailshire & Burgard, 2012; Chung, 2017; Gosling et al., 2014). Yet, very few studies have examined this link. Additionally, strain from other relationships such as family and friends may also increase one's stress and anxiety (Hall et al., 2000), however, the previous literature has mainly focused on relationship with partner and the contribution of other sources of social strain to sleep outcomes is still not clear.

The purpose of the present study was to extend our understanding of the association between social relationships and sleep outcomes by determining whether 1) the association between social relationships and sleep outcomes varied by the relationship source of that support or strain (spouse/partner, family, and friends), and 2) whether gender moderates those associations (Figure 1).

Methods

Participants

The present study included participants from the MIDUS II Biomarker (N = 1,255) and MIDUS Refresher Biomarker (N = 863) studies. Only participants with complete data for all the primary variables and covariates who shared a bed with a partner were included in the analysis. Because of the observed differences in objective sleep outcomes among individuals who shared a bed with their partner compared to individuals who did not in our data, the sample of this study only included the individuals who shared a bed with their partner. The final analytical sample was 989 individuals for analyses predicting clinical sleep disturbance and 282 individuals for analyses predicting sleep measured via daily diary or actigraphy.

The data for this study came from the MacArthur study on Midlife Development in the United States (MIDUS). The original MIDUS I study (1995-1996) is a national probability sample of noninstitutionalized, English-speaking adults in the contiguous United States obtained by random-digit telephone dialing. Of the 7,108 participants in MIDUS I, 4,963 individuals participated in wave II. The MIDUS II Biomarker project (2004-2009) was conducted 5 to 64 months after wave II. A subsample of these respondents participated in a seven-day daily diary and actigraphy sleep study. The MIDUS Refresher study (2011-2014; El-Sheikh et al., 2013) was conducted using a novel sample with the same methods as MIDUS II. Further details regarding

the sample and methods of the study have been reported in prior reports of the study (Ryff, 2017; Weinstein, 2017).

Procedure

Participants in the MIDUS II Biomarker and MIDUS Refresher Biomarker projects completed a self-report questionnaire for demographics and psychosocial assessments, including the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) in their two-day visit to the laboratory. After completion of the Biomarker project, participants were invited to participate in a seven-day sleep study. After completing informed consent to participate in the sleep study, participants were sent home with instructions and study materials. The instructions included completing a daily sleep diary and wearing a wrist actigraph for seven consecutive days. All studies began on a Tuesday. After completion of the study, participants mailed the study materials back to the research team.

Measures

Social Support and Strain

Social support. Perceived social support was measured using 4-items that participants answered for each of the following relationship categories a) spouse/partner, b) family members, and c) friends. An example of these items was: "How much do your (spouse/partner; family; and friends) really care about you?" Social support from spouse/partner included two additional items: (i) How much does he or she appreciate you? (ii) How much can you relax and be yourself around him or her? Participants answered all the items on a 4-point scale ranging from 1 to 4 (support items: 1= "a lot"; 4 = "not at all"). All the items were then reverse coded so that higher scores indicated higher support. To compute total social support, the partner/spouse, family, and friends scores were averaged. Internal reliability for each social support variable was high for the total

sample and the sub-sample included in daily diary and actigraphy analyses, respectively: spouse/partner support (.89 and .88), family support (.84 and .86), friend support (.87 and .88).

Social strain. Perceived social strain was measured via participant self-report on four items for each of the following relationship categories a) spouse/partner, b) family members, and c) friends. An example of these items was: "How often do your (spouse/partner, family, or friends) make too many demands on you?" Participants answered all items on a 4-point scale ranging from 1 to 4: 1 = "often", 4 = "never"). All items were then reverse coded so that higher scores indicated higher strain. To compute total social strain data, partner/spouse, family, and friends scores were averaged. Internal reliability for each strain variable was acceptable for the total sample and the sub-sample included in daily diary and actigraphy analyses, respectively: spouse/partner strain (.87 and .85), family strain (.77 and .76), and friend strain (.79 and .80).

Sleep Outcomes

Clinical sleep disturbance. Participants completed the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) on day one of the laboratory visits as part of a large questionnaire battery. This self-report instrument is a 19-item scale that assesses sleep quality over the past month. This instrument yields a total score on sleep disturbance with a possible range of 0-21 with lower scores representing better sleep (Buysse et al., 1989). A global score of five or greater indicates a likely clinical sleep disturbance (Buysse et al., 1989). This instrument is well-validated and reliable with 98.7% sensitivity and 84.4% specificity distinguishing insomnia patients versus controls (Buysse et al., 1989).

Subjective daily sleep. Subjective daily sleep was measured using a seven-day sleep daily diary, which included a morning and evening section. Participants were instructed to complete the morning questionnaire upon awakening, waiting no more than 10 minutes and the evening

questionnaire before going to sleep. An average score was computed for each daily sleep outcome across the seven days.

Daily Sleep Disturbance. Participants reported their overall quality of sleep every morning on a 5-point Likert scale (1 = "very good", 5 = "very poor") by rating: "Overall quality of sleep last night".

Light Sleep. Participants rated how deeply they slept the previous night every morning on a 5-point Likert scale (1 = "very deeply", 5 = "very lightly") by answering, "How deeply you slept last night?"

Feeling Less-rested. Participants rated how well-rested they felt every morning on a 5-point Likert scale (1 = "well-rested", 5 = "poorly rested") by answering, "How well-rested you feel this morning?"

Objective daily sleep. Each participant wore a sensor on the wrist of the non-dominant arm that allowed tracking movement (i.e. actigraphs) for seven days. The actigraph used in MIDUS was the MiniMitter Actiwatch 64. Actiwatches were programmed to begin collecting data at 7:00 am on the start day until the end of the study. The Actiware software (Versions 5 or 6) was used to detect sleep based on 30 second epochs in order to generate summary statistics about the participants' sleep (Lemola et al., 2013). To compute summary statistics about an individual's objective sleep, the Actiware software requires the rest and exclusion periods to be specified for each day in the study period. Participants completed daily diaries to indicate bedtime and rise time, which were used as start and end times for actigraphic records (Lemola et al., 2013). Rest interval was defined as time spent in bed on a given day as reported by the individual in the collection period. Start and end date and time for rest interval were collected for an individual based on their responses to the following questions: "What time did you go to bed and

begin trying to go to sleep?" and "What time did you wake up for the day and not return to sleep?", respectively. After the technology became available in 2005, in some cases, participants also used an event marker on the actiwatch to indicate bed and rise times. These markers were used when diary entries were missing for a specific day (Lemola et al., 2013). In case of incomplete information or exceptional experiences during the data collection period such as traveling to a different time zone, the cases were reviewed, and the intervals were deleted. Activity periods were also marked in order to be excluded when generating summary statistics. A more detailed explanation of the procedure of coding activity data can be found elsewhere (Ryff, 2017; Weinstein et al., 2017). Also, for a more detailed description of actigraphy data collection and scoring please see the Interuniversity Consortium for Political and Social Research (ICPSR) website (URL: http:// www.icpsr.umich.edu). Sleep efficiency, sleep onset latency, and total sleep time were computed by the Actiware program algorithms based on the rest intervals. Data for the sleep indices were averaged across the seven days of data collection.

Sleep Efficiency. Sleep efficiency, percent of time spent in bed asleep, was coded as the percentage of scored total sleep time to rest interval duration minus total invalid time for the given rest interval.

Sleep Onset Latency. Sleep onset latency, time in bed before falling asleep, was coded as the time elapsed between the start time of a given rest interval, and the following sleep start time in minutes.

Total Sleep Time. Total sleep time was coded as the total number of epochs between the start and the end time of the given interval scored as SLEEP by Actiware program multiplied by the epoch length in minutes.

Covariates

Based on the previous literature, several variables have been linked to variability in sleep outcomes such as major health events (Shankar et al., 2010), age (Ohayon et al., 2004), and working status (Lallukka et al., 2010). These variables were assessed and included as covariates in the regression model for predicting clinical sleep disturbance. In addition, the number of caffeinated drinks (Clark & Landolt, 2017), the number of alcoholic drinks (Ebrahim et al., 2013), minutes of moderate or vigorous exercise (Driver & Taylor, 2000), and minutes of napping (Dhand & Sohal, 2006) during the day were also averaged across the 7 days of data collection and included as covariates for daily diary and actigraphy sleep outcomes.

Data Analysis

All predictor and outcome variables were examined for normality and heteroscedasticity. Sleep onset latency and sleep efficiency were winsorized to three standard deviations (3SD) from the mean. 8 values were winsorized for sleep onset latency and 9 values were winsorized for sleep efficiency. To determine the main effect of total social support and social strain on clinical, daily subjective, and objective sleep outcomes, we conducted multiple regression models predicting sleep outcomes from total social support and strain while accounting for the covariates. If the association between perceived social support and strain with any of the sleep outcome variables was significant, we then examined the unique contribution of each potential source of social support and strain (i.e. spouse/partner, family, friends) as predictors of variance in each sleep outcome.

Post Hoc Analyses

In the case of a significant association between perceived social support and strain with any of the sleep outcome variables, we used a separate set of multiple regressions with different sources of social support and strain sources (i.e. spouse/partner, family, friends) to predict the

variance in sleep outcomes. More specifically, we conducted post-hoc tests in regression models where $p < .05$ for the estimated prediction of clinical, subjective, and objective sleep outcomes from total social support or total social strain. To do so, we probed total social support and/or strain to determine which social component (i.e. partner/spouse; family; friends) was driving the effect.

The Moderating Role of Gender

We then examined whether gender moderated the association between total social support and sleep outcomes, then total social strain and sleep outcomes. All predictors were mean-centered prior to the analysis. In models where the estimated interaction between support/strain and gender was reliable at $p < .05$, we estimated the association between social support or strain with sleep outcomes separately for men and women using PROCESS (Version 3.4) in SPSS (Hayes, 2012).

Results

More than half (54.4%) of our sample reported clinically meaningful sleep disturbances. There were significant bivariate associations between perceived social support and strain with clinical sleep disturbance (Table 2, all *p*s<.04), daily sleep disturbance, light sleep, feeling less-rested, and lack of alertness measured with daily diary (Table 3, all *p*s<.03).

Social support and strain as predictors of clinical sleep disturbances

The model predicting clinical sleep disturbance from total social support and strain, while controlling for the major health events, age, and employment status accounted for 3% of variance in clinical sleep disturbance as measured by PSQI, *Adj*. R^2= .03, $F(5,983)= 6.40$, $p<.001$. Greater perceived social strain was associated with higher clinical sleep disturbance, $b=.78$, $SE= .26$, $p=.003$. Among all the sources of perceived social strain, only strain from family

was significantly associated with a higher global sleep score, *b*=.71, *SE*= .21, *p*=.001. Gender did not moderate the association between social support or strain and clinical sleep disturbance.

Social support and strain as predictors of subjective daily sleep outcomes

The multiple regression models predicting daily sleep disturbance, light sleep, and feeling less-rested from total social support and strain, while controlling for all the covariates, accounted for 7% of variance in daily sleep disturbances, *Adj.* R^2= .07, *F*(9,272)= 3.51, *p*<.001, 4% of variance in sleep depth, *Adj.* R^2= .04, *F*(9,272)= 2.19, *p*=.023, and 10% of variance in feeling less-rested, *Adj.* R^2= .10, *F*(9,272)= 4.54, *p*<.001. While only greater perceived social support was significantly associated with lower daily sleep disturbances, *b*= -.30, *SE*= .10, *p*=.004, and feeling more rested, *b*= -.29, *SE*=.10, *p*=.004, both perceived social support and social strain were associated with light sleep, *b*= -.24, *SE*=.10, *p*=.022, and, *b*=.26, *SE*=.11, *p*=.023, respectively. The association between social support and strain, and subjective sleep outcomes were not uniquely driven by any relationship type (spouse/partner, family, and friends).

Gender moderated the link between perceived social support and daily sleep disturbances, *b* = -.40, *SE* = .19, *p* = .04. Women, *b* = -.57, *SE* = .16, *p* <.001, but not men, *b* = -.17, *SE* = .13, *p* = .20, who reported more social support had less daily sleep disturbances. Gender also moderated the link between perceived social strain and daily sleep disturbances, *b* = .56, *SE* = .21, *p* = .007. Specifically, higher social strain was associated with higher sleep disturbance for women, *b*=0.39, *SE*=0.15, *p*=.008, but not men, *b*=-0.16, *SE*=0.16, *p*=.31.

Gender moderated the association between perceived social strain and light sleep, *b* =.52, *SE* = .20, *p* = .01. Women, but not men with more perceived social strain reported lighter sleep, *b* =.48, *SE* = .14, *p* =.001, for women and, *b* = -.05, *SE* = .16, *p* = .77 for men. Finally, gender moderated the link between perceived social strain and feeling less-rested, *b* =.62, *SE* =

.20, p = .002. Women, but not men, with more perceived social strain reported higher average of feeling less-rested in the morning, b =.48, SE = .14, p =.001 for women and b = -.14, SE = .15, p = .35 for men. Gender did not moderate the link between perceived social support and light sleep, b = -.35, SE = .19, p = .07, or feeling less-rested, b = -.36, SE = .19, p = .056.

Social support and strain as predictors of objective daily sleep outcomes

Total perceived support and strain did not account for a significant amount of variance in sleep efficiency, sleep onset latency, and sleep time. However, gender moderated the association between social strain with objective daily sleep outcomes. Specifically, gender moderated the link between perceived social strain and sleep efficiency, b =-4.36, SE = 2.19, p = .048; higher social strain was associated with lower sleep efficiency for women, b=-4.26, SE=1.57, p=.007, but not men, b=.10, SE=1.70, p=.95[1]. Gender also moderated the link between perceived social strain and sleep onset latency, b =13.13, SE = 5.84, p = .025. Women, but not men, with more perceived social strain had higher sleep onset latency, b =9.91, SE = 4.18, p =.018 for women and b = -3.22, SE = 4.52, p = .48 for men[2].

Discussion

In this study, we characterized the association between perceived social support and strain from different sources (partner, family, and friends) with both subjective and objective sleep outcomes and investigated whether gender moderated this association. Both perceived social support and strain predicted subjectively measured sleep outcomes. Specifically, higher social support was associated with lower daily sleep disturbance, fewer daily reports of light sleep, and

[1] After excluding participants with influential values (|DFFITS|>2, n= 4), gender no longer moderated the association between social strain and sleep efficiency (b =-3.34, SE = 2.33, p = .15).

[2] After excluding participants with influential values (|DFFITS|>2, n= 14), gender no longer moderated the association between social strain and sleep onset latency (b =5.61, SE = 5.63, p = .32).

feeling more rested in the morning, while higher social strain was associated with higher clinical sleep disturbance, and more daily reports of light sleep. The associations between perceived social support with daily sleep disturbance and social strain with light sleep were only significant for women. Additionally, women with higher perceived social strain reported higher sleep disturbance, feeling less rested in the morning, lower sleep efficiency. and longer sleep onset latency. These findings have important implications for both sleep and relationship research, as well as interventions focused on social relationships.

Social support predicts day-to-day variability in subjective sleep outcomes. Consistent with previous studies (Pow et al., 2017) our findings suggest that higher social support predicts better subjective daily sleep outcomes. It is well-established that social support is related to better health and later mortality (Holt-Lunstad et al., 2010). Social support may improve sleep outcomes through different mechanisms. Perceived social support may act as a buffer in the link between daily stress and adverse sleep outcomes (Cohen, 2004). The association between social support and subjective daily sleep outcomes may suggest the importance of positive interactions with close others in order to cope with daily hassles, increase feeling confident and competent in response to the demands of daily stressors (Cohen, 2004). Social support may also facilitate the neurobiologic systems in more effective regulation of stress response (Ozbay et al., 2007), reduce the heightened physiologic arousal to daily stressful events (Cohen, 2004) and contribute to lower subjective sleep disturbance (Dahl & El-Sheikh, 2007). More research is needed to identify and isolate the mechanisms linking social support to sleep outcomes. Considering the importance of sleep as a transdiagnostic process that influences physical and mental health (Harvey, 2008; Irwin, 2015), it is important to identify modifiable determinants of sleep such as quality of social relationships to reduce the burden of physical and mental illness.

The difference in findings between clinical sleep disturbance and subjective reports of sleep parameters, measured by daily diary, may indicate that daily diary is a more sensitive measure of the role of interpersonal factors in sleep quality and sleep problems. Clinical sleep disturbance, measured by PSQI, is used in medical settings as a screening measure to identify people with insomnia and other sleep disorders (Buysse et al., 1989) and the daily diary approach provides more nuanced characterizations of the antecedents and consequences of sleep outcomes (Kalmbach et al., 2017; Pillai et al., 2014). Improving social support may be particularly important to prevent daily sleep disturbances in order to interrupt the pathogenesis of illness states such as insomnia. Future research may benefit from experimentally studying the contribution of social support to sleep outcomes, as a transdiagnostic outcome impacting health, in order to identify the modifiable determinants of sleep.

Strain in relationships as a source of stress may contribute to emotional and physiological arousal, interfere with sleep onset, and decrease sleep quality (Dahl, 1996) and therefore, have detrimental effects on health and well-being (Hall et al., 2000). We observed a positive association between social strain and clinical sleep disturbance. Gender did not moderate this association. However, the association between perceived social strain with daily subjective and objective sleep outcomes varied as a function of gender. Specifically, only among women, perceived social strain was associated with daily sleep disturbance, daily reports of light sleep, and feeling less-rested, lower sleep efficiency and longer sleep onset latency. Subjective and objective sleep outcomes are important risk factors for insomnia, depressive and anxiety symptoms (Kalmbach et al., 2017) and prevention, early detection and treatment of sleep disturbance may interrupt this cycle at early stages. Overall, compared to men, women report more subjective sleep problems (Friedman, 2011; van den Berg et al., 2009) and are at greater risk

for various mental health problems such as depression (Kessler et al., 2005). This gender difference is consistent with previous research showing that gender-related differences such as interpersonal stressors may increase mental and physical health risks for women compared to men (Hasler & Troxel, 2010; Kiecolt-Glaser & Wilson, 2017). Based on our findings, it is plausible that women may benefit more from interventions targeting social strain and conflict to improve subjectively measured sleep outcomes. The association found between perceived social strain and day-to-day subjective and objective sleep outcomes among women may reflect arousal (e.g. post-conflict rumination) in response to perceived strain (e.g. Ebrahim et al., 2013; Driver & Taylor, 2000). The association between strain and sleep may indicate deficiency in recovery of nervous and biological systems that regulate stress response (Kalmbach et al., 2017). In other words, social strain and conflict may contribute to rumination as a hyperactivating emotion regulation strategy (Mikulincer et al., 2003), amplify arousal in nervous and biological systems and delay their recovery from stress, which in turn impacts sleep outcomes. Future research may benefit from investigating the moderating role of gender in the impact of social strain on magnitude and duration of physiological arousal, particularly in the context of sleep-onset latency. Interestingly, gender did not significantly moderate the association between social strain and clinical sleep disturbance. In other words, men appear to be also vulnerable to social strain when looking at clinical sleep outcomes. This finding may indicate that although there was no association between strain and day-to-day sleep outcomes among men, in the long-term, chronic social strain such as relationship stress may still contribute to adverse sleep outcomes in men as well.

When we probed the association between social strain from partner, family, and friends and clinical sleep disturbance, only the strain from family contributed to the higher clinical sleep disturbance. This is consistent with another study from MIDUS showing a positive association

between perceived strain from family and clinical sleep disturbance (Ailshire & Burgard, 2012). However, this study only examined the association between perceived strain from family and sleep outcomes. Our findings add to the previous literature by showing that perceived strain from family may predict clinical sleep disturbance above and beyond perceived strain from other close relationships. Family relationships in this study included an individual's relationship with family members (both origin and current family members, excluding spouse/partner). Demanding family relationships may add to the problems and stressors that one experience, lead to greater stress and anxiety (Hall et al., 2000) and impact sleep and physical and mental health. Future research may benefit from experimentally manipulating social strain and assessing sleep outcomes in order to investigate how different relationships uniquely contribute to sleep outcomes. In addition, it would be interesting to differentiate among family members in order to identify the source of influence of social strain – in order to investigate whether social strain deriving from children is more harmful than social strain from parents or siblings, for instance.

Limitations

This study should be interpreted in the context of its limitations. First, this study is limited by its cross-sectional design. Whether social support and strain are causally linked to sleep outcomes remains unknown; it is plausible that the association between social relationships and sleep is bidirectional. Sleep parameters such as disrupted sleep and daytime fatigue could also contribute to lower relationship quality (Ben Simon et al., 2020; Brooks Holliday & Troxel, 2017). It is important to note that the interaction between strain and gender were non-significant for sleep efficiency and sleep onset latency after removing a small number of influential participants from the analysis. This may suggest that there are additional factors to consider in these processes. The sample, although diverse in age and sex, was not diverse in race and

ethnicity thereby limiting the generalizability of findings regarding these important demographic factors. This limitation is relevant to sleep research because, for example, African Americans compared to Caucasian Americans have poorer sleep continuity and duration (Yip et al., 2020). Whether social support and strain can explain this racial and ethnic differences remains unknown. Finally, the average age of our sample was 52.95 years (*SD*=12.13). Considering specific, and adaptive roles of social relationships in different lifespan contexts (Mikulincer et al., 2003) and changes in sleep quality and duration across the lifespan (Buysse et al., 1989) we do not expect the association between social relationships and sleep outcomes to be constant across the lifespan.

Conclusion

Quality and quantity of social relationships may be a modifiable factor to target for the benefit of sleep and overall health. The contribution of contextual and social factors such as ethnicity, SES, diversity and quality of social relationships to sleep outcomes are largely neglected. Social relationships are associated with an important transdiagnostic outcome, sleep, which may have implications for a wide range of health disparities. Improved sleep outcomes may enhance daily functioning, physical health (During & Kawai, 2017; Irwin, 2015), and mental health outcomes (Harvey, 2008). In light of our results, mainly among women, quality of social relationships is associated with sleep outcomes. Social relationships may impact health risks differently for women compared to men and one mechanism that may link social relationships to long-term health outcomes is sleep. If supported with future experimental studies, these findings may have important implications for identifying potential intervention targets for improvement of mental and physical health.

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Tables

Table 1
Sociodemographic Characteristics of Participants

	Global sleep score			Global sleep score and share bed			Daily diary and actigraphy			Daily diary and actigraphy and share bed		
	M(SD)	*n*	*%*	*M(SD)*	*n*	*%*	*M(SD)*	*n*	*%*	*M(SD)*	*n*	*%*
Gender												
Male		624	52		516	52.2		168	50		141	50
Female		575	48		473	47.8		168	50		141	50
Marital status												
Married		1110	92.6		945	95.6		318	94.6		272	96.5
Separated		13	1.1		2	.2		1	.3		1	.4
Divorced		43	3.6		20	2.0		10	3.0		4	1.4
Widowed		4	.3		2	.3		0	0		0	0
Never married		29	2.4		19	1.9		7	2.1		5	1.8
Age	53.84 (12.28)			52.95 (12.13)			52.46 (12.19)			51.25 (11.98)		
Share bed with partner[a]		989	82.5		989	100		282	83.9		282	100
Highest level of education												
< high school		29	2.4		20	2		13	3.9		11	3.9
GED or graduated from high school		208	17.3		168	17		66	19.6		53	18.8
Some college		326	27.2		262	26.5		100	29.8		81	28.7
Bachelor's degree		308	25.7		253	25.6		84	25		73	25.9
Some graduate school or graduate degree		326	27.2		284	28.7		73	21.7		64	22.7
Employment status												
Currently employed		659	55		558	56.4		184	54.8		165	58.5
Not employed		540	45		431	43.6		152	45.2		117	41.5
Number of health events	.96 (1.24)			.96 (1.25)			.79 (1.07)			.75 (1.04)		
0		619	51.6		516	52.2		182	54.2		157	55.7
1		263	21.9		206	20.8		83	24.7		68	24.1
2		141	11.8		119	12		42	12.5		35	12.4
3		100	8.3		86	8.7		17	5.1		14	5
4		76	6.3		62	6.3		12	3.6		8	2.8

Note: [a] Reflects the number and percentage of participants answering "yes" to this question.

Table 2

Means, standard deviations and correlations between social variables and clinical sleep disturbance

			Correlations								
		M(SD)	1	2	3	4	5	6	7	8	9
	Perceived support										
1.	Total	3.49 (.42)	1								
2.	Partner	3.64 (.51)	.66**	1							
3.	Family	3.52 (.59)	.78**	.31**	1						
4.	Friends	3.32 (.61)	.75**	.21**	.37**	1					
	Perceived strain										
5.	Total	1.97 (.42)	-.41**	-.43**	-.33**	-.17**	1				
6.	Partner	2.13 (.61)	-.46**	-.65**	-.25**	-.15**	.73**	1			
7.	Family	2.00 (.58)	-.27**	-.15**	-.34**	-.10**	.78**	.29**	1		
8.	Friends	1.77 (.48)	-.17**	-.11**	-.14**	-.12**	.74**	.28**	.48**	1	
9.	Clinical sleep disturbance	5.45(3.14)	-.11**	-.08*	-.10**	-.06	.14**	.08**	.16**	.06*	1

Note: † $p<.10$.
* $p<.05$.
** $p<.01$.

Table 3

Means, standard deviations and correlations between social variables and daily diary and actigraphy sleep indicators

		Correlations													
	M(SD)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Perceived support															
1. Total	3.48 (.43)	1													
2. Partner	3.65 (.49)	**.66****	1												
3. Family	3.48 (.63)	**.78****	**.31****	1											
4. Friends	3.31 (.63)	**.76****	**.26****	**.35****	1										
Perceived strain															
5. Total	2.0 (.39)	**-.42****	**-.37****	**-.36****	**-.21****	1									
6. Partner	2.13 (.58)	**-.56****	**-.58****	**-.26****	**-.23****	**.67****	1								
7. Family	2.06 (.56)	**-.27****	-.10†	**-.37****	-.09	**.78****	**.21****	1							
8. Friends	1.82 (.48)	**-.15****	-.07	**-.13***	-.12†	**.73****	**.18****	**.48****	1						
Daily diary measured sleep outcomes															
9. Sleep disturbance	2.36 (.70)	**-.24****	**-.17****	**-.19****	**-.17****	**.17****	**.16****	.11†	.11†	1					
10. Light sleep	2.22 (.67)	**-.21****	**-.14***	**-.17****	**-.16****	**.20****	.10†	**.18****	**.16****	**.84****	1				
11. Less-rest	2.37 (.68)	**-.25****	**-.23****	**-.19****	**-.13***	**.21****	**.24****	**.13***	.08	**.85****	**.67****	1			
Actigraphy measured sleep outcomes															
12. Sleep efficiency	83.45 (7.56)	.005	.03	.03	-.05	-.06	-.13*	.01	-.01	-.04	-.07	-.01	1		
13. Sleep onset latency	22.65 (19.51)	-.001	.004	-.05	.05	.03	.03	.03	.01	-.01	.01	-.01	**-.73****	1	
14. Sleep time	386.25 (62.38)	0.0	.02	0.0	-.02	.01	-.11†	.07	.09	.01	-.01	.02	**.59****	**-.35****	1

Note: † $p<.10$.
* $p<.05$.
** $p<.01$.

Table 4
Adjusted estimates predicting clinical sleep disturbance from perceived social support and strain, gender, and their interactions

	Clinical Sleep Disturbance			
	b(SE)	*p*	95% CI	
Model 1[a]			*LL*	*UL*
Total perceived support	-.57 (.31)	.07	-1.20	.06
Gender	.91 (.21)	<.001	.50	1.31
Total perceived support * Gender	-.24 (.48)	.62	-1.19	.71
R^2	.05			
F	7.41	<.001		
Model 2[b]				
Total perceived strain	.60 (.35)	.09	-.09	1.30
Gender	.89 (.20)	<.001	.49	1.29
Total perceived strain * Gender	.14 (.47)	.77	-.79	1.06
R^2	.05			
F	7.38	<.001		

Note: n=989; [a] Adjusted for social strain, major health events, age, employment status
[b] Adjusted for social support, major health events, age, employment status

Table 5

Adjusted estimates predicting subjective daily sleep outcomes from perceived social support and strain, gender, and their interactions

	Daily Sleep Disturbance				Light Sleep				Less rested			
	b(SE)	*p*	95% CI		*b(SE)*	*p*	95% CI		*b(SE)*	*p*	95% CI	
Model 1[a]			*LL*	*UL*			*LL*	*UL*			*LL*	*UL*
Total perceived support	-.17 (.13)	.20	-.43	.09	-.12 (.13)	.33	-.38	.13	-.17 (.13)	.17	-.42	.07
Gender	.12 (.09)	.20	-.06	.30	.11 (.09)	.23	-.07	.29	.10 (.09)	.25	-.07	.28
Total perceived support * Gender	-.40 (.19)	.04	-.78	-.02	-.35 (.19)	.07	-.73	.03	-.36 (.19)	.06	-.73	.01
R^2	.12				.08				.14			
F	3.38	<.001			2.19	.015			4.14	<.001		
Model 2[b]												
Total perceived strain	-.16 (.16)	.31	-.48	.15	-.05 (.16)	.77	-.35	.26	-.14 (.15)	.35	-.44	.16
Gender	.09 (.09)	.34	-.09	.26	.08 (.09)	.36	-.09	.25	.07 (.09)	.41	-.10	.24
Total perceived strain * Gender	.56 (.21)	.007	.15	.97	.53 (.20)	.01	.13	.92	.62 (.20)	.002	.23	1.01
R^2	.13				.09				.16			
F	3.68	<.001			2.52	.005			4.79	<.001		

Note: n=282; [a] Adjusted for social strain, major health events, age, employment status, number of caffeinated drinks, number of alcoholic drinks, minutes of moderate or vigorous exercise, and length of nap time (minutes)

[b] Adjusted for social support, major health events, age, employment status, number of caffeinated drinks, number of alcoholic drinks, minutes of moderate or vigorous exercise, and length of nap time (minutes)

Table 6

Adjusted estimates predicting daily sleep disturbance from different sources of perceived social support and total social strain

	Daily sleep disturbance			
	b(SE)	*p*	95% CI	
			LL	*UL*
Support from partner	-.12 (.09)	.21	-.37	.09
Support from family	-.10 (.07)	.18	-.27	.06
Support from friends	-.09 (.07)	.21	-.23	.06
Total perceived strain	.15 (.12)	.19	-.11	.38
R^2	.10			
Adj. R^2	.07			
F	2.8	.001		

Note: Adjusted for major health events, age, employment status, number of caffeinated drinks, number of alcoholic drinks, minutes of moderate or vigorous exercise, and length of nap time (minutes)

Table 7

Adjusted estimates predicting clinical sleep disturbance and subjective daily sleep outcomes from different sources of perceived social support and strain

	PSQI				Light sleep				Less rest			
	b(SE)	*p*	95% CI		*b(SE)*	*p*	95% CI		*b(SE)*	*p*	95% CI	
			LL	*UL*			*LL*	*UL*			*LL*	*UL*
Support from partner	-.17 (.26)	.53	-.69	.33	-.12 (.10)	.26	-.41	.14	-.14 (.10)	.16	-.45	.12
Support from family	-.18 (.19)	.35	-.53	.17	-.07 (.08)	.32	-.24	.09	-.08 (.07)	.30	-.25	.08
Support from friends	-.12 (.17)	.50	-.46	.24	-.10 (.07)	.15	-.25	.05	-.05 (.07)	.45	-.20	.11
Strain from partner	.11 (.22)	.61	-.34	.57	-.03 (.09)	.72	-.23	.14	.16 (.09)	.056	-.03	.34
Strain from family	.71 (.21)	.001	.31	1.11	.13 (.09)	.13	-.05	.33	.03 (.09)	.72	-.13	.21
Strain from friends	-.13 (.24)	.59	-.58	.35	.13 (.09)	.18	-.07	.31	.02 (.09)	.83	-.17	.20
R^2	.04				.07				.14			
Adj. R^2	.03				.03				.10			
F	4.26	<.001			1.70	.06			3.42	<.001		

Note: Adjusted for major health events, age, employment status, number of caffeinated drinks, number of alcoholic drinks, minutes of moderate or vigorous exercise, and length of nap time (minutes)

Figures

Figure 1
Theoretical Model

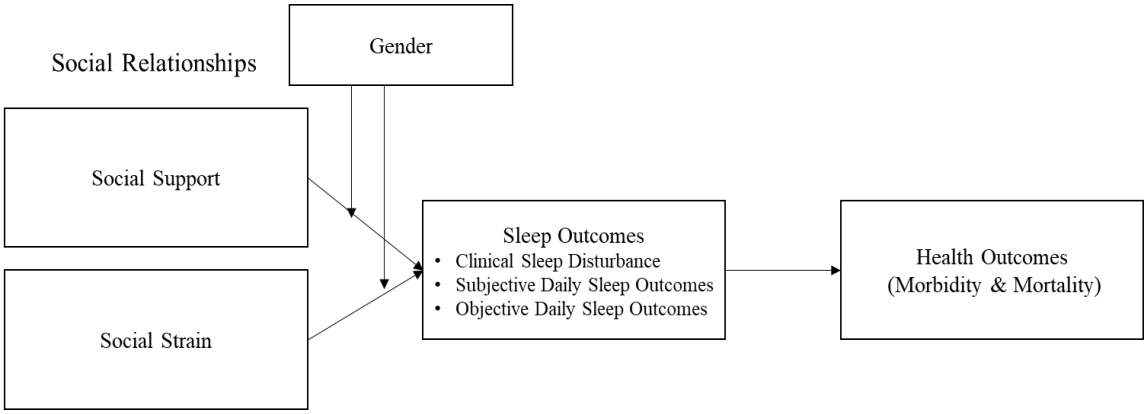

Figure 2
Flow of Participants

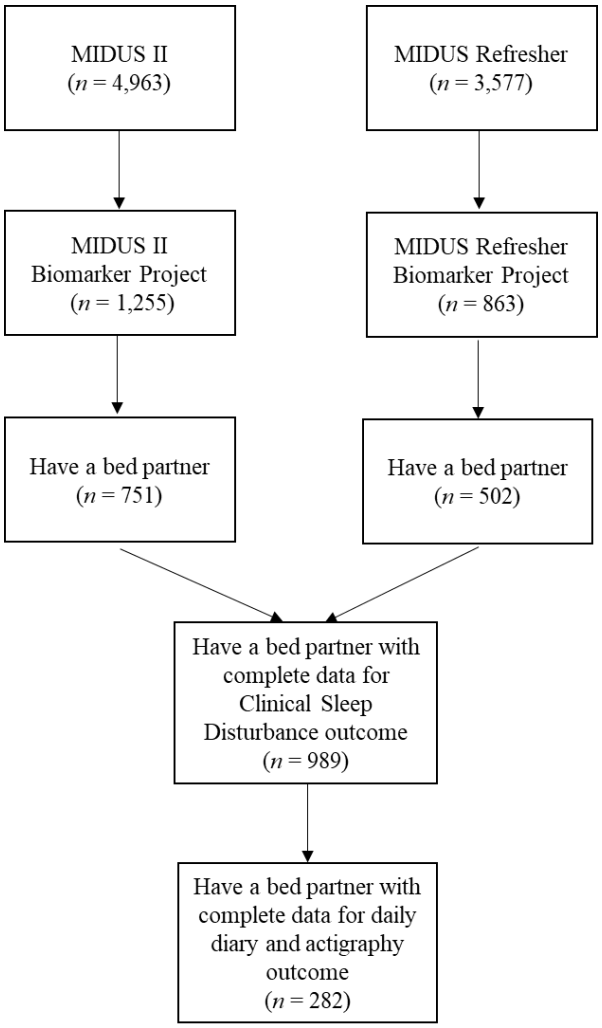

Figure 3

Moderating role of gender in the relationship between social support and strain and daily sleep outcomes.