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THE RELATIONSHIP BETWEEN SLEEP AND WORK: A META-ANALYSIS

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF PSYCHOLOGY

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Abstract

Sleep has tremendous importance to organizations as a predictor of employee performance, safety, health, and attitudes. Moreover, sleep is a malleable behavior that may be improved by individual and organizational changes. Despite sleep's consequential and modifiable nature, little consensus exists regarding its conceptualization or role in causal models of organizational antecedents and consequences. To fill this gap in theoretical knowledge, this study calculated meta-analytic correlations and tested a meta-analytic path model with data obtained from 99 primary studies of sleep among workers in organizations. Meta-analytic correlation identified sleepiness, sleep quality, and sleep quantity as associated with a number of forms of job demands, job control, and job support. Each sleep variable was also associated with a number of individual characteristics, health outcomes, and attitudinal outcomes. Small to moderate relationships were found between the three sleep variables themselves. As a result, a meta-analytic path model was tested that identified all three sleep variables as mediators of the effects of job demands, job control, and job support on important outcomes, like depression, physical strain, job satisfaction, and work-family conflict. The implications of these findings for intervening in organizations and advancing future sleep research are discussed.

The Relationship between Sleep and Work: A Meta-Analysis

The quantity and quality of a person's sleep has major implications for cognitive performance (Lim & Dinges, 2010), motor functioning (Durmer & Dinges, 2005) mental health (Benca, Obermeyer, Thisted, & Gillin, 1992), and long-term physical health (Strine & Chapman, 2005). Nonetheless, findings from a recent national level survey reveal that 37% percent of employed Americans average less than 7 hours of sleep a night, 34% of employed Americans fell asleep unintentionally during the past 30 days, and 5% of employed Americans fell asleep while driving during the past 30 days (Mcknight et al., 2011). In response to this discordance between the essential value of sleep and the amount of sleep received by workers, occupational health researchers have examined sleep with increasing frequency (Kucharcyk, Morgan, & Hall, 2012). Though these individual studies have produced many useful findings, a comprehensive understanding of the importance of sleep to workplace behavior has yet to emerge. The development of a broader understanding of the relationship between sleep and work has been impeded by differences across studies related to the conceptualization of sleep, the method used to study sleep, and examination of sleep as only a theoretical predictor or criterion.

These impediments to the development of a comprehensive model of the relationship between sleep and work informed the goals of this study. Patterned off of the research approach used by Christian, Wallace, Bradley, and & Burke (2009) to study workplace safety, this meta-analysis had four goals. First, the study resolved definitional discrepancies by providing clear conceptualization of the most widely studied sleep constructs. Second, this study reviewed existing research to classify work

related antecedents and outcomes of the most widely studied sleep constructs. Third, this study reconciled differences in theoretical relationships among widely studied sleep variables by meta-analytically estimating the relationships between sleep quantity, sleep quality, and sleepiness. Fourth, this study identified the importance of these variables to a number of organizational antecedents and outcomes by testing a multiple mediator meta-analytic path model.

Conceptualizing Sleep

Sleep is most frequently described as a state of immobility that consists of greatly diminished physical responsiveness and is more rapidly reversible than anesthesia or coma (Siegel, 2005). Although questions still exist about the function and mechanisms of sleep, sleep does appear to be an actively regulated activity that allows for reorganization of neural activity (Hobson, 2005). The prevailing theory of sleep regulation states that two processes play dominant roles in sleep regulation: sleep-dependent processes and sleep-independent processes (Borbély, 1982; 2009). Sleep-dependent regulating processes are homeostatic in nature and consist of a need to sleep that accumulates during prolonged wakefulness and is met during sleep. Sleep-independent regulating processes are circadian in nature and consist of internal bodily processes that regulate when a person feels sleepy.

Relevant to occupational research, allostatic processes that regulate sleep may allow physiological adjustments that temporarily overwhelm homeostatic and circadian drives for sleep in response to demanding environmental conditions (Saper, Scammel, & Lu, 2005). Allostasis refers to physiological changes made to achieve homeostasis. An example of an allostatic process occurs when adrenaline or cortisol is produced by

the body to promote adaptation to a stressor. Research regarding allostatic systems within the human body suggests that a variety of allostatic systems help people cope effectively with environmental stress. Nonetheless, these allostatic systems can lead to disease or distress when they are overused or fail to shut off after exposure to a stressor (McEwen, 1998). As a result, environmental stressors that require the adjustment of homeostatic and circadian sleep regulating processes may have long-term consequences. The physiological consequences of disrupted homeostatic and circadian sleep regulating processes underscore the influence of physiology on subjective perceptions of workplace sleepiness (DeArmond and Chen, 2009).

Research on the implications of sleep for organizations has generally conceptualized sleep as best represented by one of three variables: sleep quality, sleep quantity, and workplace sleepiness. Workplace sleepiness describes how sleepy a person feels during their time at work (DeArmond & Chen, 2007). Measures of sleepiness used with occupational samples typically ask respondents to rate the probability that they would fall asleep in different situations (Johns, 1991) or rate the severity of various sleepiness symptoms (Hoddes, Dement, & Zarcone, 1972). Workplace sleepiness appears to be stable across workdays in a given week (DeArmond & Chen, 2007). Often, workplace sleepiness may be measured as fatigue. Fatigue refers to a biological drive for recuperative rest that can take the form of subjective feelings of sleepiness (Williamson et al., 2011). As such, measures of fatigue that assess subjective needs for sleep ultimately measure workplace sleepiness.

Like workplace sleepiness, sleep quality has an inherently subjective component. Sleep quality consists of quantitative aspects of sleep, such as sleep

duration and number of awakenings, as well as subjective components, such as degree of restfulness (Harvey, Stinson, Whitaker, Moskovitz, & Virk, 2008). Sleep quality is typically assessed with self-report measures (e.g., Buysse, Monk, Reynolds, Berman, & Kupfer, 1989). Sleep quality may often be measured with an assessment of insomnia symptoms. Insomnia is a categorical sleep disorder that is defined in the Diagnostic and Statistical Manual of Mental Disorders as dissatisfaction with sleep quality or sleep quantity associated with difficulty initiating sleep, maintaining sleep, or early morning awakenings with an inability to return to sleep (American Psychiatric Association, 2013). Additional symptoms of insomnia include clinically significant distress or impairment in an important area of functioning, a problem frequency of at least three nights a week, duration of at least three months, and difficulty despite adequate opportunity for sleep. The categorization of insomnia as sleep quality or sleep quantity depends largely on the nature of the measure used to assess insomnia. The inclusion of subjective and objective components in the definition of sleep quality, though, makes insomnia measures more likely to be measures of sleep quality.

Unlike the more subjective constructs of sleep quality and sleepiness, sleep quantity describes the amount of time an individual spends in a sleeping state (Barnes, 2012). Research about sleep quantity suggests that adults should sleep seven to nine hours every night to function optimally at work (National Sleep Foundation, 2009). National level survey findings showing that 30% of Americans to get less than six hours sleep (Luckhaupt, Tak, & Calvert, 2010) and that Americans sleep less on work nights (National Sleep Foundation, 2008) underscore the centrality of sleep quantity to feelings of sleepiness at work. Often, sleep quantity is measured dichotomously as sleep

deprivation. Sleep deprivation describes a condition of inadequate sleep that can be either acute or chronic in nature (Pilcher & Huffcut, 1996). This characteristic of inadequate sleep is equivalent to low sleep quantity.

Little understanding exists regarding the relationship between sleep quantity, sleep quality, and sleepiness among workers in organizational settings. Sleep is most frequently described as a state of immobility that consists of greatly diminished physical responsiveness and is more rapidly reversible than anesthesia or coma (Siegel, 2005). Although questions still exist about the function and mechanisms of sleep, sleep does appear to be an actively regulated activity that allows for reorganization of neural activity (Hobson, 2005). The prevailing theory of sleep regulation states that two processes play dominant roles in sleep regulation: sleep-dependent processes and sleep-independent processes (Borbély, 1982; 2009). Sleep-dependent regulating processes are homeostatic in nature and consist of a need to sleep that accumulates during prolonged wakefulness and is met during sleep. Sleep-independent regulating processes are circadian in nature and consist of internal bodily processes that regulate when a person feels sleepy. Relevant to occupational research, allostatic processes that regulate sleep may allow physiological adjustments that temporarily overwhelm homeostatic and circadian drives for sleep in response to demanding environmental conditions (Saper, Scammel, & Lu, 2005). Allostasis refers to physiological changes made to achieve homeostasis. An example of an allostatic process occurs when adrenaline or cortisol is produced by the body to promote adaptation to a stressor. Research regarding allostatic systems within the human body suggests that a variety of allostatic systems help people cope effectively with environmental stress. Nonetheless, these allostatic systems can

lead to disease or distress when they are overused or fail to shut off after exposure to a stressor (McEwen, 1998). As a result, environmental stressors that require the adjustment of homeostatic and circadian sleep regulating processes may have long-term consequences. The physiological consequences of disrupted homeostatic and circadian sleep regulating processes underscore the influence of physiology on subjective perceptions of workplace sleepiness (DeArmond and Chen, 2009).

Although the same physiological processes may underlie workplace sleepiness sleep quality, and sleep quantity, notable differences exist in the operationalization of each sleep construct. The widespread use of many different sleep constructs impedes the development of theory regarding the antecedents and consequences of sleepiness in organizational settings (Kucharczyk et al., 2012). This study will attempt to bridge past research about workplace sleepiness, sleep quality, and sleep quantity. Specifically, the relationship of workplace sleepiness, sleep quality, and sleep quantity to each other and a number of antecedents and consequences will be examined separately with meta-analytic correlations. Additionally, this study will use meta-analytic path modeling techniques to assess how sleep quality and sleep quantity contribute to feelings of sleepiness at work.

Sleep and Work: A Conceptual Model

Despite its importance, only one conceptual model of the organizational antecedents and consequences of sleep has been proposed. Krauss, Chen, DeArmond, and Moorcraft's (2003) model identifies workplace sleepiness as a mediator. In their review of existing literature, the authors identified workplace sleepiness as a variable that generally transmits the effects of individual and organizational antecedents to

individual and organizational level consequences (Krauss et al, 2003). A decade of additional research has clarified the relationship of workplace sleepiness with these general antecedent and consequence categories and provided more specific constructs for each general category. Additionally, increases in organizational sleep research provided a sufficient number of studies to differentiate sleepiness, sleep quality and sleep quality in a causal model.

A revised version of Krauss et al.'s (2003) model guides our organization of literature and study of construct relations (See Figure 1). Our model presents five categories of organizational outcomes affected by sleep: performance outcomes, safety outcomes, health outcomes, affective outcomes, and attitudinal outcomes. These five categories are distinct because each consequence of sleep may be differentially affected by sleepiness, sleep quality, and sleep quantity. For example, this model posits that affective outcomes could mediate the relationship between sleep and related attitudinal outcomes. In our categorization of the consequences of sleep, we also introduced new constructs that reflect recent findings in sleep literature. Organizational and individual antecedents of sleep also receive attention in this conceptual model. Categories of organizational antecedents include job demands, job control, and job support. Individual characteristics refer to variety of individual traits (i.e. age) and behaviors (i.e., tobacco use) that may influence the effects of demands on sleep. These antecedents are included in a conceptual model that proposes that sleepiness, sleep quality, and sleep quantity can explain how job demands, job control, and job support, affect widely studied consequences of sleep.

Organizational Antecedents

In the model, organizational antecedents refer to variables specific to an organizational environment or job that have been found to affect employee sleep. A 2004 meta-analysis of 27 studies identified occupational stressors, role ambiguity, role conflict, workload, interpersonal conflict, situational constraints, and perceived control as correlates of workplace sleepiness (DeArmond & Chen, 2004). Our model expands upon these meta-analytic correlations by using contemporary job stress theory to examine the effects of organizational antecedents on workplace sleepiness, sleep quality, and sleep quantity. Specifically, our model uses the Job-Demand-Control-Support model (JDCS; Johnson & Hall, 1988) to classify the effects of different organizational antecedents on employee sleep. The JDCS model has been used extensively to examine various job strain outcomes (Van der Doef & Maes, 1999). Job strain refers to workers' psychological and physical reactions to work-related environmental conditions (Hurrell, Nelson, Simmons, 1998). In research examining the JDCS model, sleep is often examined as a strain outcome along with a number of other specific physical (e.g., musculoskeletal pain), psychological (e.g., depression) or general (e.g., overall physical pain) strain outcomes

The JDCS model posits that job demands, job control, and job support predict both positive (e.g., motivation) and negative work outcomes (e.g., strain). For example, high demands, lower control, and lower support increase the probability of higher strain outcomes (Ganster & Perrewé, 2011). Recent meta-analytic findings from thirty years of JDCS research support the value of the model for conceptualizing work environments and predicting a number of important performance and organizational

outcomes (Luchman & Gonzalez-Morales, 2013). Frequently used definitions for each component of the JDCS model provide understanding for how to model the effects of organizational antecedents on employee sleep.

In its earlier iteration, job demands referred primarily to psychological stressors related to task performance (Karasek, 1979). For example, constructs such as workload, time pressure, and task complexity were examined as job demands in earliest job demands research (Van der Doef & Maes, 1999). Follow-up studies, though, identified that physical demands associated with a job, such as the physical work environment (Andries, Kompier, & Smulders, 1996) or situational safety constraints (Snyder, Krauss, Chen, Finlinson, & Huang, 2008), were better predictors of health and safety outcomes for some high-risk professions. A review of existing organizational sleep research identified several specific examples of particular job demands that have been examined as predictors of employee sleep. General job demands (e.g., Landsbergis, 2008), shift work (e.g., Takahashi et al., 2008), number of hours worked per week (e.g., Blau 2011), environmental hazards (e.g., Lalluka, Rahkonen, Lahelma, & Arber, 2010), job complexity (Zohar, 1999), and workplace aggression (e.g., Niedhammer, David, Degioanni, Drummond, & Philip, 2009) have all been examined in multiple studies as demands that predict sleepiness, sleep quality, or sleep quality. Although little theory has been proposed to determine why these hazards positively correlate with these sleep variables, two potential explanations exist. One, job demands may simply reduce the amount of time that people have to sleep. Two, job demands may disrupt the homeostatic or circadian processes that regulate sleep by increasing people's need for

sleep or causing sleep disrupting physiological changes (i.e., increased cortisol secretion).

Like job demands, job control has also been frequently used to predict employee sleep. Control describes the perceived ability of employees to alter their work environment, work activities, and outcomes of work activities (Karasek, 1979). Self-report measures of job control are most predictive of job outcomes when they reflect specific job demands or occupational contexts (Wall, Jackson, Mullarkey, & Parker, 1996). As a result, job control is often operationalized as consisting of decision authority and skill discretion or autonomy in job stress research (Rafferty & Friend, 2001). Decision authority refers to the amount of freedom that employees have to make decisions regarding the way they work (Ganster & Fusiler, 1989). Autonomy assesses the extent to which a job allows freedom to make decisions about the time of job tasks and select the method used to perform job tasks (Hackman & Oldman, 1975). Although job control has minimal relationship with workplace demands (Luchman & Gonzalez-Morales, 2013), job control may still prevent a job from disrupting sleep. Employees with greater control can change their work environment and work processes to reduce strain (Spector, 2002) and preserve valued resources (Hobfoll, 1991). The capability to make changes enabled by higher control may allow employees to prevent demands from impeding on sleep time or disrupting sleep regulating processes.

Job support represents another component of the JDCS model that may improve employee sleep outcomes. In the prediction of work outcomes, the effects of job support are generally independent of the effects of job control (Luchman & Gonzalez-Morales, 2013). In the JDCS model, support reflects social support provided by co-workers,

supervisors, or the larger organization (Bakker & Demerouti, 2007). Co-worker support (Gadinger et al., 2009), supervisor support (Jansson & Linton, 2006), and organizational support (Diaz-Ramiro, Rubio-Valdehita, Luceno-Moreno, & Martin-Garcia, 2010) have all been examined multiple times as predictors of employee sleep outcomes. In addition to these three levels of organizational support, safety climate has also been identified a specific high level support construct in JCDC model (Snyder et al., 2008). Although safety climate can be measured at multiple levels, at the group or organizational level it describes "shared perceptions with regards to safety policies, procedures and practices" (Zohar 2011, p. 143). Other more specific forms of support may also reduce the risk of workplace sleepiness. In general, support's role in improving employee sleep outcomes may reflect its role as a buffer that helps people cope with stress (Nordin, Knutsson, Sunbom, & Stegmayr, 2005). Factors that may interrupt sleep regulating processes, such as physiological reactions have been shown to stabilize more quickly after returning home from a supportive work environment (Rau, Georgiades, Fredriksson, Lemne, & de Faire, 2001).

Individual Antecedents

Unlike organizational antecedents of sleepiness, individual characteristics have received comparatively little attention. The only existing model predicts that some individual differences, such as neuroticism and self-efficacy, may influence how people choose to cope with stimuli in the work environment and thereby moderate the relationship between environmental stimuli and sleep (DeArmond & Chen, 2009). Despite this lack of theory, several salient individual characteristics have been identified repeatedly as significant correlates of workplace sleepiness. These individual

characteristics include chronological age (e.g., Winwood & Lushington, 2006), family responsibilities (e.g., Querstret & Cropley, 2012), and the personality trait of negative affectivity (e.g., Parkes, 2002). Theory regarding each of these individual characteristics explains its importance to sleep and its potential role as moderator of the effects of job demands.

Chronological age is a continuous variable that represents the amount of time that has passed since a person's birth (Barnes-Farrell 2005). A number of age differences in sleep behavior exist. As people age, changes occur in their sleep regulating processes. Specifically, people's period of peak sleepiness shifts earlier after young adulthood and the amount of time people spend in the non-rapid eye movement and overall sleep diminish with age (Moorcroft & Belcher, 2005). Age related changes in sleep quantity have been identified as a possible explanation for age related increases in cognitive decline and cardiovascular disease risk (Prinz, 2004). In occupational samples, workplace sleepiness and chronological age have been found to be positively related (Lee, 1992). For jobs that contain shift work demands, age has been identified as a positive predictor of insufficient sleep (Chan, 2008). Consistent with theory about the effects of age on sleep, older workers have been found to have more difficulty adjusting to shift work than younger workers (Parkes, 1994). Age related effects of other job demands on sleepiness have received little attention, but sleep-related theory suggests that age may influence the impact of many different job demands on workplace sleepiness.

Like age, family responsibilities represent another individual characteristic that has implications for a person's sleep behavior and resultant sleepiness at work. As

examples of family responsibilities, both marital status (Blau et al., 2008) and number of children (e.g., Landsbergis et al, 1988) have been examined repeatedly as correlates of workplace sleepiness. For both men and women, family time and time spent working have non-linear and interactive effects on time spent sleeping (Barnes, Wagner, & Ghumman, 2012). Similarly, the number of dependents in the household has been shown to predict workplace sleepiness (Spelten, Totterdell, Barton, & Folkard, 1995). These findings suggest that greater family responsibility will increase the negative effect of work demands on the amount of time that a person has to sleep.

Personality may also influence the effects of job demands on workplace sleepiness. Although many different personality traits have been examined as correlates of workplace sleepiness, negative affectivity (NA) represents the trait that has received the most attention. NA describes a person's disposition to experience negative mood states (Watson & Clark, 1984) and positively predicts a large number of mental and physical health problems (Watson & Pennebaker, 1989). Personality theory differentiates NA from neuroticism by positing that neuroticism represents a more general personality characteristic under which NA is subsumed (Nemanick & Munz, 1997). Similar to NA, neuroticism assesses negative emotionality (John, Nauman, & Soto, 2008). In meta-analyses examining their predictive validity, trait NA has been found to predict more variance in task performance than neuroticism (Kaplan, Bradley, Luchman, & Haynes, 2009). NA has also been shown to account for a substantial proportion of the shared variance between job demands and physical strains, such as physical stain symptoms, work absences, and doctor's visits (Chen & Spector, 1991). With college students, NA has been found to moderate the relationship between work-

related stressors and sleep quality, such that higher NA results in worse sleep quality (Fortunato & Harsh, 2006). NA may moderate the relationship between job demands and sleep symptoms because people higher in NA exhibit more physiological response to environmental stressors and require a longer recovery period (Zellars, Meurs, Perrewe, Kacmar, & Rossi, 2009). This heightened arousal may lead to the activation of allostatic sleep regulating processes that could disrupt traditional circadian and homeostatic sleep regulating processes. Theoretical support exists for the role of NA and individual characteristics as moderators of the effects demands on sleep. Nonetheless, the low number of primary studies examining the relationship between sleep and employee characteristics may limit testing of the individual characteristics component of conceptual model of sleep and work.

Job Performance

Workplace sleepiness and the JDCS model have both been shown to account for a number of important outcomes. Job performance provides an example of a set of outcomes that can be negatively predicted by workplace sleepiness (e.g., Rosa, 1991) and job demands (Gilboa, Shirom, Fried, & Cooper, 2008) and positively predicted by support (Beehr, Jex, Stacy, & Murray, 2000) and job control (Bond & Bunce, 2003). Although multiple models of job performance exist (Viswevaran & Ones, 2000), a distinction between two aspects of performance, task and contextual, is widely supported (Borman & Motowildo, 1997). Task performance describes the effectiveness with which an individual performs activities that contribute to an organization's technical core and contextual performance describes how effectively an individual contributes to the organizational environment that catalyzes the task activities.

Organizational citizenship behavior or OCB represents a frequently measured example of contextual performance (Organ, 1997). OCB is often defined as behavior not directly recognized by formal reward systems that contribute to organizational effectiveness (i.e., volunteering to help a co-worker; Organ, Podsakoff, & Mackenzie, 2006)

Cognitive deficits associated with sleepiness represent explanations for the effects of sleepiness on task performance. Across many studies, short-term sleep deprivation of one day in length has been found to dramatically reduce speed and accuracy scores on measures of simple attention, complex attention, working memory, processing speed, short-term memory and reasoning (Lim & Dinges, 2010). The cognitive capabilities impaired by insufficient sleep overlap substantially with the abilities deemed fundamental by job analysts (Fleishman, Costanza, & Marshall-Mies, 1999). The theoretical importance of sleep to performance of cognitive tasks draws empirical support from meta-analytic findings showing sleep loss to greatly increase the risk of error for medical residents (Philibert, 2005). Although sleep-related cognitive deficits represent a clear influence on task performance, several possible mechanisms have been proposed through which sleepiness may affect organizational citizenship behavior. Research regarding the effects of sleepiness on self-regulation suggests that impaired self-regulation can alter social decision making in the workplace (Barnes, 2012). More recent findings show that losses in job satisfaction associated with sleepiness represent another mechanism that can explain the relationship between sleepiness and OCB performed towards the organization (Barnes, 2013). Such findings

indicate that affective reactions associated with sleepiness have implications for explaining job performance outcomes.

Safety Outcomes

Workplace sleepiness may also mediate the effects of job demands, resources, and control on a number of important safety outcomes. Although only recently tested in safety research, the JDCS model does have value for explaining safety outcomes (Snyder et al., 2008). Higher demands, lower control, and lower support are predictive of worse performance of voluntary and mandatory safety behaviors (Turner, Stride, Carter, McCaughey, & Carroll, 2012). Workplace sleepiness may help explain how the JDCS model influences traditional safety outcomes. Workplace sleepiness has been repeatedly identified as a correlate of occupational injuries (e.g., Dearmond et al., 2009), accidents (e.g., Hayes, Perander, Smecko, & Trask, 1998), and a variety of indicators of unsafe driving, such as falling asleep at the wheel (e.g., Tzamalouka, Papadakaki, & Chliaoutakis, 2005).

Many of the same sleep-related cognitive deficits proposed to explain negative effects on job performance are also used to explain the positive effects of sleepiness on accidents and injuries. The effects of sleepiness on accidents and injuries become more pronounced on monotonous tasks that require sustained attention, such as long-haul driving (Williamson, et al., 2011). The importance of task characteristics to sleepiness provides a rationale for past findings showing that safety behavior can mediate the relationship between workplace sleepiness and occupational injuries (Dearmond & Chen, 2009). Without the motivation or cognitive resources that are crucial to the

performance of safety behavior, workers are substantially more likely to experience accidents or injuries (Christian et al., 2009).

Health Outcomes

Health outcomes may represent the most frequently studied outcomes of both the JDCS model and workplace sleepiness. During the last thirty years, high demands, lower control, and lower support have been found to positively associate with almost all physical (Häusser, Mojzisch, , Niesel, & Schulz-Hardt, 2010) or mental health outcomes of work (Van der Doef & Maes, 1998; Vander Doef & Maes, 1999). Repeatedly identified specific health correlates of workplace sleepiness include depression (e.g., Britt & Dawson, 2004), anxiety (Flo et al., 2012), burnout (e.g., Schreurs & Taris, 1998), somatic complaints (e.g.,Geurts, Rutte, & Peters, 199), musculoskeletal symptoms (e.g.,Sorensen et al., 2011), cardiovascular health (e.g.,Steinmetz & Schmidt, 2010), headaches (e.g., Schat, Kelloway, & Desmarais, 2005), acute fatigue, chronic fatigue (e.g., Mandersheid, 2009), and Body Mass Index (e.g., Jones 2010).

In recent years, sleep has increasingly been found to mediate the effects of stressors on health outcomes. Specifically, sleep related variables have been found to mediate the effects of job stress on somatic symptoms (Mohr et al., 2003), social support on myocardial infarction (Nordin, Knutsson, & Sunbom, 2008), bereavement on immune system functioning (Hall et al., 1998), and socioeconomic status on diabetes, obesity, and hypertension (Cauter & Spiegel, 2006). A number of physiological consequences of poor sleep could help explain its role as an antecedent to major health outcomes. Results from a number of studies indicate that sleep loss produces

hyperalgesic changes that increase pain sensitivity and interfere with analgesic or pain relieving treatments (Lautenbacher, Kundermann, & Krieg, 2006). The hyperalgesic changes caused by sleep loss lead to greater pain sensitivity and the analgesic interference diminishes the efficacy of treatment for that pain. Sleep loss also increases cortisol secretion, which has been consistently found to play a causal role in the development of depression (Holsboer, 2001). This physiological consequence of sleep loss may explain why insomnia symptoms have been frequently found to precede the development of depression (Rieman & Voderholzer, 2003). Additional physiological consequences of sleep loss include reductions in leptin and increases in ghrelin. Changes in these two appetite regulating hormones may account for sleep loss's relationship with obesity (Taheri, Lin, Austin, Young, & Mignot, 2004). Shorter sleep has also been shown been to result in low grade cardiovascular inflammation. Such inflammation could explain the well-established relationship between sleep and heart disease (Cappuccio, Cooper, D'Elia, Strazzullo, & Miller, 2011). Sleep loss has also been found to negatively affect several forms of immune system response (Banks & Dinges, 2007). Changes in specific forms of immune system response may explain the effects of sleep on illness and disease. The cumulative effects of sleep loss on physiological processes that effect mood disorders, pain perception, cardiovascular health, chronic illness, and body weight underscore the importance of understanding's sleep relationship to as many workplace variables as possible.

Affective and Attitudinal Outcomes

Like health outcomes, a large body of research supports the value of the JDCS model and workplace sleepiness for explaining variance in a wide variety of affective

and attitudinal outcomes that employees experience. Combinations of high demands, low control, and low support have been shown to predict a number of frequently studied negative attitudinal (Fox, Dwyer, & Ganster 1993) and emotional outcomes (e.g., Demerouti, Bakker, Nachreiner, & Schaufeli, 2001) in organizations. Workplace sleepiness also has consequences for employee affect and attitudes.

Recent research has repeatedly identified workplace sleepiness as a positive correlate of employee deviance (e.g., Christian et al., 2011), turnover cognition (e.g., Rogers & Kelloway, 1997), state hostility (e.g., Nishikitani, Nakao, Karita, Nomura, & Yano, 2005), and work-family conflict (e.g., Lalluka Rahkonen, Lahelma, & Arber, 2010). Workplace sleepiness has also been found to negatively relate to job satisfaction (e.g., Scott and Judge, 2003), organizational commitment (e.g., Tucker & Rutherford, 2005), and general positive affect (e.g., Sonnentag et al., 2008). In comparison to health and performance outcomes, relatively little research has occurred to determine the mechanisms through which workplace sleepiness influences employees' affect and attitudes. Nonetheless past research has identified emotions as a mediator of the effects of workplace sleepiness on some types of employee attitudes. Specifically, hostile emotional states preceded by workplace sleepiness have been found to decrease job satisfaction (Scott & Judge, 2006) and increase interpersonal deviance (Christian et al., 2011). The recently recognized benefit of sleep in regulating emotional brain reactivity (Walker, 2009; Walker & Van der Helm, 2009) provides an explanation for how sleep could affect the affective outcomes that people experience at work. As a result, a need exists for further examination of the relationships between sleep, emotion, and salient workplace attitudes.

Method

Literature Search

A literature search was conducted to identify any empirical examination of consequences or antecedents of workplace sleepiness. The first component of the literature search consisted of searching examining electronic databases for any relevant study published between 1970 and 2013. Four article databases were included in this component of the search, PsycInfo, MEDLINE, Dissertation Abstracts, and ERIC. The following keywords for sleepiness were used: *sleep, fatigue, insomnia*. The following keywords for workplace were used: *job, work, occupational.* A truncation character (*) was used when possible to obtain alternate tenses and word forms (e.g., sleep* returns matches for sleepy, sleepiness, etc.).

A second component of the literature search was a manual literature search of major industrial-organizational, health, sleep, and safety journals to locate any articles that did not appear in the electronic search. Manually searched journals included *Journal of Applied Psychology*, *Personnel Psychology*, *Journal of Organizational Behavior*, *Journal of Occupational Health Psychology*, *Health Psychology*, *Safety Science*, *Journal of Safety Research*, *Accident Analysis and Prevention*, *Work & Stress*, *Sleep*, and *Journal of Sleep Research*. A manual search was also conducted of reference sections of recently published literature reviews (e.g., DeArmond & Chen, 2009; Kucharcyk et al., 2012) and articles that cited frequently used sleepiness measures (e.g., Buysse, et al., 1989). Authors that published studies without relevant effect sizes were also contacted in order to capture additional codable studies. The initial search resulted in 472 English language citations.

Criteria for Inclusion

To merit inclusion in the meta-analysis, studies needed to meet three criteria. First, an included study had to quantitatively measure sleepiness, sleep quality, or sleep quantity and some previously identified predictor or outcome of one these sleep variables. Second, an included study needed to contain a sample of employees at one or more organizations. Thirdly, an included study needed to report sample sizes and correlations or statistics that could be transformed into correlations (e.g., odds ratios) between a sleep variable and a correlate. After independent evaluation by two coders, the researchers resolved any discrepancies about study inclusion through discussion. Agreement about which studies to include was near 99%. Based on these inclusion criteria, 99 studies with unique samples were retained (see Table 1).

Coding of Studies

A team of three graduate students coded the included studies for pertinent sample information, aspects of the study design, and effect sizes of the relationships among constructs in each study. Before coding, each coder completed a training program designed specifically for this meta-analysis. During the training, all three coders learned about the database and coding procedures. The training protocol provided specific definitions for each construct in the database. At the end of the training, all three coders coded the same five articles. All three coders met to review and discussed the coding decisions for these five articles. For this sub-set of five articles, there was 100% agreement across the three coders. After the training, two coders independently coded each article. For instances of disagreement, a third coder also coded the study and resolved the discrepancy at a consensus meeting. To assure

agreement across all data points and minimize coding error, the authors developed and used a Visual Basic macro that identified any discrepancies in spreadsheet cell values among raters. The database of potential constructs consisted of 83 variables generated from theory and previous research (see Table 2). To ensure the inclusion of all possible variables, any additional correlates of sleepiness included in an article were also coded. Some relationship effect sizes were transposed to ensure that all effect sizes shared the same directionality. This ratings procedure resulted in 95% agreement among raters for the entire set of articles across all decision points.

Meta-Analytic Correlations

Meta-analytic correlations were calculated for any variable that was examined in at least two studies of workplace sleepiness (Valentine, Pigot, & Rothstein, 2010). To calculate effect sizes, meta-analytic procedures outlined by Hunter and Schmidt (2004) were followed. This method of synthesizing results from multiple studies assumes a random effects model of meta-analysis. In meta-analysis, a random effects model is appropriate when the author wants to make inferences that extend beyond articles in the meta-analysis and assumes that complex differences exist between studies (Borenstein, Hedges, Higgins & Rothstein 2011). The correlation calculation procedures applied corrections for sampling error and measurement reliability because these measurements artifacts have the potential to distort the findings of study (Hunter & Schmidt, 2011). If a study failed to provide useable reliability coefficients, the mean of the observed reliabilities for the focal variable was calculated. Consistent with recommendations for determining significant correlations (Borenstein, Hedges, Higgins & Rothstein 2011), 95% confidence intervals were computed for each meta-analytic effect size and

intervals not including zero were deemed significant. To detect potential moderators, 90% credibility intervals were also computed. To calculate correlations, confidence intervals, and credibility intervals with minimal error, a second Visual Basic macro was developed and used by the study authors that automatically pulled values from Excel spreadsheets and inserted them into equations.

Meta-Analytic Path Analysis

To further examine the relationship between workplace sleepiness and a number of theorized antecedents and consequences, a series of meta-analytic path models were tested. These models were tested using a correlation matrix generated from variables in the study. This matrix included variables from each predictor category that had reported effect sizes in at least two studies in the meta-analysis. Consistent with previous recommendations, the harmonic mean of the cell sample sizes was used (Viswesvaran & Ones, 1995) and missing at random assumptions were evaluated (Furlow & Beretvas, 2005). Path analyses were performed in SAS and verified in AMOS. Although the likelihood of Type I error may increase when fitting meta-analytic path models to correlation matrices, no research has determined if increased Type I error is a problem for meta-analyses that have large samples or assume random effects (Cheung & Chan, 2005). As a result, the meta-analytic path modeling approach outlined by Hunter and Schmidt (2004) and used frequently in past research (e.g., Nahrgang, Morgeson, & Hoffman, 2011) was implemented.

Results

Sleep Measurement Characteristics

To identify basic characteristics of the measures used in the primary studies, information related to the sleep measures used in each primary study was coded and analyzed. Specifically, data was obtained about the measurement method, number of items, number of time points, length of measurement period, and survey response rate for each sleep measure. If an article did not specifically provide that information related to its sleep measure, efforts were made contact the study author and clarify the exact characteristics of the measure.

Of the 99 primary studies included in the meta-analysis, only 2 studies used an objective method of measuring sleep, such as an EEG (Barnes, Ghumman, & Scott, 2013) or wrist worn actigraph (Zohar, Tzischinsky, Epstein, & Lavie, 2005). The other 97 primary studies measured sleep variables solely with subjective self-report measures, with the majority (n = 61) using measures of sleep quality. Measures of central tendency and skewness describe differences in the measurement of sleepiness, sleep quality, and sleep quantity (see Table 3). For example the average number of items used to measure sleepiness (M = 5.78), sleep quality (M = 6.01), and sleep quantity (M = 5.21) were highly similar. Nonetheless, skewness statistics indicate that a higher number of sleep quality (S = 6.07) and sleep quantity (S = 4.42) measures had a very small number of items. Differences in the mean number of time points each construct was measured in a study and the length of time between those time points also distinguishes the three constructs. Specifically, sleepiness was measured fewer times on average in studies (M = 1.18) than sleep quality (M = 3.13) or sleep quantity (M = 5.41). The number of days of sleep assessed (M = 43.44) at each time point on

sleepiness measures was higher, though, than the number of days of sleep assessed at each time point with sleep quality (M = 7.50) or sleep quantity measures (M = 9.75). The final measurement characteristics of each construct, survey response rate, was similar for sleepiness (M = .60), sleep quality (M = .62), and sleep quantity (M = .59).

Meta-Analysis of Sleepiness

The relationship between sleepiness and variables identified as predictors or outcomes of sleepiness appear in Table 4. Of the three sleep variables, sleepiness was measured in the fewest number of studies (N = 18) and had the fewest number of correlations. Nonetheless, sleepiness was found to relate negatively to both sleep quality (ρ = -.22) and sleep quantity (ρ = -.15). A number of forms job demands positively related to sleepiness. Specifically, general job demands (ρ = .30), the number of hours worked per week (ρ = .15), the variability in the number of hours worked per week (ρ = .16), physical demands (ρ = .36), and total workload (ρ = .18) all related positively to sleepiness scores. As theorized by the JDCS model, general job control (ρ = -.14) and co-worker support (ρ = -.21) were found to relate negatively to reports of sleepiness. Several relationships between sleepiness and individual characteristics were also calculated meta-analytically. Both age (ρ = -.06) and female gender status (ρ = -.10) were found to relate negatively to sleepiness. Sleepiness also related positively to a number of negative health outcomes, such as acute fatigue (ρ = .57), anxiety (ρ = .35), back pain (ρ = .32), depression (ρ = .34), general job strain (ρ = .25), and other health problems (ρ = .62). With attitudinal outcomes, sleepiness related positively to work-family conflict (ρ = .34) and negatively to engagement (ρ = -.65) and job satisfaction (ρ = -.11).

Meta-Analysis of Sleep Quality

The relationship between sleep quality and variables identified as predictors or outcomes of sleep quality appear in Table 5. Of the three sleep variables, sleep quality was measured in the highest number of studies (N = 68) and had the highest number of correlations with other variables. Sleep quality related negatively to sleepiness (ρ = -.22) and positively to sleep quantity (ρ = .16). Sleep quality was found to relate negatively to 11 different types of job demands, including cognitive demands (ρ = -.29), general job demands (ρ = -.32), the number of hours worked per week (ρ = -.09), working night shifts (ρ = -.05), perceived job risk (ρ = -.31), physical demands (ρ = -.20), shift work (ρ = -.05), workload (ρ = -.29), work pace (ρ = -.19), workplace bullying (ρ = -.23), and workplace violence (ρ = -.20). As predicted by the JDCS model, sleep quality was associated positively with number of types of job control and job support. Specifically, job autonomy (ρ = .22), decision authority (ρ = .10), and general job control (ρ = .20) all related positively to sleep quality. Similarly, co-worker support (ρ = .22), organizational support (ρ = .16), and supervisor support (ρ = .17) also all related positively to sleep quality. A number of individual characteristics were also found to associate with sleep quality. Specifically, employee age (ρ = -.08), alcohol consumption (ρ = -.08), body mass index (ρ = -.06), job tenure (ρ = -.08), being married (ρ = -.06), negative affectivity (ρ = -.31), and tobacco use (ρ = -.05) all associated negatively with sleep quality. Of the individual characteristics, only the amount of time spent with family (ρ = .15) had a positive relationship with sleep quality.

In the domain of job performance, sleep quality was found to have a positive relationship with task performance (ρ = .15). Unlike with job performance, sleep

quality was found to relate negatively to 11 different health outcomes. These outcomes included acute fatigue (ρ = -.48), anxiety (ρ = -.51), back pain (ρ = -.20), chronic fatigue (ρ = -.58), depersonalization (ρ = -.17), depression (ρ = -.44), emotional exhaustion (ρ = -.52), gastrointestinal problems (ρ = -.39), general job strain (ρ = -.39), headaches (ρ = -.37), and other health problems (ρ = -.26). Similar patterns appeared in the relationship of sleep quality to affective outcomes. Specifically, sleep quality related positively to joviality (ρ = .46) and positive affect (ρ = .24) and negatively to hostility (ρ = -.16) and state negative affect (ρ = -.48). This trend of sleep quality relating positively to positive outcomes and negatively to negative outcomes also appeared with attitudinal outcomes. Sleep quality related positively to engagement (ρ = .05), family-work facilitation (ρ = .21), job satisfaction (ρ = .29), relaxation (ρ = .30), and family-work facilitation (ρ = .07) and negatively to family-work conflict (ρ = -.30), work-family conflict (ρ = -.33), and turnover cognition (ρ = -.27).

Meta-Analysis of Sleep Quantity

The relationship between sleep quantity and variables identified as predictors or outcomes of sleep quantity appear in Table 6. Of the three sleep variables sleep quality was measured the second most frequently (N = 36) and was most likely to be measured as a second sleep variable in a study that also measured sleepiness or sleep quality. In such studies, sleep quantity was found to relate negatively to sleepiness (ρ = -.15) and positively to sleep quality (ρ = .16). Like sleep quality, sleep quantity was also negatively related to a number of different types of job demands. Specially, negative correlations were detected for cognitive demands (ρ = -.10), general work demands (ρ =

-.18), the number of hours worked per week (ρ = -.17), and workload (ρ = -.15). Of all the demands, only being a shift worker (ρ = .10) related positively to sleep quantity.

The relationship between sleep quantity and job control variables was not assessed because the relationship between sleep quantity and job control was only examined in one study (Sonnentag & Zijlstra 2006). However, a sufficient number of studies were available related to safety climate and supervisor support. Of the support variables, safety climate was found to relate significantly (ρ = .08) to sleep quantity, but the effect of supervisor support was not significant (ρ = .05). Sleep quantity was also related to several important individual characteristics, such as age (ρ = -.10), body mass index (ρ = -.07), family time (ρ = -.05), gender (ρ = .02), and tobacco use (ρ = -.04). Several individual characteristics that were theorized to relate to sleep quality, though, did not. These unrelated characteristics included alcohol consumption (ρ = -.02), caffeine use (ρ = -.01), positive affectivity (ρ = -.03), negative affectivity (ρ = -.03), and number of children (ρ = .01). Unlike individual characteristics, a consistent trend existed in the relationship between sleep quantity and health outcomes. In particular, sleep quantity related negatively to acute fatigue (ρ = -.14), anxiety (ρ = -.15), chronic fatigue (ρ = -.07), depersonalization (ρ = -.22), depression (ρ = -.18), emotional exhaustion (ρ = -.40), general job strain (ρ = -.16), and other health problems (ρ = -.06). Sleep quantity also related negatively to several potentially detrimental affective and attitudinal outcomes. Specifically, sleep quantity negatively related to negative affect (ρ = -.11) and counterproductive work behavior (ρ = -.19). Sleep quantity also related positively to job satisfaction (ρ = .15). Sleep quantity did not have a noteworthy relationship with a number of affective and attitudinal outcomes, such as hostility (ρ = -

.03), positive affect (ρ = .03), engagement (ρ = .03), relaxation (ρ = .03), and work-family conflict (ρ = -.01).

Path Analysis

To further explore the theoretical relationships among the variables included in the meta-analysis, a series of path models were tested. The information needed to test these models was obtained from a matrix of corrected correlations among study variables (see Table 7). Eleven variables were included in the correlation matrix: sleepiness, sleep quality, sleep quantity, job demands, job control, job resources, anxiety, depression, physical strain, job satisfaction, and work-family conflict. Four of these variables, job demands, job control, job support, and physical strain represented aggregations of more specific variables measured in the study. Each of these aggregated variables included all of the correlations for a number of specific variables. For example, the aggregated variable of job control contained all of the correlations for more specific variables within that category, such as flexibility, decision authority, general job control, and skill discretion.

When a study included two specific variables, such as flexibility and decision authority, that merited inclusion in the aggregated variable, the study's sample was only counted once and the effect size and reliability information for the two variables were averaged. The job demands variable consisted of cognitive demands, general demands, physical demands, and workload. The job support variable consisted of co-worker support, organizational support, supervisor support, and safety climate. Lastly, the physical strain variable consisted of acute fatigue, chronic fatigue, back pain, gastrointestinal problems, headaches, and general job strain.

From the studies included in the meta-analysis, there was not enough information to calculate a meta-analytic correlation between job satisfaction and work-family conflict and sleep quantity and job control. For job satisfaction and work-family conflict, a previously calculated meta-analytic correlation between the two variables (Shockley & Singla, 2011) was included in the study correlation matrix. The sample size for this meta-analytic correlation (N = 61,340) was not used to calculate a harmonic mean. A harmonic mean of 2448 was derived from the sample sizes of the other 53 meta-analytic correlations in the correlation matrix.

Five path models were tested to determine the model that best fit the meta-analytic correlations. As a consequence of small to medium sized relationships between the three sleep variables, each path model attempted to discern if sleepiness, sleep quality, and sleep quantity individually act as mediators of the effects of demands, control, and support on work outcomes. The first full mediational model (A) tested the proposition that sleepiness, sleep quality, and sleep quantity each separately mediated the effects of demands, control, and support on anxiety, depression, physical strain, job satisfaction, and work-family conflict. In this and in all other path models, the error terms for the residuals of the endogenous variables were correlated. To determine if sleep variables had different roles in the causal chain, a second full mediational model was also tested. The second full mediational model (B) proposed that demands, control, and support would directly influence both sleep quality and sleep quantity and that sleepiness would mediate the effects of sleep quality and sleep quantity on the five different outcomes.

The first partially mediated model (C) retained model B's structure and added direct effects from sleep quality to the five different outcome variables. The second partially mediated model (D) retained model B's structure and added direct effects from sleep quantity to the five outcome variables. In addition to these pairs of partial and full mediation models, a fifth mediational model (E) was tested. This model was informed by theory about how sleep quantity and sleep quality might differentially affect the five different outcomes. This fifth model identified sleepiness as a full mediator of the effects of sleep quantity on the five outcomes and sleep quantity as a predictor that only had direct effects on the outcome variables (see Figure 2).

Several fit indices were used to compare the fit of the five models to the data. Multiple fit indices were included because of differences in the ways that different fit indices are influenced by large sample sizes and complex models. The four included fit indices were chi-square (χ^2), GFI, AGFI, and RMSEA. Kline (2010) provides information needed to interpret each fit statistic. The chi-square statistic is a long used and frequently reported fit statistic that rewards large sample sizes. In contrast, GFI rewards models for complexity. AGFI accounts for this potential source of bias by using the model degrees of freedom to adjust the R^2 value. For AGFI, values of .90 or higher that a good fit of the model to the data. The final fit index used to compare models, RMSEA, does not reward model complexity or sample size. Values below .08 on RMSEA indicate a good fit of the model to the data.

The first full mediated model (A) did not fit the data well (χ^2 [19] = 2025.78, $p < .001$; GFI = .892; AGFI = .308; RMSEA = .208) (see Table 8). As a result, no attempts were made to interpret the model's estimate of the different mediating effects of

sleepiness, sleep quantity, and sleep quality. The second full mediation model (B) mediation model fit the data better, but still failed to meet criteria for good fit (χ^2 [13] = 423.65, p< .001; GFI = .971; AGFI = .854; RMSEA = .114) on most of the fit indices (see Table 8). As result, three partial mediation models were examined. The first partial mediation model (C) that tested direct effects of sleep quality on all five outcome variables exceeded criteria for good fit (χ^2 [8] = 102.05, p< .001; GFI = .992; AGFI = .934; RMSEA = .069) on all four fit indices. The second partial mediation model (D) tested direct effects on sleep quantity on all five outcome variables also exceeded criteria for good fit (χ^2 [8] = 80.91, p< .001; GFI = .994; AGFI = .951; RMSEA = .061). This model that tested direct effects of sleep quantity actually had marginally better fit than the model that tested direct effects of sleep quality.

In models B, C, and D, sleep quality mediated the effects of sleep quality, but was not a statistically significant mediator of the effects of sleep quantity. Consequently, a fifth mediational model (E) was tested that identified the effects of sleep quality on the five outcomes as being fully mediated by sleepiness and sleep quantity as only having direct effects on anxiety, depression, physical strain, and work-family conflict. No direct effect from sleep quantity to job satisfaction was included in this model because sleep quantity did not have significant direct or indirect effects in job satisfaction in the previous four models. This fifth model (χ^2 [10] = 74.89, p< .001; GFI = .995; AGFI = .964; RMSEA = .051) had more favorable fit index values than any of the previously tested four models and was more parsimonious than model C or model D. No chi-square test of difference was performed to compare model E to previous models because Model E was not nested in any of the previous models. Every effect

directly and indirectly modeled in Model E was significant (see Figure 2). All of the significant direct and indirect effects in Model E were also significant in previous models that tested those specific effects. Although many of the standardized path coefficients exceeded 1, standardized coefficients can exceed 1 and still have has as much interpretive value as coefficients less than 1 (Hayes 2009; Joreskog, 1999). Coefficients of such magnitude generally only appear when predictor variables are highly correlated (Deegan, 1978).

Discussion

The present study provides the first meta-analytic investigation of the relationship among sleepiness, sleep quality, and sleep quantity and the organizational antecedents and consequences of these three constructs. Other than an unpublished meta-analysis about the effects of job stressors on sleepiness in 27 primary studies (DeArmond & Chen, 2004), no previous meta-analytic investigation of the relationship between sleep and variables commonly measured in organizational settings has occurred. In this meta-analysis of 99 studies of sleep in organizations, a number of important theoretical findings emerged. Firstly, substantial differences appeared between the three variables often used interchangeably to study sleep in organizations. Although sleepiness, sleep quality, and sleep quantity were all related to each other, the relationships among these three measures of sleep were small to medium in size. The different role of each sleep variable in the final causal model further underscores the theoretical differences among all three sleep variables. In this model, sleepiness acts as a mediator of the effects of sleep quality, but does not mediate the effects of sleep quantity.

Theory about the functions of sleep and previous research about sleep constructs can help explain why sleepiness mediates the effects of sleep quality, but does not mediate the effects of sleep quantity. Sleep-independent and sleep-dependent processes regulate when a person feels sleepy and sleeps (Borbély, 1982; 2009). The sleep-dependent processes that influence feelings of sleepiness, such as a need to sleep that accumulates during wakefulness are more likely to be influenced by sleep quality than sleep quantity because sleep quality may provide a better indicator of how close a person has come to obtaining an optimal amount of rapid eye movement (REM) stage sleep. Findings from neuropsychological research indicate that REM sleep facilitates emotional regulation during the daytime (van der Helm et al., 2009), helps consolidate memories (Nishida, Pearsall, Buckner, & Walker, 2009), and influences the secretion of growth hormone and cortisol (Van Cauter, Leproult, & Plat, 2000). Sleep-independent processes, such as circadian rhythm, may also help explain why sleep quality's effects are mediated by sleepiness and sleep quantity's effects are not. Specifically, sleep quality may better reflect whether or not a person's sleep period corresponds to the body temperature rhythms that have been found to associate with REM sleep accumulation during sleep and alertness after sleep (Czeisler, Weitzman, Moore-Ede, Zimmerman, Knauer, 1980).

Sleep research in other domains of psychology provides additional explanation for why the effects of sleep quality and not sleep quantity are mediated by sleepiness. In studies with college students (Pilcher, Ginter, & Sadowsky, 1997) and middle aged adults (Pilcher, Schoeling, & Prosansky, 2000); sleep quality has been consistently identified as a substantially better predictor of sleepiness. This trend observed in

primary studies was also observed in the current meta-analysis, in which sleep quality was a substantially better predictor of sleepiness than sleep quality. Methodological and substantive factors can explain the importance of sleep quality to sleepiness. Methodologically, similarities in self-report measures used to assess sleepiness and the self-report measures used to measure sleep quality may have allowed individual factors, such as negative affectivity (e.g., Brief, Burke, George, & Robinson 1988), to artificially inflate the relationship between the two constructs. Substantively, sleep quality may be a better sole indicator of the sleep-dependent processes that influence perceptions of sleepiness because some people who experience low sleep quality may require higher amounts of sleep quantity to attenuate feelings of sleepiness.

The theoretical possibility that sleep quality represents a more predictive sleep measure than sleep quantity is supported by eyewitness research showing poor sleep quality to have significantly larger effects on eyewitness recollection (Thorley, 2013), health research showing sleep quality to be a better predictor of a variety of health problems (Pilcher & Ott, 1998), and meta-analytic educational research showing sleep quality to account for more variance in the academic performance of children and adolescents (Dewald, Meijer, Oort, Kerkhof, & Bögels, 2010) than sleep quantity. Although sleep quality may be a better individual predictor than sleep quantity, these findings suggests that sleep quantity may be a valuable second sleep measure in studies that measure sleepiness or sleep quality. The importance of sleep quantity as a construct that is distinct from sleep quality and sleepiness is supported by results showing the best fitting path model to have direct effects from sleep quantity to four different outcomes. Sleep quantity may have direct effects on organizational outcomes

because sleep quantity is measured more "objectively" than the self-report measures used to assess sleep quality and sleepiness. If it is generally measured more objectively, sleep quantity could better reflect self-regulatory consequences of sleep that occur outside of the awareness of employee who are completing more subjective measures (Semmer, Grebner, & Elfering, 2004).

Despite their similarities, sleepiness, sleep quality, and sleep quantity all generally accounted for a significant amount of unique variance in number of important health and attitudinal outcomes. In the path model, the effects of sleepiness, sleep quality, and sleep quantity on the outcomes occurred for different reasons specific to each outcome. For the outcomes of anxiety and depression, sleepiness mediated the effects of sleep quality. Sleep quality may have indirectly affected anxiety and depression as a result of its influence on cortisol secretion (Holsboer, 2001) and other physiological processes that regulate emotional brain activity (Walker, 2009; Walker & Van der Helm, 2009) and possibly perceptions of sleepiness. With anxiety and depression, sleep quantity may have had direct effects because sleep quantity better measures consequences of sleep that are not assessed by sleep quality or sleepiness measures. Sleepiness may have mediated the effects of sleep quality on physical strain because of sleep's effects on processes related to pain perception (Lautenbahcher, 2006), cardiac inflammation (Cappuccio et al, 2011), and immune system functioning (Banks & Dinges, 2007). Like sleepiness, these negative consequences of less restorative sleep may be noticeable to employees. Again, sleep quantity may have only had direct effects because sleep quantity better measures consequences of sleep that are outside the awareness of an employee reporting sleepiness.

In contrast to physical and mental health outcomes, the effects of sleep quantity on job satisfaction were fully mediated by sleepiness and sleep quantity had no direct effect. Sleep quality may have had direct effects on job satisfaction because the demands of a job were found to have twice as large an effect on sleep quality as on sleep quantity. Although sleep quantity did not have direct effects on job satisfaction, it did have direct effects of work-family conflict. Although it was not a relevant correlate of work-family conflict ($\rho = -.01$), sleep quantity may have had direct effects on work-family conflict because sleep quantity is affected non-linearly by increases in the amount of time committed to home and work (Barnes et al, 2012). In this explanation, sleep quantity better captures the effects of high demands on work-family conflict than sleep quality.

In addition to their role as predictors of important outcomes, the role of the sleep constructs as mediators of the effects of job demands, job control, and job support has tremendous theoretical value. Specifically, the relative strength of job demands as a predictor of sleep quality and sleep quantity provides support for theoretical models that identify sleep as critical to replenishing energy expended by task demands (Barnes & Van Dyne, 2009), influenced by environmental stimuli at work (DeArmond & Chen, 2009), and a mediator of the effects of organizational antecedents on organizational consequences (Krauss et al, 2003).

Practice Implications, Future Research Directions, and Limitations

The effects of sleep on important organizational outcomes and its relationship to malleable work characteristics suggests that sleepiness, sleep quality, and sleep quantity may have tremendous practical value to organizations. Specifically, employees

experiencing poor sleep are at greater risk for developing a number of long-term health problems. Additionally, meta-analytic correlations suggest that employees experiencing poor sleep could be less effective performers who are less likely to be safe and more likely to turnover. Although interventions to help poor sleepers would expend valuable organizational resources, such interventions may save resources over the long-term. To discern if an employee is experiencing poor sleep, employers could administer a brief, but comprehensive, measure like the Pittsburgh Sleep Quality Inventory (Buysse et al., 1989) or simply ask employees about the amount of sleep they have been averaging over a certain time frame. To help employees experiencing poor sleep, organizations can reduce the most difficult job demands. Depending on the nature of the employee's sleep problem, increased job control and relevant job support may also attenuate sleep difficulties.

Although this meta-analysis provides information for theory and practice, it does have a number of noteworthy limitations. Firstly, the absence of a sufficient number of primary studies related to task performance and safety outcomes prevented the inclusion of these important variables in the meta-analytic path model. As another limitation, the measurement of sleep in primary studies was limited almost exclusively to self-report measures. The use of self-report measures to assess sleep introduces potential method bias into any examination of the effects of sleep on self-report outcomes (Podsakoff, Mackenzie, Lee, & Podsakoff, 2003). Lastly, meta-analytic path modeling is a relatively new form of analysis. Consequently, questions remain about optimal procedures for generating the meta-analytic correlation matrix needed to fit the meta-

analytic path model (e.g., Cheung & Chan, 2005). As such, the results from this meta-analytic path model may be interpreted as exploratory in nature.

Future research has the capability to address many of these limitations related to current sleep research. A glaring need exists for additional studies related to the effects of sleep quality, sleep quantity, and sleepiness on safety and performance outcomes. Although a number of studies have measured sleep and safety and performance outcomes, many of these studies are not amenable to inclusion in a meta-analysis because of problems related to design, measurement, or sample. Relatedly, future organizational sleep research should use more observational measures of sleep quality or sleep quality. Advances in technology are making such observational measures more cost-effective and less intrusive. Increased observational measurement of activity during sleep and sleep duration could provide valuable information about the relationship between "objective" and "subjective" measures of sleep. As a final direction for future research, a need exists for increased longitudinal sleep and multilevel sleep research. Although job characteristics have clear effects on sleep, research at the team or organizational level would more clearly identify the environmental characteristics that most strongly influence the critical constructs used to measure employee sleep.

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Appendix: Tables and Figures

Table 1: Studies Included in the Meta-Analysis

Author and Year	Sample Size	Sleep Construct	Sleep Antecedent	Sleep Outcome
Jung 1986	33	Sleep Quality, Sleep Quantity	Age, Caffeine Use	Job Strain
Landsbergis 1988	289	Sleep Quality	Hours Worked Per Week, Perceived Job Risk, Night Shift/ Day Shift, Physical Demands, Workload, Flexibility, Decision Authority, General Job Control, Decision Authority, Co-Worker Support, Organizational Support, Supervisor Support, Age, Gender, Education, Job Tenure, Marital Status, Number of Children, Tobacco Use,	Depersonalization, Depression, Emotional Exhaustion, Physical Strain, Other Health Problems, Job Satisfaction
Raggat 1991	93	Sleep Quality, Sleep Quantity	Hours Worked Per Week, Alcohol Consumption, Job Tenure	Driving Safety
Lee 2002	759	Sleep Quantity	Hours Worked Per Week, Night Shift/ Day Shift, Age, BMI, Caffeine Use, Number of Children, Tobacco Use	
Tanz & Charrow 1993	19	Sleep Quantity	Workload	

Barton et al. 1995A	581	Sleep Quality, Sleep Quantity	Trait NA,	Anxiety, Chronic Fatigue, Gastrointestinal Problems, Other Health Problems, Job Satisfaction, Work-Family Conflict
Barton et al. 1995B	761	Sleep Quality	Trait NA	Chronic Fatigue, Gastrointestinal Problems, Job Strain, Other Health Problems, Work-Family Conflict
Totterdell et al. 1995	61	Sleep Quality, Sleep Quantity		State NA, State PA
Barling et al. 1996A	437	Sleep Quality	Workplace Bullying	
Barling et al. 1996B	137	Sleep Quality	Workplace Bullying	
Hackett & Bycio 1996	20	Sleepiness, Sleep Quantity		Anxiety, Job Strain, Other Health Problems, Job Satisfaction
Rogers and Kelloway 1997	194	Sleep Quality	Workplace Violence	Gastrointestinal Problems, Job Strain, Headaches, Organizational Commitment, Turnover Cognition
Geurts et al. 1999	166	Sleep Quantity	General Job Demands	
Mccart et al. 2000	553	Sleepiness, Sleep Quality	General Job Demands, Hours Worked Per Week, Age, Job Tenure	
Neylan et al. 2002	727	Sleep Quality, Sleep Quantity	General Job Demands, Hours Worked Variability, Workplace Violence, Age,	

			Gender	
Parkes 2002	786	Sleep Quality, Sleep Quantity	Age, Trait NA, Tobacco Use,	
Britt & Bliese 2003	1181	Sleep Quantity,	General Job Demands	Job Strain, Engagement, Home-Family Conflict
Hossain et al. 2003	195	Sleepiness, Sleep Quantity		Chronic Fatigue
Akerstedt et al. 2004	5720	Sleep Quality		Chronic Fatigue
Britt et al. 2004	100	Sleep Quantity	Role Ambiguity, Workload	Anxiety, Depression, Job Strain, Engagement, Job Satisfaction
Brown 2004	102	Sleep Quality	Cognitive Demands, Physical Demands, Decision Authority, Co-Worker Support, Supervisor Support	Depression, Job Satisfaction
Bystrom et al. 2004	275	Sleepiness	Physical Demands, Workload	Back Pain, Chronic Fatigue, Job Strain, Withdrawal
Kudielka et al. 2004	709	Sleep Quality	Age	
Morrow & Crum 2004	116	Sleepiness, Sleep Quantity	General Job Demands, Hours Worked Variability, Workload, Safety Climate	Accidents, Driving Safety, Acute Fatigue
Nakata et al. 2004	1161	Sleep Quality		Depression, Job Satisfaction
Zohar et al. 2005	78	Sleep Quality, Sleep Quantity		Acute Fatigue, State NA, State PA

Britt & Dawson 2005	493	Sleep Quantity		Work-Family Conflict
Schat et al. 2005A	197	Sleep Quality		Task Performance
Schatt et al. 2005B	434	Sleep Quality		Task Performance, Gastrointestinal Problems, Job Strain, Headaches, Respiratory Infections, State NA
Lindblom et al. 2006	1812	Sleep Quality	Workload, Organizational Support	Anxiety, Depersonalization, Depression, Emotional Exhaustion, Engagement
Scott & Judge 2006	51	Sleep Quality		Acute Fatigue, Hostility, Joviality, Job Satisfaction
Sonnentag & Zijlstra 2006	704	Sleep Quantity	Cognitive Demands, Hours Worked Per Week, Workload, Flexibility, Decision Authority, General Job Control, Organizational Support, Family Time	Chronic Fatigue, Relaxation
Takahashi et al. 2006	112	Sleepiness	Hours Worked Per Week, Hours Worked Variability, General Job Control, Co-Worker Support, Supervisor Support	Depression, Job Satisfaction
Van Hooff et al. 2006	113	Sleep Quality	Hours Worked Per Week, Workload, Family Time	Acute Fatigue, Relaxation, Work-Family Conflict
Winwood &	760	Sleep	Cognitive	Acute Fatigue,

Lushington 2006		Quality	Demands, Emotional Demands, General Job Demands, Physical Demands, Work Pace, Co-Worker Support, Supervisor Support, Age, Gender	Chronic Fatigue, Relaxation
Williams et al. 2006	168	Sleep Quality	Cognitive Demands, Hours Worked Per Week, Physical Demands, Decision Authority, Organizational Support, Age, Marital Status, Number of Children	Depression, Job Strain, Home-Family Conflict, Family-Work Facilitation, Work-Family Conflict, Work-Family Facilitation
Nylén et al. 2007	1810	Sleep Quality	Work Pace	Chronic Fatigue, Job Strain, Detachment, Home-Family Conflict, Work-Family Conflict
Preckel et al. 2007	1587	Sleep Quality	General Job Demands, Trait NA	Chronic Fatigue, Depression, Job Strain, State NA, Detachment, Job Satisfaction
Samaha et al. 2007	111	Sleep Quality		Chronic Fatigue
Sonnentag & Fritz 2007	267	Sleep Quality	Hours Worked Per Week, Role Ambiguity, Work Pace, Flexibility, Job Control, Agreeableness, Conscientiousness, Trait PA, Trait NA, Openness	Depression, Emotional Exhaustion, Job Strain, Detachment, Engagement, Relaxation, Work-Family Conflict,
Canivet et al. 2008	4140	Sleep		Back Pain, Job

		Quality		Strain
Chan 2008	163	Sleep Quality		Job Strain
Fang et al. 2008	581	Sleep Quality	General Demands, Night Shift/Day Shift, Job Control, Supervisor Support	Acute Fatigue, Anxiety, Chronic Fatigue, Depression, Job Satisfaction
Granö 2008	5433	Sleep Quality, Sleep Quantity	Shift/Non-Shift, Age, Alcohol Consumption, BMI, Gender, Marital Status, Tobacco Use	Job Strain, Other Health Problems, Hostility,
Kessler et al. 2008	7320	Sleep Quality		Depression
Lai et al. 2008	130	Sleep Quality		Turnover Cognition
Peterson et al. 2008A	156	Sleep Quality, Sleep Quantity	Shift/Non-Shift	
Peterson et al. 2008B	3976	Sleep Quality	Alcohol Consumption	Anxiety, Back Pain, Depression, Exercise Emotional Exhaustion, Withdrawal
Royal & Grobe 2008	39	Sleep Quality	General Job Demands	
Sonnentag et al. 2008	166	Sleep Quality, Sleep Quantity	Age, Gender	Acute Fatigue, State NA, State PA, Detachment, Relaxation
Sveinsdóttir & Gunnarsdóttir 2008	394	Sleep Quality		Job Strain
Takeuchi et al. 2008	167	Sleep Quality		Depression
Takahashi et al. 2008	775	Sleepiness, Sleep Quality, Sleep Quantity		Chronic Fatigue, Job Strain
Barnes & Wagner 2009	14130	Sleep Quantity	Hours Worked Per Week	
DeArmond and Chen	126	Sleepiness		Injuries, Safety

2009				Performance
De Lange et al. 2009	1136	Sleep Quality	General Job Demands, General Job Control, Age, Gender, Job Tenure	Acute Fatigue
Gadinger et al. 2009	424	Sleep Quality	Workload, General Job Control, Co-Worker Support, Age, Alcohol Consumption, BMI, Exercise, Tobacco Use	
Heponiemi et al. 2009	2650	Sleep Quality	General Job Control, Age, Gender	Job Strain, Turnover Cognition
Karlson et al. 2009	255	Sleepiness, Sleep Quality	General Job Demands, General Job Control, Co-Worker Support, Age	Acute Fatigue, Anxiety, Depression, Job Strain, Other Health Problems, Engagement, Home-Family Conflict, Work-Family Conflict
Manderscheid 2009	36	Sleepiness		Acute Fatigue, Chronic Fatigue
Munir & Nielsen 2009	428	Sleep Quality	Supervisor Support	
Ota et al. 2009	1022	Sleep Quality	Hours Worked Per Week, Nigh Shift/ Day Shift, Co-Worker Support, Age, Alcohol Consumption, Gender, Tobacco Use	Job Strain
Brand et al. 2010	2231	Sleep Quality		Chronic Fatigue, Depression, Emotional Exhaustion,
Diez et al. 2010	47	Sleepiness, Sleep Quality, Sleep	Hours Worked Per Week, Age	Depersonalization, Emotional Exhaustion ,Physiological

		Quantity		Arousal
Giorgi 2010	715	Sleep Quantity	Workplace Bullying, Supervisor Support, Alcohol Consumption	Depression
Heponiemi et al. 2010	1767	Sleep Quality	Hours Worked Per Week, Shift/Non-Shift, General Job Control, Age, Gender, Marital Status, Number of Children	Work-Family Conflict
Hope et al. 2010	9601	Sleep Quality	Perceived Job Risk	
Jones 2010	2124	Sleep Quality	Hours Worked Per Week, Flexibility, BMI, Family Time, Number of Children	Job Strain, Family-Work Conflict, Work-Family Conflict
Rafferty et al. 2010	175	Sleep Quality	Workplace Bullying, Age, Gender	Anxiety
Steinmetz & Schmidt 2010	365	Sleep Quality	Hours Worked Per Week, Hours Worked Variability, Night Shift/ Day Shift, Role Ambiguity, Work Pace	Back Pain, Chronic Fatigue, Depression, Gastrointestinal Problems
Barnes et al. 2011	182	Sleep Quality, Sleep Quantity	Cognitive Demands, Workload, Gender	Chronic Fatigue, CWB
Blau 2011	7578	Sleepiness	Hours Worked Per Week, Workload, Gender, Job Tenure, Marital Status	Job Strain, Job Satisfaction, Turnover Cognition, Work-Family Conflict
Braeckman et al. 2011	476	Sleepiness	Work Pace, Age, Tobacco Use	Job Strain
Chen et al. 2011	145	Sleep Quantity	Workload, Age	
Christian & Ellis 2011	171	Sleep Quantity	Trait PA, Gender, Trait NA	Hostility, CWB
Hahn et al. 2011	95	Sleep		Anxiety,

		Quality		Emotional Exhaustion, State NA, Detachment, Relaxation
Mellor & St. John 2011	221	Sleep Quality, Sleep Quantity	Hours Worked Per Week, Physical Demands, Safety Climate	Safety Performance, Chronic Fatigue
Sanz-Vergel et al. 2011	273	Sleep Quality		Job Strain, Family-Work Conflict, Family-Work Facilitation, Work-Family Conflict, Work-Family Facilitation
Singh et al. 2011	315	Sleepiness, Sleep Quantity	Hours Worked Per Week, Age, Marital Status, Number of Children	
Whitmire 2011	106	Sleep Quantity	General Job Demands, Age, Conscientiousness, Trait PA, Gender, Trait NA	
Wright et al. 2011A	522	Sleep Quality	Alcohol Consumption	Other Health Problems
Wright et al. 2011B	659	Sleep Quality		Depression, Other Health Problems
Allen & Kiburz 2012	131	Sleep Quality	Hours Worked Per Week, Gender, Marital Status	Joviality, Family-Work Conflict
Arlinghaus et al. 2012	317	Sleep Quantity	Hours Worked Per Week, BMI, Gender, Salaried/Hourly	Injuries
Barnes et al. 2012A	10741	Sleep Quantity	Hours Worked Per Week, Age, Family Time, Gender, Number of Children	
Barnes et al. 2012B	122	Sleep Quantity	Hours Worked Per Week, Family Time	
Eek et al. 2012	581	Sleepiness,	Physical Demands	Acute Fatigue,

		Sleep Quality		Job Strain, Engagement
Flo et al. 2012	760	Sleepiness		Acute Fatigue, Anxiety, Depression
Hansen et al. 2012	4066	Sleep Quality	Age, Alcohol Consumption, Gender, Smoking	Physiological Arousal
Jackowska et al. 2012	199	Sleep Quality	Age, BMI, Marital Status, Number of Children, Tobacco Use	State PA
Macagnan et al. 2012	1206	Sleep Quantity	Age, BMI	
Saksvik-Lehouiller et al. 2012	2059	Sleepiness	Hours Worked Per Week, Age	Anxiety, Chronic Fatigue, Depression
Schmidt et al. 2012	249	Sleepiness	General Job Demands, Hours Worked Per Week, Age, Gender	Back Pain, Depression, Emotional Exhaustion
Barnes et al. 2013A	87	Sleep Quantity	Age, Caffeine Use	OCB, Job Satisfaction
Barnes et al. 2013B	85	Sleep Quantity		OCB, Job Satisfaction
de Barros et al. 2013	303	Sleep Quality	Alcohol Consumption	Anxiety, Depression, Job Strain
Hietapakka et al. 2013	2152	Sleep Quality	General Job Demands, Hours Worked Per Week, General Job Control, Age, Marital Status, Number of Children	Task Performance, Anxiety, Psychological Strain, Engagement, Work-Family Conflict
Irish et al. 2013	128	Sleep Quality		Job Strain
Sonnentag & Binnewies 2013	96	Sleep Quality		State NA. State PA, Detachment

Table 2: Variables Coded in the Meta-Analysis

Sleep Measures	Sleepiness	Sleep Quantity
	Sleep Quality	
Job Demands	Cognitive Demands	Role Ambiguity
	Emotional Demands	Role Conflict
	General Job Demands	Shift/Non-Shift
	Hours Worked Per Week	Workload
	Hours Worked Variability	Work Pace
	Night Shift/ Day Shift	Workplace Bullying
	Perceived Job Risk	Workplace Violence
	Physical Demands	
Job Control	Autonomy/Flexibility	General Job Control
	Decision Authority	Skill Discretion
Job Support	Co-Worker Support	Safety Climate
	Organizational Support	Supervisor Support
	Recovery Opportunities	Training
Individual Antecedents	Age	Job Tenure
	Agreeableness	Marital Status
	Alcohol Consumption	Number of Children
	Body Mass Index (BMI)	Openness
	Caffeine Use	Organizational Tenure
	Conscientiousness	Salaried/Hourly
	Exercise	Negative Affectivity (NA)
	Family Time	Positive Affectivity (PA)
	Gender	Tobacco Use
Job Performance	Organizational Citizenship Behavior (OCB)	Task Performance
Safety Outcomes	Accidents	Injuries
	Driving Safety	Safety Performance
Health Outcomes	Acute Fatigue	Gastrointestinal Problems
	Anxiety	General Job Strain
	Back Pain	Headaches
	Chronic Fatigue	Other Health Problems
	Depersonalization	Physiological Arousal
	Depression	Respiratory Infections
	Emotional Exhaustion	Weight Gain
Affective Outcomes	Hostility	State Negative Affect (NA)
	Joviality	State Positive Affect (PA)

Attitudinal Outcomes	Actual Turnover	Organizational Commitment
	Counter Productive Work Behavior (CWB)	Relaxation
	Detachment	Turnover Cognition
	Engagement	Withdrawal
	Family-Work Conflict	Work-Family Conflict
	Family-Work Facilitation	Work-Family Facilitation
	Job Satisfaction	

Table 3: Measurement Characteristics of Subjective Measure of Sleep Constructs

	Sleepiness	Sleep Quality	Sleep Quantity
Mean # of Items	5.78 (*N* = 14)	6.01 (*N* = 61)	5.21 (*N* = 33)
Median	6.5	4.0	1.0
Skewness	3.03	6.07	4.42
Mean # of Time Points	1.18 (*N* =15)	3.13 (*N* = 62)	5.41 (*N* = 28)
Median	1.0	1.0	1.0
Skewness	.77	1.60	2.89
Mean Days Measured	43.44 (*N* = 6)	7.50 (*N* = 22)	9.75 (*N* = 16)
Median	22.0	7.50	4.0
Skewness	2.27	4.02	1.34
Mean Response Rate	.60 (*N* =11)	.62 (*N* = 48)	.59 (*N* = 18)
Median	.71	.60	.66
Skewness	-.45	-.09	-.16

Table 4: Meta-Analytic Correlations for Sleepiness

							90% CV		95% CI	
	k	*N*	$\bar{r}$	ρ	SD_ρ	% Var.	*L*	*U*	*L*	*U*
Sleep Measures										
Sleep Quality	5	2211	-.18	-.22	.14	12	-.44	-.03	-.18	-.26
Sleep Quantity	5	1273	-.11	-.15	.00	100	-.15	-.15	-.21	-.10
Job Demands										
General Job Demands	4	1173	.23	.30	.10	27	.08	.41	.25	.35
Hours Worked Per Week	7	10913	.12	.15	.06	19	.05	.23	.13	.17
Hours Worked Variability	2	228	.13	.16	.00	100	.16	.16	.04	.29
Physical Demands	2	856	.36	.36	.04	48	.29	.43	.29	.42
Workload	2	391	.16	.18	.00	100	.18	.18	.08	.27
Job Control										
General Job Control	2	367	-.10	-.14	.00	100	-.14	-.14	-.24	-.04
Job Support										
Co-Worker Support	2	367	-.16	-.21	.06	67	-.28	-.09	-.31	-.12
Individual Antecedents										
Age	7	3954	-.06	-.06	.07	30	-.18	.06	-.10	-.03
Gender [a]	2	7827	-.08	-.10	.03	29	-.14	-.05	-.12	-.07
Job Tenure	2	8131	.02	.02	.00	100	.02	.02	.003	.05
Health Outcomes										
Acute Fatigue	5	1748	.46	.57	.20	6	.19	.86	.54	.60
Anxiety	4	3094	.28	.35	.07	19	.20	.45	.29	.36
Back Pain	2	524	.28	.32	.07	40	.17	.40	.24	.40
Chronic Fatigue	4	3145	.31	.38	.07	22	.24	.48	.33	.39
Depression	5	3435	.27	.34	.16	6	.06	.57	.31	.37
General Job Strain	11	9960	.19	.25	.14	5	-.02	.45	.23	.27
Other Health Problems	2	275	.51	.62	.00	100	.62	.62	.54	.69
Attitudinal Outcomes										
Engagement	2	836	-.54	-.65	.07	22	-.73	-.49	-.69	-.61
Job Satisfaction	3	7710	-.09	-.11	.00	100	-.11	-.11	-.13	-.08
Work-Family Conflict	2	7833	.28	.34	.04	17	.25	.37	.32	.36

Note.k = number of studies. *N* = number of participants. $\bar{r}$ = sample−weighted mean correlation. ρ = estimate of population correlation corrected for unreliability in the predictor and criterion.SD_ρ = standard deviation of corrected correlation. % Var. = percentage of variance explained by artifacts. 90% CV = 90% credibility value (L = Lower, U = Upper). 95% CI = 95% confidence interval (L = lower, U = upper).

a. Men = 0, Women = 1.

Table 5: Meta-Analytic Correlations for Sleep Quality

							90% CV		95% CI	
	k	*N*	$\bar{r}$	ρ	SD_ρ	% Var.	*L*	*U*	*L*	*U*
Sleep Measures										
Sleepiness	5	2211	-.18	-.22	.14	12	-.44	-.02	-.26	-.18
Sleep Quantity	11	7875	.15	.16	.13	8	-.06	.38	.14	.18
Job Demands										
Cognitive Demands	4	1212	-.24	-.29	.10	29	-.11	-.43	-.34	-.24
General Job Demands	9	7790	-.24	-.32	.09	15	-.41	-.12	-.34	-.30
Hours Worked Per Week	13	9285	-.08	-.09	.19	5	-.39	.20	-.11	-.07
Hours Worked Variability	2	1092	-.05	-.05	.11	15	-.22	-.11	-.11	.00
Night Shift/ Day Shift [a]	3	1968	-.05	-.05	.13	11	-.26	.16	-.09	-.01
Perceived Job Risk	2	10480	-.27	-.31	.04	11	-.29	-.25	-.33	-.29
Physical Demands	6	2121	-.16	-.20	.08	34	-.31	-.05	-.24	-.16
Role Ambiguity	2	632	-.24	-.31	.00	100	-.31	-.31	-.38	-.24
Shift/Non-Shift [b]	3	7356	-.05	-.05	.03	46	-.09	-.01	-.08	-.03
Workload	5	2840	-.19	-.29	.08	25	-.35	-.09	-.26	-.33
Work Pace	4	3202	-.16	-.19	.15	6	-.42	.06	-.23	-.16
Workplace Bullying	3	749	-.20	-.23	.00	100	-.23	-.23	-.29	-.16
Workplace Violence	2	921	-.15	-.20	.00	100	-.20	-.20	-26	-.13
Job Control										
Autonomy/Flexibility	3	2680	.17	.22	.03	65	.15	.24	.19	.26
Decision Authority	2	270	.07	.10	.00	100	.10	.10	-.02	.21
General Job Control	8	9232	.16	.20	.04	45	.11	.25	.19	.22
Job Support										
Co-Worker Support	7	3137	.18	.22	.17	08	-.08	.48	.18	.24
Organizational Support	3	2269	.13	.16	.03	71	.11	.19	.12	.20
Supervisor Support	6	2445	.15	.17	.03	80	.12	.21	.13	.21
Individual Antecedents										
Age	19	23181	-.08	-.08	.07	17	-.20	.03	-.10	-.07
Alcohol Consumption	7	15746	-.06	-.08	.07	09	-.19	.05	-.09	-.06
BMI	4	8180	-.06	-.06	.00	97	-.07	-.06	-.08	-.04
Family Time	2	2257	.13	.15	.08	14	.01	.29	.11	.19
Gender [c]	12	18215	-.02	-.02	.05	27	-.09	.06	-.03	.00
Job Tenure	3	1782	-.06	-.08	.00	100	-.08	-.08	-.13	-.03
Marital Status [d]	4	7499	-.05	-.06	.00	100	-.06	-.06	-.08	-.03
Trait NA	4	3715	-.26	-.31	.22	2	-.65	.07	-.34	-.28
Number of Children	5	6410	.00	.00	.00	100	.00	.00	-.02	-.02
Tobacco Use	5	12219	-.05	-.05	.03	46	-.10	.00	-.07	-.03
Job Performance										
Task Performance	3	2783	.13	.15	.09	12	-.01	.30	.12	.19
Health Outcomes										
Acute Fatigue	9	3741	-.37	-.48	.11	18	-.61	-.26	-.61	-.46
Anxiety	11	10504	-.42	-.51	.13	04	-.70	-.25	-.52	-.49
Back Pain	3	8481	-.17	-.20	.11	03	-.36	.00	-.22	-.18
Chronic Fatigue	14	15880	-.48	-.58	.33	00	-.99	.01	-.59	-.56
Depersonalization	3	2148	-.14	-.17	.12	10	-.04	.35	.13	.21
Depression	18	21827	-.36	-.44	.13	04	-.61	-.19	-.45	-.42
Emotional Exhaustion	7	8717	-.45	-.52	.09	08	-.62	-.34	-.54	-.51
Gastrointestinal Problems	8	3106	-.31	-.39	.12	13	-.55	-.13	-.37	-.31

General Job Strain	24	26009	-.31	.-.39	.18	03	-.65	-.06	-.40	-.38
Headaches	5	1399	-.31	-.37	.00	100	-.37	-.37	-.33	-.42
Other Health Problems	7	8500	-.23	-.26	.18	03	-.04	.55	.24	.28
Physiological Arousal	2	4113	.03	.03	.00	100	.03	.03	.00	.06
Affective Outcomes										
Joviality	2	182	.39	.46	.17	26	.16	.72	.35	.58
Hostility	2	5484	-.13	-.16	.00	100	-.16	-.16	-.18	-.13
State NA	8	2714	-.39	-.48	.10	21	-.60	-.27	-.51	-.44
State PA	7	1174	.21	.24	.04	78	.16	.31	.19	.30
Attitudinal Outcomes										
Engagement	5	5067	.05	.05	.18	03	.02	.08	.02	.08
Family-Work Conflict	6	4761	-.23	-.30	.11	10	-.45	-.07	-.32	-.27
Family-Work Facilitation	2	441	.15	.21	.07	51	.05	.31	.12	.29
Job Satisfaction	7	4352	.23	.29	.15	08	.03	51	.27	.32
Relaxation	5	1421	.25	.30	.10	29	.11	.43	.25	.34
Turnover Cognition	5	3548	-.21	-.27	.02	76	-.27	-.20	-.30	-.24
Work-Family Conflict	11	10921	-.27	-.33	.09	10	-.46	-.14	-.37	-.28
Work-Family Facilitation	2	441	.05	.07	.05	75	-.02	.14	-.02	.16

Note.*k* = number of studies. *N* = number of participants. $\bar{r}$ = sample−weighted mean correlation. ρ = estimate of population correlation corrected for unreliability in the predictor and criterion.SD_ρ = standard deviation of corrected correlation. % Var. = percentage of variance explained by artifacts. 90% CV = 90% credibility value (L = Lower, U = Upper). 95% CI = 95% confidence interval (L = lower, U = upper).

[a]. Day Shift = 0, Night Shift = 1.

[b]. Non-Shift = 0, Shift = 1.

[c]. Men = 0, Women = 1.

[d]. Not Married = 0, Married = 1.

Table 6: Meta-Analytic Correlations for Sleep Quantity

							90% CV		95% CI	
	k	*N*	$\bar{r}$	ρ	SD_ρ	% Var.	*L*	*U*	*L*	*U*
Sleep Measures										
Sleepiness	5	1273	-.11	-.15	.00	100	-.15	-.15	-.21	-.10
Sleep Quality	11	7875	.15	.16	.13	8	-.06	.38	.14	.18
Job Demands										
Cognitive Demands	2	886	-.09	-.10	.08	26	-.22	.05	-.16	-.03
General Job Demands	4	2130	-.15	-.18	.00	100	-.18	-.18	-.22	-.14
Hours Worked Per Week	9	113582	-.17	-.17	.09	1	-.17	.01	-.18	-.16
Hours Worked Variability	2	843	.03	.03	.00	100	.03	.03	-.04	.09
Shift/Non-Shift [a]	2	5589	.10	.10	.02	40	.06	.13	.07	.12
Workload	7	2540	-.13	-.15	.09	24	-.27	.02	-.19	-.11
Job Support										
Safety Climate	2	337	.08	.08	.00	100	.08	.08	-.03	.19
Supervisor Support	2	881	.05	.05	.06	37	-.05	.15	-.01	.11
Individual Antecedents										
Age	2	20091	-.09	-.10	.07	13	-.21	.01	-.11	-.08
Alcohol Consumption	2	6148	-.02	-.02	.05	10	-.11	.07	-.04	.01
BMI	4	9317	-.07	-.07	.02	14	-.10	-.04	-.07	-.06
Caffeine Use	3	879	-.01	-.01	.03	83	-.05	.03	-.07	.06
Trait PA	2	277	-.03	-.03	.00	100	-.03	-.03	-.15	.09
Family Time	3	11567	-.05	-.05	.00	100	-.05	-.05	-.07	-.03
Gender [b]	9	104009	.02	.02	.01	43	.00	.04	.02	.03
Marital Status [c]	2	5748	.01	.01	.00	100	.01	.01	-.02	.04
Trait NA	4	1644	-.02	-.03	.21	6	-.37	.32	-.07	.02
Number of Children	2	5748	.01	.01	.00	100	.01	.01	-.02	.04
Tobacco Use	3	6978	-.04	-.04	.05	15	-.12	.04	-.07	-.02
Health Outcomes										
Acute Fatigue	3	360	-.13	-.14	.00	100	-.14	-.14	-.24	-.03
Anxiety	3	1809	-.13	-.15	.05	45	-.20	-.05	-.20	-.11
Chronic Fatigue	6	2658	-.07	-.07	.19	6	-.38	.25	-.11	-.03
Depersonalization	2	213	-.16	-.22	.11	45	-.34	.01	-.30	-.03
Depression	2	1923	-.17	-.18	.06	19	-.27	-.07	-.22	-.14
Emotional Exhaustion	2	213	-.36	-.40	.11	36	-.55	-.18	-.51	-.28
General Job Strain	7	8816	-.14	-.16	.04	27	-.22	-.07	-.18	-.14
Other Health Problems	3	6034	-.06	-.06	.06	13	-.16	.04	-.08	-.03
Affective Outcomes										
Hostility	2	5604	-.03	-.03	.03	22	-.08	.03	-.06	.00
State NA	3	305	-.10	-.11	.00	100	-.11	-.11	-.21	.01
State PA	3	305	.03	.03	.00	100	.03	.03	-.08	.15
Attitudinal Outcomes										
CWB	2	353	-.19	-.19	.00	100	-.19	-.19	-.29	-.09
Engagement	2	2389	.03	.03	.00	100	.03	.03	-.01	.07
Job Satisfaction	5	1981	.13	.15	.10	21	-.03	-.29	.11	.19
Relaxation	2	870	.03	.03	.00	100	.03	.03	-.03	.09
Work-Family Conflict	2	747	-.01	-.01	.23	5	-.39	.38	-.08	.07

Note. *k* = number of studies. *N* = number of participants. $\bar{r}$ = sample–weighted mean correlation. ρ = estimate of population correlation corrected for unreliability in the predictor and criterion. SD_ρ = standard deviation of corrected correlation. % Var. = percentage of variance explained by artifacts. 90% CV = 90% credibility value (L = Lower, U = Upper). 95% CI = 95% confidence interval (L = lower, U = upper).

[a]. Non-Shift = 0, Shift = 1.

[b]. Men = 0, Women = 1.

[c]. Not Married = 0, Married = 1.

Table 7: Meta-Analytic estimate of population correlations corrected for unreliability in the predictor and criterion

	Sleepiness	Sleep Quality	Sleep Quantity	Job Demands	Job Control	Job Support	Anxiety	Depression	Physical Strain	Job Satisfaction
Sleep Quality	-.22									
(k, N)	(5, 2211)									
Sleep Quantity	-.15	.16								
(k, N)	(5, 1273)	(11, 7875)								
Job Demands	.31	-.29	-.17							
(*k, N*)	(6, 2029)	(20, 12173)	(11, 4775)							
Job Control	-.14	.21	N/A	.02						
(k, N)	(2, 367)	(11, 5985)		(9, 5811)						
Job Support	-.16	.18	.05	-.20	.38					
(k, N)	(3, 483)	(12, 6415)	(5, 1922)	(11, 5174)	(8, 2635)					
Anxiety	.35	-.51	-.15	.42	-.21	-.36				
(k, N)	(4, 3094)	(11, 10504)	(3, 1809)	(5, 6008)	(3, 2988)	(5, 3222)				
Depression	.34	-.44	-.18	.45	-.27	-.37	.79			
(k, N)	(5, 3425)	(18, 21827)	(2, 1923)	(10, 6419)	(7, 1774)	(10, 4608)	(10, 11528)			
Physical Strain	.42	.34	-.14	.34	-.17	-.27	.42	.48		
(k, N)	(13, 13435)	(41, 42489)	(13, 10815)	(21, 13713)	(10, 10326)	(9, 3792)	(12, 12411)	(15, 14569)		
Job Satisfaction	-.11	.29	.15	-.45	.46	.37	-.40	-.49	-.36	
(k, N)	(3, 7710)	(7, 4352)	(5, 1981)	(5, 3767)	(4, 1084)	(3, 795)	(3, 1809)	(6, 3879)	(9, 13482)	
Work-Family Conflict	.34	-.33	-.01	.35	-.19	-.38	.43	.39	.31	-.25
(k, N)	(2, 7833)	(11, 10921)	(2, 747)	(5, 2874)	(6, 6733)	(3, 589)	(2, 2407)	(5, 3097)	(11, 16274)	(140, 61340)

Table 8: Comparison Among Fit Indices for Tested Meta-Analytic Path Models

	Model A	Model B	Model C	Model D	Model E
χ^2	2025.78	423.65	102.05	80.91	74.89
$\chi^2 df$	19	13	8	8	10
GFI	.892	.971	.992	.994	.995
AGFI	.308	.854	.934	.951	.964
RMSEA	.208	.114	.069	.061	.051

Figure 1: Workplace Antecedents and Consequences of Sleep

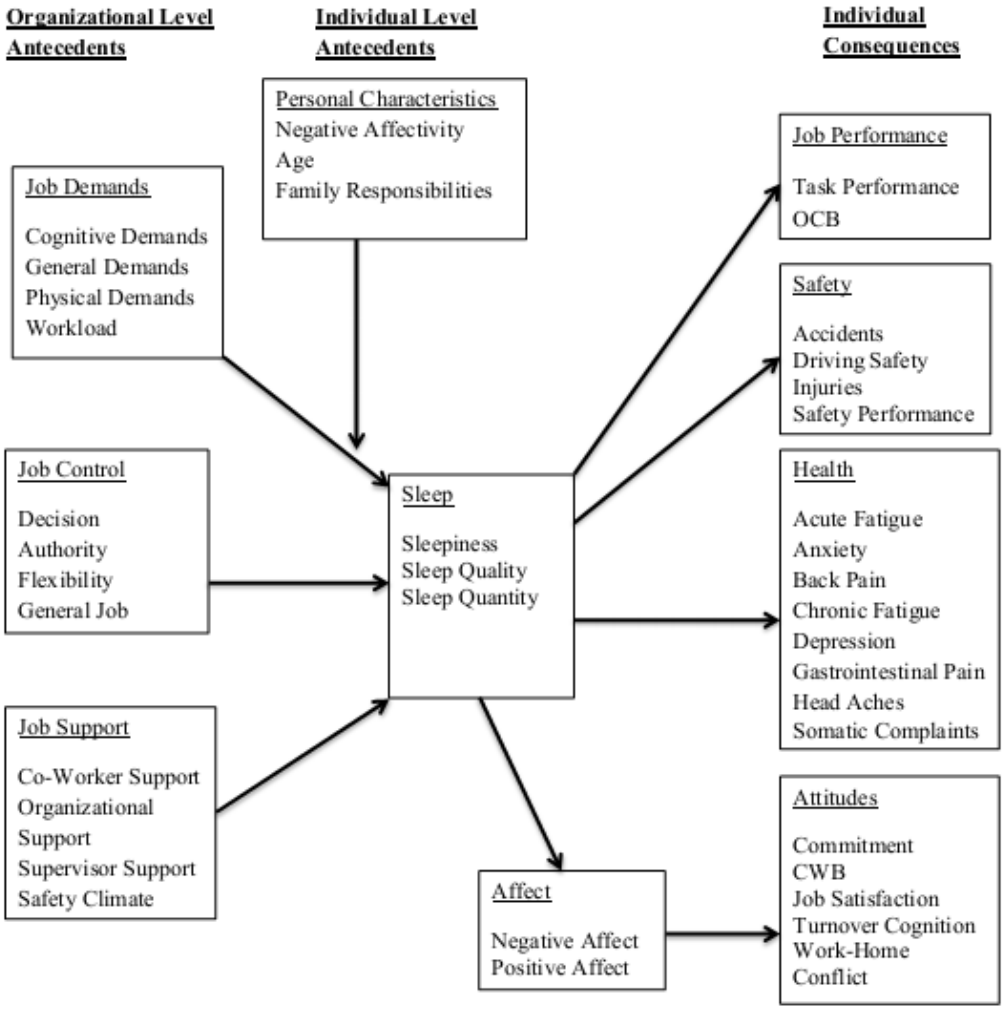

Figure 2: Maximum Likelihood Parameter Estimates for the Hypothesized Model

