



Precarious Work Schedules and Sleep: A Study of Unionized Full-Time Workers

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Abstract

Unlike *precarious employment* which is temporary and insecure, with inadequate pay, benefits, and legal protections, *precarious work schedules* can affect workers with permanent full-time jobs in sectors where employment has historically been secure, well-compensated, and even unionized. Precarious work schedules – characterized by long shifts, non-daytime hours, intensity and unsocial work hours – are increasingly prevalent. Relations between precarious work schedules and poor health are not well understood, and less is known about how to attenuate this relation. We examined the indirect effects of precarious work schedules on fatigue and depressive symptoms through sleep quantity. Two moderators – schedule flexibility and sleep quality – were examined as buffers of these associations. Workers from the Departments of Correction and Transportation in a northeast state ($N=222$) took surveys and reported on demographics, work schedule characteristics, schedule flexibility, sleep quality and quantity, fatigue, and depressive symptoms. Results revealed that precarious work schedules had indirect effects on fatigue and depressive symptoms through sleep quantity. Schedule flexibility moderated the relation between precarious work schedules and sleep quantity, such that workers with greater schedule flexibility had more hours of sleep. Sleep quality moderated the association between sleep quantity and fatigue and depressive symptoms, such that workers reported greater fatigue and depressive symptoms when they had poorer sleep quality. Findings have direct applicability for developing initiatives that enhance Total Worker Health® through individual and organizational changes.

Keywords Precarious work schedules · Sleep · Schedule flexibility · Fatigue · Depressive symptoms

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Contemporary economic and social conditions and technological innovations, particularly in the aftermath of the 2008 financial crisis and more recently during the COVID-19 pandemic, have meant the loss of the typical 9 to 5 workday for a large and growing subset of the American workforce. By the age of 40, nearly 90% of U.S adults have worked a non-standard work schedule (Presser & Ward, 2011). Unlike standard work schedules, non-standard work schedules consist of hours that are typically non-daytime, irregularly scheduled, or both (Winkler et al., 2018). Beyond non-standard work schedules, Americans are also working longer hours. As of 2010, 18.7% of workers reported working more than 48 h per week and 7.2% reported working 60 or more hours per week (Alterman et al., 2013).

Relations between extended and irregular work schedules with health outcomes are not well understood (Golden, 2015; Johnson & Lipscomb, 2006; Winkler et al., 2018), and less is known about the physiological and behavioral mechanisms linking work schedules and disease. In this cross-sectional study, we examine two unionized workforces in the public sector—corrections and transportation—who experience extended and irregular schedules in the context of their full-time employment, to understand how schedules affect their well-being. Over our many years of using participatory action research (PAR) with these populations (Cavallari et al., 2019, 2020a, b, 2021; Cherniack et al., 2016; Dugan et al., 2016, 2021, 2022), the topic of extended and irregular work schedules has consistently emerged as a worker health concern, both due to prolonged exposure to workplace hazards and adverse effects on health, including sleep (Suleiman et al., 2021). In addition to this study being observational, it is a rare example of translational PAR research in which the selection of study variables was informed by worker input with the intent of identifying and testing modifiable factors that, if found to ameliorate the adverse effects of schedules on sleep and well-being, may serve as the basis for occupational health interventions.

Building on prior research, we investigate sleep quantity as a mechanism through which the association between extended and irregular work schedules and poor health may occur. Moreover, we explore two modifiable factors (moderators) – schedule flexibility and sleep quality – as buffers of these associations that may alleviate the adverse impact of extended and irregular work schedules. This study model was specifically selected because although workers perceive extended and irregular work schedules to be an intractable reality that inevitably reduces well-being and sleep hours, they consider certain factors to have real-world potential for change within their workforce and in the context of their organization. Specifically, increasing schedule flexibility as a modifiable organizational factor, and improving sleep quality as a modifiable individual factor, were identified by workers as acceptable and feasible points of intervention, and thus they hold promise for later implementation success (Dugan & Punnett, 2017).

Another novel contribution of this study, we utilize a new work schedule construct – precarious work schedules – which simultaneously takes into consideration key characteristics of extended and irregular work schedules (i.e., long shifts, non-daytime hours, intensity (working 6 + days without a day off), and lack of free time during hours when most social activities occur). This is noteworthy because common measures, such as overtime characterized by work hours alone, do not capture

the time of day when extended hours or discretionary time occurs, nor do they capture the intensity of work schedules. Schedule characteristics have mainly been studied individually in relation to health (in isolation from one another; van de Ven et al., 2016; Winkler et al., 2018), and have not been assessed as comprehensively as we do, as a confluence of broad schedule characteristics that in combination with one another can concurrently affect a worker's health.

Work Schedules and Well-being

Characteristics of work schedules such as shift work, irregular hours, overtime hours, and long hours have been linked to a host of acute and chronic health conditions, including stress and fatigue, obesity, depression, stroke, cancer, heart disease, and musculoskeletal disorders (Golden, 2015; Johnson & Lipscomb, 2006; Kecklund & Axelsson, 2016; Kivimäki et al., 2011; Virtanen et al., 2012; Winkler et al., 2018). Prior research has linked shift work to fatigue, which is a state in which a person feels very tired, weary or sleepy, due to sleep loss and disruptions in circadian rhythms (Caldwell et al., 2019; Canadian Centre for Occupational Health and Safety, 2017; Dorrian et al., 2011). Workers who get less than 5 h of sleep in the 24-h period before work, or less than 12 h of sleep in the 48 h prior to starting work, have an increased risk of fatigue (Dawson & McCulloch, 2005). Most research on fatigue has been focused on a few occupational groups such as nurses, medical residents, truck drivers, rail workers, and nuclear power plant workers (Caldwell et al., 2019). However, fatigue is important across all occupations, as it is linked to health and safety risk (Dawson & McCulloch, 2005) due to its association with decreased cognitive function, impaired performance, and increased error rates (Dawson & McCulloch, 2005).

Research suggests an association between many work characteristics and depression, a highly prevalent mental health disorder in the general population and among the most common disorders found in working populations (Sanderson & Andrews, 2006). Night shift work is associated with an increased risk of depressive symptoms (Lee et al., 2017), and is also positively associated with depressed mood (Driesen et al., 2010). Frequently unpredictable schedules and lack of schedule control are associated with workers' depressive symptoms (Cavallari et al., 2020a, b). There is evidence for a dose–response relation between long working hours and depression scores, such that overtime work is associated with increased depressive symptoms (Kleppa et al., 2008; Nishikitani et al., 2005).

Fatigue and depression are problematic because of their critical implications for the short-term and long-term safety and health outcomes of workers in different occupations. Fatigue resulting from long work shifts and inability to recover between shifts tends to reduce an employee's cognitive function and ability to concentrate, decreasing the quality of decision-making (Scott et al., 2014), therefore increasing possibilities of errors and injuries; while depression may contribute to adverse health behaviors and outcomes including all-cause mortality (Bădescu et al., 2016; Del Campo et al., 2017; Machado et al., 2018; Penninx, 2017; Saneei et al., 2016).

Sleep Quantity as a Mechanism Linking Precarious Schedules and Well-being

The mechanisms linking non-standard and extended work schedules with disease are not well-understood, partly due to the variety of research designs and methodologies employed by scholars across disciplines (Arlinghaus et al., 2019; Kantermann et al., 2010). Chronobiological, physiological, social, and behavioral pathways have all been proposed to explain the relation between extended and irregular workdays and unfavorable health outcomes, such as fatigue and depressive symptoms, with insufficient sleep quantity as one of the more likely culprits (Winkler et al., 2018). Sleep quantity is defined as the amount of time a person spends in a sleeping state (Barnes et al., 2012). According to the effort-recovery model (Meijman & Mulder, 1998), sufficient sleep is essential for good health because it allows the central nervous system to recover from the effort expended and energy depleted by daily life activities, including work (Åkerstedt et al., 2009). Regular, sufficient sleep restores a person's alertness, memory capacity, and mood (Åkerstedt et al., 2009). Insufficient recovery over time may result in sustained activation (Sluiter et al., 2001) in which workers must function in a chronic suboptimal psycho-physiological state and are likely to experience fatigue, poor physical and mental well-being, burnout, and work performance breakdowns (Eden, 2001; Elfering et al. 2002; Lundberg & Lindfors, 2002; Sonnentag, 2001, 2003; Sonnentag & Zijlstra, 2006).

On average, American adults get 6.8 h of sleep per night, which falls short of the expert recommended minimum of 7 h per night (Watson et al., 2015). Insufficient sleep has been declared a public health epidemic, as more than one third of American adults regularly report not getting enough sleep (Liu et al., 2013). This is concerning as insufficient sleep duration is associated with seven out of the top fifteen leading causes of death in the United States, including cardiovascular disease, malignant neoplasm, cerebrovascular disease, accidents, diabetes, septicemia and hypertension (Kochanek et al., 2017). Specifically, people who sleep less than 7 h per night are at an increased risk for obesity, diabetes, high blood pressure, coronary heart disease, stroke, frequent mental distress and all-cause mortality (Grandner et al., 2014; Liu et al., 2013).

Along with stress, irregular hours are one of the main causes of disturbed sleep (Åkerstedt et al., 2009). Sleep quantity is largely dependent on time, which is increasingly scarce due to the growing demand for 24/7 work (Litwiller et al., 2017) and the rise of precarious employment. According to conservation of resources (COR) theory, people have a limited amount of resources to allocate to activities associated with various life domains (i.e., work, family, sleep), and the loss (or threat of loss) of these resources can result in stress and strain (Hobfoll, 1989). Time is considered a critical finite resource (Dugan & Barnes-Farrell, 2017, 2020; Hobfoll, 1989). Extended and irregular work schedules can threaten time resources and lead to feelings of time scarcity, as they are not aligned with the social activity in any society and are often inconsistent with the daily schedules of a working family's household (Härmä et al., 2015). The loss of time can be a source of stress when it interferes with workers not being able to use time resources to fulfill other life

demands (family), or constrains opportunities for recovery and health behaviors such as sleep (Greenhaus & Parasuraman, 2002; Sonnentag, 2001, 2003). In an effort to manage time resources and fulfill responsibilities across all life domains, people may choose to get fewer hours of sleep to have more time available for their work and family demands (Barnes et al., 2012; Winkler et al., 2018). Research supports this proposition in that night and early-morning shifts, quick returns, extended shifts (> 16 h) and long weekly working hours (> 55) are all associated with short sleep durations and increases in sleepiness (Sallinen & Kecklund, 2010). Both shift work and working more than 48 h per week are risk factors for sleep disorders (Ribet & Derriennic, 1999).

Short sleep duration is an explanatory factor accounting for the association between several work time characteristics and fatigue. Shiftwork (e.g., night work) and long work hours have adverse impacts on fatigue among nurses, mainly due to sleep deficiency (Caruso, 2014; Caruso et al., 2017). Moreover, quick returns (< 11 h between work shifts) may have a stronger adverse impact than night work, and are associated with fatigue and sleepiness on a worker's subsequent shift (Dahlgren et al., 2016; Vedaa et al., 2016).

Sleep may also be one mechanism that explains the association between work time characteristics and depressive symptoms. First, as described above, sleep problems are more prevalent for workers with extended and irregular work hours, yet sleep is also a risk factor for depression (Charles et al., 2011; Driesen et al., 2010). At the biological level, sleep loss can influence the secretion of hormones, like cortisol, which can contribute to the development of mood and anxiety disorders (Litwiller et al., 2017).

A New Look at Work Schedule Characteristics

Although various types of non-standard work schedules and their health effects have received attention in the literature (Lambert & Henly, 2014), a limitation of existing studies is that most assess only one isolated aspect of work schedules (e.g., shift type, shift length, overtime, irregular hours) at a time. This approach does not account for the interrelatedness of the various work time characteristics present in today's workforce (Härmä et al., 2015). In reality, many workers have work schedules that are simultaneously rigid, irregular and unstable, such that they have little control over work hours, short advance notice, and frequent fluctuations in work schedules (Lambert et al., 2014). Scholars have coined this grouping of work time characteristics as *precarious work schedules* and have urged researchers to measure various aspects of precarious work schedules including number of hours, non-standard work timing, intensity, and social aspects of work hours (i.e., non-work free time, control, predictability, variability) (Härmä et al., 2015; Lambert & Henly, 2014). Unlike *precarious employment* which is temporary and insecure, with inadequate pay, benefits, and legal protections, *precarious work schedules* can affect workers with permanent full-time jobs in sectors where employment has historically been secure, well-compensated, and even unionized.

In this study of corrections and transportation workers, we use a novel working time measure to examine multiple interacting characteristics of precarious schedules and their association with two important indicators of well-being, depressive symptoms and fatigue. We further investigate sleep quantity as a mechanism through which this association occurs. Thus, we propose the following (see Fig. 1):

Hypothesis 1: Precarious work schedules are indirectly related to (1a) fatigue, and (1b) depressive symptoms through sleep quantity. Specifically, precarious work schedules will be negatively associated with sleep quantity, and sleep quantity will be negatively associated with both fatigue and depressive symptoms.

The Role of Schedule Flexibility in the Association between Work Schedules and Sleep Quantity

One organizational factor that may mitigate the effects of precarious work schedules is schedule control. Control is an overarching concept that describes phenomena related to workers having some discretion and autonomy in their scheduling, such as when workers have input in setting their own schedules (i.e., input into number of work hours, start/end times, or days off) or have schedule flexibility related either to work timing (i.e., ability to adjust start and end times) or within their workday (i.e., ability to take time off during the workday for non-work activities) (Lambert & Henly, 2014). Consistent with COR theory (Hobfoll, 1989), flexibility may reduce stress by placing less of a temporal demand on workers, and also permits workers to manage their time resources so that they can engage in other important life activities such as getting physical exercise, eating a healthy diet, engaging in leisure activities, fulfilling personal and family obligations, and getting sufficient sleep (Allen, 2002; Costa et al., 2004; Crain et al., 2019; Dugan & Barnes-Farrell, 2020; Grzywacz et al., 2007).

Several studies have examined the relation between schedule control and sleep, and found significant associations between: control over daily working hours with depressive symptoms (Takahashi et al., 2011), work time control with longer sleep and fewer insomnia symptoms (Takahashi et al., 2012), and schedule control with sleep duration and sleep quality (Brossoit et al., 2020). Schedule flexibility falls under the overarching concept of control, and a particular form of flexibility, within-workday flexibility, has shown promise in supporting worker well-being. It has been associated with longer sleep hours (Grzywacz et al., 2007) and increased happiness (Golden et al., 2014). Within-workday flexibility is also associated with larger reductions in stress and improvements in concomitant sleep difficulties than other forms of flexibility (e.g., opportunity for compressed workweek), likely due to having a higher degree of flexibility (i.e., it is short-notice flexibility) (Haley & Miller, 2015).

There is some evidence that worker discretion over their schedule may buffer the effects of extended and irregular work hours on sleep; this is in keeping with the job demands-control model in which worker control can reduce the effect of high job demands on strain outcomes (Karasek, 1979). One study showed that although

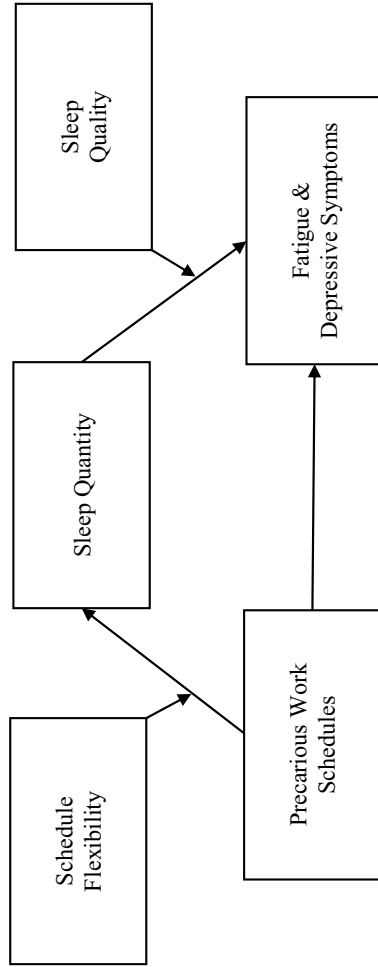


Fig. 1 Conceptual Model of Hypothesized Relationships

workers with highly variable, company-controlled working hours experience sleep problems, these effects are weaker when employees have more schedule flexibility and autonomy (Janssen & Nachreiner, 2004). Another study of various work time characteristics showed that control moderated the relation between night-shift work with sleep quantity and sleep disturbance (i.e., working 4 + hour night shifts weekly with low time control resulted in shorter and more disturbed sleep), but did not moderate other work time characteristics (i.e., short inter-shift intervals, weekend working, unpaid overtime) (Tucker et al., 2015). Therefore, the influence of schedule control is complex and more research is needed to better understand its impact, as well as the effects of particular forms of schedule control, such as within-workday flexibility. To explore the buffering effect of schedule flexibility on the relation between precarious work schedules and sleep quantity (see Fig. 1), we propose:

Hypothesis 2: Schedule flexibility will moderate the negative relation between precarious work schedules and sleep quantity, such that the relation will be weaker when schedule flexibility is high.

The Role of Sleep Quality in the Association between Sleep Quantity and Well-being

Sleep quality and sleep quantity are distinct constructs. Sleep quantity, as previously explained, is the amount of time a person is asleep, whereas sleep quality is defined as how well a person sleeps (Crain et al., 2018). However, the constructs are related; a meta-analysis found a small but positive significant relation between sleep quality and sleep quantity ($\rho=0.16$) (Litwiller et al., 2017), and sleep quantity has been described as a component of sleep quality (Buysse et al., 1989). Sleep is integral to health, with previous studies reporting the synergistic effect of sleep quantity and quality on health outcomes such as impaired fasting glucose and glycemic control (Lou et al., 2014; Tang et al., 2014). Sleep is also essential for mental well-being, and both sleep quantity and quality have been associated with fatigue (Åkerstedt et al., 2014; Patterson et al., 2010) and mental disorders such as depression in multiple populations (Bhati & Richards, 2015; Le Grande et al., 2016; Zhai et al., 2015).

Crain and colleagues (2018) recommend that sleep quality and quantity be studied together, suggesting the potential for an interaction between sleep quantity and quality. Few studies have examined the interactive effect of sleep quantity and quality in predicting health outcomes. For example, Barnes and coauthors (2015) found support for an interactive effect such that when both sleep quantity and quality were high, ego depletion was lower ($p=0.01$) (Barnes et al., 2015).

There are two reasons for studying sleep quality as a moderator of the association between sleep quantity and well-being. First, the study of sleep is complex. Both sleep quantity and quality are important for energy resources (Crain et al., 2018) and there is merit in considering their effects simultaneously when drawing conclusions about workers' sleep health. For example, a worker who reports getting 8 sleep hours that are of poor quality may feel more tired in the morning relative to a worker who reports the same quantity of sleep but of higher quality. Second, unlike sleep

quantity which is highly dependent on time, sleep quality can be improved through sleep hygiene behavior and other practices such as exercise, yoga, and relaxation techniques that make it a more amendable factor and a potential intervention point (Robbins et al., 2019). Therefore, we propose to examine the interactive effect of sleep quality and sleep quantity on health outcomes (see Fig. 1):

Hypothesis 3: Sleep quality will moderate the negative relations between (3a) sleep quantity and fatigue and (3b) sleep quantity and depressive symptoms, such that the relations will be weaker when sleep quality is good.

Overall, we propose a moderated mediation model, such that both schedule flexibility and sleep quality will moderate the proposed indirect effect.

Hypothesis 4: Schedule flexibility and sleep quality will moderate the indirect effect of precarious work schedules on (4a) fatigue and (4b) depressive symptoms through sleep quantity, such that the indirect effect will be weaker when schedule flexibility is high and sleep quality is good.

Method

This study is part of the larger the WorkTime Study, which utilizes PAR methods to study the impact of working time on the health and well-being of two state-based workforces in the northeast United States, at the Department of Correction (DOC) and the Department of Transportation (DOT). These state workforces were selected due to their exposure to precarious work schedules. Although employment at DOT and DOC is unionized and has historically been secure and permanent, workers experience extended and irregular schedules in the context of their full-time employment in hazardous and mandatory service jobs, where employers have increasingly imposed work schedules that not only have extended hours, but are irregular (unpredictable, variable) and also mandatory due to the round-the-clock nature of critical public safety needs. The DOC manages correctional facilities (state prisons and jails) which function 24/7 with staff assigned to shifts, though overtime is common and often on short notice. The DOT maintains the state's roadways, requiring staff to work extended and irregular hours during storms and road construction projects. We build upon a preexisting history of PAR with both of the organizations/populations in this study (at least ten years each) and will use findings to directly inform interventions for future implementation (Cavallari et al., 2019, 2020a, b, 2021; Cherniack et al., 2016; Dugan et al., 2016, 2021, 2022; Suleiman et al., 2021).

A Participatory Action Research Approach

The WorkTime Study uses a PAR approach, infrequently found in occupational health studies (Cook, 2008), to develop interventions with the direct and active participation of front-line workers. We use PAR because bottom-up

worker-driven interventions yield better health and implementation outcomes than top-down, employer-driven approaches, mainly due to the identification and remediation of the root causes of poor health (Cherniack et al., 2016; Dugan et al., 2016). Early worker involvement in studies prior to developing interventions is especially important in PAR as it improves intervention effectiveness by ensuring that investigators do not miss critical aspects of the psychosocial and workplace contexts that determine health. It also results in interventions designed to be relevant, feasible, appropriate, acceptable and scientifically-credible to end users, and have a greater likelihood for implementation success (Dugan & Punnett, 2017).

As background, the WorkTime Study started with a workforce needs assessment (focus groups and surveys of workers) to better understand the different aspects of working time exposures for both DOC and DOT workers, and mechanisms by which schedules affected health (e.g., reduced opportunities for sleep, health behaviors, and family/social life). Focus group findings elucidated the effect of precarious schedules on insufficient sleep (see Suleiman et al., 2021) and were instrumental in the development of a contextually-relevant survey for further needs assessment of these worker populations (Dugan et al., 2021). We then used an intervention planning tool to facilitate the brainstorming of intervention ideas with workers to address the root causes of their health concerns. Specifically, workers identified modifiable individual and organizational factors that could serve as the basis for designing Total Worker Health® interventions to alleviate the impact of precarious work schedules. (Total Worker Health® initiatives address health problems related to workers and workplaces to simultaneously protect and promote worker health [National Institute for Occupational Safety and Health, 2020]).

This paper's hypotheses were informed by the ideas workers generated for intervention, two of which pertained to improving sleep and increasing schedule discretion (flexibility). We specifically chose to examine these variables as moderators in an effort to provide an empirical basis of support for selecting these topics as the focus of future implementation efforts. The PAR method provided relevant information about the worker groups in this study that would have been unknown using conventional research approaches, and without which our future interventions may have been derailed. For instance, we learned from workers that although precarious schedules were employer-imposed, they are also often embraced by workers concerned with financial insecurity who frequently volunteer for overtime to increase income (often knowingly at the expense of their sleep health), and are protective over their ability to work as many hours as possible (Dugan et al., 2021, 2022). Thus, with worker input, we were able to avoid backlash that could have resulted from initiatives aimed at changing current scheduling practices, and identify points of intervention (moderators/buffers) that were more immediately acceptable to the worker population. Workers helped us to understand that more education and awareness about the health effects of precarious schedules are needed to obtain worker buy-in prior to initiating any change to current scheduling practices.

Participants

Eligible participants at DOT and DOC were invited to take an electronic survey via tablet computer on days when they were scheduled to attend organizational training sessions. The University's Institutional Review Board approved all study procedures involving human subjects. Informed consent was obtained from all participants enrolled in the study. Although 318 employees participated in the study, only 222 employees were included in the current analyses (DOT $N=113$; DOC $N=109$) due to missing data. Multiple imputation was not possible due to the analytic technique we used (ordinary least squares regression), however, t -tests on key demographics (between the 222 included and the 96 not included) showed no statistically significant differences.

Measures

Precarious Work Schedules The WorkTime Scale was used to assess the frequency of working extended hours, non-daytime hours, unsocial work hours, and an intense schedule (6+ days without a day off). For the purposes of this study, we used the 10-item *Extended and Irregular Work Days* (EIWD) subscale with sample items which included, "I worked more than 12 h per day," "I worked at least 3 evening hours after 6 pm," "I worked on the weekend," and "I worked 6 or more days in a row." Response options ranged from 1 (*Always*) to 5 (*Never*). All items were reverse scored and averaged, such that higher scores reflected more frequent extended and irregular workdays. Cronbach's α for this scale was 0.92. We conducted a CFA on the 10-item EIWD subscale which revealed that the 10-item factor had an adequate fit to the data, with a chi-square value of 72.31 ($df=29$; $p<0.001$), a CFI/TLI of 0.94/0.91, an SRMR of 0.07, and an RMSEA of 0.11.

Worker Well-Being: Fatigue and Depressive Symptoms The four-item Fatigue Assessment Scale (Michielsen et al., 2003) was used to assess fatigue. Sample items included "I get tired very quickly" and "Mentally, I feel exhausted". Participants were asked to indicate how often they felt this way over the past month. Response options ranged from 1 (*Never*) to 5 (*Always*). The items were averaged, such that higher scores reflected greater fatigue. Cronbach's α for this scale was 0.91.

The 8-item short version of the Centers for Epidemiological Studies Depression Scale (CES-D) (Van de Velde et al., 2009; Turvey et al., 1999) was used to assess depressive symptoms. Sample items included "I felt sad" and "I could not get going". Participants were asked to indicate how often they felt this way during the past week. Response options ranged from 1 (*Rarely or none of the time [less than 1 day per week]*) to 4 (*All of the time [5 to 7 days per week]*). Two positively worded items were reverse scored. The items were averaged, such that higher scores reflected more frequent depressive symptoms. Cronbach's α for this scale was 0.83.

Intervening Variable: Sleep Quantity To assess sleep quantity, participants were asked “In the past month, about how many hours of sleep did you typically get per 24-h period during the work week?” (Adapted from Buysse et al., 1989). Response options were continuous, ranging from 0 to 10 h.

Moderators: Schedule Flexibility and Sleep Quality To assess schedule flexibility, we adapted an item from the General Social Survey (GSS) that evaluates difficulty taking time off during the workday (within-workday flexibility; Smith et al., 2018; Golden et al., 2014; Lambert & Henly, 2014). Participants were presented with the item “It is difficult to take time off from work to take care of personal or family matters.” Response options ranged from 1 (*Strongly disagree*) to 5 (*Strongly agree*). We reversed scored this item so that low scores represent low schedule flexibility and high scores represent high schedule flexibility.

To assess sleep quality, participants were asked “During the past month, how would you describe the quality of your sleep on a typical night?” (Adapted from Buysse et al., 1989). Response options ranged from 0 (*poor or fairly poor*) to 1 (*fairly good or good*).

Control Variables Both organizations in this study have hierarchical organizational structures, (particularly corrections which is paramilitary in nature) in which ascribed sociodemographic variables (e.g., age, gender, race/ethnicity, income) can confer higher or lower social status to workers. These facets of a worker’s social status may put them at risk for poorer well-being, and can affect their degree of schedule precariousness or flexibility. Age, gender, race/ethnicity, family income and employer were included as control variables. Age was indicated as a continuous variable in years, and gender was coded as 0 (*female*) or 1 (*male*). Race/ethnicity was coded as 0 (*Person of Color* [Black, African American, African; American Indian, Alaska Native; Asian, Asian American; Other or Multiracial] or *Hispanic*) or 1 (*White and Non-Hispanic*); this coding was done to reflect the social strata of the United States in which people with certain socio-demographic characteristics (i.e., White, concealed ethnicity) have better well-being and access to rewards/civil treatment on the basis of their ascribed race/ethnicity, than people without those socio-demographic characteristics (i.e., People of Color, Hispanic ethnicity). Family income was coded as either 0 (*Less than \$100,000*) or 1 (*\$100,000 or more*). Lastly, employer was coded as either 0 (*DOC*) or 1 (*DOT*).

Data Analysis

We examined our hypotheses using Hayes’s (2017) PROCESS macro version 3 in SPSS 22.0. PROCESS is a modeling tool that uses an ordinary least squares regression-based path analytic framework. It is widely used to estimate moderation and direct and indirect effects. Models 1, 4, and 21 were used to test our hypotheses. Model 1 in this macro represents a simple moderation model. Model 4 in this macro represents a simple mediation model. Model 21 represents a conditional indirect effects model in which an indirect effect is moderated at both the a-path and the

b-path. We chose to use PROCESS because it allows for the estimation of moderated mediation. We estimated the indirect effects using unstandardized coefficients. Significance of the indirect effects was evaluated using 95% confidence intervals, such that an indirect effect was considered significant when confidence intervals did not include zero (Hayes, 2017). Continuous variables that define interaction terms were centered prior to analyses. Interactions and conditional indirect effects were probed for significance at -1 SD, Mean, and $+1$ SD.

Results

Participant demographics are presented in Table 1. The sample consisted of 186 males (84%) and 36 females (16%), ranging in age from 22 to 62 years old ($M=43.4$, $SD=8.8$). More than half of the sample self-identified as White and Non-Hispanic (59%). Most of the participants reported having a high school diploma or some college (76%). Most participants were married or partnered (71%). Regarding family income, 45% reported their total family income as less than \$100,000. The sample consisted of 133 (60%) supervisors or managers. Mean tenure was 12.5 years ($SD=8.7$). On average, participants reported working 43.1 ($SD=12.2$) hours in the past seven days including regular overtime hours. Mean overtime hours in the last seven days was 10.7 h ($SD=14.5$).

Preliminary Analyses

The transportation and correction samples were compared on each of the demographic variables (see Table 1). Chi-square analyses revealed that the samples differed significantly with respect to gender $\chi^2(1)=31.153$, $V=0.375$, $p<0.001$, family income $\chi^2(1)=29.414$, $V=0.364$, $p<0.001$, education $\chi^2(1)=47.901$, $V=0.465$, $p<0.001$, and supervisory responsibility $\chi^2(1)=136.814$, $V=0.785$, $p<0.001$. A series of t-tests revealed that the samples differed significantly with respect to job tenure $t(220)=5.64$, $p<0.001$, work hours $t(219)=3.04$, $p<0.003$, and overtime hours $t(204)=2.30$, $p<0.02$. The samples did not differ significantly on age, race/ethnicity or marital status. Due to the differences between samples, employer was included as a control variable in all analyses, in addition to age, gender, race/ethnicity and family income.

Descriptive statistics and bivariate correlations for all study variables are reported in Table 2. Precarious work schedules were negatively associated with sleep quantity ($r=-0.22$, $p=0.001$) and positively associated with depressive symptoms ($r=0.18$, $p=0.007$), though not associated with fatigue. Sleep quantity was negatively associated with both fatigue ($r=-0.33$, $p<0.001$) and depressive symptoms ($r=-0.38$, $p<0.001$). Of the demographic variables, gender (male) was positively associated with precarious work schedules ($r=0.17$, $p=0.012$) and negatively associated with fatigue ($r=-0.22$, $p=0.001$). Employer (DOT) was positively associated with sleep quantity ($r=0.16$, $p=0.017$) and negatively associated with both fatigue ($r=-0.32$,

Table 1 Demographics and work information of overall sample and by employer

	Overall Sample	Transportation	Correction	P-value
Age (In Years) ^a	N (%) or Mean (SD) 43.4 (8.8)	N (%) or Mean (SD) 44.3 (10.4)	N (%) or Mean (SD) 42.5 (6.6)	.13
Sex ^b				
Female	36 (16%)	3 (8%)	33 (92%)	< .000***
Male	186 (84%)	110 (60%)	76 (41%)	
Race/Ethnicity ^b				
Hispanic/People Of Color	92 (41%)	43 (47%)	49 (53%)	.30
White/Non-Hispanic White	130 (59%)	70 (54%)	60 (46%)	
Education ^b				
High School Or Some College	169 (76%)	108 (64%)	61 (36%)	< .000***
College Degree Or Graduate Degree	53 (24%)	5 (11%)	48 (91%)	
Marital Status ^b				
Widowed, Divorced, Separated, Or Single	64 (29%)	38 (59%)	26 (41%)	.11
Married Or Live With Partner	158 (71%)	75 (48%)	83 (53%)	
Annual Family Income ^b				
Less Than \$100,000	100 (45%)	71 (71%)	29 (29%)	< .000***
\$100,000 Or More	122 (55%)	42 (34%)	80 (66%)	
Supervisory Responsibility ^b				
No	89 (40%)	88 (99%)	1 (1%)	< .000***
Yes	133 (60%)	25 (19%)	108 (81%)	
Job Tenure (In Years) ^a	12.5 (8.7)	9.5 (9.6)	15.7 (6.4)	< .000***
Total Hours Per Week (In Hours) ^a	43.1 (12.2)	40.7 (12.1)	45.6 (11.8)	.0033**
Overtime Per Week (In Hours) ^a	10.7 (14.5)	8.60 (11.6)	13.2 (17.0)	.02*

N = 222. Percentages, means, and standard deviations listed were calculated by excluding missing cases

* $p < .05$, ** $p < .01$, *** $p < .001$

^a t-test

^b chi square

Table 2 Means, standard deviations and correlations among study variables

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11
1. Age	43.4	8.76	—										
2. Gender (male)	.84	.37	-.01	—									
3. Race/Ethnicity	.59	.49	-.02	.10	—								
4. Family Income	.55	.50	.00	.08	-.01	—							
5. Employer (DOT)	.51	.50	.10	.38**	.07	-.36**	—						
6. Precarious Work Schedules	3.04	.92	-.09	.17*	-.05	-.08	.19**	(.92)					
7. Schedule Flexibility	3.86	1.07	-.03	.01	-.04	.05	-.09	-.12	—				
8. Sleep Quantity	6.12	1.18	-.05	.12	.01	-.04	.16*	-.22*	.19**	—			
9. Sleep Quality	.70	.46	.07	-.05	-.02	-.04	.08	-.17**	.18**	.38**	—		
10. Fatigue	2.22	.88	-.07	-.22**	.00	.07	-.32**	.13	-.33**	-.33**	-.46**	(.91)	
11. Depressive Symptoms	1.61	.55	-.12	-.11	-.03	-.05	-.13*	.18**	-.34**	-.38**	-.54**	.66**	(.83)

N = 222. Reliabilities (Cronbach's α) are on the diagonal in parentheses. Race/ethnicity coded as 0 (Hispanic Person of Color) or 1 (Non-Hispanic White). Family income coded as 0 (Less than \$100,000) or 1 (\$100,000 or more)

* $p < .05$. ** $p < .01$

$p < 0.001$) and depressive symptoms ($r = -0.13$, $p = 0.046$). Age, race/ethnicity and family income were not significantly correlated with any of the main study variables.

Hypothesis Testing

For all analyses, we controlled for age, gender, race/ethnicity, family income and employer.

Indirect Effects We tested the model using Model 4 of Hayes's (2017) PROCESS macro. Hypothesis 1a proposed that precarious work schedules are indirectly related to fatigue through sleep quantity (Fig. 1). Precarious work schedules were positively related to fatigue ($B = 0.137$, $SE = 0.063$, $LLCI = 0.012$, $ULCI = 0.261$). Precarious work schedules were negatively related to sleep quantity ($B = -0.364$, $SE = 0.086$, $LLCI = -0.534$, $ULCI = -0.194$), and in turn sleep quantity was negatively related to fatigue ($B = -0.180$, $SE = 0.048$, $LLCI = -0.274$, $ULCI = -0.085$). Therefore, precarious work schedules were indirectly related to fatigue through sleep quantity (Indirect Effect = 0.065, BootSE = 0.022, BootLLCI = 0.027, BootULCI = 0.111). These results provide support for Hypothesis 1a.

Hypothesis 1b proposed that precarious work schedules are indirectly related to fatigue through depressive symptoms (Fig. 1). Precarious work schedules were not directly related to depressive symptoms ($B = 0.071$, $SE = 0.040$, $LLCI = -0.008$, $ULCI = 0.150$). However, precarious work schedules were negatively related to sleep quantity ($B = -0.364$, $SE = 0.086$, $LLCI = -0.554$, $ULCI = -0.194$), and in turn sleep quantity was negatively related to depressive symptoms ($B = -0.156$, $SE = 0.030$, $LLCI = -0.216$, $ULCI = -0.096$). Therefore, precarious work schedules were indirectly related to depressive symptoms through sleep quantity (Indirect effect = 0.071, BootSE = 0.016, BootLLCI = 0.028, BootULCI = 0.092). These results provide support for Hypothesis 1b. See Appendices A and B for the full results of analyses.

Moderator Results Model 1 of Hayes's (2017) PROCESS macro was used to test Hypothesis 2, 3a and 3b. Hypothesis 2 proposed that schedule flexibility would moderate the negative relation between precarious work schedules and sleep quantity, such that the relation would be weaker for those with high schedule flexibility. The interaction term between precarious work schedules and schedule flexibility was significant ($B = -0.208$, $t = -3.094$, $p = 0.002$). Simple slopes analysis revealed that when schedule flexibility was 1 standard deviation below the mean, there was a non-significant relation between precarious work schedules and sleep quantity (Effect = -0.153, $t = -1.485$, $p = 0.139$). However, when schedule flexibility was at the mean (Effect = -0.374, $t = -4.412$, $p < 0.001$) or 1 standard deviation above the mean (Effect = -0.595, $t = -5.022$, $p < 0.001$) there was a significant negative relation between precarious work schedules and sleep quantity. As shown in Fig. 2, employees reported the most sleep when schedule flexibility was high, and the negative relation between precarious work schedules and sleep quantity was stronger (not weaker) for those with high schedule flexibility, therefore providing partial support

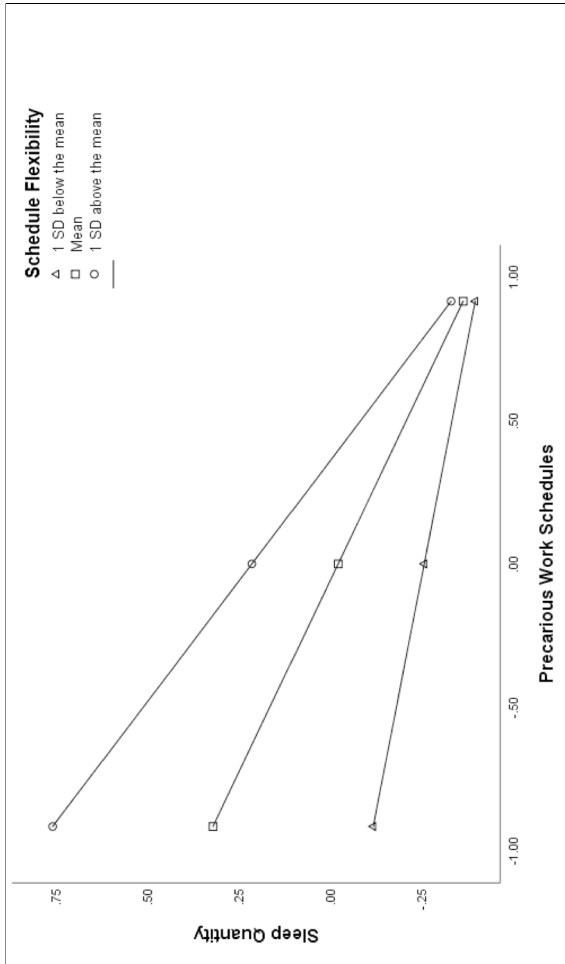


Fig. 2 Interaction Effect of Precarious Work Schedules X Schedule Flexibility on Sleep Quantity (Hypothesis 2)

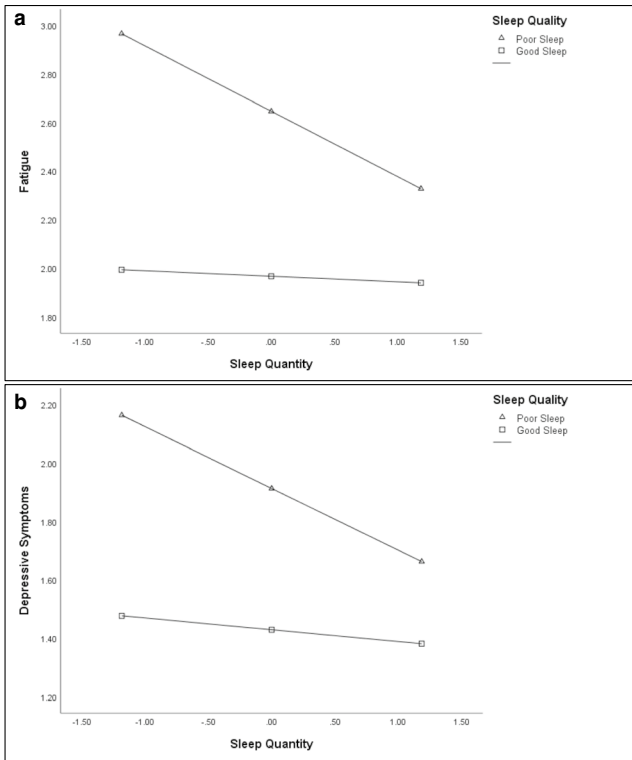


Fig. 3 Interaction Effect of Sleep Quantity X Sleep Quality on Fatigue and Depressive Symptoms (Hypotheses 3a and 3b)

for Hypothesis 2, because moderation did not take the form that we hypothesized. See Appendix C for the full results of moderation tests.

Hypothesis 3a proposed that sleep quality moderates the negative relation between sleep quantity and fatigue, such that the relation is weaker when sleep quality is good. The interaction term between sleep quantity and sleep quality was significant ($B=0.247$, $t=2.493$ $p=0.013$). Simple slopes analysis revealed that when sleep quality was poor, sleep quantity was negatively related to fatigue (Effect= -0.269 , $t=-3.194$ $p=0.002$). However, when sleep quality was good (Effect= -0.023 , $t=-0.427$, $p=0.670$) sleep quantity was not significantly related to fatigue. As shown in Fig. 3, employees reported the most fatigue when sleep quality was poor, and the negative relation between sleep quantity and fatigue was weaker when sleep quality was good. These results provide support for Hypothesis 3a.

Hypothesis 3b proposed that sleep quality would moderate the negative relation between sleep quantity and depressive symptoms, such that the relation would be weaker when sleep quality is good. The interaction term between sleep quantity and sleep quality was significant ($B=0.171$, $t=2.834$ $p=0.005$). Simple slopes analysis revealed that when sleep quality was poor, sleep quantity was negatively related to

Table 3 Bootstrap results for conditional indirect effects

Condition	Dependent Variable = Fatigue				Dependent Variable = Depressive symptoms			
	Indirect effect	Boot SE	Boot LL 95% CI	Boot UL 95% CI	Indirect effect	Boot SE	Boot LL 95% CI	Boot UL 95% CI
Low flexibility, poor sleep quality	.038	.031	-.012	.109	.031	.024	-.009	.085
Low flexibility, good sleep quality	.001	.010	-.025	.019	.005	.006	-.004	.018
Average flexibility, poor sleep quality	.093	.043	.012	.185	.076	.029	.025	.136
Average flexibility, good sleep quality	.002	.021	-.044	.039	.012	.010	-.008	.031
High flexibility, poor sleep quality	.149	.070	.019	.294	.121	.042	.042	.207
High flexibility, good sleep quality	.003	.033	-.067	.063	.019	.015	-.013	.048

$N=222$. Significant conditional effects are bolded; CI=confidence interval; LL=lower limit, UL=upper limit; Unstandardized regression coefficients reported. Bootstrap sample size 10,000

depressive symptoms (Effect = -0.212, $t = -4.112$, $p = 0.001$). However, when sleep quality was good (Effect = -0.041, $t = -1.248$, $p = 0.214$), sleep quantity was not significantly related to depressive symptoms. As shown in Fig. 3, employees reported the most depressive symptoms when sleep quality was poor, and the negative relation between sleep quantity and depression was weaker when sleep quality was good. These results provide support for Hypothesis 3b. See Appendix D for the full results of moderation tests.

Moderation Results

Model 21 represents a conditional indirect effects model in which an indirect effect is moderated at both the a-path and the b-path. Hypothesis 4a proposed a conditional indirect effect model that examines whether the indirect effect of precarious work schedules on fatigue via sleep quantity is moderated by schedule flexibility (a-path) and sleep quality (b-path) (Fig. 1). Specifically, we predicted that the indirect effect would be weaker for those with high schedule flexibility and good sleep quality. The results are presented in Table 3, which provides indirect effects, standard errors, and confidence intervals for the conditional indirect effects of precarious work schedules on fatigue, through sleep quantity at different combinations of schedule flexibility and sleep quality levels. The indirect effects of precarious work schedules on fatigue through sleep quantity were conditional on schedule flexibility and sleep quality (Index of moderated mediation = -0.051, BootSE = 0.031, BootLLCI = -0.119, BootULCI = -0.001). As shown in Table 3, the indirect effect was significant when

schedule flexibility was high or average and sleep quality was poor. The indirect effect was strongest when schedule flexibility was high and sleep quality was poor. The indirect effect was conditional on schedule flexibility and sleep quality, but not in the hypothesized direction, providing partial support for Hypothesis 4a.

Hypothesis 4b proposed a conditional indirect effect model that examines whether the indirect effect of precarious work schedules on depressive symptoms via sleep quantity is moderated by schedule flexibility (a-path) and sleep quality (b-path) (Fig. 1). Specifically, we predicted that the indirect effect would be weaker for those with high schedule flexibility and good sleep quality. The results are presented in Table 3. The indirect effects of precarious work schedules on depressive symptoms through sleep quantity were conditional on within schedule flexibility and sleep quality (Index of moderated mediation = -0.035, BootSE = 0.018, BootLLCI = -0.074, BootULCI = -0.005). As shown in Table 3, the indirect effect was significant when schedule flexibility was high or average and sleep quality was poor. The indirect effect was strongest when schedule flexibility was high and sleep quality was poor. The indirect effect was conditional on schedule flexibility and sleep quality, but not in the hypothesized direction, providing partial support for Hypothesis 4b.

Discussion

In this study, we examined the associations between precarious work schedules and two health outcomes, fatigue as an acute stress reaction, and depressive symptoms as a chronic strain consequence (Geurts & Sonnentag, 2006; Lovallo, 2015). We utilized a new construct – precarious work schedules – to simultaneously assess key work time characteristics (i.e., long shifts, non-daytime hours, unsocial hours, and intense schedules) that have separately been shown in research to adversely affect well-being. Our measure permits us to gain an understanding of the confluence of work time factors that can interfere with sleep and well-being. Using a single design with indirect effects and moderation that depicts relations among variables as a system of conditional and interactive effects among work schedules, control, sleep, and mental health processes, we found that precarious work schedules have indirect effects on both fatigue and depressive symptoms through sleep quantity; we also found evidence of two moderators. Specifically, we found that an organizational factor, schedule flexibility, moderated the relation between precarious work schedules and sleep quantity, while an individual factor, sleep quality, moderated the association between sleep quantity and fatigue and depressive symptoms.

Among transportation and correction employees with unionized full-time jobs in the public sector, we found associations between precarious work schedules with both fatigue and depressive symptoms. This is consistent with findings from previous studies which support the link between precarious schedule characteristics and unfavorable health consequences (e.g., fatigue, depression, obesity, diabetes, cardiovascular diseases; Riedy et al., 2020), unhealthy behaviors (e.g., greater screen time, worse dietary practices, and substance use; Winkler et al., 2018), poor safety outcomes (e.g., risk for accidents; Kecklund & Axelsson, 2016) and occupational

injuries (Arlinghaus et al., 2012; Fischer et al., 2017). Precarious work schedules should receive particular attention in future research, because fatigue may increase rates of error or injury by impairing workers' cognitive functioning (Scott et al., 2014), and depression may contribute to poor health behaviors, health status, and all-cause mortality (Bădescu et al., 2016; Del Campo et al., 2017; Machado et al., 2018; Penninx, 2017; Saneei et al., 2016). The short-term and long-term safety and health outcomes of employees with precarious schedules in different occupations is of critical importance to employers and state agencies.

Sleep Quantity as an Intervening Variable

As expected, precarious work schedules also related to employee fatigue and depressive symptoms indirectly through sleep quantity. This physiologic mechanism explaining the association between precarious schedule characteristics and poor health consequences has been supported in previous studies (Winkler et al., 2018). Evidence suggests that precarious work schedules mainly cause sleep loss (Ohayon et al., 2010), and insufficient sleep can in turn lead to acute fatigue (Åkerstedt et al., 2014) as well as chronic diseases (Kecklund & Axelsson, 2016) and chronic conditions such as depression (Zhai et al. 2015). In addition to sleep quantity, work-family conflict has been previously reported as a significant mediator between precarious work schedules and employee health and well-being (Cho, 2017; Haines III et al., 2008). This finding may explain the important role of sleep quantity in translating precarious work schedules into negative acute and chronic health outcomes among employees. For example, when practicing irregular or non-standard work shifts, employees may suffer sleep loss (e.g., borrowing sleep time to meet their work and family demands), which in turn contributes to poor health outcomes such as fatigue and depressive symptoms. To further inform health interventions, future studies should assess the degree to which out-of-work activities interfere with having a suitable sleep schedule and evaluate sleep hygiene practices as a possible solution.

Schedule Flexibility and Sleep Quality as Moderators

In this study, we have provided evidence that schedule flexibility is a moderator of the association between precarious work schedules and sleep quantity and poor health and well-being. Specifically, we found that workers with less precarious work schedules and greater schedule flexibility had the greatest number of sleep hours. Previous studies have reported a positive effect of schedule control on employee sleep quantity and quality (Brossoit et al., 2020; Takahashi et al., 2012), as well as its buffering effect in the association between night shift and sleep quantity and disturbances (Tucker et al., 2015). Berkman and colleagues reported that employees whose managers were supportive of work-family needs, such as providing flexibility with work schedules, had longer sleep duration and lower cardiovascular risks (Berkman et al., 2010). Another study also suggested that the health effect of non-standard work shifts such as stress, burnout and well-being, is less severe if it is chosen or determined by employees (Buessing, 1996). Schedule control has previously

been reported as a moderator in the association between work hours and work-family interference (Hughes & Parkes, 2007). One unexpected finding from our study was that a proposed moderation did not take the form that we hypothesized (Hypothesis 2); specifically, the negative relation between precarious work schedules and sleep quantity was stronger for those with high schedule flexibility. The form the moderation took suggests that work schedules with a high degree of precariousness are associated with lower sleep quantity, regardless of how much schedule flexibility the worker has. Therefore, although flexibility may buffer the potential negative effects of work schedules with lower levels of precariousness, for workers with higher levels of precariousness, alternative solutions for increasing sleep hours, such as reducing levels of schedule precariousness or offering alternative forms of schedule control, need to be considered. Future research should examine the effectiveness of organizational efforts that improve time control including flexible work arrangements and other innovative scheduling practices (Kossek et al., 2014; Swanberg et al., 2011).

Following our expectations, sleep quality served as a significant moderator in the association between sleep quantity and fatigue and depressive symptoms. Specifically, employees reported the most fatigue and depressive symptoms when sleep quantity was low and sleep quality was poor. Our results are consistent with findings from prior studies that show the interrelatedness of sleep quantity and quality (Buysse et al., 1989; Litwiller et al., 2017). Our results also confirm research that shows associations of both sleep quantity and quality with fatigue (Åkerstedt et al., 2014; Patterson et al., 2010) and mental disorders (e.g., depression) in multiple populations (Bhati & Richards, 2015; Le Grande et al., 2016; Zhai et al., 2015). We extended prior work on the role of sleep quantity and quality in health by conducting an empirical examination of interactive effects of these variables on depression and fatigue. Findings suggest that short sleep duration alone may not result in poor health and well-being, but having a good quality of sleep may buffer the adverse effect of short sleep duration on health and safety outcomes.

Implications for Intervention

We have provided evidence to suggest a model to describe the relations between precarious work schedules and employee fatigue and depressive symptoms. These findings, embedded within a larger PAR study, enabled us to identify organizational and individual points of intervention, which is in line with the National Institute for Occupational Safety and Health's Total Worker Health® approach to protecting and promoting worker health (NIOSH, 2020). Sleep quantity had a significant intervening role, while schedule flexibility and sleep quality had significant moderating roles in these associations. The study suggests that when translating findings into practice, employers should avoid designing work schedules with excessive precarious features, and should consider initiatives to attenuate or buffer the consequences of precarious schedules, including organizational policies that increase schedule flexibility or worker health education on improving sleep quantity and quality. This is in keeping with expert consensus that a multi-level approach to managing occupational sleep-related fatigue is optimal, and should include work scheduling strategies that

permit opportunities for rest breaks and adequate sleep, as well as training programs to educate workers about best practices for sufficient recovery and sleep (Wong et al., 2019).

Problems with sleep quantity are difficult to address given that time is a finite resource split across work and family responsibilities (Dugan & Barnes-Farrell, 2017, 2020) and employees often borrow sleep time to fulfill work and family demands. In this study, with worker input, we identified schedule flexibility and sleep quality as moderators in the relation between precarious work schedules and worker health, and these were generally perceived as feasible and acceptable points of intervention. For example, schedule control can be improved through the implementation of common flexible work arrangements and culture change initiatives in organizations (Kelly & Moen, 2007; Kelly et al., 2011). Organization and employer support may greatly improve employees' schedule control and reduce the potential negative impact of precarious work schedules (Hughes & Parkes, 2007). Sleep quality may be improved through healthy sleep hygiene practices and other sleep promotion interventions such as cognitive behavioral therapy (Robbins et al., 2019), or complementary and integrative health strategies (e.g., yoga, meditation) that have been found to be effective in pilot tests at DOC (Sarris & Byrne, 2011). Taken together, study findings suggest that targeted interventions, such as evidence-based shift system designs that reduce precarious work schedules, organizational and management support on working hours tailored to and selected by employees, and evidence-based education and training programs improving sleep quality should be implemented in the workplaces to improve short- and long-term health and safety of employees (Centers for Disease Control & Prevention, 2012).

Strengths and Limitations

The strengths of this study include its embeddedness within a larger PAR study of transportation and correction employees, as well as its consideration of multiple confounders, indirect effects, and moderators in the data analyses. The findings are of interest to workers for whom precarious work schedules seem to be an unchangeable reality, but who nevertheless want evidence-informed interventions to reduce the adverse effects of schedules on sleep and well-being. By identifying a modifiable organizational factor (increasing schedule control) and a modifiable individual factor (improving worker sleep quality), this study provides two points of intervention which together offer a Total Worker Health® approach in alleviating the adverse effects of precarious work schedules.

Despite these strengths, this study is not without its limitations. First, the cross-sectional study design cannot draw causal relations among study variables. Future analyses of longitudinal and experimental data are needed to verify the study findings. Second, although the sample was moderate in size, the data was collected from two occupations within one state. Furthermore, these two populations were a unionized, full-time workforce with full benefits, and the precarious nature of their schedules may not compare to workers whose precarious schedules co-occur with a precarious employment situation that includes an inadequate number of work hours,

low pay and few benefits. The homogeneity of our sample makes our findings a conservative test of our hypotheses; it is likely that we would find stronger effects among workers with more precarious schedules, or different groupings of precarious schedule characteristics, or wider variability in schedule control. A nationally representative sample of data from across multiple occupations is needed to understand the generalizability of these results to the broader U.S. population and to understand heterogeneity in these associations between subpopulations of workers. Also, due to the analytic technique we used where multiple imputation was not possible, we had missing data which further means that generalizability of results is a limitation, and we will need to replicate our findings with other samples. We acknowledge the limits of our flexibility measure, in that it only captures one aspect of flexibility (i.e., ability to take time off during the workday) rather than other types of flexibility that exist, such as the ability to change work start/end times, or the ability refuse work beyond the usual scheduled hours. We also acknowledge that there is a moderately (but not excessively) strong correlation between fatigue and depression; however the inclusion of both variables is beneficial as it provides comprehensive coverage of the well-being content domain. Finally, although the measures were reliable and well-validated scales of work, sleep, and health, they were self-reported by workers rather than being directly observed or verified through multiple reporters and therefore may suffer from bias.

Conclusions

In the context of these cautions, findings from this study suggest that precarious work schedules are problematic, due to their association with fatigue and depressive symptoms among transportation and correction employees. Sleep quantity partially explained these associations. In addition, results revealed that schedule flexibility and sleep quality, two modifiable aspects of work scheduling and worker behavior, moderated these associations and may reduce the adverse effects of precarious work schedules on well-being. These findings have direct translational applicability because they can inform future health interventions. As precarious work schedules continue to be common in the contemporary economy, and with the support of future research to replicate these findings, results from this study offer an opportunity for government and workplace policies and programs to target modification of work scheduling practices and employee health behaviors to enhance Total Worker Health®.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s41542-022-00114-y>.

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Authors' Contributions AGD, RED, and JMC contributed to the conception of the scientific questions and design of the work. AGD and RED contributed to data analysis approach and RED performed data analysis. All authors contributed to manuscript preparation. RED, AGD, and YZ wrote the manuscript, and CML, JLG, RAL, AOS, SN, and JMC contributed to interpretation of results and manuscript revisions.

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Data Availability The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Code Availability The code that supports the findings of this study are available on request from the corresponding author.

Declarations

Ethics Approval The Institutional Review Board at the University of Connecticut's School of Medicine approved the study protocol and written informed consent was obtained. Protocol number: 18–094-2.

Consent to Participate Written informed consent was obtained by all study participants.

Consent for Publication Obtained.

Conflicts of Interest The authors declare no conflicts of interest.

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