

BRIEF REPORT

Work-related fatigue: A hazard for workers experiencing disproportionate occupational risks

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Abstract

Background: Long working hours and fatigue are significant occupational safety and health (OSH) hazards for working populations who experience disproportionate risks of injury and illness. These groups include young or new workers, aging workers, contingent and temporary workers, immigrant and nonnative workers, female workers, minority workers, workers with low levels of education and lower socioeconomic status, and small business employees. An increasing focus on newer determinants of health in the workplace, such as health equity and work-life conflict, in worker populations at greater risk for injury or illness, provides an opportunity for researchers to address the causes and consequences of work-related fatigue in high-risk populations.

Methods: Articles in the OSH literature that addressed fatigue in higher-risk workers were identified by the authors or recommended by subject matter experts in workplace fatigue as part of a Working Hours, Sleep and Fatigue Forum. Additional articles were identified by searching for a combination of specific at-risk worker group titles (e.g., female workers, temporary workers) with fatigue or working hours.

Results: There remains a paucity of research specifically addressing working hours and fatigue among disproportionately at-risk worker populations. The literature reviewed in this paper suggests that several of these populations are at increased risk of fatigue due to multiple factors, such as irregular shifts, lack of access to fatigue management resources, and socioeconomic barriers.

Conclusions: More research is needed to identify solutions to address fatigue in working populations who may be at greater risk for its consequences by virtue of adverse socioeconomic and related factors. Interventions to address work-related fatigue in specific at-risk worker groups should also consider the multiple and overlapping categories of risk within these populations.

KEYWORDS

at-risk populations, fatigue, health equity, occupational safety and health, working hours

1 | INTRODUCTION

Work-related fatigue is a significant occupational safety and health (OSH) problem especially for working populations which experience disproportionate risk of injury and illness, as they may not be able to avoid working conditions that cause fatigue. Over 43% of workers are sleep-deprived (those at the highest risk work nights, or long or irregular shifts), and fatigued worker productivity losses cost employers \$1200 to \$3100 per employee annually.¹

Fatigue, while lacking a universal definition, is broadly defined as a feeling or state of weariness, tiredness, or lack of energy.² While fatigue can stem from a number of different factors, it is most commonly associated with insufficient sleep or rest.³ Fatigue can be described as either acute or chronic. Acute fatigue, results from a short-term lack of sleep or from short periods of intense physical or mental work. It can also result from short-term circadian disruption such as with overnight shift work. Workers with acute fatigue may have reduced reaction time, lower productivity levels, and a reduction in the ability for complex planning, as well as an increase in decision errors. Fatigue occurring over the long term, without sufficient rest or recovery, can lead to a severe state of tiredness, or chronic fatigue, and may result in physical problems such as digestive complaints and mental health disorders such as depression, as well as performance problems.⁴

Managing fatigue in the workplace is critical, as both acute and chronic fatigue can dramatically increase the risk of workplace accidents and subsequent injury.^{5–16} However, there are many risk factors and causes of work-related fatigue, including social norms around work and sleep, individual behaviors, individual health conditions, and the workplace itself. While sleep is an effective countermeasure against fatigue, preventing fatigue is more difficult than prescribing sleep to workers. Effective interventions for reducing fatigue in the workplace should focus on addressing the causes of workplace fatigue to protect workers from work-related injury and other safety-critical events.

The organization of working hours continues to be a significant and common risk factor for work-related fatigue. To meet the needs and demands of a 24-h society, roughly 20% of US workers alternate shifts or engage in shift work.¹⁷ “Shift work,” while lacking a standard definition,¹⁸ is commonly used to refer to any arrangement of working hours that occurs outside of standard work hours of (7:00/8:00 a.m. to 5:00/6:00 p.m.).¹⁸ If not well-managed, working hours may directly contribute to fatigue through work schedules with extended hours, night work, and insufficient recovery time within and between shifts. Working hours can also indirectly cause fatigue through the disruption of circadian rhythms which may lead to decreased sleep quality, increased sleep interruptions, and shorter sleep duration.^{19–23} Additionally, extended daily working hours limit time for recovery which increases sleep debt across consecutive shifts.^{24–26} Furthermore, jobs that alternate shifts often have low control and high demand, which may amplify levels of stress and fatigue.^{27,28} However, due to individual fatigue tolerances and coping mechanisms, workers experience different levels of work-related

fatigue, even when they have the same job and work schedule, making fatigue a difficult hazard to manage. While risk for fatigue may be examined by industry or occupation, a special focus should be placed on populations with an elevated risk for fatigue—disproportionately at-risk worker populations. These groups, who have been demonstrated to be at higher risk than other workers to occupational injuries and illnesses, may not be able to exercise control over their working conditions or the organization of work and working hours, which are determined by their employers. While there have been focused efforts to address occupational health disparities,^{29–31} as well as efforts to address working hours and fatigue, there is limited research on these topics as they pertain to and affect vulnerable worker groups. This review, which is not intended to be comprehensive, summarizes key and limited research specifically examining and addressing fatigue experienced by certain disproportionately at-risk worker groups and offers considerations for developing interventions to address working hours and fatigue that takes into account the unique experiences of individuals who may belong to multiple at-risk groups. The articles identified included several that were known to the authors, as well as several which were recommended by subject matter experts in workplace fatigue. Additional articles were identified by conducting searches on Google Scholar using specific at-risk worker group titles (e.g., female workers, temporary workers) and fatigue, and/or working hours. The aim of this study was to synthesize knowledge rather than do a systematic review of the thousands of papers that would be included in searches of the subject matter “shift work” and “fatigue.”

This manuscript is part of series of papers developed following the National Institute of Occupational Safety and Health (NIOSH) Working Hours, Sleep and Fatigue Forum in September 2019.^{32,33} The purpose of this series is to identify the research gaps and needs around working hours, sleep, and fatigue that are specific for industry sectors and vulnerable working populations in the United States. Collectively, the papers provide overviews of the current state of research, identify health and safety risks, highlight effective interventions, and suggest future research directions.

2 | DEFINING WORKER POPULATIONS EXPERIENCING DISPROPORTIONATE RISK

In OSH, the definition of the term occupational health disparities varies, but generally refers to differential patterns of hazard exposure and injury or fatality risk in certain worker groups.^{29–31} These groups have been demonstrated to experience occupational health disparities—higher burdens of illness, injury, disability, or mortality, compared to “non-vulnerable” populations. Workers in these groups have often been identified using demographic, job-related and organizational characteristics,^{31,34} such as young or new workers,^{35–37} aging workers,³⁸ contingent and temporary workers,^{39–42} immigrants or nonnative workers,²⁹ and small business employees.³⁴ Research has been conducted to expand the definition of OSH vulnerability beyond individual-level or occupational characteristics to

include additional dimensions such as worker awareness of OSH rights and responsibilities and employees' "empowerment" to act to make the workplace safer.⁴³ Research from Lay and colleagues defined and operationalized worker vulnerability as whether the employee reported being exposed to on-the-job hazards. They indicated poor access to at least one type of resource to manage the exposure risk (workplace policies and procedures, awareness or empowerment), with demographics characteristics, such as age, gender, occupation and employment arrangement (temporary vs. permanent), included as covariates in their model.³¹ While no consensus definition exists to determine who is a worker experiencing disproportionate risk, this is an area of current interest and engagement in public health research, especially in light of the COVID-19 pandemic, which has severely affected communities experiencing health disparities. Indeed, the term "vulnerable worker" has been replaced in OSH domains with other terms which emphasize systems that lead to disadvantages for people as opposed to the people themselves, such as workers at disproportionate risk.⁴⁴ Minority populations are overly represented in "essential" jobs that require both travel and regular interaction with the public, in industries such as retail (e.g., grocery stores), service (e.g., restaurants and bars), transportation, meat and poultry processing, and health care, increasing their potential exposure to the virus that causes COVID-19.^{45,46} In summary, although no consensus definition exists, NIOSH has defined workers at disproportionate risk as those workers who are at higher risk for occupational injury and illness as a result of social and economic structures historically linked to discrimination or exclusion.⁴⁴ This increased focus on occupational health disparities has implications for the design of OSH interventions that protect and promote the health and well-being of the workforce, including in the area of work-related fatigue management/mitigation.

While workers at disproportionate risk for injury and illness can be concentrated in certain sectors, such groups of workers exist in every sector. Because of the broad range of factors that can impact disproportionate risk, workers may experience multiple risk factors which interact in unknown ways. These characteristics interact between the individual and the environment to increase antagonistic exposures or modify an individual's etiological response to exposure.

3 | IMPACT ON WORK-RELATED FATIGUE AMONG SPECIFIC WORKER POPULATIONS EXPERIENCING DISPROPORTIONATE RISK

Our approach to examining how workers at disproportionate risk are affected by fatigue builds off our understanding of the impacts of work organization, job insecurity, and its impact on occupational health disparities as outlined by Landsbergis et al.⁴⁷ For each group we identified both differential exposure to fatigue-inducing working hours such as long work, irregular hours, and shift work which may cause fatigue, as well as differential vulnerability to fatigue based on characteristics of the group (see Table 1).

3.1 | Female workers

While women on average spend fewer hours at paid work than men in the United States⁹¹ there is less evidence regarding exposure to fatigue-inducing working hours such as night shifts or rotational schedules; likely due to the imbalance of sex in observed cohorts. Most occupational cohorts in studies examining specific fatigue inducing components of working hours comprise either overwhelmingly female occupations, such as nurses, or traditionally male occupations such as manufacturing workers, petroleum workers, or the police workforce.^{48,92} Each workplace has customized schedules to suit staffing needs, which complicates cross-industry comparisons of working hour exposures. Among the limited studies, females are more likely than males to work permanent shifts, including permanent night shift.^{49,50} A permanent schedule, even permanent nights, affords a predictability that makes arranging child-care easier^{49,93} and the selection of women into permanent schedules may reflect social norms around childcare expectations.^{49,50} However, a greater proportion of male workers compared to female workers may be exposed to night shifts and shifts with a rotational schedule.^{50,67} Both permanent night shifts and rotational shifts with or without night work are expected to cause fatigue, therefore, it is not clear whether females or males are more exposed to fatigue-inducing working hours.

Furthermore, while some studies have concluded that there is no difference between females and males with respect to fatigue management,^{94,95} the majority of studies suggest that females are more vulnerable to fatigue as they report needing to sleep longer and report more sleep problems than males.⁵²⁻⁶⁶ Women may be at higher risk of work-related fatigue due to less time for recovery and sleep, as women actually work longer hours on average after accounting for time spent on household activities compared to men.⁹⁶⁻⁹⁸ Women in rotating shift work report the most difficulties in managing work-home conflict,⁹⁹ and given greater levels of time spent on household activities, the added responsibility of work at night may also contribute to job strain, role overload, and role conflict.¹⁰⁰

This increased risk of fatigue may be offset by coping mechanisms as women are more likely to have social support networks at work which may protect against fatigue and occupational stress, which often co-occur^{56,101} while men tend to utilize a "disengagement" style of coping.⁶⁸ Nevertheless, women in shift work also tend to be at higher risk for occupational injury than men.^{102,103}

3.2 | Young and/or new workers

In the United States, young workers under the age of 25 comprise roughly 13% of the US labor force and are injured at almost twice the rate of adults.³⁶ Youth under the age of 18 are a group that experiences particular risk¹⁰⁴ as numerous developmental and environmental factors predispose young people to job injury.¹⁰⁵⁻¹⁰⁷ In the United States, the 1938 federal Fair Labor Standards Act (FLSA) child labor provisions prohibit the employment of minors in jobs and

TABLE 1 Some of what we know about disproportionately at-risk populations, working hours, and fatigue

Characteristic	Differential exposure to working hours	Differential risk of fatigue
Sex	Female workers are more likely to work permanent, including permanent day shifts, perhaps reflecting childcare expectations. ^{48–51}	Female workers need to sleep longer, and report more sleep problems ^{52–57} and fatigue than male workers ^{53,58} ; they may be more susceptible to fatigue. ^{59–66}
	A greater proportion of male workers are exposed to night work in both Canada and the United States. ⁶⁷	Female workers are more likely to have social support networks to protect against fatigue and occupational stress; male workers may have higher shift work tolerance. ⁵⁶
		Male shift workers engage in more disengagement styles of coping which is associated with hardiness. ⁶⁸
Age (younger workers)	Younger workers may have no seniority at work and may have little to no control to select their working schedule.	Younger workers have an increased likelihood of experiencing fatigue due to physical and cognitive developmental and social factors. ^{69,70}
	Younger workers fear refusing to accept long or irregular hours may jeopardize their jobs.	Younger workers may be more robust to the effects of fatigue and able to recover more quickly. ^{56,71–79}
Age (older workers)	Older workers may have seniority at work and be able to select their working schedule. ⁵⁰	Sleep duration, ⁸⁰ sleep content, and fatigue recovery vary across lifespan. ^{81–83}
	Older workers fear refusing to accept long or irregular hours may jeopardize their jobs. ⁵⁶	Sleep time decreases with age, and insufficient sleep is positively associated with older age ⁷⁴ ; older workers experienced more fatigue. ⁷⁶
	Healthy shift work effect: older workers who remain in jobs with long working hours may be healthier and may be able to cope better. ⁵⁶	Adaptation to night shift is poorer at increasing age ⁷¹ ; reduced tolerance to shift work around age 40–50. ⁵⁶
Contingent/temporary status	Temporary workers have little or no control over work schedule. ⁸⁴	Temporary workers reported long/irregular/unpredictable work hours, lower control over work hours, and more work-life conflict. Health-related concerns related to work-life conflict included fatigue, sleep disturbance, lack of exercise & poor diet. ⁸⁵
	Temporary workers have unpredictable work hours. ⁸⁵	
Minority status	Latinos and Blacks work disproportionately more during evening/late night and midnight hours. ⁵¹	Race is a social construct and not a biological grouping and therefore may reflect different coping strategies due to socioeconomic health disparities due to racism.
	Black/African American workers are more likely to perform work with rotations ^{50,51} ; Black and Hispanic minorities have less flexible/less control over schedules than white workers. ⁸⁶	
Immigration status	Immigrants tend to work more often in “dirty, dangerous, and demeaning” (3D) jobs which tend to also involve fatigue-inducing work hours. ⁸⁷ Immigrants fear refusing to accept long or irregular hours may jeopardize their jobs. ⁸⁸	Immigration status may impact coping strategies for fatigue management, by limiting access to health, social, and financial resources as well as alternative employment opportunities.
Small business employment	May face increased exposure to fatigue-inducing hours at work. Small businesses are more likely to hire other workers from other at-risk groups.	Small business employees may not have access to the same type of employee support for fatigue management.
Education level or lacking qualifications	Workers with lower education levels fear refusing to accept long or irregular hours may jeopardize their jobs. ⁷⁶ Long working hours and shift work are more common in occupations that do not require advanced degrees ⁸⁹ ; workers' education influences access to flexible schedules/control over working hours. ⁸⁶ Shift work comes with a higher income than standard jobs that require higher education levels.	Education may impact coping strategies for fatigue management, by limiting access to social, health, and financial resources, as well as alternative employment opportunities.

TABLE 1 (Continued)

Characteristic	Differential exposure to working hours	Differential risk of fatigue
Low income	<p>Financial need may increase likelihood of accepting long or irregular shift hours, which tend to come with a pay premium.^{76,90}</p> <p>Workers with family incomes below the poverty level are more likely to work at nonstandard times.</p> <p>Working nonstandard hours allows for "moonlighting" more easily.⁷⁶</p>	Income may impact coping strategies for fatigue management, by limiting access to health, social, and financial resources as well as alternative employment opportunities.

under conditions harmful to their health or well-being.^{108,109} These provisions restrict work hours, which differ between the summer and school months for youth aged 14–15 years, and define occupations that are too dangerous for minors under age 18 to perform.^{108,109} Where present, hour restrictions for adolescents aged 16–17 years are established by individual states.¹¹⁰ Certain businesses are exempt from FLSA provisions, and varying standards apply to minors employed in agricultural occupations.^{108,109}

Research in the United States suggests that violations of child labor regulations for adolescent workers are common^{69,70} and create hazardous conditions contributing to young worker deaths.¹⁰⁹ Although few studies have specifically focused on the topic, work-related fatigue has been identified as a potential hazard for working youth¹¹¹ as they have an increased likelihood of experiencing fatigue due to developmental and social factors.^{112,113} Elevated likelihood of fatigue for adolescents and young adults is of concern given the adverse consequences of fatigue for performance in safety-critical situations, such as while driving a vehicle and working on a job site.¹¹⁴ Seminal research from Frone identified exposure to heavy workloads and "boring job" tasks as significant predictors of work-related injuries among a sample of working adolescents (aged 16–19 years) in the United States, and he hypothesized that these conditions may increase the likelihood of injuries occurring due to fatigue or distraction.⁷¹ Research from LaBerge and colleagues with Canadian young workers (aged 17–18 years) working at a paid job while attending school found that exposure to a greater number of physical work demands (among other predictors) was a significantly associated with higher acute and chronic fatigue levels among the sample population.¹¹¹ The authors of the study suggest that managing the physical work demands/work environment of adolescents may help to prevent occupational injuries indirectly through reduction of work-related fatigue.¹¹¹ In a mixed methods study by Paterson and colleagues of Australian young workers, fatigue was identified as a significant problem by 75% of participants and was associated with unpredictable working time arrangements, precarious employment, high workload, working long hours and limited job control.¹¹⁴

Employers are critical to protecting young workers from occupational fatigue (and work-related hazards generally), as young workers have little to no control over their work tasks and schedules^{72,73,106} and may be more exposed to unpredictable working hours as they may fear that a refusal of assigned hours could jeopardize their employment. However, younger workers may be more

robust to the effects of fatigue and may be able to recover more quickly.^{56,74–80,115,116}

3.3 | Aging workers

While evidence suggests that for night shifts, older workers as compared to younger workers have more sleep-related problems,⁸¹ the link between night shift and increased fatigue is more tenuous. While some research suggests an association between night shifts and fatigue among older workers has not been observed,^{81,82} other evidence supports that older workers may be vulnerable as sleep duration, sleep quality, and fatigue recovery decreases with age.^{83,117–119}

Furthermore, the study of fatigue and working hours among aging workers is complicated due to the healthy worker survivor effect where older workers who remain in jobs with fatigue-inducing working hours may be healthier and have more effective fatigue management skills.^{56,120} Additionally, older workers are likely to have seniority at work and may be able to exercise more selection over their working schedules based on their circadian preferences. However, not all older workers have tenure at their current jobs, and they may face age-discrimination at work, which may lead to lack of control over their work schedules as they may accept more fatigue-inducing work to avoid job loss.

3.4 | Contingent/temporary workers

Contingent workers are defined as those with a job they do not expect to last. Temporary workers, contract workers, and on-demand workers are all types of contingent workers, and much of the limited OSH literature specifically focuses on temporary workers.^{121–123} The number of workers employed through temporary staffing companies roughly tripled from just over one million in 1990 to over three million in 2018.¹²⁴ Temporary workers may be assigned to more hazardous tasks and less likely to object to doing dangerous work because of their precarious status.^{123,125–127} Temporary workers are likely to be new hires multiple times a year, which is also associated with higher risk of injury.^{128,129} Furthermore, job insecurity,¹³⁰ has been established as a chronic work-related stressor^{131,132} that can have a negative impact on mental and physical well-being.^{84,85}

Temporary workers have reported higher rates of fatigue compared to permanent workers¹³³ as well as having less control over work hours compared to permanent workers.⁵¹ Temporary workers have specifically reported long, irregular, and unpredictable work hours, lower control over work hours, and more work-life conflict compared to permanent workers, resulting in health-related concerns related to work-life conflict including fatigue, sleep disturbance, lack of exercise, and poor diet.⁸⁶ Irregular and unpredictable hours were also associated with uncoordinated schedules across multiple jobs. Additionally, a recent systematic review found higher levels of fatigue and depression among temporary workers compared to permanent employees.¹³⁴

3.5 | Minority workers

Minority workers may face discrimination at work and as a result may work the least desirable shifts; often shifts with night work or shifts that rotate. While data on race or ethnicity and working hours are also limited, Black/African-American and Latinx workers are more likely to perform work with rotations and may have less control over their schedules than white workers.^{50,87,135} It is also worth noting that indigenous worker populations have been described as occupying the lowest levels of socioeconomic status, and have the least desired and often most dangerous jobs.¹³⁶

These differences by race and ethnicity may reflect underlying social factors such as institutionalized racism and higher rates of poverty among racial minorities in America. As race does not reflect biology and is instead a social construct, there is no reason to believe race influences how a body manages fatigue. However, by studying race in fatigue vulnerability studies, researchers may capture different coping strategies which may reflect socioeconomic health disparities. For example, certain coping strategies are likely dependent on available resources (social, financial, etc.) that may covary with group membership. There is currently a gap in the research on the health and safety impacts of work-related fatigue among minority populations, and this is a critical area for future investigation.

3.6 | Immigrant/nonnative workers

It is estimated that immigrants will comprise approximately a quarter of the US working population by 2050.¹³⁷ Hispanic immigrant workers endure a higher burden of occupational injury and fatality than US-born Hispanic, non-Hispanic, and nonimmigrant workers.¹³⁸ Immigrants often work in "3D" (dirty, dangerous, and demeaning) jobs¹³⁹ and jobs considered to be high-risk.¹⁴⁰ These jobs typically include those with less standard schedules and are generally more physically demanding. In addition to their work in dangerous jobs, a substantial proportion of Hispanic farmworkers experience levels of sleepiness that places them at risk for occupational accidents or unintentional injury.^{88,141,142} Similar to the United States, migrant workers across Europe and in Canada are more likely to be exposed

to certain working and employment arrangements that may place them at higher risk of future health problems, including working >10 h/day, working >5 days/week, on Sundays, and not being able to take days off.^{143,144} Although workers often agree to these hours out of financial need, they also fear that refusing to accept long shifts will jeopardize their jobs.¹⁴³

3.7 | Small business employees

In 2010, firms with fewer than 500 workers accounted for 99.7% of all businesses in the United States, and businesses with fewer than 20 workers accounted for 89.8% of the total number of firms.¹⁴⁵ Evidence suggests that employees of smaller businesses experience a disproportionate burden of occupational injuries, illnesses, and fatalities. Previous research has found that employees from smaller businesses may face increased exposure to physical hazards,¹⁴⁶ and numerous studies report a linear, inverse relationship between organization size and reports of injury, illness, or fatality,^{146–150} as well as an association with longer duration of work-related disability. Small businesses are also more likely than larger businesses to hire workers who are at a greater risk for occupational injury, including young workers, people who are less educated, and immigrants.⁸⁹ While little research attention has focused on working hours of small business employees, there is evidence to suggest long work hours coupled with poor sleep characteristics are synergistically associated with increased risk of workplace injury among employees in small firms.⁹⁰

3.8 | Education level or lacking qualifications/low income

Since 2012, people with some college or an associate's degree have made up the largest share of the US civilian labor force compared to other major categories of educational attainment.¹⁵¹ Workers with limited or incomplete educations or low income are more likely to work in occupations with long working hours and other fatigue-inducing hours.^{79,152} Not only are longer and irregular hours more common among occupations that do not require an advanced degree, jobs with these hours often have higher pay than standard hours that are not associated as strongly with work-related fatigue. Workers with limited education or limited finances may find themselves selecting into these occupations as they enable a higher income than standard jobs that require a higher education level.^{79,153}

Additionally, workers with limited education or finances may be more dependent on their jobs and may be more willing to accept hours with a pay premium and also fear that refusing to accept hours may jeopardize their employment.¹⁴³ Both income and education levels may impact availability and quality of coping strategies for fatigue management which could contribute to differential risk of fatigue.

The categories of worker populations experiencing disproportionate risk described above are by no means mutually exclusive, and workers may experience overlapping group memberships associated

with disproportionate risk; that is, they are simultaneously a member of two or more at-risk groups, such as being an immigrant and a temporary worker, or being a young worker and employed by a small, nonunion business. Each group has characteristics that add unique barriers to the worker's OSH.¹⁵⁴ Implications of overlapping group-associated risk factors for work-related fatigue will be discussed later in this paper.

4 | EFFECTS OF WORK-RELATED FATIGUE AND THE NEED FOR INTERVENTIONS

The impact of long working hours and fatigue among high-risk workers is not well understood, largely due to a lack of fatigue research specifically focused on specific groups at disproportionate risk. While several OSH issues have been given greater priority for these populations (e.g., physical and chemical hazard exposure)¹⁵² there is a need for both more research to develop the body of knowledge regarding the burden of long working hours and fatigue among worker groups at disproportionate risk, as well as a need for research to develop effective interventions to address these OSH hazards.

For example, few studies focus specifically on fatigue in young workers and its impact on their OSH outcomes.¹¹¹ Thus, there is a need for exploration of opportunities to integrate additional content related to working hours, sleep, and fatigue into young worker trainings and interventions, including the young worker curriculum (*Youth@Work-Talking Safety*).¹⁵⁵ *Talking Safety* has been shown to have a positive, significant impact on middle school students' OSH knowledge, attitude, norms, self-efficacy, and behavioral intention to enact workplace safety and health skills in the workplace.¹⁵⁶ Adaptations of training to deliver the foundation OSH skills taught in *Talking Safety* are also being developed for other vulnerable worker populations, including temporary workers. These adaptations may provide additional opportunities to address working hours, sleep, and fatigue among populations of particularly at-risk workers.

For Hispanic immigrant workers, there have been calls to address mental health and well-being in national surveillance systems,¹⁵⁷ and current NIOSH research is taking a more holistic approach to the problems of immigrant safety and health to consider threats to well-being beyond traditional OSH hazards, including consideration of work arrangements. Thus, there is increasing opportunity to explore the impact of factors such as work hours and fatigue among this disproportionately at-risk worker group.

4.1 | Overlapping group-associated risk factors

As mentioned previously, there is a growing recognition that members of various disproportionately at-risk worker groups also belong to one or more additional at-risk groups which are not mutually exclusive. For example, in 2013, about 40% of the approximately 1.5 million Hispanic

immigrants working in construction worked in firms with fewer than 10 employees.¹⁵⁴ Overlapping group memberships may expose a worker to more work-related fatigue as group-associated risk factors may interact and have a multiplicative effect. For example, working for a small business may expose a worker to unpredictable schedules and longer work hours, and as an immigrant worker one may be less likely to feel supported in voicing concerns about fatigue and other OSH problems. Additionally, within-group variation may cause higher or lower exposure to fatigue-inducing work hours. For example, among immigrant workers, those with less experience or lower language abilities may have less control of setting their work hours. In another example, young workers are more likely to be engaged in precarious or contingent employment, and also balance multiple demands including school and social commitments,¹¹⁴ and are therefore at risk for experiencing work-related fatigue.^{111,114} In summary, we know that risk factors co-occur, but how these multiple risk factors impact exposure to fatigue inducing hours and fatigue is not well documented. Thus, intervention research aimed at reaching any particular at-risk group should also consider the additional group memberships which may be encountered.

The potential impact of developing effective interventions to address fatigue among these disproportionately affected groups is significant and wide-reaching. Yet, such efforts will likely be extremely challenging as many of the barriers associated with occupational health disparities are beyond training needs and will likely require changes at the policy and cultural level.³² Moreover, employers have the primary responsibility for maintaining safe and healthy workplaces and are critical in these efforts.¹¹⁴ Given young workers are at the beginning of their working life, developing good fatigue-management habits will contribute to good health throughout their careers. With the projected increase in the proportion of Hispanic immigrants in the workforce, efforts to address fatigue among these workers could affect as much as one quarter of US workers. And, given the overwhelming majority of firms are small, developing interventions to address fatigue among small employers could have wide-reaching impact on the health and productivity of the US economy.

5 | NEXT STEPS

In September 2019, a session focused on workers at disproportionate risk at the *Forum on Working Hours, Sleep, and Fatigue*³⁵ considered the multiple groups workers belong to and related risk factors. A discussion which included representatives from labor, academia, government, and industry offered many similar observations on the needs for research and intervention as those noted above. One critical question that was raised was whether we should be studying working hours and fatigue among working populations at disproportionate risk, given the multiple other challenges (e.g., livable wages, health care costs, access to healthy foods and communities) many workers in at-risk groups encounter. Suggested next steps to address research needs included: oversampling for specific at-risk

populations; integration of sleep as a vital sign measure; understanding of cultural values around fatigue and long work hours; use of participatory research approaches to take into account needs and contextual barriers of at-risk populations; and studying other systems issues, including other exposures. For example, many tasks that are performed during night shifts may be performed at that time to minimize exposure to other workers or customers. Thus, shift work, a problem of work organization, is intertwined with higher exposure to hazardous materials or processes. In addition to the exposure to long and irregular working hours, other factors should also be considered in future research on fatigue with populations experiencing disproportionate OSH risks. The effects of physically or mentally demanding labor, monotonous work, or living conditions that are barriers to rest and recovery, may not be easily disentangled among populations of workers who are disproportionately represented in jobs with long hours or irregular shifts.

The multistakeholder discussion also emphasized intervention needs should focus on both the community and employer levels. There was a lack of consensus as to whether the state of research is such that current efforts should be focused on the implementation, evaluation, and dissemination of interventions,¹⁵⁸ or rather focus more on formative research to address the many gaps in the research on the myriad factors influencing fatigue and well-being related outcomes for all workers, especially those representing at-risk working populations. For example, basic guidance on fatigue management has been readily developed,¹⁵⁹ but it is not known whether this guidance can be effectively disseminated or implemented among at-risk worker groups.

6 | CONCLUSION

The burden of working hours is clearly substantial and the need for research to document the burden and experience of long working hours on fatigue among at-risk worker groups persists. More research is needed to identify solutions to address fatigue among working populations experiencing health disparities. More specifically, interventions to address work-related fatigue among specific at-risk worker groups should also consider the multiple and overlapping categories of at-risk groups to which workers may belong.

The field of OSH does not yet have a clear or complete picture of how working hours and social determinants of health relate, and research needs in both large-scale quantitative studies, such as the need to get basic demographic information included in more fatigue and working hours research, and needs to understand the lived experience gained through in-depth qualitative and participatory research approaches, can be addressed as interest in working hours and fatigue research grows.

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The authors declare that there are no conflicts of interest.

ETHICS APPROVAL AND INFORMED CONSENT

No ethics review and approval and no informed consent were required for this study, as it represents only review and analysis of existing literature.

DISCLOSURE BY AJIM EDITOR OF RECORD

Paul A Landsbergis declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHOR CONTRIBUTIONS

Thomas R. Cunningham and Rebecca J. Guerin conceived the overall idea of this study. All four authors contributed article retrieval and review. Thomas R. Cunningham and Rebecca J. Guerin wrote the initial draft, and all four authors contributed to multiple revisions, and final approval of the version to be published. All four authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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