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RESEARCH ARTICLE

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A longitudinal study of work-related psychosocial factors and injuries: Implications for the aging United States workforce

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Introduction: This study aimed to identify psychosocial work factors that may individually or, in combination, influence injury outcomes among aging United States (U.S.) workers.

Methods: Data from the U.S. Health and Retirement Study (HRS) of 3305 working adults, aged 50 years and above, were used to identify associations between work-related psychosocial factors and injury incidence from 2006 to 2014, using adjusted incidence rate ratios.

Results: Employees perceiving their work as high in psychological and physical demands/efforts, low in support, and rewards, compared to those in workplaces with low demands, high support, and high rewards, had a risk of injury two times greater. Males, compared with females, had a greater risk for injuries when interactions among several psychosocial work-related factors were modeled.

Conclusions: The fact that important gender-based differences emerged when interactions among the psychosocial factors and injury were modeled, suggests opportunities for further research and potential interventions to enhance the working environment.

KEYWORDS
aging workers, work-related psychosocial factors, work-related stress, work-related injuries

1 | INTRODUCTION

Recent evolutionary changes in the organization of work activities that have outpaced knowledge about their impact may affect the workers' health by several pathways that increase the risk of stress-related illnesses and injuries.[1] Specifically, today's work life involves several types of psychological demands and forms of controls and resources for meeting such demands.[2] An imbalance between such demands and resources may lead to increased stress. This stress may, in turn, increase an individual's risk for injuries or illnesses,[1,3] which have been associated with an annual total economic burden of $250 billion in the United States (U.S.).[4] Still, not only is there a dearth of studies using standardized generic questionnaires to measure such stressors, but much remains uncovered regarding characteristics of the stressors and their effects on safety and health at work.[1]

The relations between stressors and safety and health outcomes are affected not only by the stressors but also by individual characteristics. While stress responses in young, healthy individuals may be adaptive and not impose a health risk, if it is unremitting over the long-term particularly in older or unhealthy individuals, it may affect health.[5] In addition to illnesses, aging workers are also at a higher risk of experiencing more severe injury outcomes. The Bureau of Labor Statistics (BLS) reported that, in 2015, the overall incidence rate of days away from work was 104 cases per 10 000 full-time equivalent (FTE) workers. Those aged 55-64 years had one of the highest incidence rates among all occupations (116 cases per 10 000 FTE).[6] Additionally, those aged 65 years, and above, experienced a fatal injury

Institution at which the work was performed: University of Minnesota.

rate that was four-times greater than for those between 25 and 34 years.[7] Integral to this issue, is that the proportion of aging employees in the U.S. workforce is increasing and, by the year 2020, will comprise of 25% of the workforce.[8]

Several work-related psychosocial factors may be individually associated with poor safety and health-related outcomes.[9–13] Research has further indicated that combinations of multiple stressors, including task-level psychological and physical demands at work and work decision latitude or control (work strain model),[14] job demands and rewards obtained (effort-reward imbalance model),[15,16] and work-related strain and support,[12,17] may act together and be more potent than single stressors.[5] The effort-reward imbalance model, while similar to the work strain model, also explores intrinsic personality characteristics which may influence the perceived stressors and resultant hazards.[18,19] Over-commitment to work, a personality trait considered in this model, may lead to work-family conflict and play an important role in shaping employees' safety and health outcomes. However, occupational health psychology frameworks have rarely studied these aspects together.[20,21] Interestingly, it has been suggested that work-family conflict (work-related demands interfering with family responsibilities), but not family-work conflict (family life impeding work activities), is related to work-related injuries.[21]

Much of the presented evidence, even though limited, comes from cross-sectional studies, primarily focused on small, selected populations.[10,15,16,22,23] Additionally, many previous studies have focused only on specific, rather than all categories of potentially stressful work-related factors. Research efforts are needed to provide a holistic understanding of how various work-related psychosocial factors and their interactions influence an employee's injury experiences at work. Further, it is important to understand how socio-demographic characteristics like gender, race, ethnicity, age, and health-related factors play a role in this complex mechanism.[1,5,11,13,22] Importantly, gender has been identified as a biological determinant for psychological stress.[24] Research has also suggested that there may be gender-based differences in coping strategies.[25] Previous studies have reported that there are gender-differential associations for work strain, work-related support, and psychological distress.[22] Therefore, this study also assesses gender-stratified associations between psychosocial work-related factors and injuries among the aging workforce.

The present study enabled investigation of the associations between a spectrum of psychological work-related factors and injury occurrences among a working cohort of aging U.S. adults. In addition to individual work-related psychosocial factors, combinations of such factors that may shape an aging employee's injury experiences, were also analyzed.

2 | METHODS

Approval to conduct this study was obtained from the Institutional Review Board, University of Minnesota, under exempt status since only secondary, de-identified data were utilized. The cohort for this repeated-measures study was obtained from the Health and Retirement Study (HRS), a biennial nationally representative longitudinal panel study of U.S. adults aged 50 years and above that has been active since 1992. HRS has maintained a response rate of over 85% for all survey waves. Data pertaining to the study variables were obtained from various HRS survey modules.[26] While the core HRS survey facilitates data collection every 2 years, the HRS module that provides longitudinal information regarding work-related psychosocial factors is available only every 4 years. Pilot-tested on a random 10% of the study sample in 2004, the HRS's self-administered psychosocial and lifestyle (PSL)[27] questionnaire has enabled collection of biennial information regarding participants' evaluations of their life circumstances, subjective well-being, and lifestyle, including evaluations of work-related factors since 2006. The latter part of the survey dealing with work-related psychosocial factors was administered only to those working for pay. A random (rotating) sample of 50% of the core panel participants receives the PSL questionnaire every biennial survey wave. The alternating 50% receives it the next survey wave. Thus, the longitudinal data are available only at four-year intervals.[26,27] Two separate sub-cohorts with one obtained from the year 2006 HRS survey wave, and the other from the 2008 wave formed the cohort for this study. Figure 1 provides a pictorial representation of the PSL survey administration among these sub-cohorts that is, sub-cohorts 2006 and 2008.

2.1 | Study design

The cohort for this study includes U.S. individuals, aged 50 years and above, who were working for pay during 2006-2014 and responded to the work-related exposures section of the PSL questionnaire. While, the data on the demographic characteristics, personal, and work-related characteristics, including work-related psychosocial factors were obtained from 2006 to 2012. In order to make causal assumptions considering exposure and outcome temporality,[28] data on the outcome, that is, work-related injuries were obtained from waves subsequent to each PSL survey wave. Thus, repeated measures data on injuries were obtained from the 2008-2014 survey waves and relevant repeated measures of exposure data were obtained from the 2004-2012 HRS survey waves.

2.2 | Study sample

As previously identified, due to a rotating sample of PSL surveys, two separate sub-cohorts formed the sample for this study. The two study sub-cohorts, collected in 2006 and 2008, were combined to form the overall study sample of 3305 working U.S. adults.

2.3 | Study variables

The outcome for this study, work-related injuries was obtained from the core HRS questionnaire. Work-related injuries were defined as "any injuries at work that required special medical attention or treatment or interfered with your work activities." Those who reported

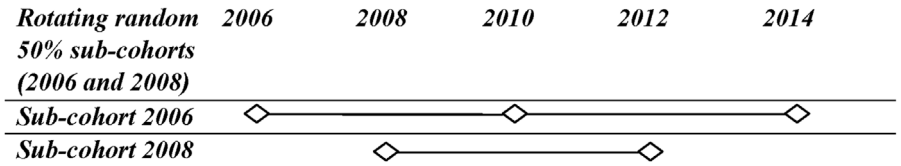

FIGURE 1 Timeline for the HRS psychosocial and lifestyle questionnaire administration from 2006 to 2014

having a work-related injury were further asked about the number or counts of such events. The primary exposures of interest that is, work-related psychosocial factors, were obtained from the work-related psychosocial exposures section of the PSL questionnaire (Chronbach's alpha = 0.70[27]) (Table 1). These were measured on a four-level Likert scale as shown in Table 1. Information was obtained regarding perceptions about physical work demands, salary adequacy, promotion aspects, work security, workload, freedom, skill development, control, need to work fast, conflicting work demands, and work-personal life conflict. The stated variable exposures were used to evaluate the relations between (i) work-related strain[14]; (ii) effort-reward imbalance[18,19]; (iii) work-related support[9,12,17]; (iv) work-family conflict[21]; (v) along with the interactions among the stated factors[12,17]; and the outcome of injuries.

Other variables considered that could be potential confounders, included; (i) socio-demographic characteristics that is, respondents' age as of the survey wave, gender, race, ethnicity, education, marital/partner status, being born in the U.S. or not; (ii) health-related information regarding presence of chronic physical and mental health conditions, and presence of depression-related symptoms since 2 weeks prior to the interview (acute depression); (iii) lifestyle factors of number of alcoholic drinks consumed per week, and smoking behavior; and (iv) total household assets and income. Also included, were other work-related characteristics including; work category grouped as white collar, blue collar, and service; total hours worked during each wave in primary and second employment, if any; work status assessed as full-time, part-time, and partly-retired; having a second job; wages; tenure in the current work; and any previous history of work-related injuries.[5,11,13,22] All of these, as indicated earlier were obtained from the core HRS questionnaire that is administered biennially.

2.4 | Statistical methods

Similar to previous studies,[9,11,13,23] psychosocial work factors including work demands, work control, efforts put into the work, rewards obtained from the work, and work-family conflict were created by

TABLE 1 Psychosocial work-related factors and the respective questions from the PSL questionnaire

Work-related psychosocial factors	Respective questions
[a]Work demands (created by summarizing three psychological and one physical demand)	• I am under constant time pressure due to a heavy workload. • Considering the things I have to do at work, I have to work very fast. • In my work, I am free from conflicting demands that others make. • My work is physically demanding.
Work control	• I have very little freedom to decide how I do my work. • I have the opportunity to develop new skills. • At work, I feel I have control over what happens in most situations.
Support at the work	I receive adequate support in difficult situations.
[a]Efforts involved in the work (physical and psychological work demands)	• I am under constant time pressure due to a heavy workload. • Considering the things I have to do at work, I have to work very fast. • In my work, I am free from conflicting demands that others make. • My job is physically demanding.
Rewards obtained from the work	• I receive the recognition I deserve for my work. • My salary is adequate.• My job promotion prospects are poor. • My job security is poor.
[b]Work-family conflict	• Work makes personal life difficult. • Other people determine most of what I can and cannot do. • What happens in my life is often beyond my control.

[a]Both work demands and efforts measure "task-level" demands.
[b]Intrinsic characteristic; measured as rarely, sometimes, often, and most of the time (all others measured as strongly disagree, disagree, agree, and strongly agree).

summarizing the respective individual factors (Table 1). The remaining work condition (ie, support at work) was used as recorded in the survey. For the factors created, by summarizing several individual factors, researchers[23] have suggested using the median to signify high and low exposures. For example, a summary score was first calculated for each individual's survey wave specific work demands. Then, the overall median score for work demands was estimated, and an individual, whose score was above the median, was considered to have high work demands and vice versa. Next, work-related strain, and effort-reward imbalance scales were created by dividing the total psychological work demands by work control (Work-related strain = Work demands/Work control), and total work-related efforts by the rewards obtained (Effort-reward imbalance = Work-related efforts or demands/Rewards obtained), respectively. Values on the scale that were greater than one were considered high and those at or below one were considered low.[13,23]

Directed acyclic graphs (DAGs) were developed a priori to graphically understand the hypothesized associations between the psychosocial exposures of interest and the outcome, and to then select potential confounders for adjustment for each of the individual multivariable models.[29] The variables, for which the models were adjusted, included: age; race; ethnicity, marital/partner status; chronic physical and mental health conditions; acute depression; alcohol consumption; work category; work status; and work tenure.

Work-related injuries were modeled as the number of injury events (counts); the exposure time used was total hours worked since the last interview wave. Incidence rate ratios (IRRs) were estimated using the generalized estimating equations (GEE) with a negative-binomial error distribution and accounting for within-person and within-household correlations.[30] The models were then stratified by gender, as suggested by previous researchers.[22] In study waves where there was missing exposure information, the last available observation was carried forward to impute the missing value. All analyses were conducted using SAS statistical software.[31]

3 | RESULTS

From the overall study cohort of 3305 persons, 158 persons (4.6%) experienced at least one work-related injury between 2008 and 2014 (Table 2). At baseline, most injured males and females were in the 50–<60 year age group. The majority of those injured, were White/Caucasian, non-Hispanic, and were U.S. born. While over half of the injured males were employed in blue-collar occupations, less than 10% of the injured females had such employment. In general, perceptions about various psychosocial factors were similar between both genders.

The data were then analyzed using unadjusted and multivariable regression models (GEE), stratified by gender as discussed before. Tables 3 and 4, respectively, present the gender stratified crude and adjusted rate ratios as obtained from GEE models for each of the individual psychosocial factors, and their interactions.

Table 3 shows that males and females who perceived their workplaces to have high versus low demands, had a greater risk for experiencing a work-related injury event. Although high versus low work-related strain, demonstrated similar elevated risks for both genders, this was significant only for women. As also shown in Table 3, low support, low rewards, and high effort-reward imbalance, compared with high support, high rewards, and low effort-reward imbalance respectively, were all associated with a risk twice as high for injuries in both genders.

Table 4 presents estimates for the associations between interactions among various psychosocial factors and work-related injuries. As is illustrated in the table, an interaction of both work demands and control with work support showed that high demands, in combination with low support, compared with low demands and high support contribute to the highest risks for injuries in both genders. The effect was more pronounced among males. Females employed in high strain and low support workplaces, compared with those in low strain and high support workplaces, had a risk two times greater than those who had low work strain and high support. Further, high work-related efforts, combined with high work-family conflict, compared with a combination of low efforts and low conflict, were associated with a higher risk for injuries only among males. For both genders, the risk for injuries was almost twice as high among those who experienced high versus low effort-reward imbalance, and high versus low in work-family conflict. Further, low effort-reward imbalance and high work control, compared with high effort-reward imbalance and high control were associated with higher risks for injuries for both genders.

4 | DISCUSSION

Multivariable gender-stratified models in this study, showed that males and females who perceived their workplaces to have high, compared with low, work demands had a risk nearly two times greater for work-related injury occurrence. Low, versus high, work control among males, in the current study, was also associated with a higher but not important risk for experiencing a work-related injury event. In a previous study,[23] this risk among both genders was about two-times greater if they had high psychological work demands. Similarly, a study[12] conducted among adolescent workers in Brazil reported that, high work demands compared to low psychological demands, were associated with greater odds of experiencing injuries. It was also observed that the higher the scale score, the higher the prevalence of work-related injuries [odds ratio = 3.0 (P = 0.02)]. The study results also suggested that lower work control could have serious consequences as adolescent workers with lower control tended to do more daily work on average. Another study,[16] conducted in a cohort of aluminum production and maintenance workers across all ages found that, those with high work demands compared with low, had a 49% higher risk of experiencing a serious injury. Further, workers engaged in low control work also had a significantly higher risk for injuries.

From the current study, analysis conducted with work support as the exposure of interest and injuries as the outcome, revealed that those who perceived low versus high support at their workplaces had over twice the risk for experiencing an injury. A previous cross-

TABLE 2 Baseline demographic and other personal characteristics of the study cohort of United States aging workers, by injury status (*N* = 3,305)

	Injured (*n* = 158)		Uninjured (*n* = 3,147)	
Exposures	**Males *n* = 74**	**Females *n* = 84**	**Males *n* = 1,434**	**Females *n* = 1,713**
	Number (%)			
Demographic and other personal factors:				
Age-groups				
50-<60 year old	42 (56.8)	55 (65.5)	655 (45.7)	898 (52.4)
60-<65 year old	21 (28.4)	20 (23.8)	532 (37.1)	588 (34.3)
65 years and above	8 (10.8)	5 (6.0)	231 (16.1)	176 (10.3)
Race				
White/Caucasian	62 (83.8)	67 (79.8)	1,235 (86.1)	1,390 (81.1)
Black	10 (13.5)	12 (14.3)	123 (8.6)	221 (12.9)
Others	2 (2.7)	5 (6.0)	76 (5.3)	102 (5.9)
Ethnicity				
Hispanic	7 (9.46)	10 (11.9)	120 (8.4)	119 (7.0)
Non-Hispanic	67 (90.5)	74 (88.1)	1,314 (91.6)	1,594 (93.1)
Place of birth				
U.S. born	67 (90.5)	76 (90.5)	1,304 (90.9)	1,564 (91.3)
Born elsewhere	7 (9.5)	8 (9.5)	125 (8.7)	146 (8.5)
Education				
GED/Left high-school	15 (20.3)	10 (11.9)	190 (13.2)	217 (12.7)
High-school graduate	26 (35.1)	26 (30.9)	341 (23.8)	510 (29.8)
Some college	19 (25.7)	26 (31.0)	344 (24.0)	508 (30.0)
College or above	14 (18.9)	22 (26.2)	559 (39.0)	478 (27.9)
Marital status				
Married/partnered	58 (78.4)	54 (64.3)	1,240 (86.5)	1,189 (69.4)
Separated/divorced/widowed/never married	15 (20.3)	30 (35.7)	185 (12.9)	508 (29.7)
Net household income and assets ($)				
<=210 000	41 (55.4)	51 (60.7)	601 (41.9)	839 (49.0)
>210 000	33 (44.6)	33 (39.3)	833 (58.1)	874 (51.0)
Average number of alcoholic drinks consumed per week				
0	37 (50.0)	58 (69.1)	687 (47.9)	1,079 (63.0)
1-5	15 (20.3)	20 (23.8)	373 (26.0)	387 (22.6)
6 or more	20 (27.0)	6 (7.1)	361 (25.2)	229 (13.4)
Number of chronic health problems				
0	13 (17.6)	16 (19.1)	381 (26.6)	442 (25.8)
1	38 (51.4)	23 (37.4)	478 (33.3)	541 (31.6)
2 or more	22 (29.7)	43 (53.6)	566 (39.5)	714 (41.7)
Acute depression				
Yes	38 (51.3)	53 (63.1)	548 (38.2)	781 (45.6)
No	34 (45.9)	31 (36.9)	852 (59.4)	910 (53.1)
Previous work-related injury history				
Previously injured	19 (25.7)	12 (14.3)	1,266 (88.3)	1,503 (87.7)
Previously uninjured	55 (74.3)	69 (82.1)	147 (10.3)	172 (10.0)
Work-related characteristics:				
Work category				

(Continues)

TABLE 2 (Continued)

Exposures	Injured (*n* = 158)		Uninjured (*n* = 3,147)	
	Males *n* = 74	Females *n* = 84	Males *n* = 1,434	Females *n* = 1,713
White-collar	16 (21.6)	46 (54.8)	809 (56.4)	1,123 (65.6)
Service	14 (18.9)	29 (34.5)	215 (15.0)	465 (27.1)
Blue-collar	39 (52.7)	7 (8.3)	383 (26.7)	100 (5.8)
Work status				
Full-time	59 (79.7)	61 (72.6)	1,042 (72.7)	1,066 (62.2)
Part-time or partly-retired	14 (18.9)	23 (27.4)	383 (26.7)	631 (36.8)
Tenure in the current work				
Five years or less	29 (39.2)	29 (34.5)	495 (34.5)	662 (38.6)
More than 5 years	43 (58.1)	51 (60.7)	920 (64.2)	1,024 (59.8)
Work-related psychosocial factors:				
Work demands or Efforts involved in the work				
High	46 (62.2)	47 (56.0)	619 (43.2)	688 (40.2)
Low	28 (37.8)	34 (40.5)	792 (55.2)	1979 (57.2)
Work control				
Low	46 (62.2)	47 (56.0)	781 (54.5)	989 (57.7)
High	26 (35.1)	35 (41.7)	636 (44.4)	684 (40.0)
Work-related strain (Work demands/Control)				
High	13 (17.6)	18 (21.4)	168 (11.7)	228 (13.3)
Low	59 (79.7)	62 (73.8)	1,237 (86.3)	1,420 (83.0)
Support at the work				
Low	16 (21.6)	18 (21.4)	240 (16.7)	276 (16.1)
High	56 (75.7)	65 (77.4)	1,177 (82.1)	1,416 (82.7)
Rewards obtained from the work				
Low	41 (55.4)	50 (59.5)	692 (48.3)	875 (51.1)
High	31 (41.9)	26 (31.0)	688 (48.0)	764 (44.6)
Effort-reward imbalance (Efforts involved in the work/Rewards obtained from the work)				
High	25 (33.8)	30 (35.7)	286 (19.9)	348 (20.3)
Low	47 (63.5)	45 (53.6)	1,083 (75.5)	1,262 (73.4)
Work-family conflict				
High	44 (59.5)	45 (53.6)	638 (44.5)	753 (44.0)
Low	28 (37.8)	36 (42.9)	787 (54.9)	943 (55.1)

Missing values are not shown.

sectional Canadian study[17] reported that both males and females, 15-74 years of age, who had high versus low social support at their workplaces, were significantly less likely to report a repetitive strain injury. Another review[32] showed that the magnitude of risks (odds ratios, or risk ratios) for experiencing musculoskeletal problems among those who experienced low versus high support, ranged from 1.2 to 2.1.

The current research further examined combinations of work-related psychosocial factors, and found gender-based differences in risks for injuries. The results indicated that males engaged in high demand and low support work, compared with those in low demand and high support work had a risk of injury occurrence over four times greater. Of further interest, males working in occupations with low control and high support, compared with high control and high support, had an increased risk for injuries. Also, in females, high strain (high work demands and low control) in combination with low support, compared with low strain and high support, was associated with a risk of injury that was nearly two times greater. From a previous longitudinal study,[11] conducted among transit operators, it was reported that the hazard rate (HR) for experiencing an injury was

TABLE 3 Associations between each of the work-related psychosocial factors and injuries in the study cohort of aging United States workers (*N* = 3,305)

	Counts (number) of work-related injury events			
	Crude IRR (95% CI)		*Adjusted IRR (95% CI)	
Work-related psychosocial factors	Males	Females	Males	Females
Work demands or efforts involved				
High vs Low	2.66 (1.64, 4.34)	1.69 (1.15, 2.50)	2.63 (1.50, 4.64)	1.68 (1.07, 2.62)
Work control				
Low vs High	1.58 (0.95, 2.62)	1.18 (0.79, 1.76)	1.48 (0.88, 2.50)	0.94 (0.61, 1.47)
Work-related strain (Work demands/work control)				
High vs Low	2.52 (1.00, 6.37)	2.06 (1.34, 3.18)	1.65 (0.68, 4.00)	1.73 (1.06, 2.81)
Support at the work				
Low vs High	2.34 (1.06, 5.18)	1.18 (0.73, 1.90)	2.48 (1.34, 4.57)	2.47 (1.53, 3.98)
Rewards				
Low vs High	1.30 (0.73, 2.33)	1.73 (1.12, 2.67)	1.73 (1.12, 2.67)	1.78 (1.13, 2.80)
Effort-reward imbalance (efforts/rewards)				
High vs Low	2.87 (1.49, 5.50)	2.02 (1.32, 3.07)	1.91 (1.01, 3.62)	1.78 (1.13, 2.80)
Work-family conflict				
High vs Low	1.84 (0.95, 3.58)	1.28 (0.85, 1.93)	1.22 (0.70, 2.13)	1.04 (0.67, 1.60)

*Adjusted for Age, Race, Ethnicity, Marital status, Presence of chronic physical and mental health conditions, Presence of acute depression, Number of alcoholic drinks consumed per week, Work status, Work category, Work tenure, and Previous history of injuries

not significant, but was increased [HR: 1.41 (95%CI = 0.98–2.01)] among those who perceived their workplace involved high strain and low support versus those with high strain and high support.

Another finding in the current study was that high, compared with low effort-reward imbalance was associated with a risk for injuries that was twice as great in both genders. In another study[13] high compared to low effort-reward imbalance was found to be associated with a higher risk for neck injuries among transit drivers [HR: 1.66 (CI = 1.16–2.38)]. Further, the current research found that males with high imbalance at work and low work control, compared to those with low imbalance and high work control, had a risk nearly three times greater for experiencing injuries. A previous study[18] that involved male sawmill workers found that high versus low imbalance was associated with a risk three times greater for reporting poor health status. The study also found that this imbalance, along with low control, versus imbalance and high control was also associated with a greater risk for reporting poor health status. These findings suggest that there are gender-differential associations between combinations of work-related stressors and injury experiences in the aging workforce.

In the current study, combinations of high work-related efforts with work-family conflict, compared to low efforts and conflict were associated with a risk for injuries nearly three times greater among males. Specifically, effort-reward imbalance was more strongly associated with injuries than work-family conflict. In contrast, a previous study[33] found that work-family interference was more strongly associated with stress and burnout, compared to effort-reward imbalance.

This comprehensive repeated measures longitudinal study in the cohort of aging U.S. workers, enabled estimations of incidence rate ratios while adjusting for within-person and within-household correlations. The study design also allowed for the identification of potential causal associations, with consideration of temporality. However, the results of this study must be interpreted with recognition of potential limitations. First, the results may not be valid for younger workers and working populations in general, as they may have had exposures different from those of the cohort for this study. The results may also not be generalizable to other countries. In addition, the data used for these analyses are based on self-report and, thus, may be biased away from the null, especially among those who experienced injury events. This is because those injured may remember their exposures better or may have exaggerated perceived psychosocial factors. As a result, differential misclassification resulting from reporting bias of the exposures may have occurred by injury status. Table 1 also indicates that a higher proportion of injured versus uninjured workers perceived their workplaces to be high in psychological and physical demands. Hence, it is possible that the observed risk is overestimated. Next, dichotomizing the study exposures into high and low stress categories could have resulted in loss of information. Last, even though, HRS maintains high retention rates,[26] it is also possible that those who dropped out due to disability or death over the cohort study period were different from those who

TABLE 4 Associations between different combinations of individual work-related psychosocial factors and injuries in the study cohort of aging United States workers (*N* = 3,305)

	Counts (number) of work-related injury events			
	Crude IRR (95%CI)		[a]Adjusted IRR (95%CI)	
Work-related psychosocial factors	Males	Females	Males	Females
Work-related demands or efforts X support at the work				
Low demands X High support	1	1	1	1
Low demands X Low support	1.37 (0.42, 4.50)	0.68 (0.25, 1.85)	1.19 (0.26, 5.37)	0.37 (0.09, 1.52)
High demands X High support	2.31 (1.37, 3.90)	1.51 (0.98, 2.33)	2.20 (1.15, 4.19)	1.44 (0.88, 2.35)
High demands X Low support	5.19 (2.09, 12.88)	1.95 (1.11, 3.43)	4.34 (1.81, 10.41)	1.82 (0.99, 3.23)
Work control X support at the work				
High control X High support	1	1	1	1
High control X Low support	2.52 (1.10, 5.74)	1.35 (0.73, 2.51)	2.55 (1.05, 6.20)	1.12 (0.58, 2.15)
Low control X High support	2.05 (1.08, 3.91)	0.73 (0.30, 1.75)	2.40 (1.16, 4.95)	0.64 (0.24, 1.71)
Low control X Low support	1.51 (0.54, 4.23)	1.35 (0.70, 2.60)	1.26 (0.40, 4.04)	1.06 (0.51, 2.22)
Work-related strain X support at the work				
Low strain X High support	1	1	1	1
Low strain X Low support	1.69 (0.78, 3.70)	0.57 (0.22, 1.46)	1.57 (0.61, 4.04)	0.48 (0.17, 1.35)
High strain X High support	1.67 (0.86, 3.24)	1.57 (0.84, 2.92)	1.19 (0.51, 2.75)	1.19 (0.60, 2.35)
High strain X Low support	3.90 (1.12, 13.66)	2.30 (1.35, 3.92)	2.20 (0.66, 7.36)	1.97 (1.08, 3.59)
Efforts involved in the work X work-family conflict				
Low efforts X Low conflict	1	1	1	1
Low efforts X High conflict	1.07 (0.53, 2.15)	0.90 (0.47, 1.74)	1.03 (0.47, 2.25)	0.65 (0.33, 1.28)
High efforts X Low conflict	2.15 (0.79, 5.90)	1.34 (0.76, 2.37)	2.13 (0.81, 5.58)	1.22 (0.64, 2.32)
High efforts X High conflict	2.92 (1.66, 5.13)	1.77 (1.09, 2.88)	3.17 (1.61, 6.21)	1.52 (0.84, 2.74)
Rewards obtained X work-family conflict				
High rewards X Low conflict	1	1	1	1
High rewards X High conflict	1.90 (0.87, 4.13)	1.43 (0.70, 2.92)	1.96 (0.83, 4.60)	1.02 (0.46, 2.23)
Low rewards X Low conflict	1.64 (0.66, 4.08)	1.82 (0.99, 3.35)	1.30 (0.50, 3.38)	1.65 (0.85, 3.20)
Low rewards X High conflict	1.66 (0.95, 2.92)	2.30 (1.29, 4.09)	1.39 (0.74, 2.61)	1.82 (0.99, 3.33)
Effort-reward imbalance X high work-family conflict				
Low imbalance X Low conflict	1	1	1	1
Low imbalance X High conflict	2.02 (1.11, 3.67)	1.03 (0.61, 1.74)	2.20 (1.13, 4.29)	0.87 (0.49, 1.55)
High imbalance X Low conflict	7.67 (2.34, 25.20)	1.52 (0.70, 3.31)	4.61 (1.46, 14.57)	1.17 (0.48, 2.82)
High imbalance X High conflict	2.94 (1.63, 5.30)	2.32 (1.39, 3.86)	2.66 (1.36, 5.20)	1.85 (1.04, 3.30)
Effort-reward imbalance X low work control				
Low imbalance X High control	1	1	1	1
Low imbalance X Low control	1.70 (0.84, 3.45)	1.28 (0.62, 2.64)	1.40 (0.51, 3.87)	0.89 (0.32, 2.51)
High imbalance X High control	3.27 (1.57, 6.79)	2.27 (1.43, 3.62)	2.50 (1.28, 4.87)	1.88 (1.15, 3.10)
High imbalance X Low control	2.09 (0.82, 5.33)	1.15 (0.45, 2.95)	2.70 (1.23, 5.90)	0.97 (0.42, 2.20)

X, Combination of individual psychosocial factors.

[a]Adjusted for Age, Race, Ethnicity, Marital status, Presence of chronic physical and mental health conditions, Presence of acute depression, Number of alcoholic drinks consumed per week, Work status, Work category, Work tenure, and Previous history of injuries.

were retained in terms of their exposures. However, sensitivity analyses revealed that censored and non-censored respondents were similar in terms of their exposures.

5 | CONCLUSIONS

This study suggests that aging workers face several stressors in their work environments, which increases their risk of experiencing injuries. It is important to obtain a comprehensive representation of an employee's psychosocial work environment and determine how various factors may act together and affect their injury occurrences. Importantly, there are significant gender differences among aging employees with respect to their perception of work-related psychosocial factors and injury outcomes.

From research endeavors, it is suggested that strategies to prevent or reduce work-related stress can be addressed at the federal level, workplace or employer level, task level, and finally at the employee or individual level. At the federal level, legislation, or policies like the ban on mandatory overtime, or providing paid family leave can be helpful. Examples of strategies at the workplace level may include worksite surveillance programs and work-family programs. To target the job or task level stressors, researchers have suggested using task redesign strategies including increased job control, skill development, and clear promotion pathways. Finally, employer-initiated programs like those targeted towards stress resilience training can be helpful in mitigating stress at the employee level.[34]

Future researchers must explore specific mechanisms of how such psychosocial factors in the work environment may interact to shape the gender-based injury experiences of the employees. This information will be helpful in designing gender-specific strategies to mitigate work-related stress.

AUTHOR CONTRIBUTIONS

NKB, was primarily responsible for acquiring comprehensive knowledge of the intricacies of the very complex HRS database and designing the relevant methodological approach, conducting the data analyses, and preparing a draft manuscript following regular meetings and discussions with the research team of co-authors who also contributed to the manuscript. SGG and HK, mentored the primary author regarding study design and analysis during the entire research project, together with AR who additionally provided mentorship relevant to database management and analysis. TC, Biostatistician, provided insights and feedback on the overall project. BC with experience and expertise with the HRS, provided key input to this very complex and important effort.

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ETHICS APPROVAL AND INFORMED CONSENT

Approval to conduct this study was obtained from the Institutional Review Board, University of Minnesota, under exempt review as de-identified secondary data were used.

DISCLOSURE (AUTHORS)

The authors identify no conflict of interests.

DISCLOSURE BY AJIM EDITOR OF RECORD

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

DISCLAIMER

None.

REFERENCES

1. Landsbergis PA. The changing organization of work and the safety and health of working people. A commentary. *J Occup Environ Med*. 2003;45:61–72.
2. Clougherty JE, Souza K, Cullen MR. Work and its role in shaping the social gradient in health. *Ann N Y Acad Sci*. 2010;1186:102–24.
3. Sauter S, Murphy L, Colligan M, et al. *Stress at work*. DHHS (NIOSH) Publication. 1999; 99–101. https://www.cdc.gov/niosh/docs/99-101/
4. Leigh J. Economic burden of occupational injury and illness in the United States. *The Milbank Q*. 2011;89:728–72.
5. Schneiderman N, Ironson G, Siegel SD. Stress and health: psychological, behavioral, and biological determinants. *Annu Rev Clin Psychol*. 2005;1:607–28.
6. Bureau of Labor Statistics- News release: Nonfatal occupational injuries and illnesses requiring days away from work. https://www.bls.gov/news.release/pdf/osh2.pdf. Accessed on 2/22/2017.
7. Bureau of Labor Statistics- Economic news release: Census of fatal occupational injuries summary. https://www.bls.gov/news.release/cfoi.nr0.htm. Accessed on 2/22/2017.
8. The aging US workforce: A chartbook of demographic shifts. http://files.ctctcdn.com/5cbb303c001/4de185c9-02e6- 4598-9541-5d1ac9a74696.pdf. Accessed on 6/10/2016.
9. Vafaei A, Kristman VL. Social support in the workplace and work-related injury in Canada: a cross-sectional analysis. *Occup Med Health Aff*. 2013;1:131.
10. Cantley LF, Tessier-Sherman B, Slade MD, Galusha D, Cullen MR. Expert ratings of work demand and work control as predictors of injury and musculoskeletal disorder risk in a manufacturing cohort. *Occup Environ Med*. 2015;73:229–36.
11. Rugulies R, Krause N. Work strain, iso-strain, and the incidence of low back and neck injuries. A 7.5-year prospective study of San Francisco transit operators. *Soc Sci Med*. 2005;61:27–39.

12. Johnson JV, Hall EM. Work strain, work place social support, and cardiovascular disease: a cross-sectional study of a random sample of the Swedish working population. *Am J Public Health*. 1988;78:1336–42.
13. Rugulies R, Krause N. Effort-reward imbalance and incidence of low back and neck injuries in San Francisco transit operators. *Occup Environ Med*. 2008;65:525–33.
14. Karasek Jr RA. Work demands, work decision latitude, and mental strain: implications for work redesign. *Adm Sci Q*. 1979;1:285–308.
15. Nakata A, Ikeda T, Takahashi M, et al. Impact of psychosocial work stress on non-fatal occupational injuries in small and medium-sized manufacturing enterprises. *Am J Ind Med*. 2006;49:658–69.
16. Lee SJ, You D, Gillen M, Blanc PD. Psychosocial work factors in new or recurrent injuries among hospital workers: a prospective study. *Int Arch Occup Environ Health*. 2015;88:1141–48.
17. Fischer FM, Oliveira DC, Nagai R, et al. Work control, work demands, social support at work and health among adolescent workers. *Rev Saude Publica*. 2005;39:245–53.
18. Ostry AS, Kelly S, Demers PA, Mustard C, Hertzman C. A comparison between the effort-reward imbalance and demand control models. *BMC Public Health*. 2003;3:10.
19. Siegrist J. Adverse health effects of high-effort/low-reward conditions. *J Occup Health Psychol*. 1996;1:27–41.
20. Krisor SM, Rowold J. Effort-Reward imbalance theory and irritation: the important role of internal and external work-Family conflict. *J Bus Psychol*. 2013;4:1–0.
21. Turner N, Hershcovis MS, Reich TC, Totterdell P. Work-family interference, psychological distress, and workplace injuries. *J Occup Organ Psychol*. 2014;87:715–32.
22. Vermeulen M, Mustard C. Gender differences in work strain, social support at work, and psychological distress. *J Occup Health Psychol*. 2000;5:428.
23. Kim HC, Min JY, Min KB, Park SG. Work strain and the risk for occupational injury in small-to medium-sized manufacturing enterprises: a prospective study of 1,209 Korean employees. *Am J Ind Med*. 2009;52:322–30.
24. Wang J, Korczykowski M, Rao H, et al. Gender difference in neural response to psychological stress. *Soc Cogn Affect Neurosci*. 2007;2:227–39.
25. Matud MP, Bethencourt JM, Ibáñez I. Gender differences in psychological distress in Spain. *Int J Soc Psychiatry*. 2015;61:560–68.
26. Sonnega A, Faul JD, Ofstedal MB, Langa KM, Phillips JW, Weir DR. Cohort profile: the health and retirement study (HRS). *Int J Epidemiol*. 2014;43:576–85.
27. Psychosocial and lifestyle questionnaires 2006 −2010: Documentation report core section leave-behind. https://hrs.isr.umich.edu/sites/default/files/biblio/HRS2006-2010SAQdoc. pdf. Accessed on 8/15/2016.
28. Hill AB. The environment and disease: association or causation? *J R Soc Med*. 2015;108:32–7.
29. Greenland S, Pearl J, Robins JM. Causal diagrams for epidemiologic research. *Epidemiology*. 1999;10:37–48.
30. Ballinger GA. Using generalized estimating equations for longitudinal data analysis. *Organ Res Methods*. 2004;7:127–50.
31. SAS Institute. Base SAS 9. 4 Procedures Guide. SAS Institute. 2015.
32. Bongers P, Kremer A, Ter Laak J. Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist?: A review of the epidemiological literature. *Am J Ind Med*. 2002;41:315–42.
33. Hämmig O, Brauchli R, Bauer GF. Effort-reward and work-life imbalance, general stress and burnout among employees of a large public hospital in Switzerland. *Swiss Med Wkly*. 2012;142:135–47.
34. Landsbergis PA, Dobson M, LaMontagne AD, Choi B, Schnall P, Baker DB. Occupational stress. In: Levy BS, ed. *Occupational and environmental health*. 7th ed. Oxford University Press. 2017.

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