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Work-related musculoskeletal symptoms among loggers in the Ark-La-Tex region

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Abstract

Background: The U.S. logging sector is among the most dangerous industrial sectors, with high fatality and non-fatal injury rates. Limited research has addressed work-related musculoskeletal disorders among logging machine operators (LMOs). The purpose of this study was to estimate the 12-month prevalence of musculoskeletal symptoms and the associated work-related risk factors among LMOs in the Arkansas, Louisiana, and Texas (Ark-La-Tex) logging region.

Methods: A self-administered 93-item questionnaire with six different sections: (1) demographics, (2) lifestyle and medical background, (3) work experience, (4) job training, (5) occupational heat-related stress, and (6) occupational injuries and MSS was administered to LMOs (n = 88) using Qualtrics Mobile Survey Software®. Poisson regression models were used to estimate crude prevalence ratios (PR), adjusted PR [aPR], and corresponding 95% confidence intervals (95% CI).

Results: Regarding organizational, ergonomic, and handling equipment occupational factors and 12-month MSS prevalence, the adjusted model controlled for age, BMI, smoking status, and drinking status. For organizational, the most problematic factors for the lower back were performing a task over and over (63.2%) and working very fast, for short periods (60.0%). For ergonomics, the most problematic factor for the lower extremities was awkward or cramped conditions (58.1%) and for the lower back was bending/twisting back awkward (55.9%). Last, for handling equipment, the most problematic for both the lower back and lower extremities was handling or grasping small objects (57.1%).

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Disclosure statement

No potential conflict of interest was reported by the authors.

Conclusion: Our findings revealed associations between work-related MSS and specific job factors (e.g., organizational, ergonomic, handling equipment, etc.), extreme environmental conditions or environmental, and personal risk factors. In particular, study findings suggest lower back and lower extremities MSS are associated with the a majority of job-related risk factors, lower extremities with extreme environmental conditions, and neck and upper back with personal risk factors.

Keywords

Logging; musculoskeletal symptoms; injury; machine operator

Introduction

Agriculture, Forestry, and Fishing (AgFF) is one of the most hazardous industrial sectors in the United States (U.S).[1] Within this sector, the logging industry experiences the highest fatality rate of 23.2 per 100,000 full-time equivalent (FTE) workers and a non-fatal incident rate of 8.5 per 100 FTE workers.[2] The most common type of injuries or illnesses at work include musculoskeletal disorders (MSDs), which include an extensive list of "inflammatory and degenerative conditions affecting the muscles, tendons, ligaments, joints, peripheral nerves, and supporting blood vessels."[3] Overall, work-related MSDs are the second leading cause of occupational disability in the world.[4] Given the physically demanding job tasks in the logging industry, work-related MSD may also be among the most common work-related health conditions. However, determining the incidence of medically diagnosed MSDs among logging machine operators (LMOs) is challenging because it requires extensive follow-up and surveillance.[5–7]

In the logging industry, adverse work-related musculoskeletal outcomes may be the result of: 1) work-related risk factors; 2) environmental conditions; 3) personal risk factors; or 4) other undetermined occupational factors.[6,8] LMO work durations can be varied. Kim et al.[9] reported 67.2% of surveyed LMOs in Virginia operated logging machinery more than eight or more hours per day. Mitchell et al.[10] surveyed logging company owners who implemented shift work in seven Southeastern U.S. states and reported shift durations 7.5 and 12 hours per day. The working shift duration among LMOs in Chile ranges from 9 to 18 hours,[11] while operators in New Zealand average 10 hours a day.[12] Prolonged operation of logging machinery can include multiple ergonomic physical exposures including whole-body vibration, hand-arm vibration, repetitive movements, awkward and/or static postures.[13–16] Extreme environmental conditions can be sporadic and unpredictable and have been linked to heat stress, dehydration, fatigue, and MSDs among LMOs.[17] Personal risk factors such as age, body mass index (BMI), or lack of sleep may also be associated with increased risk of MSDs.[18–22]

The southern U.S. contains the highest percentage (about 40%) of the nation's timberland.[23] And, by 2050, the annual timber harvest in the U.S. is expected to increase by 24% with the majority of this increased harvest coming primarily from the southern U.S. region.[24] Compared with other logging regions which rely on manual tree felling utilizing chainsaws, production practices in the southern U.S. (which includes Arkansas, Louisiana, and Texas)

utilize mechanized tree felling, skidding, and loading using large logging machinery. However, research addressing adverse musculoskeletal outcomes among LMOs in this region is limited.[6,8] The purpose of this study was to estimate the prevalence of musculoskeletal symptoms (MSS) and associated work-related factors among LMOs in the Arkansas, Louisiana, and Texas (Ark-La-Tex) timber producing region.

Methods

Study sample and setting

Study participants were recruited in the Ark-La-Tex region between April and September of 2013. A non-random sample of 89 LMOs workers was recruited at two separate logging conferences (Arkansas and Texas) and nine separate logging sites (4 Arkansas, 4 Texas, 1 Louisiana). One participant was excluded due to missing information in key variables, resulting in a sample size of 88 LMOs. A total of 33 LMOs were recruited at logging conferences, and 55 on logging sites.

All participants were male, ranging in age from 18.0 to 60.0 years (Table 1). The proportions of participants completing a grade level were as follows: 3.4% completed less than 6^{th} grade, 21.6% completed 6^{th} grade but less than 12^{th} grade, and 45.5% completed high school. Additionally, 12.5% completed trade school and/or some college, 6.8% completed an undergraduate degree, and 10.2% completed a graduate degree (data not shown). To avoid small cell problems, for purposes of data analysis we grouped participants in $\leq 12^{th}$ grade and $>12^{th}$ grade. Nearly half of participants reported as having over 21 years of experience as logging operators.

On average, LMOs reported working 5.2 days per week (SD = 0.4); and 10.6 hours (SD = 1.9) hours per day. Operators reported on average 11.0 hours (SD = 2.0) per day in summer months and 10.2 hours (SD = 1.7) per day in winter months. Among surveyed participants, 29 (33.0%) primarily operated a loader/delimber, 19 (21.6%) skidder, 15 (17.0%) feller/cutter, and 25 (28.4%) did not specify their primary logging machinery (data not shown).

A high percentage (80.5%) of participants reported their employer provided safety training to new employees prior to beginning to work on cut sites, and 89.2% of participants acknowledge having received annual safety training. Of these, 59.5% identified their employer as the source of the training, 21.6% reported having received safety training while attending a conference or workshop, and 18.9% reported having received safety training from both their employer and attending conferences and/or workshops (data not shown).

Data collection

A 93-item questionnaire was administered to participants using Qualtrics Mobile Survey Software® on Samsung Galaxy Tab GT-P3113 hand-held devices. Both the participants recruited at conferences and the workers recruited on logging sites, filled in the questionnaire under 15 minutes while seated individually. The survey was divided into six sections: (1) demographics, (2) lifestyle and medical background, (3) work experience, (4) job training, (5) occupational heat-related stress, and (6) job factors and musculoskeletal health. Section 1 consisted of 10 demographic items (e.g., age, height, ethnicity, education,

etc.) with response categories formatted as either multiple choice or text entry. Section Two was composed of nine items addressing smoking and drinking-status, medical history, and dietary lifestyle in a dichotomous format at “yes” or “no” and text entry for quantification purposes. Section Three assessed work status including number of hours worked, rest breaks, and job position. Section Four addressed job training history, and Section Five assessed issues related to hydration and heat-stress. Section Six assessed job factors which may contribute to difficulty in performing logging job tasks (i.e., job factors). The last section included the Nordic Musculoskeletal Questionnaire (NMQ). The NMQ is a reliable and valid tool for the assessment of work-related MSS.[25,26] This section of the survey contained body diagrams to assess 12-month period prevalence of MSS for nine anatomic sites (neck, shoulder, upper back, lower back, elbow, wrist/hand, hip/thigh, knee, and feet).[26]

Statistical analysis

Statistical analysis included descriptive statistics of subject characteristics. We then estimated the associations of MSS based on anatomic locations. Based on prior research, we expected MSS prevalence to be high. As a result, rather than using common logistic regression models to obtain odds ratios, which are known to overestimate risk when prevalence is high, we used Poisson regression models as suggested by Zou[27] to estimate crude prevalence ratios (PR), adjusted PR [aPR], and corresponding 95% confidence intervals (95% CI). We started with bivariate associations between each covariate and MSS. Due to the large number of potential covariables, we conducted separate regression models within each group of demographic variables as well each domain of job factors (i.e., organizational, ergonomic, handling equipment). The variable selection strategy was guided by standard recommendations resulting in potentially richer models by retaining the important confounding variables.[28] Thus, we used a P-value <0.25 in bivariate analyses to select covariates within each domain. Next, we created a multivariate model combining all individual variables selected from the prior step. All these potentially confounding variables in this combined model with a P-value <0.10 in at least one of models including the job factors were retained in the final model for consistency. As result of our model building strategy, the final multivariate models were adjusted by age, BMI, smoking and alcohol consumption. All these variables are reasonably associated with MSS: older workers tend to report musculoskeletal complaints more frequently than younger counterparts[18]; higher BMI is related to increased musculoskeletal pain[19]; and smoking[20] and alcohol consumption[29] may have deleterious effects on the musculoskeletal system. Further, the final models were assessed for signs of multicollinearity by checking the variance inflation factors (VIF). None of the models exhibited any VIF warranting further investigation.[30] All statistical analyses were performed using Stata v.14 [StataCorp LP, College Station, TX].

Results

Table 1 presents self-reported MSS during the last 12-months by selected sample demographic characteristics. Overall, nearly 60% (55.7%) of participants reported as having MSS in any body region. A higher percentage (75.0%) of younger workers (18–29 years) reported having MSS in any body region as compared to older workers. A higher percentage of participants with a smoking history reporting having MSS as compared to those without a

smoking history. Symptoms were reported across all body regions including the neck and upper back (31.8%), lower back (30.7%), lower extremities (30.7%), and upper extremities (20.5%). Nearly 11.6% of participants reported as having had at least one work-related injury in the previous 12-month period. One participant reported having eight work-related injuries in his logging career (data not shown).

The percentage of job factors reported by participants as well as prevalence of MSS for each job factor is shown in Table 2. Overall, the least reported job factors reported were provison of training on how to do the job (11.4%) and insufficient breaks during the work day (18.2%); whereas, the most reported job factors were working in the same position for long periods (55.7%) and working in hot, cold, humid, or wet conditions (51.1%). In relation to organizational job factors, the highest MSS prevalences were in the low back when performing the same task over and over (56.5%) and by challenging work schedules (overtime, length of workday) (52.2%). Regarding ergonomic-related factors, the highest MSS prevalences were found for the lower extremities when working in awkward or cramped conditions (55.6%) and for the low back when bending and/or twisting in an awkward way (50.0%). For handling equipment job factors, the highest MSS prevalences were observed in the low back (50.0%) when carrying/lifting/moving heavy materials or equipment and lower extremities (47.4%) when having to handle or grasp small objects. In general, LMOs who reported experiencing any job factors also reported having a higher percentage MSS in any body region, as compared to those who did not report MSS in any body region. For example, a larger percentage of LMOs who reported working in the same position for long periods also reported as having MSS in any body region (69.4%), as compared to those who did not report as having MSS in any body region (38.5%). The pattern was consistent across all job factors.

Table 3 shows the crude and adjusted associations of each job-related risk factor and the prevalence of MSS during the past 12-months. In the adjusted model, participants who reported exposure to eight out of the 14 job-related work factors showed higher prevalences of MSS ($P < 0.05$) compared to their counterparts. The PR of MSS in the low back was higher for participants reporting being exposed to four of the five organization job factors including performing the same task over and over [PR = 2.3; 95%CI:1.3–3.9], working overtime [PR = 2.3; 95%CI:1.3–4.1], continuing to work when injured or hurt [PR = 2.9; 95%CI:1.6–5.3] and working very fast for short periods [PR = 2.5; 95%CI:1.4–4.3]). The PR of MSS in the low back was also higher for participants reporting being exposed to ergonomic-related job factors including working in awkward or cramped positions [PR = 3.3; 95%CI:1.8–6.1], reaching/working over head or away from body [PR = 2.4; 95%CI: 1.3–4.4], working in the same position for long periods [PR = 4.1; 95%CI:1.6–10.6] and bending/twisting in an awkward way [PR = 3.5; 95%CI:1.9–6.7]).

Discussion

This cross-sectional study estimated associations between MSS and job-factors among LMOs in the Ark-La-Tex logging region. Our study suggests that more than 55.7% of participants reported having a work-related MSS in at least one body part in the past 12-month period. In particular, the neck and upper back was reported the most problematic

among study participants. In comparison, Lynch et al. estimated the prevalence of MSDs associated with personal and occupational-related risk factors among LMOs in the Alabama, Georgia, Mississippi, and Tennessee region and found that 74.3% LMOs reported back pain, and 71.7% reported neck pain in the past 12-month period.[6] A recent cross-sectional survey of Virginia loggers revealed nearly all (98%) of loggers reported as having MSS in at least one body region in the prior 12 month period, and 93% experienced symptoms in more than one body region. The body region most commonly reported as having symptoms included the lower back (49.2%) and knee (37.7%).[9] A cross-sectional study of French and Norwegian forest machine operators revealed organizational risk factors were related to adverse musculoskeletal health outcomes in the neck, shoulder, and wrist.[31] Other studies revealed Swedish LMOs also have high rates of neck pain and MSDs.[5,7,15]

The general observation was that those who reported experiencing any job factors also reported having a higher percentage MSS in any body region, as compared to those who did not report MSS in any body region. Of note, large percentages (greater than 75%) of those reporting MSS in any body region also reported job factors of performing the same task repeatedly, continuing to work when injured or hurt, working in awkward or cramped positions, and carrying/lifting/moving heavy materials or equipment. Regarding associations between job factors and work-related MSS during the past 12-months, MSS in the low back and lower extremity regions were associated with the majority of job factors.

Work-related MSS are multi-causal since they may be the result of one or more, or their combination, of factors of occupational (e.g., ergonomic), environmental (e.g., cold temperatures) individual (e.g., age), or undetermined origin.[32] Work-related MSS could also be related to a current or prior injury or some type. For instance, in our study, nearly 11.6% of the participants reported to have had at least one work-related injury in the previous 12 months. Unfortunately, we were not able to ascertain if the reported MSS in our study were related to those reported injuries. In our study, job factors were grouped into organizational, ergonomic, handling equipment, and other categories. Work organizational factors were identified as problematic for the low back when performing the same task over and over, working schedule (overtime, length of workday), and working very fast, for short periods. In the logging industry, LMOs operate heavy machinery an average of 9 to 18 hours per day performing the same machine tasks (e.g., felling, driving a truck, etc.) in prolonged static postures.[7,10–13,33] During our discussions with study participants, LMOs reported operating a single machine type, and occasionally may operate other machinery as needed when a co-worker was absent. If LMOs primarily operate the same machinery on a daily basis, planned job-rotation or strategic rest breaks may be effective administrative control mechanisms to minimize physical exposures.[34] However, the benefits of a job-rotation strategy should be compared to the possible offsetting increased safety risk resulting from workers not being as proficient with the operation of other logging machinery. However, Helmkamp et al.[35] reported safety training among northeastern U.S. loggers may increase awareness of workplace risks while completing different logging tasks.

Our findings suggest working in awkward or cramped conditions and bending/twisting the trunk were problematic for the low back and lower extremities. Prior studies have reported that LMOs are exposed to whole-body vibrations (WBV), hand-arm vibrations (HAV),

repetitive movements, awkward postures, and prolonged static postures which may increase the risk for the development of adverse musculoskeletal outcomes.[13,33,36,37] Our study found that participants exposed to multiple job factors had a higher PR of MSS in the low back. As a result, job factors and modern machinery cab designs should also be considered when developing cost-effective interventions to protect the health and safety of LMOs. Future studies should investigate logging machinery design characteristics which may lead to enhanced operator comfort and reduced risk for the development of work-related musculoskeletal health outcomes.

Personal risk factors may also contribute to the development of MSS in different ways.[6] Even though increased risk of MSS is associated with greater age,[38] older participants in our study reported a lower MSS prevalence compared to younger participants. These counterintuitive findings may reflect LMO culture and seniority. Anecdotal observations by study personnel on multiple logging cut sites reveal younger LMOs operate mobile feller and skidder machinery which often must be navigated over bumpy terrain, as opposed to more stationary delimbing/loading machinery. These observations are partially supported by our data, which shows a higher percentage (50.0%) of younger LMOs (29 years and below) as reporting operating a skidder or feller as compared to a delimber/loader (35.0%). Mobile logging machinery such as a skidder or feller may have different degrees of physical exposures such as whole body vibration, which older or more senior LMOs may prefer not to operate. Loading/delimbing machinery may also require more experience, different skill sets or decision making as compared to mobile machinery. As a result, more senior LMOs may assign mobile machinery to younger operators. Future studies should measure these physical exposures and link them to reported symptoms based on machinery operated.

Several study limitations must be considered. First, a cross-sectional study design does not allow us to determine if the job factors, environmental conditions, or personal risk factors led to the development of MSS, or if these risk factors were a result of existing MSS. When using the cross-sectional study design causal temporality cannot be established because the exposure and the outcome were collected simultaneously; therefore, only associations between variables of interest can be determined. However, a prospective longitudinal cohort study in this sector would be challenging, expensive, and time consuming. Second, given we recruited a non-random sample, selection bias may be present in our data. Unfortunately, a census of LMOs does not exist and accessing this working population must rely on approaches like the ones used in the present study (i.e., recruiting at conferences and logging work sites). Therefore, representativity of our sample is unknown. Future studies should recruit a larger and diverse sample of LMOs to more adequately assess prevalence of work-related musculoskeletal health outcomes. Third, a small sample size restricts the generalizability of findings to the LMO population in the U.S. Lastly, LMO self-reported MSS is subject to recall bias.

Conclusion

In this cross-sectional study of LMOs in the Ark-La-Tex timber producing region, work-related MSS were reported at lower levels relative to other southern timber producing states. However, close to 60% of study participants reported work-related MSS over the prior 12-

month period. Our findings reveal associations between reported MSS and specific job factors, environmental conditions, and personal risk factors.

LMOs have a challenging occupation due to inherent work-related safety and health hazards. Our results support future interventional research to facilitate a reduction of adverse musculoskeletal outcomes in this vulnerable working population.

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Table 1.

Work-related musculoskeletal symptoms (MSS) during the last 12 months by sample characteristics.

		Musculoskeletal Symptoms (MSS)				
		Neck & Upper Back[a]	Lower Back[b]	Upper Extremities[c]	Lower Extremities[d]	Any[e]
Characteristics	**Mean (SD) or %**	**%**	**%**	**%**	**%**	**%**
Gender (%)						
Male	100.0	33.7	33.7	20.5	30.1	57.8
Age groups (%)						
18–29 years	20.5	64.7	47.1	29.4	41.2	82.4
30–49 years	47.0	25.6	33.3	23.1	30.8	51.3
+50 years	32.5	25.9	25.9	11.1	22.2	51.9
Highest education level achieved (%)						
≤ 12th grade	79.5	31.8	31.8	18.2	28.8	56.1
> 12th grade	20.5	41.2	41.2	29.4	35.3	64.7
Body Mass Index (kg/m^2)						
Normal	13.3	27.3	36.4	27.3	54.6	63.6
Overweight/Obese	86.8	34.7	33.3	19.4	26.4	56.9
Years of experience (%)						
1–10 years	30.5	44.0	40.0	24.0	24.0	64.0
11–20	19.5	31.3	37.5	31.3	50.0	62.5
21+ years	50.0	26.8	29.3	14.6	26.8	51.2
Smoking status (%)						
Currently smoking	36.6	50.0	40.0	30.0	33.3	66.7
Did smoke but not currently	13.4	36.4	45.5	54.6	27.3	72.7
Never smoked	50.0	21.9	26.8	4.9	29.3	48.8
Drinking status (%)						
No	49.4	29.3	19.5	17.1	29.3	51.2
Yes	50.6	38.1	47.6	23.8	31.0	64.3
Daily physical exercise (%)						
No	43.4	30.6	30.6	19.4	19.4	52.8
Yes	56.6	36.2	36.2	21.3	38.3	61.7

[a] Includes neck and upper back body parts;

[b] Includes lower back body part;

[c] Includes shoulders, elbows, wrist, and hand body parts;

[d] Includes hips, thighs, knees, and feet body parts;

[e] Any of the above.

Table 2.

Work-related musculoskeletal symptoms (MSS) during the last 12 months by job-related risk factor.

		Musculoskeletal Symptoms				
		Neck & Upper back[a]	Lower back[b]	Upper extremities[c]	Lower extremities[d]	Any[e]
Job-related risk factor	**% (n)**	**%**	**%**	**%**	**%**	**%**
ORGANIZATIONAL						
Performing the same task over and over						
No	77.1 (64)	28.1	25.0	15.6	23.4	50.0
Yes	22.9 (19)	52.6	63.2	36.8	52.6	84.2
Working very fast, for short periods						
No	75.9 (63)	30.2	25.4	17.5	23.8	52.4
Yes	24.1 (20)	45.0	60.0	30.0	50.0	75.0
Insufficient breaks during the work day						
No	89.2 (74)	31.1	32.4	17.6	27.0	56.8
Yes	10.8 (9)	55.6	44.4	44.4	55.6	66.7
Work scheduling (overtime, length or workday)						
No	75.9 (63)	30.2	25.4	17.5	27.0	52.4
Yes	24.1 (20)	45.0	60.0	30.0	40.0	75.0
Continuing to work when injured or hurt						
No	65.1 (54)	29.6	22.2	11.1	20.4	48.2
Yes	34.9 (29)	41.4	55.2	37.9	48.3	75.9
ERGONOMIC						
Working in awkward or cramped conditions						
No	62.7 (52)	26.9	23.1	11.5	13.5	44.2
Yes	37.4 (31)	45.2	51.6	35.5	58.1	80.6
Working in the same position for long periods						
No	43.4 (36)	22.2	13.9	8.3	19.4	41.7
Yes	56.6 (47)	42.6	48.9	29.8	38.3	70.2
Bending/twisting back in an awkward way						
No	59.0 (49)	28.6	18.4	12.2	16.3	44.9
Yes	41.0 (34)	41.2	55.9	32.4	50.0	76.5
Working at or near physical limits						
No	68.7 (57)	33.3	31.6	14.0	21.1	54.4
Yes	31.3 (26)	34.6	38.5	34.6	50.0	65.4
Reaching/working over head or away from body						
No	62.7 (52)	30.8	23.1	13.5	19.2	50.0
Yes	37.4 (31)	38.7	51.6	32.3	48.4	71.0
Hot cold, humid, wet conditions						

		Musculoskeletal Symptoms				
		Neck & Upper back[a]	Lower back[b]	Upper extremities[c]	Lower extremities[d]	Any[e]
Job-related risk factor	**% (n)**	**%**	**%**	**%**	**%**	**%**
No	57.8 (48)	29.2	27.1	16.7	18.8	52.1
Yes	42.2 (35)	40.0	42.9	25.7	45.7	65.7
HANDLING EQUIPMENT						
Having to handle or grasp small objects						
No	83.1 (69)	30.4	29.0	14.5	24.6	52.2
Yes	16.9 (14)	50.0	57.1	50.0	57.1	85.7
Carrying/lifting/moving heavy materials or equipment						
No	65.1 (54)	27.8	22.2	13.0	20.3	46.3
Yes	34.9 (29)	44.8	55.2	34.5	48.3	79.3
OTHER						
Training on how to do the job						
No	90.4 (75)	34.7	33.3	20.0	32.0	58.7
Yes	9.6 (8)	25.0	37.5	25.0	12.5	50.0
TOTAL	100.0 (83)	33.7	33.7	20.5	30.1	57.8

[a]Includes neck and upper back body parts

[b]Includes lower back body part

[c]Includes shoulders, elbows, wrist, and hand body parts

[d]Includes hips, thighs, knees, and feet body parts

[e]Any of the above

Table 3.

Associations between job-related risk factors and work-related musculoskeletal symptoms during the last 12 months.

	Musculoskeletal Symptoms				
	Neck & Upper back	Lower back	Upper extremities	Lower extremities	Any
Job-related risk factor	**PR (95%CI)**	**PR (95%CI)**	**PR (95%CI)**	**PR (95%CI)**	**PR (95%CI)**
ORGANIZATIONAL					
Performing the same task over and over					
Crude	1.9 (1.0–3.4)	2.5 (1.5–4.4)	2.4 (1.0–5.4)	2.2 (1.2–4.2)	1.7 (1.2–2.3)
Adjusted *	1.5 (0.9–2.6)	2.2 (1.3–3.7)	2.3 (1.0–5.6)	2.0 (1.0–3.8)	1.5 (1.1–2.1)
Working very fast, for short periods					
Crude	1.5 (0.8–2.8)	2.4 (1.4–4.1)	1.7 (0.7–4.1)	2.1 (1.1–3.9)	1.4 (1.0–2.0)
Adjusted *	1.6 (0.9–2.6)	3.0 (1.7–5.2)	1.4 (0.6–3.2)	2.0 (1.0–3.8)	1.5 (1.1–2.1)
Insufficient breaks/pauses during the work day					
Crude	1.8 (0.9–3.5)	1.4 (0.6–3.1)	2.5 (1.0–6.1)	2.1 (1.0–4.1)	1.2 (0.7–1.9)
Adjusted *	1.1 (0.6–2.1)	1.2 (0.6–2.7)	1.8 (0.7–4.5)	2.1 (1.1–4.2)	1.2 (0.6–1.6)
Work scheduling (overtime, length or workday)					
Crude	1.5 (0.8–2.8)	1.1 (1.4–4.1)	1.7 (0.7–4.1)	1.5 (0.8–2.9)	1.4 (1.0–2.0)
Adjusted *	1.0 (0.5–1.8)	2.2 (1.2–3.8)	1.6 (0.6–4.4)	1.4 (0.8–2.7)	1.3 (0.9–1.8)
Continuing to work when injured or hurt					
Crude	1.4 (0.8–2.5)	2.5 (1.4–4.5)	3.4 (1.4–8.3)	2.4 (1.2–4.5)	1.6 (1.1–2.2)
Adjusted *	1.4 (0.8–2.4)	2.8 (1.6–5.1)	2.6 (1.1–6.1)	2.3 (1.2–4.5)	1.6 (1.1–2 2)
ERGONOMIC					
Working in awkward or cramped conditions					
Crude	1.8 (0.9–3.5)	2.2 (1.2–4.1)	3.1 (1.3–7.5)	4.3 (2.0–9.2)	1.8 (1.3–5.6)
Adjusted *	1.6 (0.8–2.9)	2.5 (1.4–4.5)	2.0 (0.6–6.3)	5.0 (2.4–10.4)	1.8 (1.3–2.6)
Working in the same position for long periods					
Crude	1.9 (1.0–3.9)	3.5 (1.5–8.4)	3.6 (1.1–11.6)	2.0 (0.9–4.2)	1.7 (1.1–2.6)
Adjusted *	1.7 (1.0–3.1)	3.3 (1.4–7.9)	2.2 (0.7–6.9)	1.9 (0.9–4.1)	1.6 (1.1–2.5)
Bending/twisting back in an awkward way					
Crude	1.4 (0.8–2.6)	3.0 (1.6–5.9)	2.6 (1.1–6.5)	3.1 (1.5–6.3)	1.7 (1.2–2.5)
Adjusted *	1.3 (0.7–2.3)	3.6 (1.9–6.8)	1.8 (0.7–4.6)	3.3 (1.6–6.8)	1.7 (1.2–2.4)
Working at or near physical limits					
Crude	1.0 (0.5–2.0)	1.2 (0.7–2.3)	2.5 (1.1–5.7)	2.3 (1.3–4.5)	1.2 (0.8–1.7)
Adjusted *	1.1 (0.6–1.9)	1.4 (0.7–2.5)	2.4 (1.0–5.8)	2.4 (1.3–4.6)	1.3 (0.9–1.8)

	Musculoskeletal Symptoms				
	Neck & Upper back	Lower back	Upper extremities	Lower extremities	Any
Job-related risk factor	**PR (95%CI)**	**PR (95%CI)**	**PR (95%CI)**	**PR (95%CI)**	**PR (95%CI)**
Reaching/working over head or away from body					
Crude	1.3 (0.7–2.3)	2.2 (1.2–4.1)	2.4 (1.0–5.7)	2.5 (1.3–4.9)	1.4 (1.0–2.0)
Adjusted *	1.3 (0.7–2.1)	2.6 (1.4–4.8)	1.8 (0.7–4.6)	2.7 (1.4–5.4)	1.5 (1.1–2.0)
Hot cold, humid, wet conditions					
Crude	1.4 (0.8–2.5)	1.6 (0.9–2.9)	1.5 (0.7–3.6)	2.4 (1.2–4.9)	1.3 (0.9–1.8)
Adjusted *	1.5 (0.9–2.5)	1.6 (0.9–2.8)	1.5 (0.6–3.4)	2.3 (1.2–4.6)	1.3 (0.9–1.8)
HANDLING EQUIPMENT					
Having to handle/grasp small objects					
Crude	1.6 (0.9–3.1)	2.0 (1.1–3.6)	3.5 (1.6–7.5)	2.3 (1.3–4.3)	1.6 (1.2–2.2)
Adjusted *	1.1 (0.6–1.8)	1.7 (0.9–3.2)	2.1 (1.0–4.3)	2.4 (1.2–4.8)	1.4 (1.0–1.9)
Carrying/lifting/moving heavy materials or equipment					
Crude	1.6 (0.9–2.9)	2.5 (1.4–4.5)	2.7 (1.1–6.3)	2.4 (1.2–4.5)	1.7 (1.2–2.4)
Adjusted *	1.2 (0.7–2.2)	2.5 (1.3–5.1)	2.3 (1.0–5.4)	2.4 (1.3–4.6)	1.6 (1.1–2.3)
OTHER					
Training on how to do the job					
Crude	0.7 (0.2–2.5)	1.1 (0.4–2.9)	1.3 (0.3–4.5)	0.4 (0.1–2.5)	0.9 (0.4–1.8)
Adjusted *	0.7 (0.4–1.3)	1.2 (0.4–3.4)	1.7 (0.4–6.8)	0.4 (0.1–2.7)	0.9 (0.5–1.6)

* Adjusted for age group, body mass index, smoking status, and drinking status.