Risk Factors for Illness Absence Due to Musculoskeletal Disorders in a 4-Year Prospective Study of a Petroleum-Manufacturing Population

Shan P. Tsai, PhD, Faiyaz A. Bhojani, MD, DrPH, and Judy K. Wendt, MPH

Objectives: To quantify risk factors for nonoccupational absence from musculoskeletal disorders (MSD) among petroleum-manufacturing employees. **Methods:** We conducted a 4-year follow-up study including 860 employees with an MSD illness absence of 4 days or longer and 5691 employees with no MSD absence. Odds ratios were calculated using logistic regression. **Results:** Risk of MSD absence from low back and non–low back disorders was significantly associated with physically demanding job, overweight/obesity, prior absence from MSD, and absence from cardiovascular, respiratory, or mental illness, or accidents during the study period. Smoking also increased risk of low back disorders. **Conclusions:** Results suggest it is possible to reduce the impact of MSD through integrated safety prevention and health promotion programs including traditional elements of job factor evaluation, training, and ergonomics, but also health counseling and support for weight reduction, smoking cessation, and personal fitness programs.

Illness absence associated with non–work related musculoskeletal disorders (MSDs) resulting from low back and non–low back problems is an increasingly serious issue in industry. Musculoskeletal disorders are among the leading causes of disability, and account for a major loss of productivity among working populations worldwide.[1,2] Studies have shown that approximately one third of all workdays lost were attributable to MSDs.[3,4] The potential economic and social benefit of reducing the magnitude of MSD to both employees and employers is enormous, and therefore, it is important to identify risk factors responsible for MSD. More knowledge about the risk factors of illness absence will be valuable in developing strategies for reducing prevalence and severity of MSD.

Work-related MSDs (ie, MSD absence resulting from a workplace exposure, incident, or injury), particularly for low back pain, have been extensively examined.[5–8] Using self-reported questionnaires or workers' compensation claims data, many investigators have focused their attention on work-related and contributing personal factors, such as physically demanding work, job demands, psychological stressors, smoking habits, obesity, previous injury, and increased age. Studies on non–work-related MSD have rarely been reported for a working population in the United States although a growing number of recent studies outside the United States have focused on non–work-related MSD absenteeism due mainly to low back pain.[9–14] The ability to identify risk factors for illness absence due to MSD in a working population, when it has been determined that the MSD did not result from a workplace exposure or injury, could enhance worksite health intervention and education efforts and ultimately reduce MSD-related absenteeism.

This study is based on morbidity data from a prospective health surveillance system. The purpose of this study is to quantify the relationship between non–work-related illness absence from both low back and non–low back MSD and selected job characteristic and personal risk factors.

From the Shell Oil Company, Shell Health, One Shell Plaza, Houston, Tex.
Address correspondence to: Shan P. Tsai, PhD, Shell Oil Company, Shell Health, One Shell Plaza, PO Box 2463, Houston, TX 77252–2463; E-mail: shan.tsai@shell.com.

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METHODS

This was a prospective cohort study of an industrial working population. The study population consisted of 6551 full-time employees who worked at any one of Shell's US refinery and petrochemical facilities during the period January 1, 2005, through December 31, 2008. These employees were identified from the Shell Health Surveillance System (HSS), the data system used in the Company's ongoing monitoring of employee health.[15,16] The HSS comprises demographic, work history, absence, and physical examination (ie, health history, preplacement, periodic examinations) data for all US employees. Absence data includes all illness absences recorded in the company personnel and payroll system, and therefore, are virtually complete. Although the HSS contains "occupational" absences (ie, those determined to result from a work-related exposure or incident), this study included only absences coded in the payroll system as "nonoccupational."

Each employee was placed into one of the three job groups—operator, maintenance, and staff (office)—that were used as broad classifications of occupation. The term *operator* refers to employees with such job titles as operator, process technician, compounder, loader/unloader, and pump gauger. Maintenance included those who worked as craftsmen; examples are boilermakers, pipefitters, machinists, welders, carpenters, and electricians. Included in the staff category were clerks, engineers, laboratory technicians, and superintendents and managers. The job categories represent varying levels of physical exertion at work. An employee's inclusion into one of the job groups was based on his or her last job title.

Baseline biometric and health risk factor data including smoking status, body mass index (BMI), cholesterol, triglycerides, and blood pressure were derived from the HSS. Data from the most recent physical examination between 2001 and 2005 were used. Smoking history was used to determine whether an employee was a current cigarette smoker, nonsmoker, or ex-smoker. *Overweight* was defined as a BMI (weight [kg]/height^2 [m]) between 25 and 30 kg/m^2, and *obesity* was defined as a BMI of 30 kg/m^2 or greater. *High cholesterol* was defined as 240 mg/dL or greater. *Elevated triglyceride* was defined as 150 mg/dL or higher. *Hypertension* was defined as a diastolic blood pressure reading greater than or equal to 90 mm Hg or systolic reading greater than or equal to 140 mm Hg.

Employees were categorized as low back MSD, non–low back MSD, or non-MSD based on absence data extracted from the HSS. Only absences lasting 4 days or more were included because causes of illness for absences less than 4 days are not consistently reported. The medical causes of morbidity were coded according to the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), and only the primary cause was used in the analysis. The low back MSD group included employees with absence more than 4 day during the study period coded as ICD = 722 or 724, and the non–low back MSD group included those with absence more than 4 day coded as ICD-9 equal to 710 to 721, 723, and 725–739. All other employees were categorized as non-MSD. In our

population, commonly seen low back diagnoses include lumbago and intervertebral disc displacement, while common non–low back diagnoses include osteoarthritis or joint pain, and disorders or pain of the neck, knee, or other parts of the back.

Odds ratios (OR), as estimates of relative risks, were calculated to assess the association between selected risk factors and MSD absence using multivariable logistic regression. The analyses were conducted independently for both low back and non–low back MSD absence. Odds ratios for each risk factor were first adjusted for age (as a continuous variable) and gender only and then also calculated adjusting for all other potential risk factors identified at baseline, that is, cholesterol (normal, high), blood pressure (normal, high), triglycerides (normal, high), BMI (normal, overweight, obese), smoking status (current, former, nonsmoker), job category (staff, operator, maintenance), and absence due to MSD 12 months prior to follow-up (yes, no). Risk due to comorbidity (ie, absence during the study period due to cardiovascular (CVD) illness, respiratory system illness, mental illness, or accidents) was analyzed by including these diseases one at a time in the multiple logistic regression analysis. Absences were also categorized as long term (ie, more than 15 work days) or short term (ie, 4 to 15 work days) in the analyses to determine whether risk estimates differed by length of absence. If an employee had both a long-term and short-term absence during the study period, the long-term absence was used in the analysis. Odds ratios were considered statistically significant if their 95% confidence interval (CI) did not include 1.0. All statistical analyses were carried out using SAS System Software version 8.2 (SAS, Inc, Cary, NC).

RESULTS

The majority of employees at the manufacturing facilities were male, and nearly half were 50 years or older (Table 1). Among employees who had an MSD absence, approximately 80% were classified as operator or maintenance compared to only 50% of those in the non-MSD (ie, comparison) group. The low back and non–low back groups had a higher percentage of obese employees than the group without an MSD absence (43.8% vs 33.0%). A similar pattern was seen for cigarette smoking, particularly among employees with a low back MSD absence (19.4% vs 12.7%). Prevalence of other health risk factors such as hypertension, elevated cholesterol, and triglycerides was slightly higher among employees who had an MSD absence than among the non-MSD group.

In total, 860 employees took a sick leave of 4 days or longer because of MSD during the 4-year follow-up period. These employees had a total of 1243 illness-absence episodes because of an MSD, ranging from 1 to 7 absences per employee; 69% of cases had one absence, 20% had two absences, and 11% had three or more absences. Three quarters of MSD cases returned to work within 2 months. Ten percent of employees with an MSD absence also had an MSD absence of 4 days or longer in the 12 months prior to follow-up; 14% for low back and 7% for non–low back. Of all ICD major diagnostic categories, MSDs were responsible for the most absence episodes and missed workdays, with a frequency rate of 24.3%, which accounted for over a third (36.4%) of all workdays lost (Table 2).

Table 3 presents the effects of personal factors and job characteristics on illness absence because of low back and non–low back disorders, adjusted for age and gender. Male employees were more likely to have a low back disorder absence than female employees, although this difference was not statistically significant (OR = 1.36; 95% CI = 0.94 to 1.98). The risk of MSD absence generally increased with increasing age, but a dose–response relationship was observed only for non–low back absences. For employees with potentially more physically demanding jobs (ie, operator and maintenance), the risk of low back disorders was 4 to 5 times higher than for those with less physically demanding jobs (ie, staff). For non–low back MSD absence, the risk was about 3 times higher. There was no increase

TABLE 1. Baseline Risk Factors of Musculoskeletal Disorder Case Groups and Comparison Group

Variables	Low Back Disorders	Non–Low Back Disorders	Comparison Group
Gender			
Female	32 (8.4)	57 (11.9)	640 (11.3)
Male	349 (91.6)	422 (88.1)	5051 (88.7)
Age			
<40 yrs	71 (18.6)	81 (16.9)	1287 (22.6)
40–49 yrs	134 (35.2)	156 (32.6)	1857 (32.6)
≥50 yrs	176 (46.2)	242 (50.5)	2547 (44.8)
Job			
Staff	71 (18.6)	124 (25.9)	2865 (50.3)
Operator	178 (46.7)	207 (43.2)	1750 (30.8)
Maintenance	132 (34.8)	148 (30.9)	1076 (18.9)
Cholesterol (mg/dL)			
<240	226 (59.3)	288 (60.1)	3147 (55.3)
≥240	43 (11.3)	49 (10.2)	461 (8.1)
Unknown	112 (29.4)	142 (29.7)	2083 (36.6)
Triglycerides (mg/dL)			
<150	140 (36.7)	177 (37.0)	2137 (37.6)
≥150	129 (33.9)	160 (33.4)	1471 (25.8)
Unknown	112 (29.4)	142 (29.6)	2083 (36.6)
Hypertension*			
No	231 (60.6)	281 (58.7)	3218 (56.6)
Yes	73 (19.2)	96 (20.0)	1070 (18.8)
Unknown	77 (20.2)	102 (21.3)	1403 (24.6)
Body mass index, kg/m^2			
<25	21 (5.5)	30 (6.3)	673 (11.8)
25–29.9	121 (31.8)	149 (31.1)	1881 (33.1)
≥30	167 (43.8)	210 (43.8)	1878 (33.0)
Unknown	72 (18.9)	90 (18.8)	1259 (22.1)
Smoking status			
Nonsmoker	113 (29.7)	178 (37.2)	2017 (35.4)
Ex-smoker	89 (23.4)	96 (20.0)	1091 (19.2)
Smoker	74 (19.4)	68 (14.2)	723 (12.7)
Unknown	105 (27.6)	137 (28.6)	1860 (32.7)

Values are N (%).
*Defined as a diastolic blood pressure reading ≥90 mm Hg or a systolic reading ≥140 mm Hg.

TABLE 2. Proportion of Illness Absence Episodes and Workdays Lost Due to Musculoskeletal Disorders, by Gender

Variables	Female	Male	Total
Episodes			
Musculoskeletal system	24.0 (133)*	24.4 (1,110)	24.3 (1,243)
Low back disorders	7.0 (39)	10.6 (483)	10.2 (522)
Non–low back disorders	17.0 (94)	13.8 (627)	14.1 (721)
Workdays lost			
Musculoskeletal system	41.5 (7,279)†	35.8 (53,875)	36.4 (61,154)
Low back disorders	14.7 (2,577)	14.5 (21,765)	14.5 (24,342)
Non–low back disorders	26.8 (4,702)	21.3 (32,110)	21.9 (36,812)

Values are % (N).
*Number of absences.
†Number of workdays lost.

TABLE 3. Age and Gender Adjusted* Odds Ratios of Work-Related and Personal Factors on Illness Absence Due to Musculoskeletal Disorders

Risk Factors at Baseline	Low Back Disorders, OR (95% CI)	Non–Low Back Disorders, OR (95% CI)	Total, OR (95% CI)
Gender			
Female	1.0	1.0	1.0
Male	1.36 (0.94–1.98)	0.92 (0.68–1.21)	1.06 (0.84–1.35)
Age			
<40 yrs	1.0	1.0	1.0
40–49 yrs	1.30 (0.97–1.75)	1.34 (1.02–1.77)	1.32 (1.07–1.63)
≥50 yrs	1.23 (0.92–1.98)	1.53 (1.17–1.98)	1.38 (1.13–1.69)
Job			
Staff	1.0	1.0	1.0
Operator	4.17 (3.14–5.55)	2.90 (2.29–3.66)	3.36 (2.79–4.04)
Maintenance	5.12 (3.77–6.96)	3.32 (2.56–4.30)	3.97 (3.24–4.86)
Cholesterol			
Normal	1.0	1.0	1.0
Elevated	1.28 (0.91–1.80)	1.17 (0.85–1.61)	1.22 (0.96–1.55)
Triglycerides			
Normal	1.0	1.0	1.0
Elevated	1.29 (1.01–1.66)	1.33 (1.06–1.67)	1.31 (1.10–1.56)
Blood pressure			
Normal	1.0	1.0	1.0
Elevated	0.92 (0.68–1.19)	0.97 (0.77–1.21)	0.95 (0.78–1.15)
Obesity			
Normal	1.0	1.0	1.0
Overweight	2.02 (1.25–3.26)	1.87 (1.24–2.82)	1.93 (1.41–2.66)
Obese	2.77 (1.73–4.44)	2.58 (1.73–3.87)	2.66 (1.95–3.64)
Smoking status			
Nonsmoker	1.0	1.0	1.0
Ex-smoker	1.41 (1.05–1.90)	0.94 (0.72–1.23)	1.12 (0.91–1.38)
Smoker	1.80 (1.33–2.45)	1.04 (0.78–1.40)	1.34 (1.07–1.66)
Previous MSD absence			
No	1.0	1.0	1.0
Yes	3.67 (2.42–5.57)	3.12 (2.05–4.75)	3.28 (2.49–4.32)
Comorbidity†			
CVD illness			
No	1.0	1.0	1.0
Yes	1.62 (1.06–2.46)	1.82 (1.27–2.61)	1.73 (1.29–2.31)
Respiratory illness			
No	1.0	1.0	1.0
Yes	3.14 (2.38–4.14)	3.08 (2.40–3.96)	3.11 (2.55–3.79)
Mental illness			
No	1.0	1.0	1.0
Yes	2.65 (1.74–4.01)	1.80 (1.16–2.79)	2.18 (1.58–3.00)
Accidents			
No	1.0	1.0	1.0
Yes	3.58 (2.77–4.62)	3.20 (2.51–4.07)	3.37 (2.79–4.06)

CI, confidence interval; CVD, cardiovascular; MSD, musculoskeletal disorders; OR, relative risk.
*Gender adjusted only for age (continuous), age adjusted only for gender, all other variables adjusted for both gender and age (continuous).
†Defined as illness absence due to the selected causes during the 4-year study period.

in risk for elevated cholesterol or blood pressure. Nevertheless, elevated triglyceride level was a statistically significant risk factor for both low back and non–low back MSD absence. Obesity was also a major risk factor for both low back and non–low back disorders. Risk of a low back absence was higher in those who were overweight (OR = 2.02; 95% CI = 1.25 to 3.26) or obese (OR = 2.77; 95% CI = 1.73 to 4.44). The magnitude of relative risks of obesity were similar for non–low back cases, with OR = 1.87 and OR = 2.58, respectively. Both ex-smokers (OR = 1.41; 95% CI = 1.05 to 1.90) and current smokers (OR = 1.80; 95% CI = 1.33 to 2.45) had increased risk of low back disorders but smoking was not a risk factor for non–low back disorders. The risk of MSD absence was 3 times higher (OR = 3.28; 95% CI = 2.49 to 4.32) for employees who had a previous absence due to MSD than those who did not,

with a stronger risk for low back than for non–low back disorders (OR = 3.67 vs OR = 3.12).

Having an absence for CVD during the study period was significantly associated with absence from low back (OR = 1.62; 95% CI = 1.06 to 2.46) and non–low back disorders (OR = 1.82; 95% CI = 1.27 to 2.61). The impact of comorbid respiratory disease on these two types of disorders was greater than that of CVD, with OR = 3.14 and OR = 3.08, respectively. Mental illness was also significantly associated with absence from both low back (OR = 2.65; 95% CI = 1.74 to 4.01) and non–low back (OR = 1.80; 95% CI = 1.16 to 2.79) disorders. Furthermore, the risk of low back and non–low back MSD absence was increased 3-fold among employees who also had absences due to accidents (OR = 3.58 for low back and OR = 3.20 for non–low back) during the 4-year study period.

The pattern of increased risk of illness absence due to low back and non–low back disorders remained after incorporating all potential risk factors in a multivariable logistic regression analysis (Table 4). Job group, body mass index, and previous MSD absence were all significant predictors of both low back and non–low back absences, and smoking status was significantly associated with low

TABLE 4. Odds Ratios* of Work-Related and Personal Factors on Illness Absence Due to Musculoskeletal Disorders

Risk Factors at Baseline	Low-Back Disorders, OR (95% CI)	Non–Low Back Disorders, OR (95% CI)	Total, OR (95% CI)
Gender			
Female	1.0	1.0	1.0
Male	0.74 (0.44–1.23)	0.49 (0.34–0.71)	0.55 (0.40–0.76)
Age (continuous)	0.99 (0.98–1.01)	1.01 (1.00–1.02)	1.00 (0.99–1.01)
Job			
Staff	1.0	1.0	1.0
Operator	3.68 (2.60–5.20)	3.26 (2.46–4.32)	3.30 (2.62–4.17)
Maintenance	4.60 (3.20–6.60)	4.05 (3.01–5.45)	4.08 (3.19–5.22)
Cholesterol			
Normal	1.0	1.0	1.0
Elevated	1.17 (0.82–1.67)	1.13 (0.83–1.54)	1.13 (0.87–1.46)
Triglycerides			
Normal	1.0	1.0	1.0
Elevated	1.11 (0.85–1.46)	1.12 (0.89–1.41)	1.14 (0.94–1.38)
Blood pressure			
Normal	1.0	1.0	1.0
Elevated	0.84 (0.62–1.13)	0.79 (0.61–1.02)	0.82 (0.66–1.01)
Obesity			
Normal	1.0	1.0	1.0
Overweight	1.75 (1.06–2.90)	1.66 (1.09–2.53)	1.90 (1.33–2.70)
Obese	2.15 (1.30–3.56)	2.22 (1.46–3.37)	2.31 (1.62–3.29)
Smoking status			
Nonsmoker	1.0	1.0	1.0
Ex-smoker	1.43 (1.05–1.94)	1.04 (0.80–1.34)	1.11 (0.89–1.37)
Smoker	1.62 (1.17–2.24)	1.06 (0.79–1.40)	1.21 (0.95–1.52)
Previous MSD absence			
No	1.0	1.0	1.0
Yes	3.47 (2.08–5.76)	2.14 (1.21–3.82)	2.63 (1.83–3.76)
Comorbidity†			
CVD illness			
No	1.0	1.0	1.0
Yes	1.20 (0.69–2.09)	1.69 (1.11–2.58)	1.47 (1.01–2.12)
Respiratory illness			
No	1.0	1.0	1.0
Yes	3.07 (2.22–4.26)	2.73 (2.01–3.71)	2.89 (2.27–3.68)
Mental illness			
No	1.0	1.0	1.0
Yes	2.49 (1.51–4.11)	1.96 (1.22–3.16)	2.18 (1.48–3.20)
Accidents			
No	1.0	1.0	1.0
Yes	3.80 (2.79–5.18)	3.70 (2.83–4.85)	3.64 (2.89–4.58)

CI, confidence interval; CVD, cardiovascular; MSD, musculoskeletal disorders; OR, relative risk.
*Adjusted for all variables listed in the table.
†Defined as illness absence due to the selected causes during the 4-year study period.

back disorders. The risk of absence due to non–low back disorders was increased among employees with comorbid CVD (OR = 1.69; 95% CI = 1.11 to 2.58). The risk of absence from both types of MSD was significantly higher among employees who were absent during the study period due to respiratory or mental illness, or accidents.

Figure 1 shows the effect of selected factors on risk of low back and non–low back disorders by length of absence. In this population, 43% of absences were long-term and 57% were short-term. Because the relationship between MSD absence and risk factors remained largely the same after adjusting for all potential confounders in the regression model, ORs presented in Fig. 1 were adjusted only for age and gender. The risk of absence from low back and non–low back disorders increased substantially with increasing age for long-term but not short-term absences. Job group was significantly associated with both short-term and long-term absences, with a similar magnitude of increased risk. The same pattern of increased risk was noted for obesity. The impact of smoking on low back MSD absence was stronger for long-term than short-term absences (OR = 2.56 vs OR = 1.62). The effect of comorbidity was generally stronger on short-term absences, although the presence of respiratory illness had a similar effect on low back injuries regardless of duration.

DISCUSSION

This prospective study is one of the few that have examined the association between personal factors and job characteristics, and nonoccupational illness absence from both low back and non–low back disorders. There were no major differences in risk factors between the two MSD groups, and the risk factors we identified were generally similar to those that have been associated with occupationally related low back MSD.[5,6,8,17,18] We found that physically demanding work, obesity, cigarette smoking, previous absence due to low back disorder, and the presence of comorbidities were significant risk factors for low back disorder. With the exception of cigarette smoking, these risk factors were also associated with non–low back disorder. Physically demanding work has been repeatedly associated with increased risk of low back[19–22] and non–low back disorders,[12,20] possibly due to a longer recovery period required before employees become capable of performing the more strenuous demands of their jobs. It is not unexpected that the physical demands of the work environment, particularly jobs that require lifting, carrying, pulling and pushing, twisting, bending, or other nonneutral trunk postures are positively associated with occupational low back disorder.[5,21] Other factors such as job stress and vibration may also contribute to the occurrence of low back disorder.[10,21]

This study included only non–work-related MSD absences, although it is possible that job characteristics such as routine excessive stresses may contribute to these as well. It is difficult to delineate the origin of work-related or non–work-related MSD because persons who sustained an occupational injury are more likely to have had a previous nonoccupational injury than those who did not sustain an occupational injury.[23] Cumulative trauma occurs over a long period, and the final triggering event is not necessarily the primary underlying cause.

Of the baseline personal risk factors, obesity contributed the most to the risk of absence from both low back and non–low back MSD. Our results are consistent with findings of many cross-sectional and longitudinal population-based and industry studies.[10,20,24,25] Obesity increases the work of the spine required to hold the upper body erect and causes mechanical disadvantages and abnormal loads on the lumbar spine; it also makes it more difficult to maintain and regain body posture during and after physical exertion. On the contrary, it is also possible that aches and pains may lead to reduced physical activity and thus lower energy consumption with a concomitant increase in body weight.

The finding that smokers have significantly increased low back MSD is not unexpected.[10,26–28] It has been suggested that smoking and coughing or coughing alone can lead to increased intradiscal pressure, which may increase the risk of low back pain.[27,28] In our study, the risk of low back disorder was significantly higher among those with comorbid respiratory illness. Nicotine in cigarette smoking facilitates degeneration of the intervertebral discs by disturbing disc metabolism.[29] Furthermore, it is also possible that smokers have additional adverse lifestyle factors that lead to a greater incidence of low back disorder.[30] Cigarette smoking is not a risk factor for non–low back disorder in the present study, although an earlier cross-sectional study found a positive association.[20]

The presence of chronic illnesses such as CVD or respiratory disease was significantly associated with absence from MSD. Absence due to mental illness increased the risk of both low back and non–low back disorders, even after adjusting for all other potential risk factors. This observation has previously been reported.[21,31] In addition to these diseases, persons who had accidents were at nearly 4 times higher risk of MSD absence than those who did not. Prior illness absence from MSD was an important personal prognostic factor, which reflects the propensity of recurrence of this disorder, particularly for low back.[13] Further research is needed to identify factors responsible for increased risk of recurrence.

Accompanying health risk factors such as hypertension and elevated total cholesterol level were not found to be correlated with MSD absence. A significant association of absence from MSD was observed for subjects with elevated triglycerides; however, the significance diminished after adjustment for other risk factors.

Short-term and long-term illness absence due to MSD could have different causes. Long-term absences are more likely to reflect chronic and more serious musculoskeletal conditions. In the present study, job group and obesity were two common determinants for both short- and long-term absence. Older employees had significantly increased risk of long-term but not short-term absence, as found by others.[32] The effect of smoking was stronger for long-term absences as well. Nevertheless, the impact of comorbidity on absence from MSD was weaker for long-term than for short-term absences. One possible explanation is that long-term absences are likely to be more homogeneous and are less influenced by other illnesses.[33]

In this study, we chose to include all employees from baseline with or without MSD, instead of restricting the study to a follow-up of employees free from MSD, which has been the method used in other studies. We did that deliberately. When it comes to MSD incidence, it seems difficult to us to define an MSD-free population.[34] There was a small proportion of study cases (10%), who had absences due to MSD in the 12-months prior to the study. When we exclude these cases from the analysis, the conclusions remain the same (data not shown).

A major strength of our study was its prospective design. This study assessed baseline risk factors measured between 2001 and 2005, and then it evaluated their potential impact on absenteeism from MSD between 2005 and 2008. Although causality is difficult to assess, the analytical design of this study is more appropriate for an investigation of cause and effect as opposed to a cross-sectional design, which is used primarily to generate hypotheses or describe associations. Nevertheless, it is possible that risk factors, which were measured before the beginning of follow-up could have changed during the follow-up period.

Virtually all study subjects (99.8%) were in the same job group (ie, maintenance, operator, or staff) at the beginning and end of follow-up. Although we do not have data on smoking or BMI for every subject at the end of follow-up, only 14% had a different smoking status and 17% were in a different BMI category. Therefore, we have no reason to believe that these changes would alter the conclusion of this study. The information about illness absence included in this study was complete and reliable. All absence data included in the HSS were extracted from the personnel and payroll system. In addition, absences lasting 4 days or longer are managed

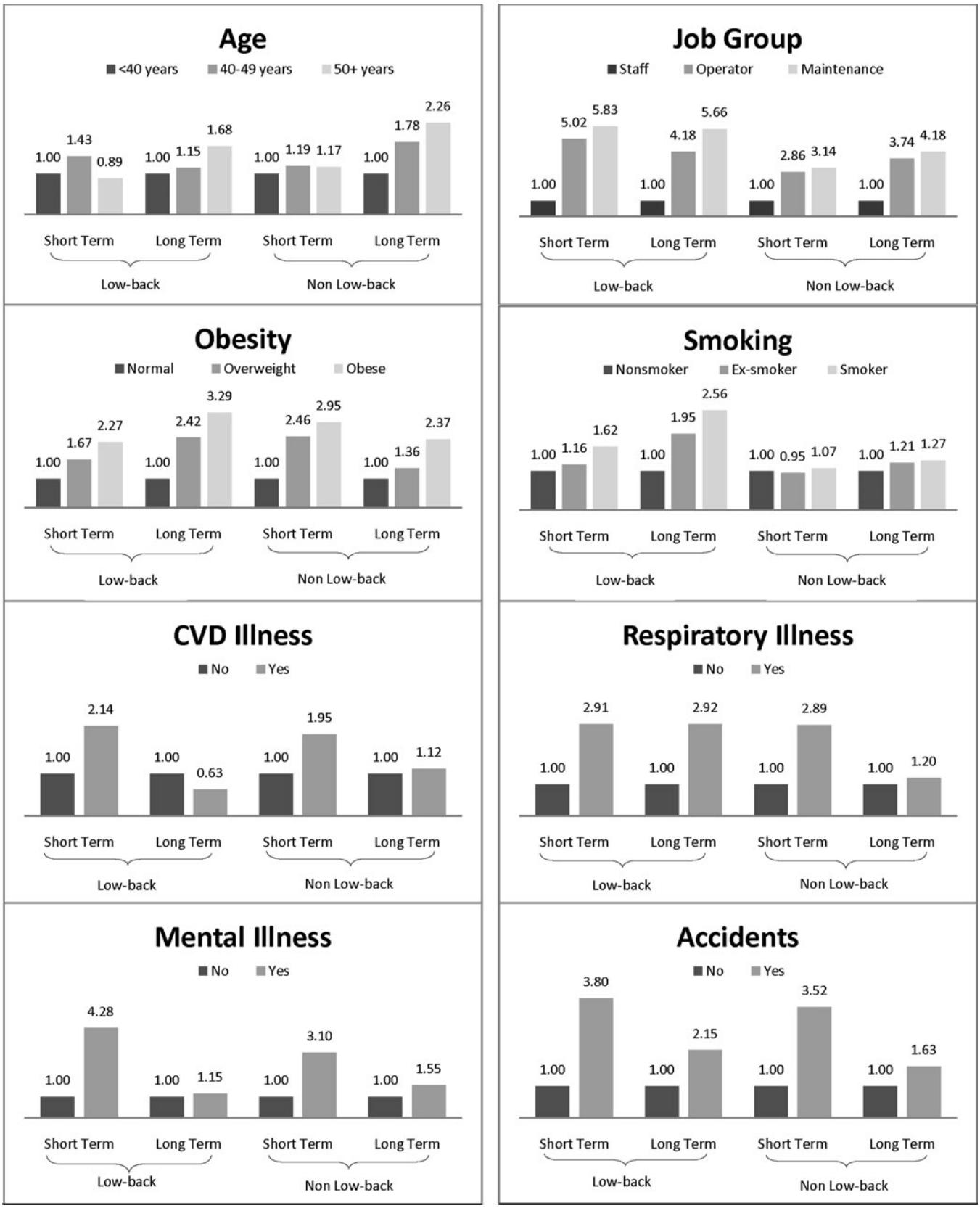

FIGURE 1. Odds ratios of short and long absences due to musculoskeletal disorder, adjusted for age and gender.

by the company's disability management program[35] and medical diagnosis was based on doctors' statement, both of which minimize the potential for reporting bias and diagnostic error.

Several limitations should be noted in interpreting the results. Job group was used as a surrogate for the physical demands a person may experience at work. Employees who already have had low back pain may have changed jobs, which would tend to reduce the association between physical jobs and low back disorders. A second limitation is the lack of data on employees' physical fitness, which may confound the effect. Although all operations employees must pass "fitness to work" evaluations, it is possible that workers who were more physically fit remained off work for a shorter time (ie, fewer than 4 days) than those less fit. Finally, because diagnosis is not available for absence of less than 4 days, the impact of these risk factors on illness absence lasting less than 4 days cannot be evaluated.

Results of this study suggest that it is possible to reduce the impact of illness absence due to MSD through implementation of integrated safety prevention and health promotion programs at work. Such programs would include not only the traditional elements of job factor evaluation and modification, employee education and training, and a greater focus on ergonomics but also health counseling and support for employee wellness programs, such as weight reduction, smoking cessation, stress management, and personal fitness. These health promotion programs could impact not only non–work related and work-related MSD but also the prevention of metabolic syndrome and CVD disease.

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