BMJ Open

Work-Related Musculoskeletal Disorders, Fatigue and Stress Among Gas Station Workers

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-081853
Article Type:	Original research
Date Submitted by the Author:	08-Nov-2023
Complete List of Authors:	Fan, Jialin; Shenzhen University; Shenzhen Humanities & Social Sciences Key Research Bases of the Center for Mental Health Tan, Xiaotong; Shenzhen University, School of Psychology Smith, Andrew; Cardiff University, School of Psychology Wang, Jing; Shenzhen University
Keywords:	Occupational Stress, Fatigue, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Work-Related Musculoskeletal Disorders, Fatigue and Stress Among Gas Station Workers

Jialin Fan[a,b*], Xiaotong Tan[a], Andrew P. Smith[c], and Jing Wang[a]

[a]*School of Psychology, Shenzhen University, Shenzhen, China*

[b]*The Shenzhen Humanities & Social Sciences Key Research Bases of the Center for Mental Health, Shenzhen, China*

[c]*Centre of Occupational and Health Psychology, School of Psychology, Cardiff University, 63 Park Place, Cardiff, CF10 3AS, UK.*

[*] FanJL@szu.edu.cn

Work-Related Musculoskeletal Disorders, Fatigue and Stress Among Gas Station Workers

Abstract

Introduction: Work-related musculoskeletal disorders (WMSDs) are disorders of the musculoskeletal system that have the highest prevalence among workers worldwide. Workers in gas stations usually work in poor ergonomic working conditions, including prolonged standing and repetitive posturing.

Objective: the study aimed to investigate the prevalence of WMSDs and fatigue and to identify the predictors of WMSDs among gas station workers.

Design: The present study was a cross-sectional study.

Setting and participants: 2,962 gas station workers from an oil and gas company in China.

Results: The prevalence of WMSDs within the 12 months prior to the study was 73.23%, with the highest prevalence in the neck, shoulders, ankles and feet. Furthermore, a correlation was observed between fatigue, stress, and WMSDs. Fatigue and job role were the strongest predictors of WMSDs, with an odds-ratio range of 2.211–3.413.

Conclusions: This research identified the detrimental impact of WMSDs and fatigue on gas station workers, indicating the critical need for interventions to reduce WMSDs and relieve fatigue.

Strengths and limitations of this study

- This study investigated the present condition of WMSDs and occupational risk among gas station workers.
- The Nordic Musculoskeletal Questionnaire and Smith Well-being Questionnaire were used to assess WMSDs, fatigue, stress and other work-related risk factors.
- Logistic regression was conducted to determine the predictors of the WMSDs.
- This was a cross-sectional study, unable to determine the mechanism and aetiology

of WMSDs.

Introduction

Gas station workers are key figures in the oil industry chain, subject to heavy workloads and safety-critical tasks, and related occupational stress, fatigue, health problems and environmental hazards. A recent review emphasised the importance of occupational health concerns for gas station workers, concluding that shift work and the specific work environment of gas station workers can adversely affect their sleep, stress levels, physical and mental health, and turnover intention.[1] The work design of this job role is varied in different countries and regions; for example, in developed countries such as the United States, self-service refuelling is common, and gas stations often employ managers, cashiers and similar staff, while in developing countries such as China, they still rely on manual refuelling operations, which increases the number of gas station workers needed. Regardless of the operational mode, very little empirical research has focused on the occupational health concerns of gas station workers in comparison to the range of risk factors to which they are exposed.

Gas station workers face inevitable occupational stress, and their extensive workloads require an elevated level of alertness and motivation to fulfil their duties. The duties of gas station workers encompass refuelling, sales, and communication with customers and colleagues, alongside additional security responsibilities.[2] As a service industry, they also require emotional intelligence to provide exceptional service quality continually. When job demands exceed workers' abilities and coping skills, they become a risk factor, generating stress and various health problems.[3] Occupational stress is a severe occupational hazard that generates problematic alcohol use,[4] depression[5] and impairment of physical health, psychological well-being and performance.[6] It can also lead to sick leave, adversely affecting productivity and placing a financial burden on employers and society.[7]

Work-related musculoskeletal disorders (WMSDs) are one of the health problems that gas station workers have frequently reported, as their work tasks include repetitive, awkward body movements. WMSDs are common painful disorders affecting the body structure that are caused by a variety of factors, such as repetitive motion, excessive force, awkward and/or sustained postures and prolonged sitting and standing.[8] WMSDs can also result in physical and mental illness, chronic pain and disability.[9] WMSDs are widespread around the world and are the second most common cause of disability in the workplace.[10] They indirectly decrease industrial efficiency, which results in significant economic burdens.[11] The prevalence of WMSDs and their related negative effects on workers' productivity, particularly in developing countries, should be treated seriously to decrease the impact on production and promote workers' well-being.[12] Many previous studies on the health and well-being of gas station workers focus primarily on the negative effects of organic solvents such as benzene on physiological health and the nervous system. However, gas station workers usually experience poor ergonomic working conditions for long periods, which can contribute to an increase in WMSDs.

Psychosocial stressors, such as high workload or low time control, may contribute to an increased risk of musculoskeletal disorders by increasing biomechanical load or physical stress. Occupational stress is associated with physical symptoms and is prevalent over time.[13] A review explored the impact of stressors on the onset of musculoskeletal disorders related to the neck/shoulder, upper limbs and waist, revealing that psychosocial factors were independent predictors of musculoskeletal disorders.[14] It indicates that work-related stress may have an impact on the incidence of MSDs. Despite the existence of work stress issues and physical health problems among gas station workers, there remains a dearth of clear evidence regarding the impact of work stress on WMSDs.

Occupational fatigue is described as a state of 'extreme tiredness and reduced functional capacity experienced during or at the end of the workday',[15] and it is a common

occupational health problem in many industries and occupations across the world. Fatigue has a myriad of negative consequences; for example, fatigue is linked to various health problems, including sleep disorders, depression, obesity,[16] and musculoskeletal disorders, and it impacts work efficiency, job satisfaction and turnover intention.[17 18] Gas station workers often experience high job demands, heavy workloads and shift work. Workers experience fatigue more quickly as a result of this condition. Thus, as a key component of safety, the fatigue of gas station workers should be given more consideration.

WMSDs and fatigue are both major occupational health issues. Musculoskeletal disorders have been associated with fatigue in nurses and office workers.[19 20] A longitudinal study found that burnout could be a risk factor for the development of musculoskeletal pain in apparently healthy individuals.[21] Although the relationship between WMSDs and fatigue has been studied in several occupations, there is currently a dearth of research related to gas station workers. Gas station employees are exposed to a multitude of risk factors for WMSDs in the workplace, including prolonged standing and repetitive motions when filling vehicles. Other factors that contribute to physical and mental fatigue include heavy workloads, maintaining a positive attitude when interacting with customers, remaining vigilant to operations that are prone to causing safety mishaps and working in shifts. Personal characteristics and work-related factors such as workload should also be considered. It is apparent that there is insufficient research on WMSDs and fatigue specific to gas station workers, and relevant risk factors should be further identified.

While WMSDs, occupational stress and fatigue are common issues that negatively affect the health and safety of gas station workers, few studies have been conducted in this field, particularly concerning physical and mental health. The current study aimed to examine the prevalence of WMSDs, determine the association between WMSDs, stress and fatigue, and investigate the predictors of WMSDs among gas station workers. It contributes to developing a better understanding of the occupational risk factors that

can result in WMSDs, which is of great significance for better monitoring and preventing WMSDs, stress and fatigue and enhancing the physical and mental health of gas station workers.

Material and methods

Participants and Procedure

Participants were staff from an oil company in China (N = 2,962). The job positions reported were gas operator (34.98%), cashier (14.45%), front-court manager (24%), gas station manager (8.85%), convenience store supervisor (6.14%), finance department staff (3.81%), management and executive staff (2.3%) and other positions (5.47%). It should be noted that the front-court manager has a unique position in Chinese gas stations. The duties of this position include but are not limited to 'being responsible for organising the staff to carry out various operations, management and service work during the shift', 'being responsible for the normal operation of the gas station during the shift', which can also be described as 'on-site duty manager'.

We conducted an online survey among gas station employees from an oil and gas company in China, with the approval and cooperation of the company. Participants were asked to complete an informed consent form, and they were free to withdraw from the survey at any point. The School of Medicine Ethical Committee at Shenzhen University reviewed and approved this study.

Measurement of Musculoskeletal Disorders

WMSDs were assessed using the Chinese version of the Nordic Musculoskeletal Questionnaire (NMQ), a self-reported questionnaire that assesses the prevalence of musculoskeletal disorders in nine areas of the body: the neck, shoulders, elbows, wrists and hands, hips, knees, lower back, upper back and ankles and feet.[22] Participants were asked to note the occurrence of these symptoms over the past week (weekly prevalence)

and over the past year (annual prevalence). The NMQ was translated for use with Chinese samples and proved to be reliable and valid.[23] The questionnaire is suitable for application in a variety of workplaces, and data can be collected quickly and easily with one study.

Considering that musculoskeletal disorders in gas station workers are a long-standing problem, in this study, the incidence of musculoskeletal disorders in the past year was used as the evaluation index. WMSDs are defined by reports of discomfort, numbness, pain and restricted movement in one or more body regions in the past year.

Measurement of Occupational Stress and Fatigue

Occupational stress and fatigue were evaluated using the Smith Well-being Questionnaire (SWELL).[24] The SWELL, which is based on the Demands-Resources-Individual-Effects (DRIVE) model, was used to assess occupational fatigue, stress at work, workload, lifestyle, personality, job satisfaction and so on.[25] This questionnaire has been used to assess a variety of occupational groups in previous studies, allowing the identification of the overall occupational risks. This questionnaire was translated into Chinese using both forward and back translation.[26]

The SWELL consists of 26 single-item questions, and most of the questions are on a 10-point Likert scale. In the current study, the main variables of interest were stress, fatigue, work characteristics (i.e., workload, job support and control, noise exposure and fume exposure) and personal characteristics (i.e., personality and lifestyle).

Analyses

Data analysis was conducted using SPSS 25. Descriptive analyses examined the frequencies of demographic variables, WMSD symptoms (NMQ), stress, fatigue, personal characteristics and work characteristics. Pearson correlation was used to examine the associations between stress, fatigue, WMSDs and other variables. Variable

scores were categorised into a high/low group using a median split. Logistic regression was then conducted to determine the predictors of the WMSDs.

Results

Descriptive Statistics

Participants' descriptive characteristics and WMSD symptoms are shown in Table 1. A total of 2,962 participants completed the online survey. The average age of the participants was 36.67 ± 7.55 years; 55.47% of participants were female. According to the work content and actual workplace, participants' job roles were divided into frontline staff (N = 2,619; 88.42%) and non-frontline staff (N = 343, 11.58%). Frontline staff work at gas stations on daily duty, including gas operators, cashiers, front-court managers, convenience store supervisors and gas station managers. Non-frontline staff include finance department staff, management and executive staff, and other positions that work in offices where they are not exposed to gasoline daily and are not required to remain in a standing position for long periods.

Participants had a mean stress score of 6.30±2.55 and a mean fatigue score of 6.00 ± 2.49. The results also showed that people with WMSD symptoms had unhealthier lifestyles ($t = 14.03$, $p < 0.001$), more negative personalities ($t = 11.05$, $p < 0.001$), higher levels of fatigue ($t = -20.262$, $p < 0.001$) and stress ($t = -16.92$, $p < 0.001$) than those without WMSDs symptoms.

Additionally, a single item from the SWELL on musculoskeletal problems (Do you suffer from musculoskeletal disorders [e.g. arthritis; back pain; sciatica; repetitive strain injury]?) was used to gauge the effectiveness of the NMQ. Participants who reported WMSDs on the NMQ scored 6.11 ± 2.96 on this question, which was significantly higher than healthy participants ($t = 29.24$, $p < 0.001$).

INSERT TABLE 1 HERE

Table 1. Descriptive Characteristics and MSD Symptoms of Participants

Prevalence of WMSDs

As shown in Table 2 and Figure 1, the prevalence of WMSDs among the respondents was unevenly distributed among most body regions and centred around three of them, namely the neck (42.27%), shoulders (35.89%) and ankles and feet (34.71%). The 12-month prevalence was 73.23%, and significant differences were found for age group ($\chi^2 = 17.95$, $p < 0.001$) and job role ($\chi^2 = 50.82$, $p < 0.001$) but not gender ($\chi^2 = 3.59$, $p = 0.058$).

INSERT TABLE 2 HERE

Table 2. WMSDs in gas station workers

INSERT FIGURE 1 HERE

Figure 1. Regions of WMSDs in the previous 12-month period prevalence

Associations among Stress, Fatigue and WMSDs

Pearson correlation was used to investigate the association among stress, fatigue, WMSDs (from the SWELL) and work and personal characteristics (Table 3). Stress showed significant positive correlations with fatigue ($r = 0.61$, $p < 0.001$) and WMSDs ($r = 0.40$, $p < 0.001$). Both stress, fatigue and WMSDs were significantly correlated

with personal characteristics (lifestyle and personality, $p < 0.001$) and other work characteristics (job control and support, noise, fumes, $p < 0.001$).

INSERT TABLE 3 HERE

Table 3. Correlation among stress, fatigue, WMSDs, work and personal characteristics

Predictors of WMSDs

Logistic regressions were run to investigate the predictors of WMSDs. The dependent variable was WMSDs, measured with or without WMSD symptoms over the past year. The independent variables included in the model were demographic variables (age, gender and job role), personal characteristics (personality and lifestyle), work characteristics (workload, job control and support, noise exposure and fume exposure), stress and fatigue, in which age was continuous, and other variables were categorical. Table 4 shows the Odds ratio for each of the independent variables.

In the final model, the results showed that job role was the strongest predictor of reported WMSD symptoms, with an odds ratio of 3.413 ($p < 0.001$), which indicated that the frontline staff were more than three times more likely to report WMSD symptoms than non-frontline staff. Fatigue was the second strongest predictor of reported WMSD symptoms, with an odds ratio of 2.211 ($p < 0.001$), which indicated that participants who reported high fatigue were over two times more likely to report WMSD symptoms than those reporting low fatigue after controlling demography and individual difference factors in the model.

The logistic regression model also found that stress (OR = 1.327, $p < 0.05$), gender (female; OR = 0.610, $p < 0.001$), negative personality (OR = 1.322, $p < 0.05$), unhealthy lifestyle (OR = 2.032, $p < 0.001$), heavy workload (OR = 1.345, $p < 0.05$), lack of job control (OR = 1.636, $p < 0.001$), noise exposure (OR = 1.585, $p < 0.001$) and fume exposure (OR = 1.327, $p < 0.05$) significantly contributed to WMSDs.

INSERT TABLE 4 HERE

Table 4. Odds ratio of IVs on WMSDs

Discussion

This is a cross-sectional study using an online questionnaire to investigate the prevalence of and relationship between WMSDs, stress and fatigue, and the predictors of WMSDs among gas station workers. Participants reported medium-to-high levels of fatigue and stress, and the 12-month prevalence of WMSDs was 73.23%. The neck, shoulders, ankles and feet were the most common body regions affected by musculoskeletal disorders. The present study also showed a significant positive correlation between fatigue, stress and WMSDs, and with higher fatigue and stress, participants were more likely to have WMSDs. In addition, job roles and personal and work characteristics were predictors of WMSDs.

In terms of occupational fatigue and stress, the findings suggest that there was indeed a certain occupational health problem among gas station employees. Firstly, fatigue was clearly associated with multiple risk factors, including individual characteristics, work characteristics and environment. Given the nature of the gas station industry, workers

usually work long hours each day, and most of this is shift work, both of which have been closely related to fatigue.[27] A growing body of literature has demonstrated that fatigue is common among gas station workers, as well as workers from the oil and gas industry, such as offshore drilling, the job characteristics of which are similar.[28-30] Meanwhile, the current study provides evidence of a significant positive association between job stress and occupational fatigue among gas station workers. These findings align with previous research conducted on various occupational groups, including nurses,[31] call centre employees,[32] and drivers,[33] thus confirming a consistent relationship between stress and fatigue. Nonetheless, this study represents the first investigation specifically focusing on the stress and fatigue experiences of gas station workers, highlighting the unique challenges faced by this particular occupational group. In addition to their primary responsibilities of providing refuelling services, frontline gas station workers often have additional responsibilities such as safety duties, sales, and prioritising customer satisfaction. Such multifaceted job demands may contribute to heightened job stress levels and subsequent fatigue among these workers. Our findings underscore the need for interventions to reduce stress and fatigue risk factors.

The majority of gas station workers reported having WMSDs in at least one anatomical region during the 12 months prior to the study, which is in line with previous research conducted both inside and outside of China.[34 35] The clustering pattern of WMSDs observed in this study, notably in the neck (42.27%), shoulders (35.89%) and ankles and feet (34.71%), is somewhat different from findings in previous studies among gas station workers. Among Nigerian gas station workers, the reported prevalence pattern of body regions was highest in the lower back (54%) and shoulders (52%),[36] whereas in Ghana, it was highest in the lower back (43%).[34] This is due in part to the larger proportion of frontline employees in our study, who engage primarily in manual labour. Although there are variations in the specific sites affected among gas station workers in different countries, the overall prevalence of moderate to high rates of work-related musculoskeletal disorders (WMSDs) ranged from 51.2% to 86%.[34-36] This

demonstrates that WMSDs are a common issue within the gas station occupation. A cross-cultural comparison research of workers in similar occupational groups revealed disparities in the prevalence of self-reported MSD discomfort between Malaysia and Australia.[37] However, there were no significant differences in the frequency and severity of symptoms across five body regions among those reporting MSD discomfort, and they shared similar predictors. Therefore, future research seeking to generalize these findings to comparable job positions in other countries should carefully consider sociocultural backgrounds as influencing factors.

WMSDs are a multi-factorial disorder linked to various demographic and work-related features. There is limited literature concerned with WMSDs in this particular field. Therefore, a comprehensive analysis based on the establishment of a logistic regression model was run to reveal the presence of multiple influencing factors for WMSDs among gas station workers, including personal and work characteristics. It's worth noting that fatigue and job role were found to be major risk factors for WMSDs. There is a clear relationship between WMSDs and occupational fatigue. This finding is consistent with previous research that has identified fatigue as a risk factor for WMSDs.[38] Fatigued workers usually perform poorly at work and may eventually face serious health problems. Ergonomically, the risk factors for gas station workers come from repetitive actions (such as filling vehicles) and long periods of standing (as with cashiers). According to previous studies, maintaining an awkward and static posture for extended periods at work can cause discomfort, pain and chronic fatigue.[17] This is supported by results from job roles, where frontline workers are more likely to have musculoskeletal problems than non-frontline workers. Frontline workers are more likely to be exposed to risk factors at work, such as repetitive motions, poor posture and physical strain. Adverse symptoms accumulate over time and can cause serious consequences for physical and mental health.

It is worthwhile to note that there was no significant difference in age between those with and without WMSDs. Similarly, in logistic regression, age was not a significant

predictor of WMSDs. However, a recent study found that there was a relationship between age and musculoskeletal disorders complaints.[39] In general, increased age causes workers' physical conditions to deteriorate, and as muscle strength and endurance decline, the risk of WMSDs increases.[40] The different results suggest that some variables might modify the relationship between age and WMSDs, such as body mass index (BMI), smoking habits and physical activity, which are individual characteristic variables associated with WMSDs, should be examined in future studies.

According to the logistic regression model, negative personality and unhealthy lifestyle were considered risk factors for WMSDs. These findings are similar to the results of other studies.[41 42] Therefore, at the individual level, adopting a healthy lifestyle may be able to mitigate the incidence of WMSDs. Personality type and WMSDs appear to be correlated, and it is suggested that organisations may consider personality type factors in employee selection and training.

The results from this study provide insight into understanding the relationship between fatigue, stress and WMSDs among gas station workers. These findings have practical implications for identifying and addressing WMSDs, particularly among frontline workers who experience severe fatigue and stress. The consequences of WMSDs are considerable for employees and employers alike. Therefore, several measures can be taken to prevent the risk of WMSDs. For example, gas station workers should be aware of risk factors and make positive changes, such as stretching between breaks. Employers should consider implementing fatigue management strategies and providing ergonomic workstations to ensure the well-being and safety of their workers.

There are a few limitations of this study. First, the study sample was exclusively from China; therefore, future studies should determine and verify our results in other regions, including workers from both developed and developing nations and state-owned and private businesses. Second, this study investigated the prevalence of WMSDs without clarification of the mechanism and aetiology of WMSDs in participants. Third, due to

the limitations of the working environment and the convenience of sampling, this was a cross-sectional study that used subjective measurement methods. Future studies should apply objective technologies, such as real-time physiological monitoring and actigraphy, which lead to more accurate and objective conclusions. A prospective longitudinal design is also needed to better understand causal relationships between the variables.

Our study also has several strengths. This study investigated the present condition of WMSDs and occupational risk among gas station workers and provided evidence of an association between fatigue, stress and WMSDs. This finding has important occupational health implications and may inform the prevention of WMSDs among gas station workers. The research results can provide a reference for empirical studies, in particular, interventions to address the current situation.

Conclusion

There is a high prevalence of WMSDs among workers in the gas station industry, most frequently in the neck, shoulders, ankles and feet. The gas station workers had a medium-to-high level of fatigue and stress, and associations between fatigue, stress and WMSDs were found in this study. The participants who reported high fatigue were more than two times more likely to report WMSDs. In addition to the risk factor of fatigue, job role, stress, and personal and work characteristics played essential roles in the prediction of WMSDs.

Declarations

Contributors

JF contributed to the study's conception and design. JW contributed to the material preparation and data collection. XT carried out the analyses and drafted the initial manuscript. All authors have read, critically revised and approved the final version of

this manuscript.

Competing interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethics approval and consent to participate

This paper received ethical approval from School of Medicine Ethical Committee at Shenzhen University: PN-202300036. All participants provided informed consent prior to completing the first survey.

Patient and Public Involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of the research.

References

1 Yin Y, Tan X, Fan J. Occupational fatigue and health of gas station workers: a review. *Work* 2023;Pre-press:1-20. doi: 10.3233/WOR-220415.

2 Sirdah M, Al Laham NA, Al Madhoun R. Possible health effects of liquefied petroleum gas on workers at filling and distribution stations of Gaza governorates. *E Mediterr Health J* 2013;19:289-294. doi: 10.26719/2013.19.3.289.

3 Gimaeva ZF, Bakirov AB, Karimova LK, *et al*. Production and genetic risk factors for cardiovascular diseases among petrochemical industry workers. *Terapevt Arkh* 2018;90:49-53. doi: 10.26442/terarkh201890149-53.

4 Frone MR. Work stress and alcohol use: developing and testing a biphasic self-medication model. *Work Stress* 2016;30:374-394. doi: 10.1080/02678373.2016.1252971.

5 Lee KS, Lee DB, Kwon IS, *et al*. Depressive symptoms and their association with sleep quality, occupational stress and fatigue among small-scaled manufacturing male workers. *Korean J Occup Environ Med* 2011;23:99-111. doi: 10.35371/kjoem.2011.23.2.99.

6 Griffin MA, Clarke S. Stress and well-being at work. In S. Zedeck (Ed.). *APA handbook of industrial and organisational psychology*. Washington, DC: American Psychological Association, 2011:359-397. doi: 10.1037/12171-010.

7 Wolvetang S, van Dongen JM, Speklé E, *et al*. Sick Leave Due to Stress, What are the Costs for Dutch Employers? *J Occup Rehabil* 2022;32:764-772. doi: 10.1007/s10926-022-10042-x.

8 Da Costa BR, Vieira ER. Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. *Am J Ind Med* 2010;53:285-323. doi: 10.1002/ajim.20750.

9 Perruccio AV, Yip C, Badley EM, *et al*. Musculoskeletal disorders: a neglected group at public health and epidemiology meetings? *Am J Public Health* 2017;107:1584-1585. doi: 10.2105/AJPH.2017.303990.

10 Armijo-Olivo S, Woodhouse LJ, Steenstra IA, *et al*. Predictive value of the DASH tool for predicting return to work of injured workers with musculoskeletal disorders of the upper extremity. *Occup Environ Med*. 2016;73:807-815. doi: 10.1136/oemed-2016-10379.

11 Lozano R, Naghavi M, Foreman K, *et al*. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;380:2095-128. doi: 10.1016/S0140-6736(12)61728-0.

12 Kataria KK, Sharma M, Kant S, *et al*. Analysing musculoskeletal risk prevalence among workers in developing countries: an analysis of small-scale cast-iron foundries in India. *Arch Environ Occup H* 2022;77:486-503. doi: 10.1080/19338244.2021.1936436.

13 Nixon AE, Mazzola JJ, Bauer J, *et al*. Can work make you sick? A meta-analysis of the relationships between job stressors and physical symptoms. *Work Stress* 2011;25:1-22. doi: 10.1080/02678373.2011.569175.

14 Hauke A, Flintrop J, Brun E, *et al*. The impact of work-related psychosocial stressors on the onset of musculoskeletal disorders in specific body regions: A review and meta-analysis of 54 longitudinal studies. *Work Stress* 2011;25:243-256. doi: 10.1080/02678373.2011.614069.

15 Frone MR, Tidwell MO. The meaning and measurement of work fatigue: Development and evaluation of the Three-Dimensional Work Fatigue Inventory (3D-WFI). *J Occup Health Psychol* 2015;20:273. doi: 10.1037/a0038700.

16 Lock AM, Bonetti DL, Campbell A. The psychological and physiological health effects of fatigue. *Occup Med* 2018;68:502-511. doi: 10.1093/occmed/kqy109.

17 Daneshmandi H, Choobineh AR, Ghaem H, *et al*. The effect of musculoskeletal problems on fatigue and productivity of office personnel: a cross-sectional study. *J Prev Med Hyg* 2017;58:E252-E258. doi: 10.15167/2421-4248/JPMH2017.58.3.785.

18 Scanlan JN, Still M. Job satisfaction, burnout and turnover intention in occupational therapists working in mental health. *Aust Occup Ther J* 2013;60:310-318. doi: 10.1111/1440-1630.12067.

19 Haghshenas B, Habibi E, Haji Esmaeil Hajar F, *et al*. The association between musculoskeletal disorders with mental workload and occupational fatigue in the office staff of a communication service company in Tehran, Iran, in 2017. *J Occup Health Epidemiol* 2018;7:20-29. doi: 10.29252/johe.7.1.20.

20 Rahman HA, Abdul-Mumin K, Naing L. Psychosocial work stressors, work fatigue, and musculoskeletal disorders: comparison between emergency and critical care nurses in Brunei Public Hospitals. *Asian Nurs Res* 2017;11:13-18. doi: 10.1016/j.anr.2017.01.003.

21 Armon G, Melamed S, Shirom A, *et al*. Elevated burnout predicts the onset of musculoskeletal pain among apparently healthy employees. *J Occup Health Psychol* 2010;15:399. doi: 10.1037/a0020726.

22 Kuorinka I, Jonsson B, Kilbom A, *et al*. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon* 1987;18:233-237. doi: 10.1016/0003-6870(87)90010-X.

23 Yang L, Hildebrandt VH, Yu SF, *et al*. Introduction of Nordic Musculoskeletal

Questionnaire [Ji Rou Gu Ge Ji Huan Diao Cha Biao Jie Shao Fu Diao Cha Biao]. *Ind Health Occup Dis* 2009;35:25-31. Available: https://kns.cnki.net/kcms2/article/abstract?v=0VgOlWnPAthMzMo-KWmM1p7kktuhZCG2kehZzbefk5Zw8nAOZHSwEoRQRiicMmR1ABuzHuolVqiVLgD5F7gRarkLe1Hp09NuHktn1vQhikPMcIosDr7re1RV4WqImOP0&uniplatform=NZKPT&language=CHS.

24 Smith AP, Smith H. An international survey of the wellbeing of employees in the business process outsourcing industry. *Psychology* 2017;08:160-167. doi: 10.4236/psych.2017.81010.

25 Margrove G, Smith AP. The Demands-Resources-Individual Effects (DRIVE) Model: Past, Present, and Future Research. In Haque A (ed.). *Handbook of Research On the Complexities and Strategies of Occupational Stress*. Hershey, PA: IGI Global; 2022:13-32. doi: 10.4018/978-1-6684-3937-1.ch002.

26 Fan J, Liu J, Smith AP. The relationship between workload, fatigue and sleep quality of psychiatric staff. In Longo L, Leva MC (eds). *Human Mental Workload: Models and Applications*. Springer Cham; 2021:151-164. doi: 10.1007/978-3-030-91408-0_10.

27 Ummul S, Rao K. Shift work and fatigue. *IOSR-JESTFT* 2012;1:17-21. doi: 10.9790/2402-0131721.

28 Alroomi AS, Mohamed S. Predictors of mental health and fatigue among isolated oil and gas workers. *Safety Reliab*. 2021;40:80-98. doi: 10.1080/09617353.2020.1858390.

29 Pan H. The cause of human fatigue and scenario analysis in the process of marine transportation. *J Southeast Univ* 2020;36:107-117. doi: 10.3969/j.issn.1003-7985.2020.01.014.

30 Wang Q, Wang C. Reducing turnover intention: perceived organisational support for frontline employees. *Front Bus Res China* 2020;14:1-16. doi: 10.1186/s11782-020-00074-6.

31 Jalilian H, Shouroki FK, Azmoon H, *et al*. Relationship between job stress and fatigue based on job demand-control-support model in hospital nurses. *Int J Preventive Med* 2019;10:56. doi: 10.4103/ijpvm.IJPVM_178_17.

32 Kim YK, Cha NH. Correlations among occupational stress, fatigue, and depression in call center employees in Seoul. *J Phys Ther Sci* 2015;27:3191-3194. doi: 10.1589/jpts.27.3191.

33 Useche SA, Cendales B, Gómez V. Measuring fatigue and its associations with job stress, health and traffic accidents in professional drivers: the case of BRT operators. *EC Neurology* 2017;4:103-118. Available: https://scholar.google.com/scholar_lookup?title=Measuring%20Fatigue%20and%20its%20Associations%20with%20Job%20Stress%2C%20Health%20and%20Traffic%20Accidents%20in%20Professional%20Drivers%3A%20The%20Case%20of%20BRT%20Operators&author=S.A.%20Useche&publication_year=2017

34 Monney I, Dramani JB, Aruna A, *et al*. Health and safety in high-risk work environments: A study of fuel service stations in Ghana. *J Env Occup* 2015;4:132-140. doi: 10.5455/jeos.20150903100137.

35 Sun J, Zhang JQ, Li W, *et al*. Investigation and analysis of musculoskeletal disorders and influencing factors in gas station workers [Jia You Zhan Gong Ren Ji Rou Gu Ge Ji Huan Ji Ying Xiang Yin Su Diao Cha Fen Xi]. *Ind Health Occup Dis* 2010;02:105-107. doi: 10.13692/j.cnki.gywsyzyb.2010.02.018.

36 Oluka CD, ObidikeE, Ezeukwu AO, *et al*. Prevalence of work-related musculoskeletal symptoms and associated risk factors among domestic gas workers and staff of works department in Enugu, Nigeria: a cross-sectional study. *BMC Musculoskelet Dis* 2020;21:1-11. doi: 10.1186/s12891-020-03615-5.

37 Maakip I, Keegel T, Oakman J. Predictors of musculoskeletal discomfort: A cross-cultural comparison between Malaysian and Australian office workers. *Appl Ergon* 2017;60:52-57. doi: 10.1016/j.apergo.2016.11.004.

38 Yan P, Li F, Zhang L, *et al*. Prevalence of work-related musculoskeletal disorders in the nurses working in hospitals of Xinjiang Uygur Autonomous Region. *Pain Res Manag* 2017;51:1-7. doi: 10.1155/2017/5757108.

39 Miftasyah A, Novrikasari N, Hasyim H. Analysis of employment attitude to musculoskeletal complaints on operators of Public Fuel Filling Station (SPBU) in Palembang City, 2021. *BIRCU-Journal* 2022;5:16524-33. Available: https://bircu-

journal.com/index.php/birci/article/view/5567.

40 Andriani B, Camelia A, Faisya HF. Analysis of working postures with musculoskeletal Disorders (Msds) complaint of tailors in Ulak Kerbau Baru Village, Ogan Ilir. *JIKM* 2020;11:75-88. doi: 10.26553/jikm.2020.11.1.75-88.

41 Baberi F, Jahandideh Z, Akbari M, *et al*. Relationship between personality types and musculoskeletal disorders among office staff. *Med Lav* 2019;110:293-303. doi: 10.23749/mdl.v110i4.7820.

42 Pradeepkumar H, Sakthivel G, Shankar S. Prevalence of work related musculoskeletal disorders among occupational bus drivers of Karnataka, South India. *Work* 2020;66:73-84. doi: 10.3233/WOR-203152.

Table 1. Descriptive Characteristics and MSDs Symptoms of Participants

Variables	ALL	WMSDs symptoms (NMQ)		*P*
		No	Yes	
	N = 2962	N = 793	N = 2169	
Age, mean ± SD	36.67 ± 7.55	36.43 ± 8.31	36.76 ± 7.26	
Sex, n (%)				
Female	1643 (55.47%)	417 (52.59%)	1226 (56.52%)	0.058[a]
Male	1266 (42.74%)	361 (45.52%)	905 (41.72%)	
Unidentified	53 (1.79%)	15 (1.89%)	38 (1.75%)	
Job Role, n (%)				
Frontline staff	2619 (88.42%)	757 (95.46%)	1862 (62.86%)	< 0.001[a]
Non-frontline staff	343 (11.58%)	36 (4.54%)	307 (15.65%)	
Personal Characteristics, mean ± SD				
Lifestyle	7.76 ± 2.07	8.57 ± 1.82	7.47 ± 2.07	< 0.001[b]
Personality	7.89 ± 1.93	8.53 ± 1.82	7.66 ± 1.90	< 0 .001[b]
Work Characteristics, mean ± SD				
Workload	6.05 ± 2.48	4.86 ± 2.68	6.49 ± 2.25	< 0.001[b]
Job support and control	7.58 ± 2.13	8.03 ± 2.20	7.41 ± 2.08	< 0.001[b]
Noise	5.37 ± 3.06	4.25 ± 3.04	5.78 ± 2.96	< 0.001[b]
Fumes	7.38 ± 2.92	6.89 ± 3.08	7.55 ± 2.84	< 0.001[b]
Outcome, mean ± SD				
Stress	6.30±2.55	5.05±2.77	6.76±2.30	< 0.001[b]
Fatigue	6.00 ± 2.49	4.45 ± 2.61	6.56 ± 2.19	< 0.001[b]
MSDs (SWELL)	6.11 ± 2.96	2.88 ± 2.54	6.11 ± 2.96	< 0.001[b]

Abbreviations: SD, standard deviation

[a]Chi square test

[b]Independent-samples t-test

Table 2. WMSDs in gas station workers

	Body Region								
	Neck	Shoulders	Elbows	Wrists\hands	Hips	Knees	Lower back	Upper back	Ankles/feet
12-month period prevalence (n=2169, 73.23%)	1252 (42.27%)	1063 (35.89%)	249 (8.40%)	654 (22.08%)	339 (11.44%)	655 (22.11%)	543 (18.33%)	515 (17.39%)	1028 (34.71%)
Gender									
Female	730 (24.65%)	643 (21.71%)	141 (4.76%)	399 (13.47%)	180 (6.08%)	339 (11.44%)	291 (9.82%)	290 (9.79%)	527 (17.79%)
Male	500 (16.9%)	402 (13.57%)	106 (3.58%)	249 (8.41%)	155 (5.23%)	309 (10.43%)	241 (8.14%)	219 (7.39%)	490 (16.54%)
Age									
≤ 30	231 (7.80%)	199 (6.72%)	55 (1.86%)	143 (4.83%)	75 (2.53%)	121 (4.09%)	116 (3.92%)	123 (4.15%)	227 (7.66%)
31–40	640 (21.61%)	532 (17.96%)	111 (3.75%)	323 (10.90%)	168 (5.67%)	302 (10.20%)	270 (9.12%)	248 (8.37%)	499 (16.85%)
41–50	312 (10.53%)	269 (9.08%)	70 (2.36%)	157 (5.30%)	79 (2.67%)	184 (6.21%)	127 (4.29%)	119 (4.02%)	251 (8.47%)
≥ 51	25 (0.84%)	19 (0.64%)	6 (0.20%)	11 (0.37%)	6 (0.20%)	22 (0.74%)	9 (0.30%)	7 (0.24%)	13 (0.44%)
Job role									
Frontline staff	1002 (33.83%)	855 (28.87%)	220 (7.43%)	583 (19.68%)	268 (9.05%)	583 (19.68%)	445 (15.02%)	403 (13.61%)	978 (33.02%)
Non-frontline staff	248 (8.37%)	206 (6.95%)	28 (0.95%)	70 (2.36%)	70 (2.36%)	70 (2.36%)	96 (3.24%)	110 (2.71%)	46 (1.55%)

Table 3. Correlation among stress, fatigue, WMSDs, work and personal characteristics

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Stress	1								
(2) Fatigue	0.61**	1							
(3) WMSDs	0.40**	0.47**	1						
(4) Lifestyle	-0.20**	–0.25**	–0.30**	1					
(5) Personality	-0.18**	–0.25**	–0.24**	0.63**	1				
(6) Workload	0.71**	0.59**	0.41**	–0.21**	–0.20**	1			
(7) Job control and support	-0.07**	–0.12**	–0.12**	0.30**	0.38**	–0.08**	1		
(8) Noise	0.38**	0.40**	0.35**	–0.15**	–0.14**	0.43**	–0.03	1	
(9) Fumes	0.23**	0.23**	0.11**	0.00	0.01	0.28**	0.06**	0.46**	1

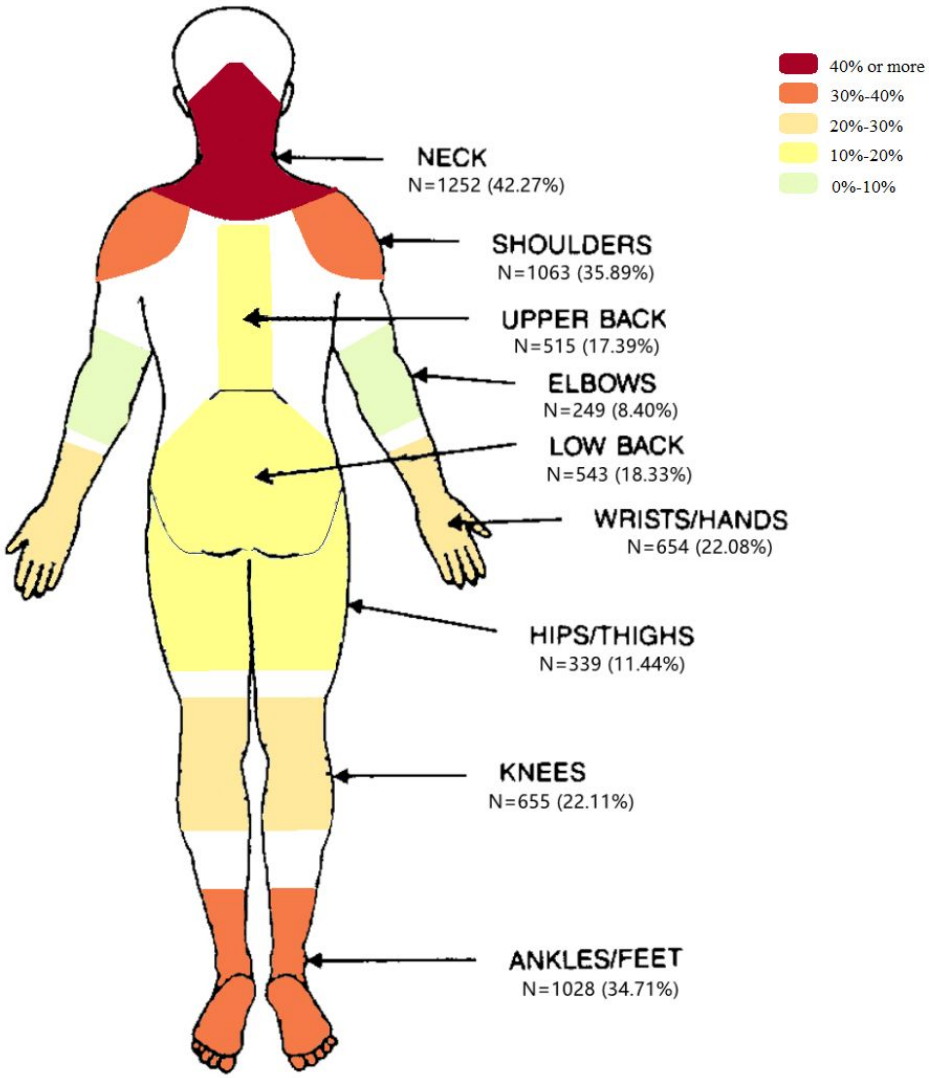
**$p < 0.001$

Table 4. Odds ratio of IVs on WMSDs

	Model 1		Model 2		Model 3	
Variables	OR	95% CI	OR	95% CI	OR	95% CI
Demographics						
Age	1.009	[0.998, 1.021]	1.006	[0.994, 1.019]	1.005	[0.993, 1.018]
Gender	0.689**	[0.574, 0.829]	0.614**	[0.507, 0.745]	0.610**	[0.501, 0.742]
Job role	2.595**	[1.794, 3.755]	3.666**	[2.499, 5.378]	3.413**	[2.318, 5.023]
Personal Characteristics						
Personality			1.357*	[1.065, 1.728]	1.322*	[1.035, 1.689]
Lifestyle			2.108**	[1.667, 2.666]	2.032**	[1.603, 2.575]
Work Characteristics						
Workload					1.345*	[1.052, 1.720]
Job control and support					1.636**	[1.323, 2.024]
Noise					1.478**	[1.199, 1.823]
Fumes					1.585**	[1.286, 1.954]
Stress					1.327*	[1.044, 1.688]
Fatigue					2.211**	[1.755, 2.784]
Nagelkerke R^2	0.116		0.208		0.238	

Abbreviations: OR, odds ratio; CI, confidence interval

**$P < 0.001$ *$p < 0.05$



Adapted from Kuorinka et al.(1987).

Figure 1. Regions of WMSDs in the previous 12-month period prevalence

Table 1. Descriptive Characteristics and MSDs Symptoms of Participants

Variables	ALL	WMSDs symptoms (NMQ)		*P*
		No	Yes	
	N = 2962	N = 793	N = 2169	
Age, mean ± SD	36.67 ± 7.55	36.43 ± 8.31	36.76 ± 7.26	
Sex, n (%)				
Female	1643 (55.47%)	417 (52.59%)	1226 (56.52%)	0.058[a]
Male	1266 (42.74%)	361 (45.52%)	905 (41.72%)	
Unidentified	53 (1.79%)	15 (1.89%)	38 (1.75%)	
Job Role, n (%)				
Frontline staff	2619 (88.42%)	757 (95.46%)	1862 (62.86%)	< 0.001[a]
Non-frontline staff	343 (11.58%)	36 (4.54%)	307 (15.65%)	
Personal Characteristics, mean ± SD				
Lifestyle	7.76 ± 2.07	8.57 ± 1.82	7.47 ± 2.07	< 0.001[b]
Personality	7.89 ± 1.93	8.53 ± 1.82	7.66 ± 1.90	< 0 .001[b]
Work Characteristics, mean ± SD				
Workload	6.05 ± 2.48	4.86 ± 2.68	6.49 ± 2.25	< 0.001[b]
Job support and control	7.58 ± 2.13	8.03 ± 2.20	7.41 ± 2.08	< 0.001[b]
Noise	5.37 ± 3.06	4.25 ± 3.04	5.78 ± 2.96	< 0.001[b]
Fumes	7.38 ± 2.92	6.89 ± 3.08	7.55 ± 2.84	< 0.001[b]
Outcome, mean ± SD				
Stress	6.30±2.55	5.05±2.77	6.76±2.30	< 0.001[b]
Fatigue	6.00 ± 2.49	4.45 ± 2.61	6.56 ± 2.19	< 0.001[b]
MSDs (SWELL)	6.11 ± 2.96	2.88 ± 2.54	6.11 ± 2.96	< 0.001[b]

Abbreviations: SD, standard deviation

[a]Chi square test

[b]Independent-samples t-test

Table 2. WMSDs in gas station workers

	Body Region								
	Neck	Shoulders	Elbows	Wrists\hands	Hips	Knees	Lower back	Upper back	Ankles/feet
12-month period prevalence (n=2169, 73.23%)	1252 (42.27%)	1063 (35.89%)	249 (8.40%)	654 (22.08%)	339 (11.44%)	655 (22.11%)	543 (18.33%)	515 (17.39%)	1028 (34.71%)
Gender									
Female	730 (24.65%)	643 (21.71%)	141 (4.76%)	399 (13.47%)	180 (6.08%)	339 (11.44%)	291 (9.82%)	290 (9.79%)	527 (17.79%)
Male	500 (16.9%)	402 (13.57%)	106 (3.58%)	249 (8.41%)	155 (5.23%)	309 (10.43%)	241 (8.14%)	219 (7.39%)	490 (16.54%)
Age									
⩽ 30	231 (7.80%)	199 (6.72%)	55 (1.86%)	143 (4.83%)	75 (2.53%)	121 (4.09%)	116 (3.92%)	123 (4.15%)	227 (7.66%)
31–40	640 (21.61%)	532 (17.96%)	111 (3.75%)	323 (10.90%)	168 (5.67%)	302 (10.20%)	270 (9.12%)	248 (8.37%)	499 (16.85%)
41–50	312 (10.53%)	269 (9.08%)	70 (2.36%)	157 (5.30%)	79 (2.67%)	184 (6.21%)	127 (4.29%)	119 (4.02%)	251 (8.47%)
⩾ 51	25 (0.84%)	19 (0.64%)	6 (0.20%)	11 (0.37%)	6 (0.20%)	22 (0.74%)	9 (0.30%)	7 (0.24%)	13 (0.44%)
Job role									
Frontline staff	1002 (33.83%)	855 (28.87%)	220 (7.43%)	583 (19.68%)	268 (9.05%)	583 (19.68%)	445 (15.02%)	403 (13.61%)	978 (33.02%)
Non-frontline staff	248 (8.37%)	206 (6.95%)	28 (0.95%)	70 (2.36%)	70 (2.36%)	70 (2.36%)	96 (3.24%)	110 (2.71%)	46 (1.55%)

Table 3. Correlation among stress, fatigue, WMSDs, work and personal characteristics

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Stress	1								
(2) Fatigue	0.61**	1							
(3) WMSDs	0.40**	0.47**	1						
(4) Lifestyle	-0.20**	–0.25**	–0.30**	1					
(5) Personality	-0.18**	–0.25**	–0.24**	0.63**	1				
(6) Workload	0.71**	0.59**	0.41**	–0.21**	–0.20**	1			
(7) Job control and support	-0.07**	–0.12**	–0.12**	0.30**	0.38**	–0.08**	1		
(8) Noise	0.38**	0.40**	0.35**	–0.15**	–0.14**	0.43**	–0.03	1	
(9) Fumes	0.23**	0.23**	0.11**	0.00	0.01	0.28**	0.06**	0.46**	1

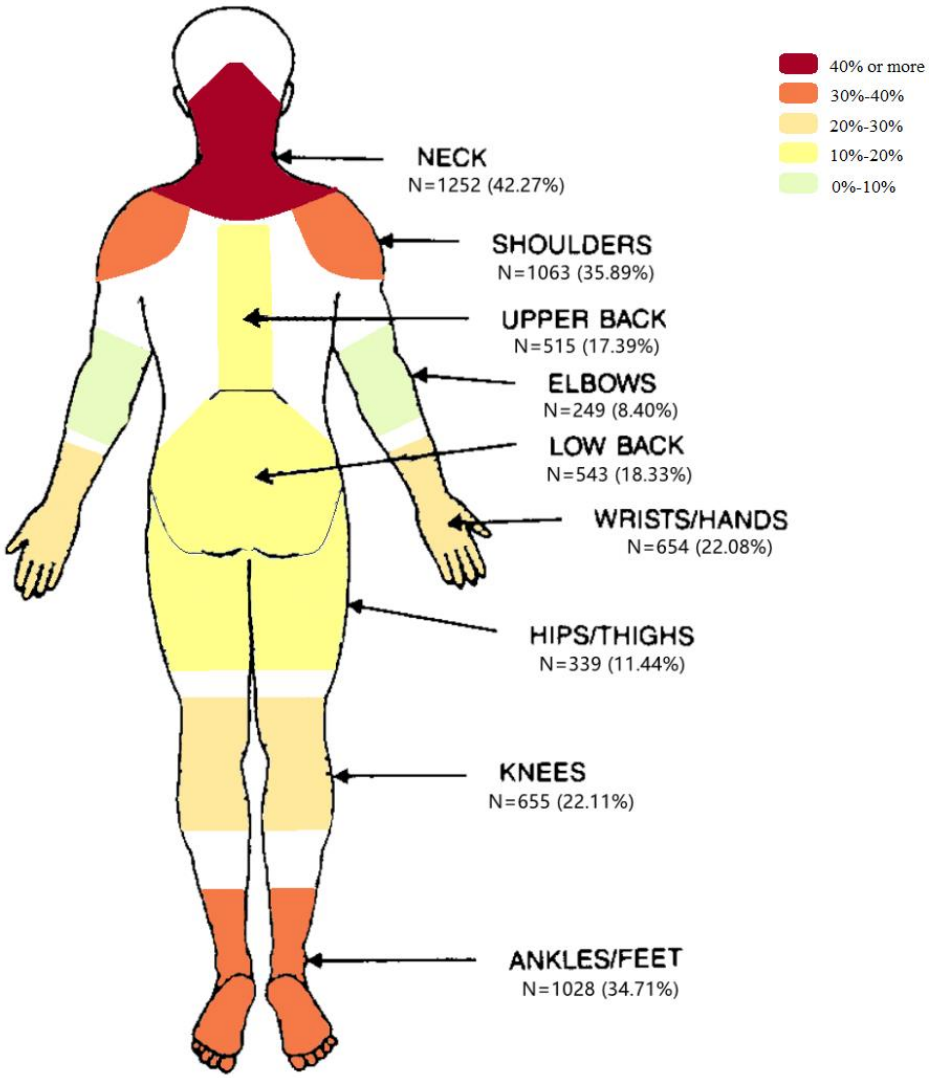
**$p < 0.001$

Table 4. Odds ratio of IVs on WMSDs

	Model 1		Model 2		Model 3	
Variables	OR	95% CI	OR	95% CI	OR	95% CI
Demographics						
Age	1.009	[0.998, 1.021]	1.006	[0.994, 1.019]	1.005	[0.993, 1.018]
Gender	0.689**	[0.574, 0.829]	0.614**	[0.507, 0.745]	0.610**	[0.501, 0.742]
Job role	2.595**	[1.794, 3.755]	3.666**	[2.499, 5.378]	3.413**	[2.318, 5.023]
Personal Characteristics						
Personality			1.357*	[1.065, 1.728]	1.322*	[1.035, 1.689]
Lifestyle			2.108**	[1.667, 2.666]	2.032**	[1.603, 2.575]
Work Characteristics						
Workload					1.345*	[1.052, 1.720]
Job control and support					1.636**	[1.323, 2.024]
Noise					1.478**	[1.199, 1.823]
Fumes					1.585**	[1.286, 1.954]
Stress					1.327*	[1.044, 1.688]
Fatigue					2.211**	[1.755, 2.784]
Nagelkerke R^2	0.116		0.208		0.238	

Abbreviations: OR, odds ratio; CI, confidence interval

**$P < 0.001$ *$p < 0.05$



Adapted from Kuorinka et al.(1987).

Figure 1. Regions of WMSDs in the previous 12-month period prevalence

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-6
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	8-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-11

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Work-Related Musculoskeletal Disorders, Fatigue and Stress Among Gas Station Workers in China: a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-081853.R1
Article Type:	Original research
Date Submitted by the Author:	21-May-2024
Complete List of Authors:	Fan, Jialin; Shenzhen University; Shenzhen Humanities & Social Sciences Key Research Bases of the Center for Mental Health Tan, Xiaotong; Shenzhen University, School of Psychology Smith, Andrew; Cardiff University, School of Psychology Wang, Jing; Shenzhen University
Primary Subject Heading:	Mental health
Secondary Subject Heading:	Public health, Mental health
Keywords:	Occupational Stress, Fatigue, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Work-Related Musculoskeletal Disorders, Fatigue and Stress Among Gas Station Workers in China: a cross-sectional study

Jialin Fan[a,b*], Xiaotong Tan[a], Andrew P. Smith[c], and Jing Wang[a]

[a]*School of Psychology, Shenzhen University, Shenzhen, China*

[b]*The Shenzhen Humanities & Social Sciences Key Research Bases of the Center for Mental Health, Shenzhen, China*

[c]*Centre of Occupational and Health Psychology, School of Psychology, Cardiff University, 63 Park Place, Cardiff, CF10 3AS, UK.*

[*]FanJL@szu.edu.cn

Abstract

Introduction: Work-related musculoskeletal disorders (WMSDs) are disorders of the musculoskeletal system that have the highest prevalence among workers worldwide. Workers in gas stations usually work in poor ergonomic working conditions, including prolonged standing and repetitive posturing.

Objective: the study aimed to investigate the prevalence of WMSDs and fatigue and to identify the predictors of WMSDs among gas station workers.

Design: The present study was a cross-sectional study.

Setting and participants: 2,962 gas station workers from an oil and gas company in China, with ages ranging from 17 to 75 years old, 55.47% female.

Results: The prevalence of WMSDs within the 12 months prior to the study was 73.23%, with the highest prevalence in the neck, shoulders, ankles and feet. Furthermore, a correlation was observed between fatigue, stress, and WMSDs. Fatigue and job role were the strongest predictors of WMSDs, with an odds-ratio range of 2.211–3.413.

Conclusions: This research identified the detrimental impact of WMSDs and fatigue on gas station workers, indicating the critical need for interventions to reduce WMSDs and relieve fatigue.

Strengths and limitations of this study

- This study investigated the present condition of WMSDs and occupational risk among gas station workers.
- The Nordic Musculoskeletal Questionnaire and Smith Well-being Questionnaire were used to assess WMSDs, fatigue, stress and other work-related risk factors.
- Logistic regression was conducted to determine the predictors of the WMSDs.
- This was a cross-sectional study, unable to determine the mechanism and aetiology of WMSDs.

Introduction

Gas station workers are key figures in the oil industry chain, subject to heavy workloads and safety-critical tasks, and related occupational stress, fatigue, health problems and environmental hazards. A recent review emphasised the importance of occupational health concerns for gas station workers, concluding that shift work and the specific work environment of gas station workers can adversely affect their sleep, stress levels, physical and mental health, and turnover intention.[1] The work design of this job role is varied in different countries and regions; for example, in developed countries such as the United States, self-service refuelling is common, and gas stations often employ managers, cashiers and similar staff, while in developing countries such as China, they still rely on manual refuelling operations, which increases the number of gas station workers needed. Regardless of the operational mode, very little empirical research has focused on the occupational health concerns of gas station workers in comparison to the range of risk factors to which they are exposed.

Gas station workers face inevitable occupational stress, and their extensive workloads require an elevated level of alertness and motivation to fulfil their duties.[1] The duties of gas station workers encompass refuelling, sales, and communication with customers and colleagues, alongside additional security responsibilities.[2] As a service industry, they also require emotional intelligence to provide exceptional service quality continually. When job demands exceed workers' abilities and coping skills, they become a risk factor, generating stress and various health problems.[3] Occupational stress is a severe occupational hazard that generates problematic alcohol use,[4] depression[5] and impairment of physical health, psychological well-being and performance.[6] It can also lead to sick leave, adversely affecting productivity and placing a financial burden on employers and society.[7]

Work-related musculoskeletal disorders (WMSDs) are one of the health problems that occupational populations have frequently reported and have a high prevalence.[8]

WMSDs are common painful disorders affecting the body structure that are caused by a variety of factors, such as repetitive motion, excessive force, awkward and/or sustained postures and prolonged sitting and standing.[9] Moreover, these musculoskeletal disorders may also be caused by or worsened by work conditions,[10] highlighting the need to consider the role of occupational factors in their development. WMSDs can also result in physical and mental illness, chronic pain and disability.[11] WMSDs are widespread around the world and are the second most common cause of disability in the workplace.[12] They indirectly decrease industrial efficiency, which results in significant economic burdens.[13] The prevalence of WMSDs and their related negative effects on workers' productivity, particularly in developing countries, should be treated seriously to decrease the impact on production and promote workers' well-being.[14] Many previous studies on the health and well-being of gas station workers focus primarily on the negative effects of organic solvents such as benzene on physiological health and the nervous system. However, gas station workers usually experience poor ergonomic working conditions for long periods, as their work tasks include repetitive, awkward body movements,[1] which can contribute to an increase in WMSDs.

Psychosocial stressors, such as high workload or low time control, may contribute to an increased risk of musculoskeletal disorders by increasing biomechanical load or physical stress. Occupational stress is associated with physical symptoms and is prevalent over time.[15] A review explored the impact of stressors on the onset of musculoskeletal disorders related to the neck/shoulder, upper limbs and waist, revealing that psychosocial factors were independent predictors of musculoskeletal disorders.[16] It indicates that work-related stress may have an impact on the incidence of MSDs. Despite the existence of work stress issues and physical health problems among gas station workers, there remains a dearth of clear evidence regarding the impact of work stress on WMSDs.

Occupational fatigue is described as a state of 'extreme tiredness and reduced functional capacity experienced during or at the end of the workday',[17] and it is a common occupational health problem in many industries and occupations across the world.[18] Fatigue has a myriad of negative consequences; for example, fatigue is linked to various health problems, including sleep disorders, depression, obesity,[19] and musculoskeletal disorders, and it impacts work efficiency, job satisfaction and turnover intention.[20 21] Gas station workers often experience high job demands, heavy workloads and shift work. Workers experience fatigue more quickly as a result of this condition. Thus, as a key component of safety, the fatigue of gas station workers should be given more consideration.

WMSDs and fatigue are both major occupational health issues. Musculoskeletal disorders have been associated with fatigue in nurses and office workers.[22-23] A longitudinal study found that burnout could be a risk factor for the development of musculoskeletal pain in apparently healthy individuals.[24] Although the relationship between WMSDs and fatigue has been studied in several occupations,[22-23] there is currently a dearth of research related to gas station workers. Gas station employees are exposed to a multitude of risk factors for WMSDs in the workplace, including prolonged standing and repetitive motions when filling vehicles. Other factors that contribute to physical and mental fatigue include heavy workloads, maintaining a positive attitude when interacting with customers, remaining vigilant to operations that are prone to causing safety mishaps and working in shifts. Personal characteristics and work-related factors such as workload should also be considered. It is apparent that there is insufficient research on WMSDs and fatigue specific to gas station workers, and relevant risk factors should be further identified.

While WMSDs, occupational stress and fatigue are common issues that negatively affect the health and safety of gas station workers, few studies have been conducted in this field, particularly concerning physical and mental health. The current study aimed to examine the prevalence of WMSDs, determine the association between WMSDs,

stress and fatigue, and investigate the predictors of WMSDs among gas station workers. It contributes to developing a better understanding of the occupational risk factors that can result in WMSDs, which is of great significance for better monitoring and preventing WMSDs, stress and fatigue and enhancing the physical and mental health of gas station workers.

Material and methods

Participants and Procedure

Participants were staff from several gas stations in different cities of southern China within an oil company (N = 2,962, ages ranging from 17 to 75 years old, 55.47% female). The job positions reported were gas operator (34.98%), cashier (14.45%), front-court manager (24%), gas station manager (8.85%), convenience store supervisor (6.14%), finance department staff (3.81%), management and executive staff (2.3%) and other positions (5.47%). It should be noted that the front-court manager has a unique position in Chinese gas stations. The duties of this position include but are not limited to 'being responsible for organising the staff to carry out various operations, management and service work during the shift', 'being responsible for the normal operation of the gas station during the shift', which can also be described as 'on-site duty manager'.

We conducted an online survey among gas station employees from an oil and gas company in China, with the approval and cooperation of the company. There was no work experience requirement for participants. The questionnaire was distributed two months after the regular complete health check-up of employees, and the employees with known trauma or other musculoskeletal disease, cardiovascular disease, severe chronic obstructive pulmonary disease, neurological or psychiatric disorders, and excessive obesity (BMI > 30 kg/m2) were excluded. Participants were asked to complete an informed consent form, and they were free to withdraw from the survey at

any point. The School of Medicine Ethical Committee at Shenzhen University reviewed and approved this study.

Patient and Public Involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of the research.

Measurement of Musculoskeletal Disorders

WMSDs were assessed using the Chinese version of the Nordic Musculoskeletal Questionnaire (NMQ), a self-reported questionnaire that assesses the prevalence of musculoskeletal symptoms in nine areas of the body: the neck, shoulders, elbows, wrists and hands, hips, knees, lower back, upper back and ankles and feet.[25] Participants were asked to note the occurrence of these symptoms over the past week (weekly prevalence) and over the past year (annual prevalence). The NMQ was translated for use with Chinese samples and proved to be reliable and valid.[26] The questionnaire is suitable for application in a variety of workplaces, and data can be collected quickly and easily with one study.

Considering that musculoskeletal disorders in gas station workers are a long-standing problem, in this study, the incidence of musculoskeletal disorders in the past year was used as the evaluation index. WMSDs are defined by reports of discomfort, numbness, pain and restricted movement in one or more body regions in the past year.

Measurement of Occupational Stress and Fatigue

Occupational stress and fatigue were evaluated using the Smith Well-being Questionnaire (SWELL).[27] The SWELL, which is based on the Demands-Resources-Individual-Effects (DRIVE) model, was used to assess occupational fatigue, stress at work, workload, lifestyle, personality, job satisfaction and so on.[28] This questionnaire

has been used to assess a variety of occupational groups in previous studies, allowing the identification of the overall occupational risks. This questionnaire was translated into Chinese using both forward and back translation.[29]

The SWELL consists of 26 single-item questions, and most of the questions are on a 10-point Likert scale. In the current study, the main variables of interest were stress, fatigue, work characteristics (i.e., workload, job support and control, noise exposure and fume exposure) and personal characteristics (i.e., personality and lifestyle).

Analyses

Data analysis was conducted using SPSS 25. Descriptive analyses examined the frequencies of demographic variables, WMSD symptoms (NMQ), stress, fatigue, personal characteristics and work characteristics. Pearson correlation was used to examine the associations between stress, fatigue, WMSDs and other variables. Variable scores were categorised into a high/low group using a median split. Logistic regression was then conducted to determine the predictors of the WMSDs. Data were mean ± standard deviation and statistical significance was set at $p < 0.05$.

Results

Descriptive Statistics

Participants' descriptive characteristics and WMSD symptoms are shown in Table 1. A total of 2,962 participants completed the online survey. The average age of the participants was 36.67 ± 7.55 years; 55.47% of participants were female. According to the work content and actual workplace, participants' job roles were divided into frontline staff (N = 2,619; 88.42%) and non-frontline staff (N = 343, 11.58%). Frontline staff work at gas stations on daily duty, including gas operators, cashiers, front-court managers, convenience store supervisors and gas station managers. Non-frontline staff include finance department staff, management and executive staff, and other positions

that work in offices where they are not exposed to gasoline daily and are not required to remain in a standing position for long periods.

Participants had a mean stress score of 6.30±2.55 and a mean fatigue score of 6.00 ± 2.49. The results also showed that people with WMSD symptoms had unhealthier lifestyles ($t = 14.03$, $p < 0.001$), more negative personalities ($t = 11.05$, $p < 0.001$), higher levels of fatigue ($t = -20.262$, $p < 0.001$) and stress ($t = -16.92$, $p < 0.001$) than those without WMSDs symptoms.

Additionally, a single item from the SWELL on musculoskeletal problems (Do you suffer from musculoskeletal disorders [e.g. arthritis; back pain; sciatica; repetitive strain injury]?) was used to gauge the effectiveness of the NMQ. Participants who reported WMSDs on the NMQ scored 6.11 ± 2.96 on this question, which was significantly higher than healthy participants ($t = 29.24$, $p < 0.001$).

INSERT TABLE 1 HERE

Table 1. Descriptive Characteristics and MSD Symptoms of Participants

Prevalence of WMSDs

As shown in Supplementary Table 1 and Figure 1, the prevalence of WMSDs among the respondents was unevenly distributed among most body regions and centred around three of them, namely the neck (42.27%), shoulders (35.89%) and ankles and feet (34.71%). The 12-month prevalence was 73.23%, and significant differences were found for age group ($\chi^2 = 17.95$, $p < 0.001$) and job role ($\chi^2 = 50.82$, $p < 0.001$) but not gender ($\chi^2 = 3.59$, $p = 0.058$).

INSERT FIGURE 1 HERE

Figure 1. Regions of WMSDs in the previous 12-month period prevalence

Associations among Stress, Fatigue and WMSDs

Pearson correlation was used to investigate the association among stress, fatigue, WMSDs (from the SWELL) and work and personal characteristics (Supplementary Table 2). Stress showed significant positive correlations with fatigue ($r = 0.61$, $p < 0.001$) and WMSDs ($r = 0.40$, $p < 0.001$). Both stress, fatigue and WMSDs were significantly correlated with personal characteristics (lifestyle and personality, $p < 0.001$) and other work characteristics (job control and support, noise, fumes, $p < 0.001$).

Predictors of WMSDs

Logistic regressions were run to investigate the predictors of WMSDs. The dependent variable was WMSDs, measured with or without WMSD symptoms over the past year. The independent variables included in the model were demographic variables (age, gender and job role), personal characteristics (personality and lifestyle), work characteristics (workload, job control and support, noise exposure and fume exposure), stress and fatigue, in which age was continuous, and other variables were categorical. Table 2 shows the Odds ratio for each of the independent variables.

In the final model, the results showed that job role was the strongest predictor of reported WMSD symptoms, with an odds ratio of 3.413 ($p < 0.001$), which indicated that the frontline staff were more than three times more likely to report WMSD symptoms than non-frontline staff. Fatigue was the second strongest predictor of

reported WMSD symptoms, with an odds ratio of 2.211 ($p < 0.001$), which indicated that participants who reported high fatigue were over two times more likely to report WMSD symptoms than those reporting low fatigue after controlling demography and individual difference factors in the model.

The logistic regression model also found that stress (OR = 1.327, $p < 0.05$), gender (female; OR = 0.610, $p < 0.001$), negative personality (OR = 1.322, $p < 0.05$), unhealthy lifestyle (OR = 2.032, $p < 0.001$), heavy workload (OR = 1.345, $p < 0.05$), lack of job control (OR = 1.636, $p < 0.001$), noise exposure (OR = 1.585, $p < 0.001$) and fume exposure (OR = 1.327, $p < 0.05$) significantly contributed to WMSDs.

INSERT TABLE 2 HERE

Table 2. Odds ratio of IVs on WMSDs

Discussion

This is a cross-sectional study using an online questionnaire to investigate the prevalence of and relationship between WMSDs, stress and fatigue, and the predictors of WMSDs among gas station workers. Participants reported medium-to-high levels of fatigue and stress, and the 12-month prevalence of WMSDs was 73.23%. The neck, shoulders, ankles and feet were the most common body regions affected by musculoskeletal disorders. The present study also showed a significant positive correlation between fatigue, stress and WMSDs, and with higher fatigue and stress, participants were more likely to have WMSDs. In addition, job roles and personal and work characteristics were predictors of WMSDs.

In terms of occupational fatigue and stress, the findings suggest that there was indeed a certain occupational health problem among gas station employees. Firstly, fatigue was clearly associated with multiple risk factors, including individual characteristics, work characteristics and environment. Given the nature of the gas station industry, workers usually work long hours each day, and most of this is shift work, both of which have been closely related to fatigue.[30] A growing body of literature has demonstrated that fatigue is common among gas station workers, as well as workers from the oil and gas industry, such as offshore drilling, the job characteristics of which are similar.[31-33] Meanwhile, the current study provides evidence of a significant positive association between job stress and occupational fatigue among gas station workers. These findings align with previous research conducted on various occupational groups, including nurses,[34] call centre employees,[35] and drivers,[36] thus confirming a consistent relationship between stress and fatigue. Nonetheless, this study represents the first investigation specifically focusing on the stress and fatigue experiences of gas station workers, highlighting the unique challenges faced by this particular occupational group. In addition to their primary responsibilities of providing refuelling services, frontline gas station workers in China often have additional responsibilities such as safety duties, sales, and prioritising customer satisfaction. Such multifaceted job demands may contribute to heightened job stress levels and subsequent fatigue among these workers. Our findings underscore the need for interventions to reduce stress and fatigue risk factors.

The majority of gas station workers reported having WMSDs in at least one anatomical region during the 12 months prior to the study, which is in line with previous research conducted both inside and outside of China.[37 38] The clustering pattern of WMSDs observed in this study, notably in the neck (42.27%), shoulders (35.89%) and ankles and feet (34.71%), is somewhat different from findings in previous studies among gas station workers. Among Nigerian gas station workers, the reported prevalence pattern of body regions was highest in the lower back (54%) and shoulders (52%),[39] whereas

in Ghana, it was highest in the lower back (43%).[37] This is due in part to the larger proportion of frontline employees in our study, who engage primarily in manual labour. Although there are variations in the specific sites affected among gas station workers in different countries, the overall prevalence of moderate to high rates of work-related musculoskeletal disorders (WMSDs) ranged from 51.2% to 86%.[37-39] This demonstrates that WMSDs are a common issue within the gas station occupation. A cross-cultural comparison research of workers in similar occupational groups revealed disparities in the prevalence of self-reported MSD discomfort between Malaysia and Australia.[40] However, there were no significant differences in the frequency and severity of symptoms across five body regions among those reporting MSD discomfort, and they shared similar predictors. Therefore, future research seeking to generalize these findings to comparable job positions in other countries should carefully consider sociocultural backgrounds as influencing factors.

WMSDs are a multi-factorial disorder linked to various demographic and work-related features. There is limited literature concerned with WMSDs in this particular field. Therefore, a comprehensive analysis based on the establishment of a logistic regression model was run to reveal the presence of multiple influencing factors for WMSDs among gas station workers, including personal and work characteristics. It's worth noting that fatigue and job role were found to be major risk factors for WMSDs. There is a clear relationship between WMSDs and occupational fatigue. This finding is consistent with previous research that has identified fatigue as a risk factor for WMSDs.[41] Fatigued workers usually perform poorly at work and may eventually face serious health problems. Ergonomically, the risk factors for gas station workers come from repetitive actions (such as filling vehicles) and long periods of standing (as with cashiers). According to previous studies, maintaining an awkward and static posture for extended periods at work can cause discomfort, pain and chronic fatigue.[20] This is supported by results from job roles, where frontline workers are more likely to have musculoskeletal problems than non-frontline workers. Frontline workers are more likely to be exposed

to risk factors at work, such as repetitive motions, poor posture and physical strain. Adverse symptoms accumulate over time and can cause serious consequences for physical and mental health.

It is worthwhile to note that there was no significant difference in age between those with and without WMSDs. Similarly, in logistic regression, age was not a significant predictor of WMSDs. However, a recent study found that there was a relationship between age and musculoskeletal disorders complaints.[42] In general, increased age causes workers' physical conditions to deteriorate, and as muscle strength and endurance decline, the risk of WMSDs increases.[43] The different results suggest that some variables might modify the relationship between age and WMSDs, such as body mass index (BMI), smoking habits and physical activity, which are individual characteristic variables associated with WMSDs, should be examined in future studies.

According to the logistic regression model, negative personality and unhealthy lifestyle were considered risk factors for WMSDs. These findings are similar to the results of other studies.[44 45] Therefore, at the individual level, adopting a healthy lifestyle may be able to mitigate the incidence of WMSDs. Personality type and WMSDs appear to be correlated, and it is suggested that organisations may consider personality type factors in employee selection and training.

The results from this study provide insight into understanding the relationship between fatigue, stress and WMSDs among gas station workers. These findings have practical implications for identifying and addressing WMSDs, particularly among frontline workers who experience severe fatigue and stress. The consequences of WMSDs are considerable for employees and employers alike. Therefore, several measures can be taken to prevent the risk of WMSDs. For example, gas station workers should be aware of risk factors and make positive changes, such as stretching between breaks. Employers should consider implementing fatigue management strategies and providing ergonomic workstations to ensure the well-being and safety of their workers.

There are a few limitations of this study. First, the study absence of data on body composition, specifically BMI, and the level of habitual physical activity among participants. The lack of this information presents a challenge in accurately associating our findings with participants' age and functional status. Second, the study sample was exclusively from China; therefore, future studies should determine and verify our results in other regions, including workers from both developed and developing nations and state-owned and private businesses. Third, this was a cross-sectional study that used subjective measurement methods. Future studies should apply objective technologies, which lead to more accurate and objective conclusions. A prospective longitudinal design is also needed to better understand causal relationships between the variables.

Our study also has several strengths. This study investigated the present condition of WMSDs and occupational risk among gas station workers and provided evidence of an association between fatigue, stress and WMSDs. This finding has important occupational health implications and may inform the prevention of WMSDs among gas station workers. The research results can provide a reference for empirical studies, in particular, interventions to address the current situation.

Conclusion

There is a high prevalence of WMSDs among workers in the gas station industry, most frequently in the neck, shoulders, ankles and feet. The gas station workers had a medium-to-high level of fatigue and stress, and associations between fatigue, stress and WMSDs were found in this study. The participants who reported high fatigue were more than two times more likely to report WMSDs. In addition to the risk factor of fatigue, job role, stress, and personal and work characteristics played essential roles in the prediction of WMSDs.

Declarations

Contributors

Conceptualization, JF; material preparation and data collection, JW; analyses, XT; original draft preparation, XT; review and editing, XT, JF and AS. All authors have read, critically revised and approved the final version of this manuscript. J.F is responsible for the overall content [as guarantor].

Competing interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data sharing statement

Data are available on reasonable request. Data supporting the findings of this study are available from the corresponding author on reasonable request. Access requests will be reviewed to ensure compliance with ethical and privacy guidelines. Please contact (FanJL@szu.edu.cn) for inquiries regarding data access.

Ethics approval and consent to participate

This paper received ethical approval from School of Medicine Ethical Committee at Shenzhen University: PN-202300036. All participants provided informed consent prior to completing the first survey.

References

1 Yin Y, Tan X, Fan J. Occupational fatigue and health of gas station workers: a review. *Work* 2023;Pre-press:1-20. doi: 10.3233/WOR-220415.

2 Sirdah M, Al Laham NA, Al Madhoun R. Possible health effects of liquefied petroleum gas on workers at filling and distribution stations of Gaza governorates. *E Mediterr Health J* 2013;19:289-294. doi: 10.26719/2013.19.3.289.

3 Gimaeva ZF, Bakirov AB, Karimova LK, *et al*. Production and genetic risk factors for cardiovascular diseases among petrochemical industry workers. *Terapevt Arkh* 2018;90:49-53. doi: 10.26442/terarkh201890149-53.

4 Frone MR. Work stress and alcohol use: developing and testing a biphasic self-medication model. *Work Stress* 2016;30:374-394. doi: 10.1080/02678373.2016.1252971.

5 Lee KS, Lee DB, Kwon IS, *et al*. Depressive symptoms and their association with sleep quality, occupational stress and fatigue among small-scaled manufacturing male workers. *Korean J Occup Environ Med* 2011;23:99-111. doi: 10.35371/kjoem.2011.23.2.99.

6 Griffin MA, Clarke S. Stress and well-being at work. In S. Zedeck (Ed.). *APA handbook of industrial and organisational psychology*. Washington, DC: American Psychological Association, 2011:359-397. doi: 10.1037/12171-010.

7 Wolvetang S, van Dongen JM, Speklé E, *et al*. Sick Leave Due to Stress, What are the Costs for Dutch Employers? *J Occup Rehabil* 2022;32:764-772. doi: 10.1007/s10926-022-10042-x.

8 Bonfiglioli, Robertaa; Caraballo-Arias, *et al*. Epidemiology of work-related musculoskeletal disorders. *Current Opinion in Epidemiology and Public Health* 2022;1:18-24. doi: 10.1097/PXH.0000000000000003.

9 Da Costa BR, Vieira ER. Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. *Am J Ind Med* 2010;53:285-323. doi: 10.1002/ajim.20750.

10 Centers for Disease Control and Prevention. Ergonomics and Musculoskeletal Disorders. 2019. Available from: https://www.cdc.gov/niosh/topics/ergonomics/

11 Perruccio AV, Yip C, Badley EM, *et al*. Musculoskeletal disorders: a neglected group at

public health and epidemiology meetings? *Am J Public Health* 2017;107:1584-1585. doi: 10.2105/AJPH.2017.303990.

12 Armijo-Olivo S, Woodhouse LJ, Steenstra IA, *et al*. Predictive value of the DASH tool for predicting return to work of injured workers with musculoskeletal disorders of the upper extremity. *Occup Environ Med*. 2016;73:807-815. doi: 10.1136/oemed-2016-10379.

13 Lozano R, Naghavi M, Foreman K, *et al*. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;380:2095-128. doi: 10.1016/S0140-6736(12)61728-0.

14 Kataria KK, Sharma M, Kant S, *et al*. Analysing musculoskeletal risk prevalence among workers in developing countries: an analysis of small-scale cast-iron foundries in India. *Arch Environ Occup H* 2022;77:486-503. doi: 10.1080/19338244.2021.1936436.

15 Nixon AE, Mazzola JJ, Bauer J, *et al*. Can work make you sick? A meta-analysis of the relationships between job stressors and physical symptoms. *Work Stress* 2011;25:1-22. doi: 10.1080/02678373.2011.569175.

16 Hauke A, Flintrop J, Brun E, *et al*. The impact of work-related psychosocial stressors on the onset of musculoskeletal disorders in specific body regions: A review and meta-analysis of 54 longitudinal studies. *Work Stress* 2011;25:243-256. doi: 10.1080/02678373.2011.614069.

17 Frone MR, Tidwell MO. The meaning and measurement of work fatigue: Development and evaluation of the Three-Dimensional Work Fatigue Inventory (3D-WFI). *J Occup Health Psychol* 2015;20:273. doi: 10.1037/a0038700.

18 Lock AM, Bonetti DL, Campbell AD. The psychological and physiological health effects of fatigue. *Occup Med* 2018;68:502-11. doi: 10.1093/occmed/kqy109.

19 Lock AM, Bonetti DL, Campbell A. The psychological and physiological health effects of fatigue. *Occup Med* 2018;68:502-511. doi: 10.1093/occmed/kqy109.

20 Daneshmandi H, Choobineh AR, Ghaem H, *et al*. The effect of musculoskeletal problems on fatigue and productivity of office personnel: a cross-sectional study. *J Prev Med Hyg* 2017;58:E252-E258. doi: 10.15167/2421-4248/JPMH2017.58.3.785.

21 Scanlan JN, Still M. Job satisfaction, burnout and turnover intention in occupational

therapists working in mental health. *Aust Occup Ther J* 2013;60:310-318. doi: 10.1111/1440-1630.12067.

22 Haghshenas B, Habibi E, Haji Esmaeil Hajar F, *et al*. The association between musculoskeletal disorders with mental workload and occupational fatigue in the office staff of a communication service company in Tehran, Iran, in 2017. *J Occup Health Epidemiol* 2018;7:20-29. doi: 10.29252/johe.7.1.20.

23 Rahman HA, Abdul-Mumin K, Naing L. Psychosocial work stressors, work fatigue, and musculoskeletal disorders: comparison between emergency and critical care nurses in Brunei Public Hospitals. *Asian Nurs Res* 2017;11:13-18. doi: 10.1016/j.anr.2017.01.003.

24 Armon G, Melamed S, Shirom A, *et al*. Elevated burnout predicts the onset of musculoskeletal pain among apparently healthy employees. *J Occup Health Psychol* 2010;15:399. doi: 10.1037/a0020726.

25 Kuorinka I, Jonsson B, Kilbom A, *et al*. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon* 1987;18:233-237. doi: 10.1016/0003-6870(87)90010-X.

26 Yang L, Hildebrandt VH, Yu SF, *et al*. Introduction of Nordic Musculoskeletal Questionnaire [Ji Rou Gu Ge Ji Huan Diao Cha Biao Jie Shao Fu Diao Cha Biao]. *Ind Health Occup Dis* 2009;35:25-31. Available: https://kns.cnki.net/kcms2/article/abstract?v=0VgOlWnPAthMzMo-KWmM1p7kktuhZCG2kehZzbefk5Zw8nAOZHSwEoRQRiicMmR1ABuzHuolVqiVLgD5F7gRarkLe1Hp09NuHktn1vQhikPMcIosDr7re1RV4WqImOP0&uniplatform=NZKPT&language=CHS.

27 Smith AP, Smith H. An international survey of the wellbeing of employees in the business process outsourcing industry. *Psychology* 2017;08:160-167. doi: 10.4236/psych.2017.81010.

28 Margrove G, Smith AP. The Demands-Resources-Individual Effects (DRIVE) Model: Past, Present, and Future Research. In Haque A (ed.). *Handbook of Research On the Complexities and Strategies of Occupational Stress*. Hershey, PA: IGI Global; 2022:13-32. doi: 10.4018/978-1-6684-3937-1.ch002.

29 Fan J, Liu J, Smith AP. The relationship between workload, fatigue and sleep quality of psychiatric staff. In Longo L, Leva MC (eds). *Human Mental Workload: Models and Applications*. Springer Cham; 2021:151-164. doi: 10.1007/978-3-030-91408-0_10.

30 Ummul S, Rao K. Shift work and fatigue. *IOSR-JESTFT* 2012;1:17-21. doi: 10.9790/2402-0131721.

31 Alroomi AS, Mohamed S. Predictors of mental health and fatigue among isolated oil and gas workers. *Safety Reliab*. 2021;40:80-98. doi: 10.1080/09617353.2020.1858390.

32 Pan H. The cause of human fatigue and scenario analysis in the process of marine transportation. *J Southeast Univ* 2020;36:107-117. doi: 10.3969/j.issn.1003-7985.2020.01.014.

33 Wang Q, Wang C. Reducing turnover intention: perceived organisational support for frontline employees. *Front Bus Res China* 2020;14:1-16. doi: 10.1186/s11782-020-00074-6.

34 Jalilian H, Shouroki FK, Azmoon H, *et al*. Relationship between job stress and fatigue based on job demand-control-support model in hospital nurses. *Int J Preventive Med* 2019;10:56. doi: 10.4103/ijpvm.IJPVM_178_17.

35 Kim YK, Cha NH. Correlations among occupational stress, fatigue, and depression in call center employees in Seoul. *J Phys Ther Sci* 2015;27:3191-3194. doi: 10.1589/jpts.27.3191.

36 Useche SA, Cendales B, Gómez V. Measuring fatigue and its associations with job stress, health and traffic accidents in professional drivers: the case of BRT operators. *EC Neurology* 2017;4:103-118. Available: https://scholar.google.com/scholar_lookup?title=Measuring%20Fatigue%20and%20its%20Associations%20with%20Job%20Stress%2C%20Health%20and%20Traffic%20Accidents%20in%20Professional%20Drivers%3A%20The%20Case%20of%20BRT%20Operators&author=S.A.%20Useche&publication_year=2017

37 Monney I, Dramani JB, Aruna A, *et al*. Health and safety in high-risk work environments: A study of fuel service stations in Ghana. *J Env Occup* 2015;4:132-140. doi: 10.5455/jeos.20150903100137.

38 Sun J, Zhang JQ, Li W, *et al*. Investigation and analysis of musculoskeletal disorders and

influencing factors in gas station workers [Jia You Zhan Gong Ren Ji Rou Gu Ge Ji Huan Ji Ying Xiang Yin Su Diao Cha Fen Xi]. *Ind Health Occup Dis* 2010;02:105-107. doi: 10.13692/j.cnki.gywsyzyb.2010.02.018.

39 Oluka CD, ObidikeE, Ezeukwu AO, *et al*. Prevalence of work-related musculoskeletal symptoms and associated risk factors among domestic gas workers and staff of works department in Enugu, Nigeria: a cross-sectional study. *BMC Musculoskelet Dis* 2020;21:1-11. doi: 10.1186/s12891-020-03615-5.

40 Maakip I, Keegel T, Oakman J. Predictors of musculoskeletal discomfort: A cross-cultural comparison between Malaysian and Australian office workers. *Appl Ergon* 2017;60:52-57. doi: 10.1016/j.apergo.2016.11.004.

41 Yan P, Li F, Zhang L, *et al*. Prevalence of work-related musculoskeletal disorders in the nurses working in hospitals of Xinjiang Uygur Autonomous Region. *Pain Res Manag* 2017;51:1-7. doi: 10.1155/2017/5757108.

42 Miftasyah A, Novrikasari N, Hasyim H. Analysis of employment attitude to musculoskeletal complaints on operators of Public Fuel Filling Station (SPBU) in Palembang City, 2021. *BIRCU-Journal* 2022;5:16524-33. Available: https://bircu-journal.com/index.php/birci/article/view/5567.

43 Andriani B, Camelia A, Faisya HF. Analysis of working postures with musculoskeletal Disorders (Msds) complaint of tailors in Ulak Kerbau Baru Village, Ogan Ilir. *JIKM* 2020;11:75-88. doi: 10.26553/jikm.2020.11.1.75-88.

44 Baberi F, Jahandideh Z, Akbari M, *et al*. Relationship between personality types and musculoskeletal disorders among office staff. *Med Lav* 2019;110:293-303. doi: 10.23749/mdl.v110i4.7820.

45 Pradeepkumar H, Sakthivel G, Shankar S. Prevalence of work related musculoskeletal disorders among occupational bus drivers of Karnataka, South India. *Work* 2020;66:73-84. doi: 10.3233/WOR-203152.

Table 1. Descriptive Characteristics and MSDs Symptoms of Participants

Variables	ALL	WMSDs symptoms (NMQ)		*P*
		No	Yes	
	N = 2962	N = 793	N = 2169	
Age, mean ± SD	36.67 ± 7.55	36.43 ± 8.31	36.76 ± 7.26	
Sex, n (%)				
Female	1643 (55.47%)	417 (52.59%)	1226 (56.52%)	0.058[a]
Male	1266 (42.74%)	361 (45.52%)	905 (41.72%)	
Unidentified	53 (1.79%)	15 (1.89%)	38 (1.75%)	
Job Role, n (%)				
Frontline staff	2619 (88.42%)	757 (95.46%)	1862 (62.86%)	< 0.001[a]
Non-frontline staff	343 (11.58%)	36 (4.54%)	307 (15.65%)	
Personal Characteristics, mean ± SD				
Lifestyle	7.76 ± 2.07	8.57 ± 1.82	7.47 ± 2.07	< 0.001[b]
Personality	7.89 ± 1.93	8.53 ± 1.82	7.66 ± 1.90	< 0 .001[b]
Work Characteristics, mean ± SD				
Workload	6.05 ± 2.48	4.86 ± 2.68	6.49 ± 2.25	< 0.001[b]
Job support and control	7.58 ± 2.13	8.03 ± 2.20	7.41 ± 2.08	< 0.001[b]
Noise	5.37 ± 3.06	4.25 ± 3.04	5.78 ± 2.96	< 0.001[b]
Fumes	7.38 ± 2.92	6.89 ± 3.08	7.55 ± 2.84	< 0.001[b]
Outcome, mean ± SD				
Stress	6.30±2.55	5.05±2.77	6.76±2.30	< 0.001[b]
Fatigue	6.00 ± 2.49	4.45 ± 2.61	6.56 ± 2.19	< 0.001[b]
MSDs (SWELL)	6.11 ± 2.96	2.88 ± 2.54	6.11 ± 2.96	< 0.001[b]

Abbreviations: SD, standard deviation

[a]Chi square test

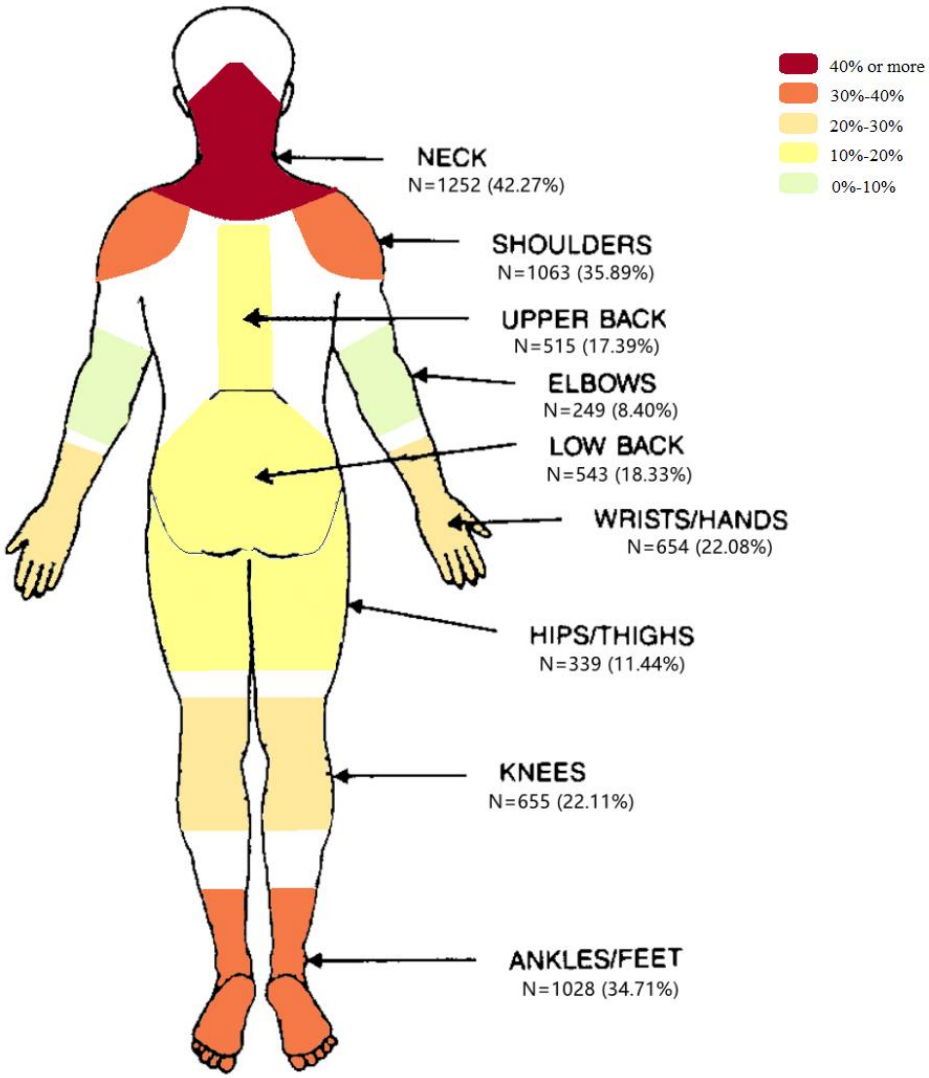
[b]Independent-samples t-test

Table 2. Odds ratio of IVs on WMSDs

	Model 1		Model 2		Model 3	
Variables	OR	95% CI	OR	95% CI	OR	95% CI
Demographics						
Age	1.009	[0.998, 1.021]	1.006	[0.994, 1.019]	1.005	[0.993, 1.018]
Gender	0.689**	[0.574, 0.829]	0.614**	[0.507, 0.745]	0.610**	[0.501, 0.742]
Job role	2.595**	[1.794, 3.755]	3.666**	[2.499, 5.378]	3.413**	[2.318, 5.023]
Personal Characteristics						
Personality			1.357*	[1.065, 1.728]	1.322*	[1.035, 1.689]
Lifestyle			2.108**	[1.667, 2.666]	2.032**	[1.603, 2.575]
Work Characteristics						
Workload					1.345*	[1.052, 1.720]
Job control and support					1.636**	[1.323, 2.024]
Noise					1.478**	[1.199, 1.823]
Fumes					1.585**	[1.286, 1.954]
Stress					1.327*	[1.044, 1.688]
Fatigue					2.211**	[1.755, 2.784]
Nagelkerke R^2	0.116		0.208		0.238	

Abbreviations: OR, odds ratio; CI, confidence interval

**$P < 0.001$ *$p < 0.05$



Adapted from Kuorinka et al.(1987).

Figure 1. Regions of WMSDs in the previous 12-month period prevalence

Supplementary Table 1. WMSDs in gas station workers

	Body Region								
	Neck	Shoulders	Elbows	Wrists\hands	Hips	Knees	Lower back	Upper back	Ankles/feet
12-month period prevalence (n=2169, 73.23%)	1252 (42.27%)	1063 (35.89%)	249 (8.40%)	654 (22.08%)	339 (11.44%)	655 (22.11%)	543 (18.33%)	515 (17.39%)	1028 (34.71%)
Gender									
Female	730 (24.65%)	643 (21.71%)	141 (4.76%)	399 (13.47%)	180 (6.08%)	339 (11.44%)	291 (9.82%)	290 (9.79%)	527 (17.79%)
Male	500 (16.9%)	402 (13.57%)	106 (3.58%)	249 (8.41%)	155 (5.23%)	309 (10.43%)	241 (8.14%)	219 (7.39%)	490 (16.54%)
Age									
⩽ 30	231 (7.80%)	199 (6.72%)	55 (1.86%)	143 (4.83%)	75 (2.53%)	121 (4.09%)	116 (3.92%)	123 (4.15%)	227 (7.66%)
31–40	640 (21.61%)	532 (17.96%)	111 (3.75%)	323 (10.90%)	168 (5.67%)	302 (10.20%)	270 (9.12%)	248 (8.37%)	499 (16.85%)
41–50	312 (10.53%)	269 (9.08%)	70 (2.36%)	157 (5.30%)	79 (2.67%)	184 (6.21%)	127 (4.29%)	119 (4.02%)	251 (8.47%)
⩾ 51	25 (0.84%)	19 (0.64%)	6 (0.20%)	11 (0.37%)	6 (0.20%)	22 (0.74%)	9 (0.30%)	7 (0.24%)	13 (0.44%)
Job role									
Frontline staff	1002 (33.83%)	855 (28.87%)	220 (7.43%)	583 (19.68%)	268 (9.05%)	583 (19.68%)	445 (15.02%)	403 (13.61%)	978 (33.02%)
Non-frontline staff	248 (8.37%)	206 (6.95%)	28 (0.95%)	70 (2.36%)	70 (2.36%)	70 (2.36%)	96 (3.24%)	110 (2.71%)	46 (1.55%)

Supplementary Table 2. Correlation among stress, fatigue, WMSDs, work and personal characteristics

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Stress	1								
(2) Fatigue	0.61**	1							
(3) WMSDs	0.40**	0.47**	1						
(4) Lifestyle	-0.20**	–0.25**	–0.30**	1					
(5) Personality	-0.18**	–0.25**	–0.24**	0.63**	1				
(6) Workload	0.71**	0.59**	0.41**	–0.21**	–0.20**	1			
(7) Job control and support	-0.07**	–0.12**	–0.12**	0.30**	0.38**	–0.08**	1		
(8) Noise	0.38**	0.40**	0.35**	–0.15**	–0.14**	0.43**	–0.03	1	
(9) Fumes	0.23**	0.23**	0.11**	0.00	0.01	0.28**	0.06**	0.46**	1

**$p < 0.001$

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-6
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-9
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	8-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-11

		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.