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Effects of occupational hazards and occupational stress on job burn-out of factory workers and miners in Urumqi: a propensity score-matched cross-sectional study

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ABSTRACT

Objective This study was designed to explore the impact of occupational hazards and occupational stress on job burn-out among factory workers and miners. This study also aimed to provide a scientific basis for the prevention and control of job burn-out among factory workers and miners.

Design A cross-sectional study based on the factory Workers and Miners of Urumqi, Xinjiang. Demographic biases, that is, confounding factors, were eliminated by the propensity score-matched analysis method.

Participants An electronic questionnaire was used to survey 7500 eligible factory workers and miners in Urumqi, the capital of Xinjiang, and 7315 complete questionnaires were returned.

Primary outcome measures A general demographic questionnaire, the Effort–Reward Imbalance (ERI) and the Chinese Maslach Burnout Inventory.

Results The total rate of burn-out was 86.5%. Noise (OR 1.34, 95% CI 1.09 to 1.64) and ERI (OR 2.16, 95% CI 1.78 to 2.61) were the risk factors for job burn-out among factory workers and miners (p<0.001).

Conclusion The job burn-out rate of factory workers and miners was high, and the noise and occupational stress factors among occupational hazard factors will affect the likelihood of job burn-out of factory workers and miners. We should control the impact of occupational hazards on factory workers and miners and reduce occupational stress to alleviate workers' job burn-out.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The propensity score-matched analysis method was used to eliminate confounding factors.
- ⇒ The study's participants are homogeneous, and the sample size is large.
- ⇒ Questionnaires used in this study have been shown to have good reliability and validity by many researchers.
- ⇒ The cross-sectional study cannot identify causal relationships among occupational hazards, occupational stress and job burn-out in factory workers and miners.
- ⇒ Electronic questionnaires are used as the only source of data collection.

INTRODUCTION

Job burn-out, which has three characteristics, emotional exhaustion (EE), cynicism (CY) and reduced personal accomplishment (PA), is usually described as a state of physical, emotional and mental exhaustion due to long-term stress from work, and usually manifests as depression, lack of motivation and decreased enthusiasm at work.[1–5] In 1970s, Herbert Freudenberger, an American psychologist, described the concept of job burn-out as follows: 'Burn-out' is 'to fail or become exhausted by making excessive demands on energy, strength or resources'.[6] Many studies from diverse countries have suggested that job burn-out is a common emotional problem in the workplace. The National Institute of Occupational Safety and Health (NIOSH) of the USA found that almost all people at work were prone to be affected by job burn-out.[7] Among medical staff, according to a survey conducted by the Statistical Information Center of the Ministry of Health of China in 2010, 52.4% of healthcare professionals had feelings of job burn-out, and 3.1% of them had high levels of burn-out.[8] Long-term job burn-out in workers is not only associated with mental illness, such as depression, but also with a series of physical diseases, such as cardiovascular disease and musculoskeletal pain. In addition, burn-out is related to absenteeism. The occurrence of job burn-out seriously affects the normal production of enterprises, reduces productivity and even leads to the loss of valuable labour.[3 4 9–11] Therefore, occupational burn-out, which seriously affects the physical and mental health and work efficiency of workers, has become an occupational health problem that concerns researchers all over the world.

According to statistics, coal resources account for about 27.6% of world energy consumption,[12 13] and, in China, coal resources account for more than 60%.[14] Urumqi is the capital of Xinjiang, located in Northwestern China. In recent year, Xinjiang has been predicted to possess approximately 2.2 trillion tons of coal, accounting for 40% of the country's total coal resources and ranking first among the other provinces in China, and is known as the 'last unexploited land' of China's coal development. The National Energy Administration of China issued the 'Guiding Opinion on Promoting the Scientific Development of the Coal Industry' in 2015, which put forward the overall requirements of 'controlling the east provinces, stabilising the central region and developing the west provinces' to optimise the layout of coal development.[15] As an important resource province in China, the steady development of coal resource development in Xinjiang plays an important role in China's energy security and stability. The development of coal resources is inseparable from the contributions of factory workers and miners. Factory workers and miners are a special professional group who not only have to face a small working space, but also face the impact of occupational hazards such as noise and coal dust. In addition, underground miners always face threats to their lives and health associated with a complex underground environment. Therefore, it is particularly important to consider the health of factory workers and miners, especially with in-depth studies of occupational hazards such as coal dust and the factors influencing job burn-out.

According to statistics, 25 000 and 46 000 factory workers and miners worldwide died of pneumoconiosis and silicosis in 2013, respectively.[16] As of 2015, in China alone, the total number of pneumoconiosis cases among workers reached 72 000, with about 6000 deaths per year.[17] Through a review of the literature, our group found that coal dust, crystalline silica and noise pollution were common causes of health problems for workers in underground mines.[18] And, exposure to coal mine dust is a significant cause of pneumoconiosis in coal miners.[19] In addition, according to the China Public Health Data Centre, the top five provinces in China for human brucellosis incidence are Inner Mongolia, Xinjiang, Ningxia, Shanxi and Heilongjiang, with Xinjiang coming in second.[20] As one of China's most important farming provinces, Xinjiang has a large population of workers in the farming and supporting industries who are highly susceptible to the disease. In addition, asbestos is one of the major occupational hazards in the daily work of workers in the construction and automotive industries[21] and China is the world's largest consumer and second largest producer of asbestos[22] . Therefore, factors such as coal dust and silica dust were selected as occupational hazards in this survey. Furthermore, the results of Siegrist and Dragano[23] showed that high work pressure not only doubles the risk of cardiovascular disease, but is also associated with an increased risk of depression. Although the Chinese government has promulgated the 'Mining Safety Law of the People's Republic of China', which systematically regulates the working conditions and organisational arrangements of underground coal mines, various occupational risk factors and work pressures still have a large number of impacts on the physical and mental health of factory workers and miners and receive less social attention.

Regarding the research on job burn-out in occupational health, a large number of research studies have mainly focused on medical workers, teachers and police[24–26]; there has been less research on factory workers and miners, and these few studies related to miners have mainly focused on the relationship between occupational hazards and occupational diseases.[27–29] A study was conducted to examine the relationship between job stress and career burn-out and hypertension in coal miners, with a total population of 1334 people surveyed.[30] However, the study's influencing factors did not include occupational risk factors present in the miners' work environment such as noise and coal dust. Therefore, it is urgent to conduct further research on job burn-out among factory workers and miners and its influencing factors. This study eliminated the demographic biases of participants by propensity score-matched analysis (PSA), and then explored the influence of occupational hazards and occupational stress on job burn-out in factory workers and miners, to provide a scientific basis for the prevention and control of job burn-out in factory workers and miners.

MATERIALS AND METHODS

Calculation of sample size for cross-sectional studies

The sample size formula for the present illness rate survey, $n = \frac{z^2_{\alpha/2} \times pq}{\delta^2}$, p is the present-hazard rate, q=1 p, δ is the tolerance error, generally taken as 0.1 p, $z_{\alpha/2}$ is the significance test statistic, $z_{\alpha/2}$ =1.96 for α=0.05, then the formula is calculated as, $n = 400 \times \frac{q}{p}$. A study using stratified whole group sampling of 1325 employees from 6 coal mining companies, with an overall burn-out rate of 90%.[31] And a study that surveyed 1334 people between March and December 2018 showed that the burn-out rate among coal miners was 52.7%.[30] In this study, we assumed a 50% prevalence of job burn-out to obtain the maximum required sample size. which would calculate a sample size of 400, taking into account non-response and a 20% loss of questionnaires, which would require approximately 500 people.

Participants

Participants in this cross-sectional survey were workers from factories and mines in the Urumqi region, and the survey covered all districts and counties in the Urumqi region. This survey was conducted by means of whole-group random sampling from January to May 2019, and a total of 202 enterprises were selected, including 21 in Tianshan district, 30 in Shaibak district, 24 in Xinshi district, 22 in Shuimogou district, 56 in Jingkai District, 37 in Midong district, 9 enterprises in Dabancheng District and 3 enterprises in Urumqi County. All participants understood the purpose of this study and participated voluntarily. The inclusion criteria were as follows: (1) workers working in mining enterprises and factories in Urumqi; (2) workers with a history of working for more than 1 year and (3) Workers with no history of mental illness and no history of taking psychotropic drugs. A total of 7500 anonymous questionnaires were distributed and 7315 were collected by trained staff, with a recovery rate of 97.5%. After investigation of the validity of the questionnaire, 7118 valid questionnaires were finally confirmed, with an effective rate of 97.3%.

Research methods

General investigation

In this study, the general survey included basic information such as gender, race, age, marital status, education level and work information such as job title, labour contract, work schedule, monthly income, working years and others. Occupational exposure factors included coal dust, silicon dust, asbestos dust, benzene, lead, noise and *Brucella* infection.

Job burn-out investigation

The job burn-out of factory miners was investigated using the Chinese Maslach Burnout Inventory (CMBI) revised by Li *et al*, which has been shown to have good reliability and validity by many researchers.[32] The CMBI has a total of 15 items on 3 dimensions: EE, depersonalisation and reduced PA. The score for each item is seven points, ranging from 1 (never) to 7 (every day). Job burn-out was divided into four levels: no burn-out (all three dimensions are below the critical value), mild burn-out (one dimension is equal to or higher than the critical value), moderate burn-out (two of the dimensions are equal to or higher than the critical value) and severe burn-out (all three dimensions are equal to or higher than the critical value) according to the critical value of each dimension: EE 25, cynicism 11 and reduced PA 16.[33] In this study, the Cronbach α of the CMBI was 0.89, the split-half reliability coefficient was 0.86, and KMO was 0.919.

Occupational stress investigation

This survey evaluated occupational stress in factory workers and miners through the Effort–Reward Imbalance (ERI) model[34] developed by Siegrist. The ERI consists of three subscales: effort (E, 6 items), reward (R, 11 items) and over commitment (6 items). A Likert five-level scoring method (1, 'highly disagree' to 5, 'highly agree') was used to score the items in the questionnaire with the same weight for each item. The Effort–Return Index, ERI=E/R×C, where C is the adjustment coefficient, and the value was 6/11. ERI values greater than 1, equal to 1 and less than 1 correspond to high pay–low return, pay–return balance and low pay–high return, respectively. Moreover, the higher the ERI value, the greater the occupational stress.[35]

Quality control

In this study, the Questionnaire Star, a questionnaire platform, was used to form a two-dimensional code to allow the participants to answer the questionnaire and to collect the electronic questionnaires. The Questionnaire Star software, which allowed participants to use their smartphones to answer on site, making it easier and faster to operate than the paper version of the questionnaire, and the respondents are more compliant. Therefore, we used an electronic questionnaire to conduct the survey. During the survey, the trained investigators showed the QR code to the participants and gave operation guidance on site. Before the experiment, we conducted a presurvey to ensure the validity of the questionnaire, explaining the purpose of the study to all participants, and all participants signed the informed consent form. Invalid questionnaires were excluded.

Statistical methods

R (V.3.5.2) was used for statistical analysis. The balance of confounding factors was evaluated through PSA. The χ^2 test and Student's t-test were used for the counting data. Multiple logistic regression was used for multivariate analysis, and the significance level (α) was set to 0.05.

Patient and public involvement

Neither patients nor members of the public had any involvement in the design of this study.

RESULTS

General demographic characteristics of factory workers and miners

Among the 7118 voluntarily participating factory workers and miners, more than half (65.3%) were male, 57.3% were over 35 years old and 78.3% were married. It could be seen that factory workers and miners were generally older, and most of them had spouses. Most of the factory workers and miners had completed high school education (83.9%), while a small percentage had completed undergraduate education (23.0%). The working duration of the miners showed that 45.4% of the workers had worked for more than 10 years, and 20.2% had worked for 25–30 years. There were 2854 factory workers and miners without professional titles, accounting for 40.1% and factory workers and miners with professional titles accounted for 59.9%, of which 1002 had senior professional titles, accounting for 14.1%. Participants who were exposed to coal dust, silica dust, asbestos dust, benzene, lead, noise and *Brucella* accounted for 1548 (21.8%), 730 (10.3%), 981 (13.8%), 1981 (27.8%), 373 (5.2%), 4942 (69.4%) and 121 (1.7%), respectively (table 1).

Table 1 Characteristics of factory workers and miners

Items	Groups	Case number	%
Sex	Male	4669	65.3
	Female	2469	34.7
Ethnicity	Han	5762	81.0
	Other	1356	19.1
Education level	high school and below	1143	16.1
	High school	1406	19.8
	Junior college	2933	41.2
	Bachelor's degree or above	1636	23.0
Labour contracts	Signed	6641	93.3
	Unsigned	477	6.7
Professional title	None	2854	40.1
	Primary	1644	23.1
	Middle	1618	22.7
	Senior	1002	14.1
Work schedule	Day shift	3986	56.0
	Night shift	270	3.8
	Day or/and night shift	2058	28.9
	Day and night continuously shift	804	11.3
Marital status	Unmarried	1104	15.5
	Married	5575	78.3
	Divorced	390	5.5
	Widowed	49	0.7
Monthly income (yuan)	<3000	1799	25.8
	3000	2418	34.0
	4000	1600	22.5
	5000	752	10.6
	6000	288	4.1
	7000	148	2.1
	8000	113	1.6
Chronic disease	Diabetes	429	6.0
	Hypertension	6689	94.0
Age (years)	<25	431	6.1
	25	786	11.0
	30	956	13.4
	35	866	12.2
	40	849	11.9
	45	3230	45.4
Working years (years)	<5	1170	16.4
	5	1065	15.0
	10	997	14.0
	15	389	5.5
	20	763	10.7
	25	1293	18.2
	30	1441	20.2

Continued

Table 1 Continued

Items	Groups	Case number	%
Working hours per day (hours)	≤7	1161	16.3
	>7	5957	83.7
Working days per week (days)	≤5	4442	62.4
	>5	2676	37.6
Occupational hazards	Coal dust	1548	21.8
	Silica dust	730	10.3
	Asbestos dust	981	13.8
	Benzene	1981	27.8
	Lead	373	5.2
	Noise	4942	69.4
	Brucellosis	121	1.7

Job burn-out and occupational stress of factory workers and miners

In terms of job burn-out, the frequencies of the responses, no, mild, moderate and severe were 959 (13.5%), 2667 (37.5%), 2900 (40.7%) and 592 (8.3%), respectively. Regarding occupational stress, the numbers and proportions of individuals with and without symptoms of occupational stress were 3971 (55.8%) and 3147 (44.2%), respectively (table 2).

Propensity score-matched analysis

As shown in table 1, among the 7118 participants, 6159 participants suffered from job burn-out problems, while the other 959 had no job burn-out. The PSA was used to minimise the following demographic confounding factors with a calliper value of 0. 02 and a random seed of 1. A total of 13 general demographic characteristics were set as confounding factors, including gender, marital status, professional title, work schedule and race. Finally, 955 pairs of factory workers and miners with similar demographic indicators according to PSA were matched (table 3).

Multiple logistic regression analysis was used to compare the factors related to job burn-out before and after PSA, with job burn-out as the dependent variable and general

Table 2 Occupational burn-out and occupational stress of factory workers and miners

Items	Groups	Case no	%
CMBI	No	959	13.5
	Mild	2667	37.5
	Moderate	2900	40.7
	Severe	592	8.3
ERI	–	3971	55.8
	+	3147	44.2

CMBI, Chinese Maslach Burnout Inventory; ERI, Effort–Reward Imbalance.

Table 3 Participants before and after matching

Items	Control group	Positive group
Before matching	959	6159
After matching	955	955
Unmatched	4	5204
Discarded	0	0

demographic characteristics as the independent variables. Before pairing, there were significant differences in education level, work arrangement, monthly income, labour contract, daily working hours and weekly working days ($p<0.05$). After PSA, there was no significant difference in other general demographic characteristics except ethnicity, professional title and working years ($p<0.05$) (table 4).

Multiple logistic regression analysis of the impact of occupational stress and occupational exposure factors on job burn-out

Table 5 shows that, among the occupational hazards, noise (OR 1.34, 95% CI 1.09 to 1.64) and ERI (OR 2.16, 95% CI 1.78 to 2.61) were significantly associated with job burn-out among factory workers and miners ($p<0.05$).

Analysis of the impact of occupational stress and noise on the three dimensions of job burn-out

The three dimensions of job burn-out are EE, depersonalisation and reduced PA. EE refers to the state of mental fatigue, which mainly represents the dimension of psychological feeling; depersonalisation refers to a negative attitude towards work and indifference towards others, which mainly represents the dimension of interpersonal relationships; reduced PA refers to negation and dissatisfaction with one's own work achievement, which mainly represents the dimension of self-evaluation. The results showed that exposure to noise had a significant effect on EE and depersonalisation ($p<0.001$); whether or not an individual suffered from occupational stress had a marked effect on EE and depersonalisation ($p<0.001$) (table 6).

DISCUSSION

With the rapid development of society and the accelerated pace of life, people who are more eager to obtain social and economic status through their own labour inevitably have to face pressure from their families, work and society. However, these pressures from various aspects have a dual effect. Moderate occupational pressure is conducive to improving work efficiency and increasing passion for work, but long-term excessive occupational pressure will have substantial adverse effects on the mental and physical health of workers.[33] A large number of countries suffer greatly from the impact of job burn-out. It has been estimated that the treatment of occupational stress-related diseases in the USA costs US$500–US$1000 billion per year. The International Labour Organization estimated that the annual economic loss caused by occupational stress was about US$300 billion.[36 37] Factory workers and miners are one of the most seriously affected by job burn-out. Therefore, this study to investigate and further explore the factors influencing job burn-out in factory workers and miners in Urumqi was urgently required.

This survey was conducted by means of whole-group random sampling from January to May 2019, and a total of 202 enterprises were selected. The response rate (recovery rate) of 97.5% for this study was very high, which is related to the thorough preparation of our subject group's preliminary work. First, our group maintained long-term cooperation with the relevant factories and mines for research and has made prior contact with the relevant person in charge, who was accompanied by the person in charge to participate in the survey and research. Second, the survey was conducted by trained surveyors who explained to all volunteers the purpose, meaning, content and requirements of the questionnaire. The requirements included criteria 2 and 3 in section 2.2, which required workers who had worked in coal mines and factories for more than 1 year and those who had no history of taking psychotropic substances to scan the QR code and complete the electronic questionnaire. Moreover, surveyors were on hand to provide instructions on how to operate the questionnaire to ensure its return rate. Finally, the survey used the Questionnaire Star software, which allowed participants to use their smartphones to answer on site, making it easier and faster to operate than the paper version of the questionnaire, and more obedient to respondents.

In this survey, we found that most factory workers and miners suffered from symptoms of burn-out, and that occupational stress and noise were strongly correlated with burn-out symptoms. In this study, the prevalence of job burn-out was 86.5%. A stratified whole-group sampling method sampled 1325 employees from 6 coal mining companies with an overall burn-out rate of 90%.[31] And, a cross-sectional survey was conducted in Hami, Xinjiang Uyghur Autonomous Region, China, from June 2017 to September 2018. A total of 1400 copper-nickel miners with a burn-out prevalence rate of 80.86%.[38] A study of 1054 oncologists in the Middle East and North Africa found that the prevalence of burn-out was about 68%.[39] It followed that the prevalence of job burn-out among factory workers and miners in Urumqi was higher. In this study, the prevalence of occupational stress was 44.2%. A study of 1334 people surveyed between March and December 2018 showed that 83.0% of coal miners in Xinjiang were experiencing occupational stress.[30] A study that used the ERI scale to measure occupational stress in 457 doctors in 21 hospitals in Shanghai found that the ERI ratio of 64.8% doctors was more than 1.[40] A survey of medical radiation workers in Xinjiang found that 53.1% of medical radiation workers had experienced occupational stress in the recent working period.[31] Apparently, the occupational stress of

Table 4 Comparison of propensity score matching for occupational burn-out

Items	Groups	Before (n=7118)					After (N=1910)				
			CMBI					CMBI			
		N	–	+	χ^2	P value	N	–	+	χ^2	P value
Sex	Male	4649	600	4049	3.556	0.059	1183	598	585	0.320	0.572
	Female	2469	359	2110			727	357	370		
Ethnicity	Han	5762	777	4985	0	0.986	1511	774	737	4.106	0.043
	Other	1356	182	1174			399	181	218		
Education level	Junior high school and below	1143	86	1057	64.663	<0.001	176	86	90	0.986	0.805
	High school	1406	165	1241			318	165	153		
	Junior college	2933	419	2514			829	418	411		
	Bachelor's degree or above	1636	289	1347			587	286	301		
Labour contracts	Signed	447	32	445	19.450	<0.001	63	32	31	0	1.000
	Unsigned	6641	927	5714			1847	923	924		
Professional title	No	2854	373	2481	4.645	0.200	690	373	317	11.307	0.010
	Primary	1644	212	1432			451	212	239		
	Middle	1618	218	1400			473	214	259		
	Senior	1002	156	846			296	156	140		
Work schedule	Day shift	3986	610	3376	29.481	<0.001	1197	606	591	2.606	0.457
	Night shift	270	22	248			55	22	33		
	Day or/and night shift	2058	244	1814			486	244	242		
	Day and night continuously shift	804	83	721			172	83	89		
Marital status	Unmarried	1104	142	962	1.680	0.641	290	142	148	3.832	0.280
	Married	5575	759	4816			1486	755	731		
	Divorced	390	54	336			121	54	67		
	Widowed	49	4	45			13	4	9		
Monthly income (yuan)	<3000	1799	227	1572	17.373	0.008	441	227	214	2.130	0.907
	3000	2418	301	2117			612	301	311		
	4000	1600	213	1387			439	213	226		
	5000	752	134	618			253	134	119		
	6000	288	46	242			93	46	47		
	7000	148	21	127			39	19	20		
	8000	113	17	96			33	15	18		
Age (years)	<25	431	49	382	3.633	0.603	91	49	42	7.874	0.163
	25	786	114	672			215	114	101		
	30	956	122	834			282	121	161		
	35	866	125	741			257	125	132		
	40	849	118	731			230	118	112		
	45	3230	431	2799			835	428	407		
Working years	<5	1170	157	1013	9.031	0.172	285	157	128	28.005	<0.001
	5	1065	132	933			288	131	157		
	10	1057	117	880			261	117	144		
	15	389	58	331			108	58	50		

Continued

Table 4 Continued

Items	Groups	Before (n=7118)					After (N=1910)				
			CMBI					CMBI			
		N	–	+	χ^2	P value	N	–	+	χ^2	P value
	20	763	102	661			231	100	131		
	25	1293	171	1122			312	171	195		
	30	1441	222	1219			371	221	150		
Working hours per day (hours)	≤7	1161	183	978	6.005	0.014	351	183	168	0.684	0.408
	>7	5957	776	5181			1559	772	787		
Working days per week (days)	≤5	4442	660	3782	19.135	<0.001	1291	656	635	0.956	0.328
	>5	2676	299	2377			619	299	320		

A p<0.05 indicates a statistical difference among groups, and the smaller the p value is, the more significant statistical difference.
CMBI, Chinese Maslach Burnout Inventory; ERI, Effort–Reward Imbalance.

factory workers and miners in Urumqi was lower than that in these other samples.

In terms of occupational hazard factors, our study found that noise was significantly correlated with job burn-out; on multiple logistic regression analysis, the risk of job burn-out increased by 1.34 times due to exposure to noise. Our result agrees with another research. The study of Sjödin *et al*[41] showed that employees exposed to noise levels higher than 71 dBA in the workplace were more likely to suffer from burn-out. Moreover, some studies have demonstrated that excessive noise levels may increase irritability, anxiety and fatigue among medical staff, and then lead to the occurrence of burn-out syndrome.[42] Regarding occupational stress, this study used multiple logistic regression analysis to show that occupational stress was significantly correlated with job burn-out and factory workers and miners with occupational stress were prone to suffer from job burn-out. The result of our study was consistent with those of previous studies[43] in which burn-out in doctors was positively correlated with the level of occupational stress, and negatively associated with job satisfaction. In addition, in a cross-sectional study from Taipei, 180 lawyers from 26 law firms were surveyed and found that high occupational stress was associated with high levels of personal and work-related burn-out among lawyers.[44]

In our study, we found that the incidence of job burn-out among workers exposed to noise and with symptoms of occupational stress was higher than that in workers without exposure to noise and without symptoms of occupational stress. In addition, the difference was observed in aspects of both the EE and depersonalisation dimensions. The job burn-out of factory workers and miners in this survey was assessed using the China Job Burnout Inventory (CMBI) revised by Li.[34] In the CMBI, EE, depersonalisation and reduced PA are representative

Table 5 Effects of occupational hazards and mental health on the occupational burn-out of factory workers and miners according to the multiple logistic regression analysis

Variable	β (95% CI)	SE	Standard β	OR (95% CI)	VIF	Wald	P value
Intercept	−0.53 (−0.72 to 0.35)	0.09	–	0.59 (0.49 to 0.70)	–	−5.748	<0.001
Coal dust	0.08 (−0.40 to 0.57)	0.25	0.03	1.08 (0.67 to 1.77)	1.02	0.332	0.740
Silica dust	0.35 (−0.01 to 0.72)	0.19	0.19	1.42 (0.99 to 2.06)	1.08	1.897	0.058
Asbestos dust	0.04 (−0.27 to 0.35)	0.16	0.03	1.04 (0.77 to 1.41)	1.21	0.257	0.797
Benzene	−0.06 (−0.28 to 0.16)	0.11	−0.05	0.94 (0.75 to 1.18)	1.14	−0.518	0.605
Lead	0.16 (−0.31 to 0.63)	0.24	0.07	1.17 (0.73 to 1.89)	1.14	0.660	0.509
Noise	0.29 (0.09 to 0.49)	0.10	0.27	1.34 (1.09 to 1.64)	1.05	2.781	0.005
Brucellosis	0.33 (−0.40 to 1.06)	0.37	0.09	1.39 (0.67 to 2.89)	1.05	0.894	0.371
ERI	0.77 (0.58 to 0.96)	0.10	0.75	2.16 (1.78 to 2.61)	1.03	7.864	<0.001

A p<0.05 indicates a statistical difference among groups, and the smaller the p value is, the more significant statistical difference. β regression coefficient of logistics, Wald probability value of Wald statistic,

ERI, Effort–Reward Imbalance.

Table 6 Comparison of three dimensions of occupational burn-out among occupational stress and noise after PSA

	Dimension of burn-out		
Item	Emotional exhaustion	Cynicism	Reduced personal accomplishment
Noise			
− (n=1327)	14.56±6.58	9.08±3.99	16.37±7.50
+ (n=583)	17.46±6.90	10.83±4.93	16.19±6.04
t	−8.73	−8.19	0.52
P value	< 0.001	< 0.001	0.60
ERI			
− (n=1159)	14.32±6.24	9.45±4.39	16.05±7.06
+ (n=751)	20.06±6.50	11.62±4.93	16.54±5.58
t	−19.17	−9.80	−1.68
P value	< 0.001	< 0.001	0.090

A p<0.05 indicates a statistical difference among groups, and the smaller the p value is, the more significant statistical difference.
ERI, Effort–Reward Imbalance; PSA, propensity score-matched analysis.

of the dimensions of psychological feelings, interpersonal relationships and self-evaluation related to job burn-out. It has been shown that the development of job burn-out is a long process; it is a syndrome caused by long-term pressure in the workplace. The mental burden level of factory workers and miners has been shown to be 8.3, which was one of the heaviest mental burdens among 150 occupations.[30] This explains why factory workers and miners suffered from a high level of job burn-out in this study, which makes the prevention and treatment of job burn-out particularly important. The results of our study can help managers of coal mines to deepen their understanding of the symptoms of job burn-out and formulate effective intervention measures for the prevention and treatment of job burn-out among factory workers and miners.

According to the NIOSH hierarchy of controls, the five levels from top to bottom are Elimination, Substitution, Engineering Controls, Administrative Controls, Personal Protective Equipment (PPE). The controls at the top of the graphic may be more effective and protective than the controls at the bottom.[45] With regard to noise, first, we would like to eliminate the impact of noise on workers, but since factory workers and miners are in a specific working environment, we recommend that company managers eliminate as much of the danger at source as possible by improving and replacing equipment. These measures require time and a significant financial investment, so we believe that the current approach to controlling the impact of noise on factory workers and miners can be achieved through personal protective equipment and the strengthening of administrative controls, such as pre-employment training, teaching workers to wear ear plugs or ear muffs correctly, and administrative measures, such as laws and codes to regulate noise levels in the workplace. With regard to job stress, studies have shown that effective organisational interventions, such as flexible working arrangements, improved communication and job redesign, can be an effective way to reduce stress in the workplace.[46] In addition, a study on dentists found that job stress was associated with income.[47] Therefore, we encourage managers to provide good working conditions for workers and to find a balance between workers' contributions and rewards by increasing workers' compensation while they bring profits to the business. In addition, we recommend a number of additional physical activity interventions. In a randomised cross-over trial of nurses, researchers found that yoga was effective in reducing occupational stress among female night shift nurses.[48] And a systematic review that included 18 experiments in the study suggests that yoga and qigong may be an effective way to reduce stress among medical staff and could be incorporated into health promotion efforts in the health sector.[49] Therefore, we recommend organising fitness activities after work, such as yoga training for factory workers and miners, which not only relaxes the body and mind, but also relieves the stress generated by work. In conclusion, noise, an occupational hazard and occupational stress were the factors influencing occupational burn-out among factory workers and miners in this survey. We should control the impact of occupational hazards on factory workers and miners and reduce occupational stress to alleviate workers' job burn-out.

Our study has certain limitations. First, a cross-sectional study cannot identify causal relationships among occupational hazards, occupational stress and job burn-out in factory workers and miners. In the future, intervention studies can be conducted enabling us to determine whether controlling occupational hazards and alleviating occupational stress will reduce job burn-out among factory workers and miners. Second, we used electronic questionnaires as the only source of data collection, which may have influenced the results of the research. Therefore, further research should refer to other supplementary information to collect information (in-depth interviews, observations, etc) to verify the results of our research. Third, occupational exposure factors are examined separately. However, there might be exposure to more than one factor in one individual.

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