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Association of psychological symptoms with job burnout and occupational stress among coal miners in Xinjiang, China: A cross-sectional study

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Objective: The study aimed to investigate the influencing factors of psychological symptoms in relation to job burnout and occupational stress among coal miners in Xinjiang, so as to provide data support for enterprises in an effort to help them identify internal psychological risk factors and improve the mental health of coal miners.

Methods: A cross-sectional study was carried out. A total of 12 coal mines were selected using the stratified cluster random sampling method and 4,109 coal miners were investigated by means of online electronic questionnaires. The Symptoms Check List-90 (SCL-90), Chinese Maslach Burnout Inventory (CMBI), and Job Demand-Control (JDC) model were respectively used to measure the status of psychological symptoms, job burnout, and occupational stress among coal miners. The mediation analysis was performed through structural equation modeling (SEM) by using Analysis of Moment Structure (AMOS).

Results: The prevalence of psychological symptoms was higher in the occupational stress group than in the non-occupational stress group, and increased with job burnout ($P < 0.05$). The multivariate logistic regression analysis results showed that mild ($OR = 1.401$, 95% $CL: 1.165, 1.685$), moderate ($OR = 2.190$, 95% $CL: 1.795, 2.672$), or severe levels of burnout ($OR = 6.102$, 95% $CL: 3.481, 10.694$) and occupational stress ($OR = 1.462$, 95% $CL: 1.272, 1.679$) were risk factors for psychological symptoms in coal miners. The results of structural equation modeling indicated that occupational stress ($\beta = 0.11$, $P = 0.002$) and job burnout ($\beta = 0.46$, $P = 0.002$) had significant positive direct effects on psychological symptoms, and job burnout was an intermediate variable between occupational stress and psychological symptoms.

Conclusion: High levels of job burnout and occupational stress were risk factors for psychological symptoms. Both occupational stress and job burnout had direct effects on psychological symptoms, and occupational stress could also have an indirect effect on coal miners' psychological symptoms through the intermediate variable of job burnout.

KEYWORDS

psychological symptoms (PS), job burnout, occupational stress, relationship, coal miners

Introduction

Psychological disorders posed a serious health problem for the current occupational population (1). The global cost of Psychological disorders is projected to reach US\$ 16.3 million by 2030, meaning that these disorders are a major global disease burden (2). The relationship between psychological health and adverse events has been consistently demonstrated. Numerous studies have shown that psychological health were associated with hypertension (3), musculoskeletal disorders (4), and chronic diseases, as well as the occurrence of absenteeism and suicide (5). There was a positive correlation between psychological health and good work outcomes (6).

Psychological disorders were potential factors affecting the quality of life and safe production. Among several self-reported psychopathological assessment tools, the SCL-90 was a popular screening scale for psychopathological testing in clinical populations and was also becoming an established measure of psychiatric symptoms in the general population. The SCL-90 includes an extensive range of psychiatric symptoms from cognition to activity based on factor analysis and can screen for individuals who may have psychiatric symptoms and the type of symptoms (7). The SCL-90 has been the most used instrument to evaluate the psychological health status of Chinese coal miners (8). The occurrence of psychological disorders have been related to a variety of influencing factors, such as the socio-demographic characteristics (e.g., socioeconomic status), occupational characteristics (e.g., work environment, job demands, and control), occupational stress, and job burnout (9, 10). Male general practitioners had poorer mental health than their female counterparts, and middle-aged males were more likely to experience job burnout and psychological disorders (11). Complicated interpersonal relationships, higher job demands, lower job control, and role ambiguity were identified as the main predictors of poor psychological health (12). Studies have also shown that a comprehensive and orderly work environment (13), work rewards, and social support could improve the psychological health level of occupational groups, reducing the risk of psychological disorders (14, 15).

Job burnout was an occupational psychological syndrome that affects safe production (16). The structural theory model was the most widely applied theoretical approach in explaining burnout. The structural theory model viewed burnout as a response to excessive occupational strain, which prompted workers to adopt a series of coping strategies when initially adopted coping strategy failed, which would lead to emotional exhaustion, depersonalization, and reduced fulfillment, which in turn harmed individual and organizational health (17). Job burnout occurred in response to factors such as excessive working hours (18), high job demands, and lower job control (19). Studies have shown that high levels of job burnout were prevalent among nurses (20), psychiatrists (21), and police staff (22), and job burnout was a significant predictor of mortality

in the occupational population under 45 years of age (23), and cardiovascular diseases (24). Job burnout contributed to the development of certain mental disorders such as anxiety and depression (23, 25), which has also been identified as an important factor affecting the safety of coal miners (16). Therefore, early identification of symptoms is critical in the work environment, and effective intervention measures should be taken to reduce occupational exhaustion, minimize sources of occupational stress, and prevent the occurrence of depression and anxiety (26).

Occupational stress was a persistent health-impairing physiological and psychological reaction caused by workers' prolonged employment in jobs characterized by high work demands and low work control (27). The JDC model was a widely applied theoretical model of occupational stress that explained the relationship between workers' health and the work environment. The JDC model considered that job demands caused stress and that workers' degree of job control and social support could moderate (or enhance) this stress (28). Heavy workload, long working hours, lower incomes and a poor working environment have been identified as the main reasons giving rise to occupational stress (29). Occupational stress was also positively correlated with the level of criticality, threat, and challenges present in the work environment (30). Occupational stress has persistent negative effects on health with increasing age (31). Associations between occupational stress and coronary heart disease, sleep disturbance (32), negative work performance (33), and suicidal ideation (34) have been reported. Some studies have also shown that long-term high levels of occupational stress may increase the risk of psychological disorders (35), and the relationship between them is a current research hotspot (36).

Cerebrovascular diseases, musculoskeletal diseases, and psychological health problems among coal miners are becoming more prominent as a result of special working environments and occupational stress (37). Psychological health status among coal miners was associated with specific demographic and job characteristics (38). Although coal mining has been automated and mechanized, the working environment of coal miners remains poor (39). These workers were not only exposed to dust and other toxic and harmful chemicals (40), but are also at risk of life-threatening injuries as a result of spontaneous coal combustion (41) and coal mine accidents (39), all of which contribute to occupational stress and job burnout among coal miners.

Previous research often ignored psychological health issues in the study of coal miners' health and the safety of their work environment, even less research has been done on job burnout and psychological health among coal miners, the mediation effect of burnout in occupational stress and psychological symptoms among coal miners in Xinjiang is still a blank. Therefore, this study investigated the psychological health status of coal miners in Xinjiang through a large sample size of data, aimed to explore the relationship between occupational

stress, job burnout, and psychological symptoms, and analyze the mediation effect of burnout in occupational stress and psychological symptoms of coal miners. At the same time, this paper lays a foundation for improving the working environment of coal miners, enhancing safety behavior, and promoting coal mine safety production, and also provides data support for enterprises to actively identify internal psychological risk factors.

Methods

Participants

This cross-sectional study was conducted from March 2021 to February 2022, and a total of 4,500 coal miners were initially selected by a stratified cluster random sampling method. Our study was conducted with the assistance of the management of coal mines and department managers. Based on the annual output of state-owned coal mines in Xinjiang, the state-owned coal mines in Xinjiang were divided into three categories as follows: small (annual output of fewer than 300,000 tons), medium (300,000–1.2 million tons), and large (1.2–3 million tons). Then, four coal mines were randomly selected from each coal mine category (12 in total), and all of the coal miners from the selected 12 coal mines were taken as the research subjects. Inclusion criteria: (1) all of the coal miners were regular employees who work in the front line of the coal mines and were registered in the coal mining company (excluding administrative managers and logisticians). (2) those who were 18–60 years old and had been employed as a miner for more than 1 year. Exclusion criteria: (1) miners with a history of mental illness. (2) those who did not agree to participate in the questionnaire. (3) questionnaires that were completed in an excessively short amount of time or had more than 20% missing data were excluded, the time taken by the participants to complete the electronic questionnaire could be seen in the background program. 4,261 coal miners who understood the purpose of this study and agreed to participate in the questionnaire.

Finally, a total of 152 questionnaires were excluded as they did not meet the requirements and were incomplete, 4,109 valid questionnaires were retrieved, with an effective recovery rate of 91.31%. According to the sample size calculation formula for cross-sectional study, $N = Z_{\alpha}^2 \times pq/d^2$: N , Sample size; Z_{α} , statistics for significance test, $Z_{\alpha} = 1.96$ (significance level $\alpha = 0.05$); p , expected current prevalence, $p = 37.8\%$ (42), $q = 1-p$; d , tolerable error, $d = 0.1p$; the calculation gives $N = 632$. Taking into account the stratification factor in the sampling method and the questionnaire response rate, we expanded the sample size to three times, $N = 1,896$, our sample size was within the requirements. All participants volunteered to participate in the investigation and provided their written informed consent. This study was approved by the Medical Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University (Approval number: 20170214-174).

Questionnaire content and research methods

In the cross-sectional study, the questionnaire data were collected by means of the online electronic questionnaires, which were administered using the Questionnaire Star Platform. The online electronic questionnaire was mainly composed of four parts: general demographic information, occupational stress measurement, job burnout measurement and mental health measurement. The detailed content corresponding to the questionnaire can be found below.

General information investigation

This study collected general information about the coal miners, such as their gender (male or female), age, working years, educational level (high school or below, college degree or above), marital status (unmarried, married, divorced or widowed), shift assignment (day shift, night shift or shifts work), monthly income (<5,000 Yuan or $\geq 5,000$ Yuan), work environment, smoking (yes or no) and alcohol use (yes or no). Smoking was defined as smoking at least one cigarette per day for more than 1 year, and alcohol use was defined as drinking at least twice a week for more than 1 year (43).

Psychological health investigation

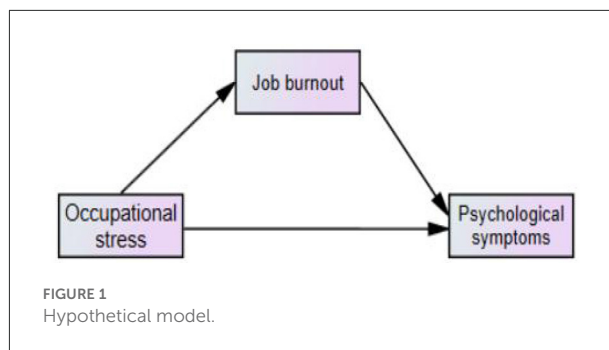
The psychological assessment was carried out using the Chinese version of the Symptoms Check List-90 (SCL-90), which was developed by Derogatis, and was currently recognized as a mental health evaluation scale (4). For the scale in this study, the Cronbach's alpha was 0.986, while the index was 0.987 and the split-half reliability coefficient was 0.94. The scale was scored from 1 to 5 (1 = Not, 2 = Very light, 3 = Medium, 4 = Heavier and 5 = Serious), consisted of 90 items, and contained 10 factors. Each factor did not contain the same number of items; these factors were somatization (12 items), compulsive symptoms (10 items), interpersonal sensitivity (nine items), depression (13 items), anxiety (10 items), hostility (six items), phobia (seven items), paranoia (six items), psychosis (10 items), and another (seven items). Psychological symptoms status was assessed on the basis of the SCL-90 total and factor scores. The SCL-90 total score was the total score of all items of the scale; and a higher total score indicated poorer mental health. The factor score was the total score for each factor divided by the number of entries for that factor. The evaluation criteria for psychological symptoms were a total SCL-90 score ≥ 160 , or any factor score > 2 .

Job burnout investigation

Job burnout was measured by the Chinese Maslach Burnout Inventory (CMBI), which was compiled by Li Yongxin and had good reliability and validity (44). In this study, the Cronbach's alpha was 0.871, while the KMO index was 0.902 and the split-half reliability coefficient was 0.86. The CMBI scale consisted of 15 items, which included three dimensions: emotional exhaustion (five items), depersonalization (five items) and reduced personal accomplishment (five items). The questionnaire was scored according to a seven-point scale (1 = never, 2 = several times a year, 3 = once a month, 4 = several times a month, 5 = once a week, 6 = several times a week, 7 = every day). Items for emotional exhaustion and depersonalization were forward-scored, while items for reduced personal accomplishment were reverse-scored. The score for each dimension was the total score for each item in that dimension. The critical values for emotional exhaustion, depersonalization, and reduced personal accomplishment were 25, 11, and 16, respectively. According to the critical value of the three dimensions, job burnout was divided into four burnout levels, namely zero burnout (the scores of all three dimensions were less than the critical value), mild burnout (the score of one of the three dimensions was greater than or equal to the critical value; the remaining two were below the critical value), moderate burnout (two of the three dimensions scored greater than or equal to the critical value, and the score of the remaining dimension was below the critical value), and severe burnout (the scores of all three dimensions were greater than or equal to the critical value) (24, 44).

Occupational stress investigation

The Job Demand-Control (JDC) model was measured by the Chinese version of the Job Content Questionnaire (JCQ) (45). JDC was proposed by Karasek et al. (46), who suggested that occupational stress occurs when workers are exposed to high psychological demands and low job control. The scale has been widely used to study the relationship between work, health, and the wellbeing of workers. For the scale in this study, Cronbach's alpha was 0.895, the KMO index was 0.906 and the split-half reliability coefficient was 0.72. The scale was scored from 1 to 5 (1 = Disagree entirely, 2 = Disagree, 3 = Agree, 4 = Agree strongly, 5 = Agree entirely), consisted of 16 items, which included three dimensions: job demands (five items), job control (six items) and social support (five items). The score of each dimension was the total score of each dimension item divided by the number of items in each dimension. The JDC ratio = job demand/(job control*C), where constant C = 5/6. According to the JDC ratio, occupational stress was divided into the occupational stress group (JDC > 1) and the non-occupational stress group (JDC ≤ 1) (45).



Structural equation model

Structural equation modeling (SEM) is a validated hypothesis model, which incorporates factor analysis and path analysis to observe the direct and indirect effects of independent variables on dependent variables and is often used extensively in empirical studies to investigate the relationship between variables (47). Common evaluation indexes for SEM are the Comparative Fit Index (CFI), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA), when CFI, GFI, AGFI, TLI are all >0.9 and RMSEA < 0.08 is considered as good model fit (48, 49). Theories were based on the fact that excessive occupational stress was associated with the occurrence of job burnout (17) and mental health (12), and that job burnout also contributed to the prevalence of certain psychological disorders (23, 25), this study established and tested the following hypotheses: occupational stress affects burnout and psychological symptoms, and job burnout has a mediating role in occupational stress and psychological symptoms (Figure 1).

Quality control

In this study, the electronic version of the questionnaire was used to collect information, and the participants completed the relevant information by scanning the two-dimensional code of the questionnaire. Before distributing the electronic questionnaire to the coal miners, we tested and modified the format many times so that the participants could complete the questionnaire easily. Many items in the questionnaire (e.g., age, gender and marital status) replaced the manual inputting of information with multiple-choice questions, which saved the participants time and improved the response rate of the questionnaire. We also set mandatory field items for some options, which meant that the questionnaire could not be submitted if the mandatory field items had not been completed. If the answers to all

of the questions in a questionnaire were the same, this was taken to indicate that the questionnaire may have been completed carelessly. In this event, such questionnaires were discarded.

Statistical analysis

Statistical analyses were performed by SPSS Windows V. 21.0 (SPSS, Inc., Chicago, IL, USA). Data that did not conform to a normal distribution were statistically described by median (*M*) and interquartile range (*Q R*). For non-normally distributed data, the Mann-Whitney *U* test was used for two-group comparisons, and the Kruskal-Wallis *H* test was used for multiple-group comparisons. The chi-square test was used to compare categorical variables, while the Wilcoxon rank sum test and trend chi-square test were used to compare rank categorical variables. Multivariate analysis of the factors influencing psychological symptoms was carried out by binary logistic regression analysis. The relationships between occupational stress, burnout, and psychological symptoms were further analyzed by IBM SPSS AMOS version 23.0, and the optimal structural equation model was fitted. The maximum likelihood estimation (MLE) method was used for the parameter estimation of SEM. The significance level was set at 0.05.

Results

The prevalence of psychological symptoms among different demographic characteristics of coal miners

A total of 4,109 coal miners participated in this study, 3,875 males (2,083 underground workers and 1,792 open-pit workers) and 234 females (all open pit workers). Among 4,109 coal miners, a total of 1,372 tested positive for psychological symptoms, with a positive detection rate of 33.4%. There were statistically significant differences in the prevalence of psychological symptoms between gender, educational level, marital status, shift assignment, monthly income, work environment, and alcohol use ($P < 0.05$). Compared to other groups of coal miners, the prevalence of psychological symptoms was higher among males (33.8%), participants with a college degree education or above (46.1%), divorced or widowed participants (40.9%), participants with a monthly income of <5,000 Yuan, worked in the underground (38.4%) and participants who used alcohol (34.7%), although it was lower among those who worked shifts (30.4%) ($P < 0.05$) (Table 1).

Comparison of SCL-90 dimensions score among different sub-groups

There was a significant difference between males and females in scores on interpersonal sensitivity and another factor ($P < 0.05$). Scores on all dimensions except obsessive-compulsive symptoms, interpersonal sensitivity, and paranoia differed statistically among age groups ($P < 0.05$). Among all dimensions, there were significant differences in education level, shift assignment, and work types groups ($P < 0.001$). Scores for somatization and compulsive symptoms were significantly different between marital status and monthly income groups ($P < 0.05$); the scores for all dimensions were significantly higher in the alcohol use group than in the non-alcohol use group ($P < 0.05$), except for compulsive symptoms and another factor. Statistically significant differences ($P < 0.05$) were found between the different smoking groups for obsessive-compulsive symptoms and interpersonal sensitivity (Table 2).

The association between job burnout and psychological symptoms among coal miners

Among 4,109 coal miners, a total of 3,179 coal miners reported different levels of job burnout in the study, accounting for about 77.4%. Among them, 1,965 (47.8%) had mild levels of burnout, 1,146 (27.9%) had moderate levels of burnout, and 68 reported severe levels of burnout (1.7%). The results of the Wilcoxon rank sum test showed that there was a statistically significant difference in the positive detection rate of psychological symptoms among different job burnout groups of coal miners ($T = -10.49$, $P < 0.001$). The results of the trend chi-square test showed that the positive detection rate of psychological symptoms increased in line with higher burnout levels (Chi-squared value = 116.85, $P < 0.001$), which suggested that there was a relationship between job burnout and psychological symptoms among coal miners (Table 3).

The association between occupational stress and psychological symptoms among coal miners

In this study, a total of 1,564 coal miners reported that they experienced occupational stress, accounting for 38.1%. The chi-squared test showed that compared with the non-occupational stress group of coal miners, the occupational stress group had a higher positive detection rate of psychological symptoms ($\chi^2 = 67.71$, $P < 0.001$), which suggested that there was a relationship between occupational stress and psychological symptoms among the coal miners (Table 4).

TABLE 1 The prevalence of psychological symptoms among different sub-groups ($N = 4,109$).

Index	Groups	Total (N)	Psychological symptoms		Chi-squared value	P -value
			Number	Positive (%)		
Total	4,109	1,372	33.4	-	-	
Gender	Male	3,875	1,308	33.8	4.07	0.025
	Female	234	64	27.4		
Age (years)	≤ 30	676	209	30.9	3.04	0.219
	31–45	1,855	616	33.2		
	≥ 45	1,578	547	34.7		
Educational level	High school or below	3,004	863	28.7	109.15	<0.001
	College degree or above	1,105	509	46.1		
Marital status	Unmarried	501	179	35.7	7.08	0.029
	Married	3,415	1,114	32.6		
	Divorced or widowed	193	79	40.9		
Shift assignment	Day shift	1,258	500	39.7	35.08	<0.001
	Night shift	61	24	39.3		
	shifts work	2,790	848	30.4		
Monthly income (Yuan)	$< 5,000$	759	281	37.0	5.52	0.011
	$\geq 5,000$	3,350	1,091	32.6		
Work environment	Open-pit	1,980	555	28.0	49.36	<0.001
	Underground	2,129	817	38.4		
Type of coal mines	Large	2,175	708	32.6	1.61	0.448
	Medium	1,362	464	34.1		
	Small	572	200	35.0		
Smoking	No	1,671	535	32.0	2.39	0.065
	Yes	2,438	837	34.3		
Alcohol use	No	1,982	633	31.9	3.63	0.031
	Yes	2,127	739	34.7		

The bold values indicate the values of $P < 0.05$.

Multivariate logistic regression analysis of psychological disorder among coal miners

After setting dummy variables for multiple classification factors, multivariate logistic regression analysis was carried out using the forward stepwise method, i.e., the likelihood ratio method. The presence or absence of a psychological disorder was taken as the dependent variable, while the variables shown in Table 1 with statistical significance, as well as job burnout and occupational stress were the independent variables, and a multivariate analysis of psychological symptoms among coal miners was carried out (the variable assignment was shown in Table 5). The results of the multivariate logistic regression analysis showed that male gender ($OR = 1.421$, 95% CL : 1.036, 1.948), college degree education or above ($OR = 1.921$, 95% CL : 1.641, 2.249), worked in the underground ($OR = 1.383$, 95% CL : 1.199, 1.595), mild ($OR = 1.401$, 95% CL : 1.165, 1.685), moderate ($OR = 2.190$, 95% CL : 1.795, 2.672), or severe levels of burnout ($OR = 6.102$, 95% CL : 3.481, 10.694) and occupational stress (OR

$= 1.462$, 95% CL : 1.272, 1.679) were risk factors for psychological symptoms in coal miners. However, being unmarried ($OR = 0.641$, 95% CL : 0.472, 0.871) or married ($OR = 0.656$, 95% CL : 0.459, 0.935), shifts work ($OR = 0.801$, 95% CL : 0.687, 0.934) and monthly income $\geq 5,000$ Yuan ($OR = 0.695$, 95% CL : 0.581, 0.832) were protective factors against psychological symptoms in coal miners (Table 6).

Structural equation model of occupational stress–job burnout–psychological symptoms

Based on the principles of accuracy and simplicity, the model was continuously revised by using AMOS software to obtain the optimal structural equation model of occupational stress–burnout–psychological symptoms (Figure 2). The model fitted well (CFI = 0.973, GFI = 0.945, AGFI = 0.907, TLI = 0.961, RMSEA = 0.078) and the differences were significant statistically

TABLE 2 Comparison of SCL-90 dimensions score among different sub-groups [M (Q R)].

Groups	N	SO	CS	IS	DE	AN	HO	PH	PA	PS	AF
Gender											
Male	3,875	14.0 (9.0)	17.0 (13.0)	13.0 (9.0)	17.0 (12.0)	11.0 (8.0)	7.0 (4.0)	7.0 (3.0)	7.0 (5.0)	12.0 (6.0)	10.0 (4.0)
Female	234	15.0 (9.0)	16.0 (11.0)	11.0 (7.0)	16.0 (10.0)	12.0 (6.0)	7.0 (3.0)	7.0 (3.0)	7.0 (3.0)	11.0 (5.0)	10.0 (6.0)
Z-value		-1.593	-0.763	-2.164	-1.499	-0.164	-0.571	-1.008	-0.773	-0.672	-2.269
P-value		0.111	0.445	0.030	0.134	0.870	0.568	0.314	0.440	0.501	0.023
Educational level											
High school or below	3,004	14.0 (8.0)	16.0 (11.0)	12.0 (8.0)	16.0 (10.0)	11.0 (6.0)	7.0 (3.0)	7.0 (2.0)	7.0 (4.0)	11.0 (5.0)	10.0 (4.0)
College degree or above	1,105	17.0 (11.5)	20.0 (11.5)	15.0 (10.0)	20.0 (15.0)	13.0 (11.0)	8.0 (6.0)	7.0 (6.0)	8.0 (6.0)	13.0 (10.0)	11.0 (6.0)
Z-value		-10.423	-12.218	-11.868	-11.208	-10.524	-10.924	-6.854	-11.664	-10.172	-9.910
P-value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Marital status											
Unmarried	501	14.0 (8.0)	18.0 (13.0)	13.0 (9.0)	16.0 (13.0)	11.0 (8.0)	6.0 (5.0)	7.0 (3.0)	7.0 (5.0)	11.0 (6.5)	10.0 (5.0)
Married	3,415	15.0 (9.0) ^a	17.0 (13.0)	12.0 (9.0)	16.0 (11.0)	12.0 (8.0)	7.0 (4.0)	7.0 (3.0)	7.0 (4.0)	12.0 (6.0)	10.0 (5.0)
Divorced or widowed	193	16.0 (11.0) ^a	20.0 (12.0) ^b	14.0 (11.5) ^b	18.0 (14.0)	12.0 (9.0)	7.0 (5.0)	7.0 (4.0)	8.0 (5.0)	13.0 (8.0)	11.0 (6.0) ^b
Chi-squared value		11.888	8.180	13.157	4.468	2.014	2.010	0.522	4.882	3.826	11.481
P-value		0.003	0.017	0.001	0.107	0.365	0.366	0.770	0.087	0.148	0.003
Shift assignment											
Day shift	1,258	16.0 (10.0)	19.0 (12.0)	14.0 (10.0)	18.0 (13.0)	12.0 (10.0)	8.0 (6.0)	7.0 (4.0)	8.0 (6.0)	12.0 (8.0)	10.0 (5.0)
Night shift	61	15.0 (11.0)	15.0 (14.0)	14.0 (12.0)	17.0 (12.5)	12.0 (9.5)	8.0 (4.0)	7.0 (3.0)	7.0 (4.0)	12.0 (6.5)	10.0 (6.5)
Work shifts	2,790	14.0 (8.0) ^c	16.0 (12.0) ^c	12.0 (9.0) ^c	16.0 (11.0) ^c	11.0 (7.0) ^c	6.0 (4.0) ^c	7.0 (2.0) ^c	7.0 (4.0) ^c	11.0 (6.0) ^c	10.0 (5.0) ^c
Chi-Squared Value		40.838	49.960	46.085	57.120	68.541	69.141	22.076	37.926	44.085	22.178
P-value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Monthly income (Yuan)											
<5,000	759	15.0 (11.0)	18.0 (13.0)	13.0 (10.0)	17.0 (13.0)	12.0 (10.0)	7.0 (5.0)	7.0 (4.0)	7.0 (5.0)	12.0 (8.0)	10.0 (5.0)
≥5,000	3,350	14.0 (8.0)	17.0 (13.0)	13.0 (9.0)	17.0 (12.0)	11.0 (8.0)	7.0 (4.0)	7.0 (3.0)	7.0 (4.0)	12.0 (6.0)	10.0 (5.0)
Z-value		-4.177	-2.472	-0.403	-0.160	-1.845	-0.596	-1.874	-0.556	-2.029	-2.682
P-value		<0.001	0.013	0.687	0.873	0.065	0.551	0.061	0.578	0.043	0.007
Work types											
Open-pit	13.0 (7.0)	16.0 (12.0)	12.0 (8.0)	15.0 (10.0)	11.0 (6.0)	6.0 (3.0)	7.0 (2.0)	7.0 (3.0)	11.0 (4.0)	10.0 (3.0)	
Underground	16.0 (11.0)	18.0 (13.0)	13.0 (10.0)	18.0 (13.0)	13.0 (10.0)	8.0 (6.0)	7.0 (4.0)	8.0 (6.0)	12.0 (8.0)	10.0 (6.0)	
Z-value		-13.746	-4.669	-6.798	-9.682	-11.963	-11.544	-9.335	-8.767	-10.565	-1.078
P-value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Alcohol use											
No	1,982	13.0 (7.0)	17.0 (13.0)	12.0 (9.0)	16.0 (11.0)	11.0 (6.0)	6.0 (3.0)	7.0 (2.0)	7.0 (4.0)	11.0 (5.0)	10.0 (4.0)
Yes	2,127	16.0 (10.0)	17.0 (12.0)	13.0 (9.0)	17.0 (13.0)	12.0 (9.0)	8.0 (5.0)	7.0 (4.0)	7.0 (5.0)	12.0 (8.0)	10.0 (6.0)
Z-value		-11.672	-0.813	-2.807	-6.812	-9.443	-11.166	-8.719	-7.632	-7.946	-1.709
P-value		<0.001	0.416	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.087

SO, Somatization; CS, Compulsive symptoms; IS, Interpersonal sensitivity; DE, Depression; AN, Anxiety; HO, Hostility; PH, Phobia; PA, Paranoia; PS, Psychosis; AF, Another factor.

Compared with the unmarried group, ^a $P < 0.05$; Compared with the married group, ^b $P < 0.05$; Compared with the day shift group, ^c $P < 0.05$. The bold values indicate the values of $P < 0.05$.

($P < 0.001$). The results of structural equation modeling indicated that occupational stress ($\beta = 0.11$, $P = 0.002$) and job burnout ($\beta = 0.46$, $P = 0.002$) had significant positive direct effects on psychological symptoms, and occupational stress had an indirect effect on psychological symptoms through the intermediate variable job burnout, with the mediating effect of $0.20 \times 0.46 = 0.092$, accounting for 47.18% of the total effect.

Discussion

This study showed that higher levels of occupational stress and burnout were associated with increased detection of positive psychological symptoms in coal miners. Poor mental health status is associated with the unsafe behaviors of coal miners and has a predictive effect on the occurrence of coal mine accidents (50). Consequently, this study provides the data support and

intervention direction for coal mine management enterprises to pay attention to the psychological health of coal miners, which is also significant in improving the occupational life quality of coal miners and ensuring the safety production of coal mining enterprises.

The prevalence of psychological disorders is increasing worldwide, and psychological disorders are now a major cause of global disease burden and disability (51). The occurrence of psychological symptoms was affected by many factors, including both the individual demographic and job characteristics of the coal miners (10, 38). This study found significant differences in the positive detection rate of psychological symptoms among different coal miner characteristic groups. These differences depended on the participants' gender, educational level, marital status, shift assignment, monthly income, work environment and alcohol use ($P < 0.05$). The results of logistic regression analysis also showed that these factors were influencing factors for psychological symptoms among coal miners except for alcohol use.

The prevalence of psychological symptoms was higher among males and underground workers than among females and open-pit coal miners, which was probably related to the fact that all the underground workers in this study were males. Studies have shown that, except for healthcare occupations and occupations that necessitate long periods of standing, males (especially middle-aged males) tend to be exposed to hazardous chemicals more often, and are at a higher risk of physical harm and job stress and burnout (52). Underground mining is a highly hazardous activity that provides workers with a narrow

space to move around (53). Other studies have also indicated that underground coal miners, most of whom were males, not only worked in hazardous environments away from family and friends but were also subjected to stressors associated with the work environment, and those challenging conditions increased the risk of psychological symptoms among underground coal miners (40). The prevalence of psychological symptoms was higher among miners with a college degree education or above than among those with a high school education or below. Educational levels can modulate mental health, and higher levels of education may protect people from symptoms of anxiety and depression when they are confronted with adverse events (51). However, the working environment and working characteristics of coal miners were special, and most of the participants had a low level of education. While miners with a higher education held job positions that corresponded to their educational level, miners in leadership positions reported higher levels of occupational stress and job demands, and an interaction was observed between job position and occupational stress in relation to psychological health (54), which may explain the higher incidence of psychological symptoms among coal

TABLE 3 Comparison of psychological symptoms among different job burnout groups.

Job burnout groups	Total N (%)	Psychological symptoms		T-value	P-value
		Number	Positive (%)		
Zero burnout	930 (22.6)	222	23.9	-10.49	< 0.001
Mild burnout	1,965 (47.8)	613	31.2		
Moderate burnout	1,146 (27.9)	489	42.7		
Severe burnout	68 (1.7)	48	70.6		

The bold values indicate the values of $P < 0.05$.

TABLE 4 Comparison of psychological symptoms between different occupational stress groups.

Occupational stress groups	Total N (%)	Psychological symptoms		Chi-squared value	P-value
		Number	Positive (%)		
Non-occupational stress	2,545 (61.9)	729	28.6	67.71	< 0.001
Occupational stress	1,564 (38.1)	643	41.1		

The bold values indicate the values of $P < 0.05$.

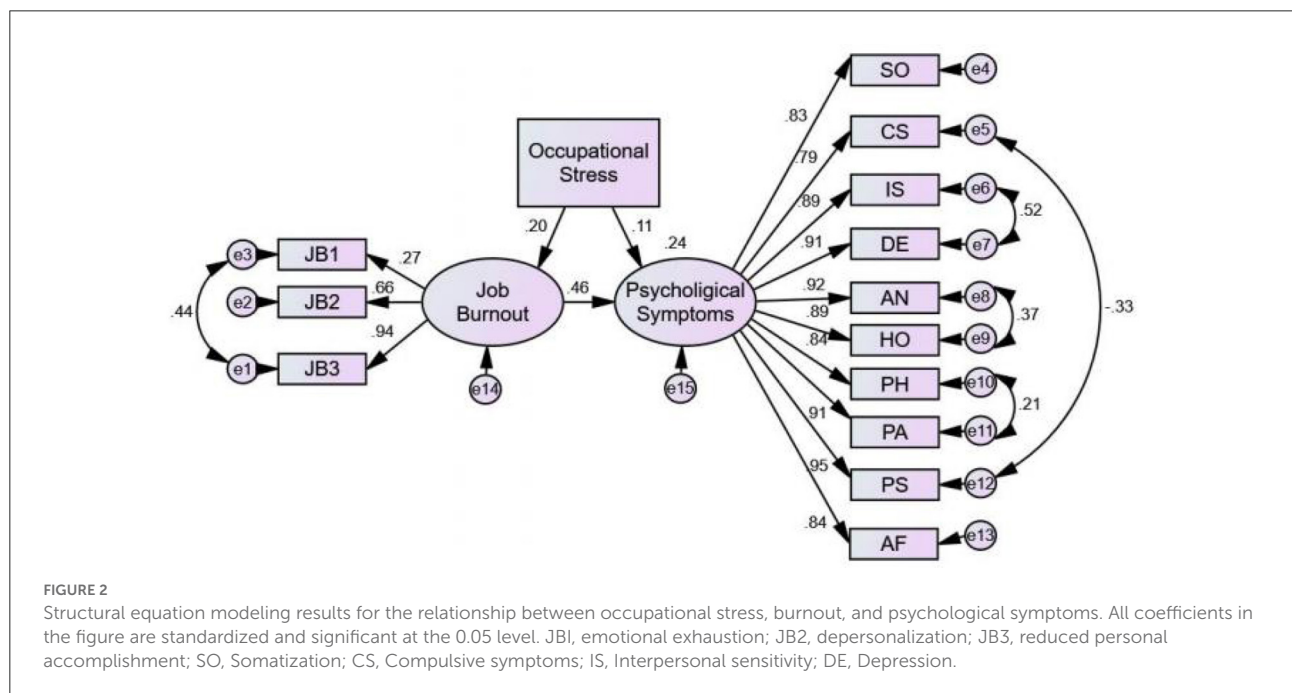
TABLE 5 Variable assignment: Logistic regression analysis.

Variable	Name of variable	Assignment
Y	Psychological symptoms	0 = No, 1 = Yes
X1	Gender	0 = Female, 1 = Male
X2	Educational level	0 = High school or below, 1 = College degree or above
X3	Marital status	0 = Divorced or widowed, 1 = Unmarried, 2 = Married
X4	Shift assignment	0 = Day shift, 1 = Night shift, 2 = Shifts work
X5	Monthly income (Yuan)	0 = <5,000, 1 = \geq 5,000
X6	Work environment	0 = Open-pit, 1 = Underground
X7	Alcohol use	0 = No, 1 = Yes
X8	Job burnout	0 = Zero burnout, 1 = Mild burnout, 2 = Moderate burnout, 3 = Severe burnout
X9	Occupational stress	0 = Non-occupational stress, 1 = Occupational stress

TABLE 6 Multivariate logistic regression analysis of psychological symptoms.

Variable	Comparison group	β	S. E	Wald	P-value	Odds ratio (95%CL)	VIF
Constant		-1.104					
Gender	Female (Ref.)	-	-	-	-	-	1.10
	Male	0.351	0.161	4.76	0.029	1.421 (1.036, 1.948)	
Educational level	High school or below (Ref.)	-	-	-	-	-	1.16
	College degree or above	0.653	0.080	65.83	<0.001	1.921 (1.641, 2.249)	
Marital status	Divorced or widowed (Ref.)	-	-	8.07	0.018	-	1.02
	Unmarried	-0.422	0.181	5.42	0.020	0.656 (0.459, 0.935)	
	Married	-0.444	0.156	8.07	0.005	0.641 (0.472, 0.871)	
Shift assignment	Day shift (Ref.)	-	-	8.82	0.012	-	1.13
	Night shift	0.084	0.282	0.09	0.765	1.088 (0.626, 1.89)	
	Shifts work	-0.222	0.078	8.05	0.005	0.801 (0.687, 0.934)	
Monthly income /Yuan	<5,000 (Ref.)	-	-	-	-	-	1.10
	$\geq 5,000$	-0.364	0.091	15.80	<0.001	0.695 (0.581, 0.832)	
Work environment	Open-pit	-	-	-	-	-	1.10
	Underground	0.324	0.073	19.89	0.000	1.383 (1.199, 1.595)	
Job burnout	Zero burnout (Ref.)	-	-	89.28	<0.001	-	1.04
	Mild burnout	0.337	0.094	12.85	<0.001	1.401 (1.165, 1.685)	
	Moderate burnout	0.784	0.101	59.76	<0.001	2.190 (1.795, 2.672)	
	Severe burnout	1.809	0.286	39.90	<0.001	6.102 (3.481, 10.694)	
Occupational stress	Non-occupational stress (Ref.)	-	-	-	-	-	1.04
	Occupational stress	0.379	0.071	28.81	<0.001	1.462 (1.272, 1.679)	

VIF, Variance Inflation Factor. The bold values indicate the values of $P < 0.05$.



miners with higher education levels than among those with low education levels. In this study, the prevalence of psychological symptoms was higher among those who were divorced or widowed than among those who were married. This finding was consistent with the results of numerous prior studies. Divorce, separation, or widowhood were all associated with an increased risk of alcoholism, anxiety, and depression (55). People with psychological symptoms have lower rates of marriage, and marriage may be a protective factor for mental disorders in the long run (56). A cross-sectional epidemiological survey of 28,140 psychological symptoms involving 31 provinces in China showed that individuals who were separated, widowed, or divorced were 1.87-times more likely to develop psychological symptoms than cohabiting or married individuals (57). The prevalence of psychological symptoms in this study was lower in the work shifts group (excluding night shifts) than in the day shift group. At present, the conclusions on the health effects of shifts work in occupational groups have not been unified. Most cross-sectional studies found a correlation between work shift and chronic disease, decreased fertility, insomnia disorders, and poor mental health (58, 59). However, some longitudinal studies have shown that shift workers (especially males) have better mental health than non-shift workers (60). The inconsistency of these findings may be attributed to cultural differences, and differences in the occupations and shift work trends of the study populations (2). In our study, the prevalence of psychological symptoms was higher among coal miners with a monthly income of <5,000 yuan than among those who earned \geq 5,000 yuan. Studies have shown that a higher prevalence of psychological symptoms was associated with lower socioeconomic status and economic income (1), with lower-income individuals being more likely to experience psychological symptoms and poorer mental health being more prevalent among miners earning <4,000 yuan per month (14). These may be due to their inability to adapt quickly to fast-paced social changes, exposure to severe adverse life events, violence, and risk of poor physical health (61). In this study, the prevalence of psychological symptoms was higher among alcohol users than non-alcohol users. The alcohol use rate among coal miners was high, and higher rates of harmful alcohol use were more pronounced among males, younger age groups and people with psychological symptoms (62).

Among the 4,109 coal miners in the study, 3,179 reported different levels of job burnout (77.4%), the positive detection rate of psychological symptoms increased in line with higher burnout levels. Job burnout played a significant role in anxiety and depression levels in the occupational population, with statistically significant correlations between emotional exhaustion, depersonalization, anxiety, and depression (36). Multivariate results suggest that higher levels of burnout may be risk factors for psychological symptoms in coal miners. That was consistent with the finding that the risk

of psychological symptoms was 2.59 times higher among workers with severe levels of burnout than workers with zero job burnout (63). The results of SEM indicated that job burnout had significantly positive and direct effects on psychological symptoms, and burnout was an intermediate variable between occupational stress and psychological symptoms. Other studies have also shown an association between psychological symptoms and job burnout in factory and mine workers, and that job burnout may also intermediate the relationship between job stress and psychological symptoms (64). Chronic high levels of job burnout can adversely affect the motivation and job satisfaction of coal miners, thereby affecting employee morale in the workforce (65). Job burnout was associated with excessive working hours (18), high job demands, and lower job control and decision-making freedom (19). Minimizing emotional exhaustion, increasing social support, and reducing occupational stressors in occupational work environments will help to prevent depression and anxiety (26).

Among the 4,109 coal miners in the study, 1,564 workers had occupational stress (38.1%), and the detection rate of psychological symptoms in the occupational stress group was higher than that in the non-occupational stress group. The multivariate results showed that occupational stress in coal miners was a risk factor for psychological symptoms, furthermore, the SEM results also indicated that occupational stress had direct and indirect effects on psychological symptoms. This finding demonstrated a close association between the occupational stress of coal miners and psychological symptoms. Studies have also reported that occupational stress was negatively correlated with mental health in occupational populations (64). Occupational stress was identified as an important factor affecting job burnout and depressive symptoms among coal miners in Xinjiang, China (24). Coal mining is characterized as a high-risk occupation, with insufficient organizational support and a lack of job security. The degree of occupational stress was positively correlated with the degree of criticality and threat in the working environment (30), which may explain the high degree of occupational stress among coal miners. The economic resources of coal miners were relatively scarce, the working environment was poor, and work-related negative emotions were strong. When the workers experienced psychological distress, they were usually not proactive in seeking help, which increased their risk of psychological symptoms (66).

Conclusion

The psychological health of coal miners was affected by many factors, and high levels of job burnout and occupational stress were risk factors for psychological symptoms. Both occupational stress and job burnout had direct effects on

psychological symptoms, and occupational stress could also have an indirect effect on coal miners' psychological symptoms through the intermediate variable of burnout. To improve the quality of the occupational lives of the miners and ensure safe production by coal mining enterprises, the relevant and responsible coal mining units should pay attention to monitoring the mental health of the coal miners, alleviate the mental burden of these workers, strive for better worker welfare standards, and strengthen the interaction between miners. Health education and occupational safety training should be carried out regularly to reduce the risk of psychological symptoms among coal miners.

Strengths and study limitations

Our study aimed to explore the association between occupational stress, job burnout, and psychological symptoms through large sample size data and further explored their structural relationship by structural equation modeling, which complemented the research lacuna that occupational stress among coal miners in Xinjiang can affect psychological symptoms through burnout as an intermediate variable. Although our study was a cross-sectional study, we selected the study subjects strictly according to the inclusion and exclusion criteria and used a measurement questionnaire with high reliability and validity, all of which minimized bias. However, there were still some limitations in our study. First, our study was a cross-sectional epidemiological survey in the form of an electronic questionnaire, and there may have been some recall bias, but the reliability and validity of the questionnaire in this study were high, which minimized the recall bias. Second, we only demonstrated an association between job burnout, occupational stress, and psychological symptoms, but did not elaborate upon a causal relationship, our studies in the future will focus on exploring and verifying the causal relationship. Third, our study population included coal miners in Xinjiang, China, and any generalization of the findings is limited to a certain extent. Therefore, the conclusions reached need to be verified in other populations. At last, because the work type in our questionnaire was fill-in-the-blank rather than multiple-choice, we collected too much information about the work type, however, it was hard to make an accurate classification, so we failed to analyze the effect of work type on psychological symptoms, in the future study, we will pay attention to a research design with comprehensive consideration.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Ethics statement

The studies involving human participants were reviewed and approved by the Medical Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University (Approval number: 20170214-174). The patients/participants provided their written informed consent to participate in this study.

Author contributions

AF and JL designed the study. TZ, XLi, and XLiu designed the electronic version of the questionnaire and conducted the investigation. TZ, XG, XLi, and XLiu carried out the data detection and formal analysis. AF and TZ were involved in writing and editing the first manuscript. All authors approved the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer WH declared a shared affiliation with one of the authors JL to the handling editor at time of review.

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