BMJ Open

Interaction between job strain, shift work and mental health among Chinese railway workers

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-037544
Article Type:	Original research
Date Submitted by the Author:	07-Feb-2020
Complete List of Authors:	Jiang, Yu; Fujian Med Univ, public health Wu, Chuancheng Hu, Tianqi Chen, meilong Liu, Wei Zhou, Yabing Chen, Zhibing Xu, Xin
Keywords:	MENTAL HEALTH, OCCUPATIONAL & INDUSTRIAL MEDICINE, PUBLIC HEALTH

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.

Interaction between job strain, shift work and mental health among Chinese railway workers

Jiang Yu[1,§*], Wu Chuancheng[1§], Hu Tianqi[1], Chen Meilong[2], Liu Wei[1], Zhou Yabing[3], Chen Zhibing[1], Xu Xin[1]

[§] These authors contribute equally to this work.

[1]*Department of Preventive Medicine, School of Public Health, Fujian Medical University, Fuzhou, Fujian, China*

[2]*Fuzhou Railway Centers for Disease Control and Prevention, Fuzhou, Fujian, China*

[3]*Department of Humanities, Fujian Medical University, Fuzhou, Fujian, China*

Correspondence to

Dr. Jiang Yu,

School of Public Health,

Fujian Medical University, Fuzhou, Fujian 350012, China;

jiangyu@fjmu.edu.cn

Abstract

Objectives The aim of this study was to assess the interaction between job strain, shift work, and mental health in railway workers.

Design Cross-sectional study.

Participants A sample of 1,270 front-line railway workers were randomly selected from Fuzhou branch of the China Railway Nanchang Bureau Group.

Methods: Using Symptom Checklist-90-Revised questionnaire measured the general mental health. Job strain variables were derived from the Job Content Questionnaire (JCQ). Based on the

records of the work schedule one month prior to the survey, the following three shift types were identified: fixed day, fixed night, and rotating night shifts.

Results: High levels of job strain were linked to a higher risk of poor mental health (odds ratio [OR]=1.73, 95% confidence interval [CI]: 1.24–2.40). After adjusting for confounding factors, night shifts and rotating night shifts were significant risk factors for mental health (OR=2.60, 95% CI: 1.87–3.64; OR=2.91, 95% CI: 2.09–4.06). Compared to participants who experienced a low level of job strain and day shifts, those with a high level of job strain and who worked rotating shifts were at the highest risk of poor mental health (OR=4.97, 95% CI: 3.01–8.19), whereas the influence of a low level of job strain and rotating night shifts was not statistically significant.

Conclusion: Job strain and night shifts among workers were associated, both independently and in combination, with an increased risk of poor mental health. Our data suggest that job strain contributes to the risk of poor mental health through an interaction with shift work. Further research is required to investigate this relationship with longitudinal data to establish the temporal ordering between these variables.

Keywords: Mental health; Job strain; Shift work

Strengths and limitations of this study

- ►There are few studies of the effects of job strain and shift work interaction on common mental health.
- ►Following three shift types were identified: fixed day, fixed night, and rotating night shifts.
- ►A randomly selected sample and analyses controlled by job tenure, smoking and exercise.
- ►Given the cross-sectional research design used, only statistical associations can be observed and hence strong causal claims are not strictly proven.
- ►Subjective assessment of job strain (questionnaire) did not allow a more objective evidence.

Introduction

Mental health disorders are a major public health concern, both globally and within China.[1] In fact, mental health (including substance abuse) affected more than one billion people globally in 2016, and caused 7% of all global burdens of disease as measured in Disability-Adjusted Life Years (DALYs), and the trend is still rising.[2 3] Mental disorders associated with chronic physical disease are more prevalent among specific occupational groups, and are a leading cause of absenteeism and long-term work incapacity.[4 5]

Many factors can influence mental health, including work-related stress.[6] Epidemiological studies have shown that job strain is linked to mental health and an increased risk of psychological disorders.[7 8] A large British cohort study assessed the prospective association between job strain and the onset of common mental disorders, and found that high job demands, low job control and high job strain remained significant independent predictors of the future onset of common mental disorders.[9] One study of healthy Swedish working men and women found that job strain was as strongly related to depressive symptoms among men as among women, and women reported higher levels of job strain than men.[10] Another study found that repeated job strain and low social support at work were associated with an increased risk of major depressive disorder, and after adjusting for earlier psychological distress, the results held.[11] These findings suggest that modifiable work-related risk factors might be an important factor for efforts to reduce the prevalence of mental disorders.

In addition to occupational stressors, shift work can increase the risk of mental health problems.[12] Since the industrial revolution, night shift work has become more and more common, and it is widespread within the services and fabricating industries as well as the transportation,

hospitality, manufacturing, and health care sectors.[13] Night shift work is defined as a working schedule that involved working partly or entirely between midnight and 6 a.m., at least three times per month.[14] Studies have shown that long-term shifts can disrupt the 24-hour circadian rhythms and increase the risk of sleep disorder.[15] In addition, a close relationship has been found between shift work and many chronic diseases, such as cancer, metabolic disorders, cardiovascular diseases, and mental health disorders, etc.[16-19] On the one hand, night shifts are known to disturb the circadian rhythms in respect to melatonin secretion, stress hormones and autoimmune functions, leading to impaired psychological well-being. On the other hand, night shifts may also impair an individual's work-life balance and social interactions, which contributes to greater mental distress.[20 21]

China's total railway mileage reached 97,625 km by 2012, and is predicted to top 120,000 km by 2020, ranking second in the world after the United States. As the world's largest populated country and the fourth largest country by area, China has the highest rail transportation density in the world [39.95 million equated ton-km/km in 2012].[22] The increasing traffic volume results in a heavy workload for about two million railway workers in China. Except for the heavy workload, railway workers, especially those who work on the front lines, work irregular shift schedules.[23] Workers in transportation industries have higher rates of mental disorders, depression and physical health effects than workers in other occupations, including professional and managerial occupations.[24] There is increasing concern about the health and wellbeing of railway workers, which is related to the safety of the country's transportation infrastructure.

Although several studies have highlighted the role of job strain or shift work in mental health, the interaction between job strain, shift work, and mental health in railway workers has, however,

received considerably less attention. We addressed this issue among railway workers in the Fuzhou region of Fujian Province in China. The study aimed to examine the main effect of shift work and job strain on mental health, and the effect of the interaction between shift work and job strain on mental health.

Methods

Study design and population

This research was carried out as part of the Occupational Health Study of Railway Workers in China and was conducted between March and September 2019. The target population included front-line employees of the Fuzhou branch of the China Railway Nanchang Bureau Group Co. Ltd. in Fuzhou City, Fujian province, China. The administration bureau has eight subordinate units and about 20,000 employees, and covers all work related to the railway industry. In summary, we used a stratified sampling method (stratified in shifts) to enroll participants who had worked for a minimum of one year so that they could take part in an interview. The study included a total of 1,862 participants. The interview focused on participants' work experience, as well as their medical and medication history. Participants aged <20 or >60 years, who had been absent from work due to occupational injuries, or who were stationed abroad, were excluded. Based on this criteria, 1,540 participants remained eligible. With the assistance of the administration bureau's managers, an announcement was forwarded to employees to explain that the survey was designed "to better understand how job strain and shift work affect mental health." Participants were selected randomly; participation was voluntary; responses were confidential; and participation did not affect health care benefits. Ultimately, 1,270 workers were included in the study. Once an individual was identified and their formal consent was obtained, a face-to-face interview was

conducted during the annual professional health examination. This interview was carried out by trained interviewers using a questionnaire that included sociodemographic, job strain, shift work and mental health components.

Exposure assessment

We measured the general mental health of participants using the Symptom Checklist-90-Revised (SCL-90-R) which is a self-administrated questionnaire used to measure psychological distress and psychological symptoms, and this questionnaire has been used in several community-based epidemiology studies.[25] It consists of 90 items across nine primary symptom domains: (a) somatization, (b) obsessive-compulsive, (c) interpersonal sensitivity, (d) depression, (e) anxiety, (f) hostility, (g) phobic anxiety, (h) paranoid ideation, and (i) psychoticism. Participants responses were measured using a five-point Likert-type scale ranging from 0 ("asymptomatic") to 4 ("very severe"). A total score of greater than 160 is a possible indication of mental health problems.[26] The Chinese version of the SCL-90-R has high reliability and validity, and can be used to measure psychological distress and psychological symptoms among the Chinese population. In the current study, Cronbach's alpha was 0.854. The internal reliabilities of all nine subscales were greater than 0.8, respectively.

The Job Content Questionnaire (JCQ) is one of the most widely used instruments to estimate job strain, and it is based on the Job Demand-Control model.[27] It is believed that job strain stems from an imbalance between work-related demands and an individual's control. The JCQ is widely used in the field of job strain research. The Chinese version of the JCQ was developed by domestic scholars, and has high reliability and validity.[28] In our study, 22 items from the original 49-item JCQ were applied, and they consisted of three dimensions: job demand, job control, and

workplace social support. Each item was scored using a four-point Likert-type scale that ranged from 'strongly disagree' to 'strongly agree,' with higher scores indicating a higher level of psychological job demands, job control and workplace social support. In line with previously published studies, the scores for these subscales were divided into tertiles (low, medium, and high scores).[9 29] A job strain measure was computed using a combination of the job demands and control subscales which were further classified into three levels of job strain including low, intermediate, and high levels of job strain.[9] In the present study, the Cronbach's alpha coefficients for demand latitude, job control and social support of the JCQ-22 were 0.81, 0.79, and 0.86, respectively.

Night shift workers: Work hours only from 10 p.m. to 6 a.m., at least ten times per month. Day shift workers: Work hours only from 9:00 a.m. to 8:00 p.m., at least ten times per month. Rotating night shift workers: Involved two rotational shifts, and at least five night shifts per month. Shift types were classified based on records for work schedules.

Several demographic, socioeconomic, occupational, and lifestyle factors have been shown to be associated with mental health. Therefore, such factors may represent potential confounding variables for the results of any interaction between mental health and job strain or shift work. We considered the following variables in the study: sex, age (<30, 30–40, 40–50, >50 years) and marital status (married/unmarried). Occupational factors included job tenure (<10, 10–20, >20 years). The following lifestyle factors were considered: alcohol consumption, no (never or rarely)/yes (daily or often); smoking, "no" (never or rarely) or "yes" (daily or occasionally); and exercise, which was assessed with the question: "During the past month, how many times have you exercised?" The choice of response included "no" (never or rarely) or "regularly" (three times

or more per week, and exercise was at least 1 hour in duration in each occasion).

Statistical analysis

Analyses were carried out using SPSS for Windows v.20.0 (SPSS, Inc., Chicago, IL, USA). Data were summarised using frequencies for categorical data. Chi-square tests were used to compare demographic characteristics. Odds ratios (ORs) and 95% confidence intervals (CIs) were determined for the risk associated with mental health using logistic regression. Interactions between job strain, shift work, and mental health were evaluated using crossover analysis. The tests were two-tailed and the significance level was set at $p<0.05$.

Patient and public involvement

Patients and the public were not involved in the design or planning of the study.

Results

The characteristics of 1,270 participants who took part in this study are shown in Table 1. Approximately 532 participants were identified as having mental health problems according to the cut-off score. Therefore, the prevalence of mental health problems among participants was 41.9% (532/1270). The associations found between mental health problems and job tenure, smoking and exercise were statistically significant ($p<0.05$). Participants whose job tenure was <10 years were more likely to report poor mental health than those whose tenure was 10–20 years or >20 years (45.0% vs. 39.5% vs. 38.6%). Participants who smoked were more susceptible to mental health problems than those who did not smoke (50.9% vs. 36.3%). Participants who did not exercise were more susceptible to mental health problems than those who engaged in regular exercise (44.90% vs. 35.0%). No statistically significant associations were observed between mental health problems and other variables such as age, sex, marital status, and alcohol consumption ($p>0.05$).

Table 1 Prevalence of poor mental health according to participant characteristics

Characteristics	n	No. mental health problems	Prevalence	χ^2	p-value
Age (years)					
<30	552	228	41.3%	3.012	0.390
30–40	217	102	47.0%		
40–50	277	110	39.7%		
>50	224	92	41.1%		
Sex					
Male	1242	520	41.9%	0.011	0.916
Female	28	12	42.9%		
Job tenure (years)					
<10	720	324	45.0%	6.959	**0.031**
10–20	167	60	35.9%		
>20	383	148	38.6%		
Marital status					
Not married	404	180	44.6%	1.728	0.189
Married	866	352	40.6%		
Alcohol consumption					
Yes	961	404	42.0%	0.036	0.849
No	309	128	41.4%		

Smoking					
Yes	483	246	50.9%	26.178	**<0.001**
No	787	286	36.3%		
Exercise					
Regularly	386	135	35.0%	10.895	**0.001**
No	884	397	44.9%		

The results of unconditional logistic regression analyses of the relationship between mental health and job strain after adjusting for job tenure, smoking, and exercise are shown in Table 2. The risk of poor mental health was higher among those who experienced a high level of job strain compared to low levels of job strain (OR=1.80, 95% CI: 1.31–2.47). The significant association persisted after adjusting for all other confounding factors, and greater odds of exhibiting case-level symptoms of common mental disorders were associated with higher job demands (OR=2.34, 95% CI: 1.68–3.24), lower job control (OR=1.66, 95% CI: 1.27–2.17), lower social support (OR=2.08, 95% CI: 1.52–2.84), and a higher level of job strain (OR=1.73, 95% CI: 1.24–2.40).

Table 2 Logistic regression analysis of job strain in relation to mental health

		Model 1		Model 2	
Job demand	n (%)	OR (95% CI)	p value	OR (95% CI)	p value
Low	496 (39.1%)	1.00	—	1.00	—
Medium	519 (40.9%)	1.49 (1.08–2.06)	**0.016**	1.44 (1.03–2.01)	**0.034**
High	255 (20.0%)	2.54 (1.85–3.50)	**<0.001**	2.34 (1.68–3.24)	**<0.001**

Job control					
Low	585 (46.1%)	1.70 (1.31–2.21)	**<0.001**	1.66 (1.27–2.17)	**<0.001**
Medium	279 (22.0%)	1.49 (1.09–2.04)	**0.013**	1.55 (1.12–2.13)	**0.008**
High	406 (31.9%)	1.00	—	1.00	—
Social support					
Low	540 (42.5%)	2.06 (1.52–2.79)	**<0.001**	2.08 (1.52–2.84)	**<0.001**
Medium	457 (36.0%)	1.33 (0.97–1.82)	0.078	1.43 (1.04–1.98)	**0.030**
High	273 (21.5%)	1.00	—	1.00	—
Job strain					
Low	349 (27.5%)	1.00	—	1.00	—
Medium	628 (49.4%)	1.04 (0.79–1.36)	0.781	1.08 (0.82–1.42)	0.606
High	293 (23.1%)	1.80 (1.31–2.47)	**0.009**	1.73(1.24–2.40)	**<0.001**

OR, odds ratio; CI, confidence interval.

Model 1 is crude. Model 2 is adjusted for job tenure, smoking and exercise

The results of multivariate analyses of the relationship between mental health and shift types after adjusting for job tenure, smoking, and exercise are shown in Table 3. The risk of poor mental health was higher among those who worked night shifts (OR=2.64, 95% CI: 1.91–3.66) and rotating night shifts (OR=3.18, 95% CI: 2.32–4.36) when compared to day shift workers. The significant association persisted after adjusting for all other confounding factors, and mental disorders were associated with shift types, especially night shifts (OR=2.60, 95% CI: 1.87–3.64) and rotating night shifts (OR=2.91, 95% CI: 2.09–4.06).

Table 3 Association between different shift types and mental health

		Model 1		Model 2	
Shift types	n (%)	OR (95% CI)	p value	OR (95% CI)	p value
Day shift	300 (23.6%)	1.00	—	1.00	—
Night shift	442 (34.8%)	2.64 (1.91–3.66)	<0.001	2.60 (1.87–3.64)	<0.001
Rotating night shift	528 (41.6%)	3.18 (2.32–4.36)	<0.001	2.91 (2.09–4.06)	<0.001

OR, odds ratio; CI, confidence interval.

Model 1 was crude. Model 2 was adjusted for job tenure, smoking, and exercise.

To investigate the interaction between job strain and shift work with respect to mental health, participants were divided into high-, low-, or moderate-job-strain groups, and day-, night- or rotating night shift types. The crossover analysis showed that compared to participants with low or moderate levels of job strain who work day shifts, day shift workers with high levels of job strain were more likely to have poor mental health (OR=2.80, 95% CI: 1.95-4.02), as were participants with high levels of job strain who work night shifts (OR=4.57, 95% CI: 2.78-7.52). Those with high levels of job strain who work rotating night shifts have the worst mental health (OR=5.53, 95% CI: 3.45-8.88). Participants with low or moderate levels of job strain who work night shifts were at risk of poor mental health (OR=2.33, 95% CI: 1.61-3.39). The interaction between job strain and shift work remained significant after adjusting for confounding factors, including job tenure, smoking and exercise, which were associated with poor mental health (OR=2.58, 95% CI:

1.77-3.76 for high levels of job strain and the day shift; and OR=4.53, 95% CI: 2.71-7.57 for high levels of job strain and the night shift; and OR=4.97, 95% CI: 3.01-8.19 for high levels of job strain and the rotating night shift when compared to lower or moderate levels of job strain and the day shift).

Table 4 The interaction between job strain and shift types on mental health

Job strain	Shift types	OR (95% CI)	P	AOR[a] (95% CI)	p value
Low and medium	Day shift	1.00	—	1.00	—
Low and medium	Night shift	2.33 (1.61–3.39)	**<0.001**	2.26 (1.54–3.34)	**<0.001**
Low and medium	rotating night shift	1.16 (0.62–2.17)	0.651	1.05 (0.55–1.99)	0.882
High	Day shift	2.80 (1.95–4.02)	**<0.001**	2.58 (1.77–3.76)	**<0.001**
High	Night shift	4.57 (2.78–7.52)	**<0.001**	4.53 (2.71–7.57)	**<0.001**
High	rotating night shift	5.53 (3.45–8.88)	**<0.001**	4.97 (3.01–8.19)	**<0.001**

[a] Adjusted odds ratios (AOR) for job tenure, smoking, and exercise.

Discussion

This study investigated the potential relationship between job stress, shift work, psychological and behavioral factors, and mental health. This is the first study to examine an interaction between job strain and shift types with respect to mental health among Chinese railway workers. This study's main findings show that job strain and shift work are correlated with mental health, and the interaction between high levels of job strain and rotating shifts were identified as effective predictors of poor mental health among railway workers.

The influence of work conditions on mental health has been extensively studied over the last decades. Specifically, the adverse effect of high levels of job strain on mental health problems has been widely accepted.[7] Indeed, in the present study, the multivariate logistic regression analyses revealed that workers with high levels of job strain, encompassing lower job control and higher job demands, were at a greater risk of poor mental health than those who experienced low or moderate levels of stress.Some studies also suggest that exposure to chronic stressors, such as job strain, can cause dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and subsequent physiological changes that are involved in the pathophysiology of depression, including loss of neuroplasticity, inhibition of neurogenesis, and increased inflammation, which implies that stress disrupts normal mental health via HPA axis activation.[30]

Shift work is now very common in most countries. A higher proportion of shift work was observed in the US where 29% of employees reported that they did not work a regular day shift.[31] The high prevalence of shift work has led to concerns about its potential adverse impact on health. The current research indicated that shift work has an even clearer impact on mental health than job strain. Night shifts, especially rotating night shifts, were identified as a risk factor for psychological problems among front-line railway workers in China. Our findings are consistent with some previous studies which reported higher risks of mental health problems among night shift workers than day shift workers.[32] Interestingly, the role of rotating night shifts has been noticed. The sample population in this study largely included male front-line railway workers, and rotating night shifts were found to be associated with increased mental health symptoms than fixed night shifts. A study found that rotating night shifts were associated with greater health risks than permanent night shifts, suggesting that the former shift type might be implicated in greater

disruptions to physiological rhythms, and workers may have less time to adapt to the circadian clock.[33]

Our findings offer new insight into the impact of job strain and night shifts on mental health. The results of this study suggested that the interaction between high levels of job strain and rotating night shifts may occur in a multiplicative fashion. In other words, the interaction effect (OR=5.53) was greatest, and the relationship was also confirmed by adjusting potential confounding factors. These results suggest that employers should consider strategies for reducing the mental health burden of shift workers, such as offering more job control and flexibility over shift schedules, reducing job strain, and providing more social support at work. Workplace policies, programs, and practices could promote awareness of the associated risk factors, and enable access to mental health services.[12] Moreover, the magnitude of the OR was not statistically significant for the subgroup who worked rotating night shifts when compared to those who worked day shifts, when there is low and moderate job strain. Although the mechanistic basis for this observation remains unclear, it may be linked to the coordinating role of low levels of job strain.[34 35] According to the Job Demand-Control model, low job strain means low job demand or high job control, and may include a high level of social support. Multiple studies suggest that these factors may act as a buffer in regulating mental health.[36 37]

Some limitations of the current study and recommendations for future efforts should be considered. First, an important limitation of our study was the cross-sectional design which prevents inference about the causal direction of the associations found. Future research should design a cohort study which may more convincingly demonstrate the relationship between job strain, shift work, and mental health. Second, the study only selected front-line railway workers,

who primarily included males, so the conclusions may not be generalized to all shift workers in China. In the future, other types of shift work can be considered, such as shift work among health-care workers, and the influence of gender can be explored. Third, individual differences in terms of vulnerability to mental health could be expected. For instance, evening-type people who have a better ability to cope with shift work may have self-selected night jobs. Moreover, younger workers are more likely to be assigned night shifts or rotating night shifts. On the other hand, poor health conditions might cause workers to quit shift work, which could lead to a healthy worker selection bias. Longitudinal studies, which follow workers' occupational paths, are needed to confirm the causal relationships between shift work and health outcomes, as well as to avoid selection effects.

Conclusion

Despite the aforementioned limitations, the findings of this study nonetheless that workers who experience job strain or who work night shifts were more likely to have mental health problems than day shift workers. Furthermore, we found that among night shift workers, those who worked on the basis of a rotating night shift schedule were at a higher risk of sleep problems than those who worked fixed night shifts. While further studies are needed to fully understand the biological and social consequences of job strain, night shifts and rotating shift among different genders and different subgroups, we suggest that employers and occupational health practitioners should pay attention to the impacts of the interaction between job strain and shift work, and effects on workers' health and well-being. Furthermore, a suitable working schedule should be designed to minimize adverse health consequences.

Acknowledgement

The authors wish to acknowledge all of the participants in this study.

Contributors

JY participated in the study design, data collation, analysis, interpretation of the data and drafted the manuscript and tables. WC contributed to interpretation of the data, and participated the first draft of the article. HT, CM and LW assisted field investigation and collected the data. ZY, CZ and XX contributed data curation and formal analysis. All authors critically revised the manuscript.

Funding

This research was funded by the Startup Fund for scientific research, Fujian Medical University (Grant numbers 2018QH1008), Fujian Medical University's Research Foundation for Talented Scholars (Grant number XRCZX2018011),and the 2019 Provincial Health Research Talent Training Program-Youth Research Project (Grant number 2019-1-59).

Competing interests

None declared.

Patient consent for publication

Not required.

Ethics approval

This study was approved by the ethics committees of Fujian Medical University (FJMU2019025).

Provenance and peer review

Not commissioned; externally peer reviewed.

Data availability statement

All data relevant to the study are included in the article or uploaded as supplementary information.

References

1 Huang Y, Wang Y, Wang H, et al. Prevalence of mental disorders in China: a cross-sectional epidemiological study. Lancet Psychiatry 2019; 6:211 – 224.

2 Rehm J, Shield KD. Global burden of disease and the impact of mental and addictive disorders. Curr Psychiatry Rep 2019; 21:10.

3 Whiteford HA, Degenhardt L, Rehm J, et al. Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. Lancet 2013; 382:1575-86.

4 Rantonen O, Alexanderson K, Pentti J, et al. Trends in work disability with mental diagnoses among social workers in Finland and Sweden in 2005-2012. Epidemiol Psychiatr Sci 2017; 26:644-54.

5 Scott KM, Lim C, Al-Hamzawi A, et al. Association of mental disorders with subsequent chronic physical conditions: World Mental Health Surveys from 17 countries. JAMA Psychiatry 2016; 73:150-58.

6 Milner A, Aitken Z, Kavanagh A, et al. Persistent and contemporaneous effects of job stressors on mental health: a study testing multiple analytic approaches across 13 waves of annually collected cohort data. Occup Environ Med 2016; 73:787-93.

7 Madsen IEH, Nyberg ST, Magnusson Hanson LL, et al. Job strain as a risk factor for clinical depression: systematic review and meta-analysis with additional individual participant data.

Psychol. Med 2017; 47:1342-56.

8 Theorell T, Hammarström A, Aronsson G, et al. A systematic review including meta-analysis of work environment and depressive symptoms. BMC Public Health 2015;15:738.

9 Harvey SB, Sellahewa DA, Wang MJ, et al. The role of job strain in understanding midlife common mental disorder: a national birth cohort study. Lancet Psychiatry 2018; 5:498-506.

10 Theorell T, Hammarström A, Gustafsson PE, et al. Job strain and depressive symptoms in men and women: a prospective study of the working population in Sweden. J Epidemiol Community Health 2014; 68:78-82.

11 Stansfeld SA, Shipley MJ, Head J, et al. Repeated job strain and the risk of depression: longitudinal analyses from the Whitehall II study. Am J Public Health 2012; 102:2360-66.

12 Torquati L, Mielke GI, Brown WJ, et al. Shift work and poor mental health: A meta-analysis of longitudinal studies. Am J Public Health 2019; 109:e13-e20.

13 Alterman T, Luckhaupt S, Dahlhamer J, et al. Prevalence rates of work organization characteristics among workers in the US: Data from the 2010 National Health Interview Survey. Am J Ind Med 2013;56:647-59.

14 Kogevinas M, Espinosa A, Papantoniou K, et al. Prostate cancer risk decreases following cessation of night shift work. Int J Cancer 2019; 145:2597-99.

15 Wright KP Jr, Bogan RK, Wyatt JK. Shift work and the assessment and management of shift work disorder (SWD). Sleep Med Rev 2013;17:41-54.

16 Lim YC, Hoe VCW, Darus A, et al. Association between night-shift work, sleep quality and metabolic syndrome. Occup Environ Med 2018;75:716-23.

17 Jaradat Y, Birkeland Nielsen M, Kristensen P, et al. Job satisfaction and mental health of

Palestinian nurses with shift work: a cross-sectional study. Lancet 2018;391 Suppl 2:S50.

18 Behrens T, Rabstein S, Wichert K et al. Shift work and the incidence of prostate cancer: a 10-year follow-up of a German population-based cohort study. Scand J Work Environ Health 2017;43:560-68.

19 Thomas C, Power C. Shift work and risk factors for cardiovascular disease: a study at age 45 years in the 1958 British birth cohort. Eur J Epidemiol 2010;25:305-14.

20 Ramin C, Devore EE, Wang W, et al. Night shift work at specific age ranges and chronic disease risk factors. Occup Environ Med 2015;72:100-7.

21 Moreno CRC, Marqueze EC, Sargent C, et al. Working time society consensus statements: Evidence-based effects of shift work on physical and mental health. Ind Health 2019; 57:139-157.

22 Qian M. China Railway Yearbook. China Railway Yearbook Editional Office, 2013, Beijing, China.

23 Zhang X, Chen G, Xu F, et al. Health-related quality of life and associated factors of frontline railway workers: a cross-sectional survey in the Ankang area, Shaanxi Province, China. Int J Environ Res Public Health 2016; 13:E1192.

24 Al-Dubai SA, Ganasegeran K, Elkalmi R, et al. Perceived stress among Malaysian railway workers. Malays J Med Sci 2016;23:38-43.

25 Derogatis LR. The SCL-90 Manual I: scoring, administration and procedures for the SCL-90. Baltimore (MD) 1977, Clinical Psychometric Research.

26 Liao J, Ma X, Gao B, et al. Psychological status of nursing survivors in China and its associated factors: 6 years after the 2008 Sichuan earthquake. Neuropsychiatr Dis Treat 2019;15:2301-11.

27 Karasek R, Brisson C, Kawakami N, et al. The job content questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol 1998;3:322-55.

28 Li J, Yang W, Liu P, et al. Psychometric evaluation of the Chinese (mainland) version of Job Content Questionnaire: a study in university hospitals. Ind Health 2004; 42:260-7.

29 Stansfeld SA, Clark C, Caldwell T, et al. Psychosocial work characteristics and anxiety and depressive disorders in midlife: the effects of prior psychological distress. Occup Environ Med 2008;65:634-42.

30 Lamers F, Vogelzangs N, Merikangas KR, et al. Evidence for a differential role of HPA-axis function, inflammation and metabolic syndrome in melancholic versus atypical depression. Mol Psychiatry 2013;18:692-99.

31 Alterman T, Luckhaupt SE, Dahlhamer JM, et al. Prevalence rates of work organization characteristics among workers in the US: data from the 2010 National Health Interview Survey. Am J Ind Med 2013;56:647-59.

32 Angerer P, Schmook R, Elfantel I, Li J. Night work and the risk of depression. Dtsch Arztebl Int 2017;114:404-11.

33 Muecke S. Effects of rotating night shifts: Literature review. J Adv Nurs 2005;50:433-9.

34 Lagerveld SE, Blonk RW, Brenninkmeijer V, et al. Work-focused treatment of common mental disorders and return to work: a comparative outcome study. J Occup Health Psychol 2012;17:220-34

35 Mache S, Bernburg M, Baresi L, Groneberg D. Mental health promotion for junior physicians working in emergency medicine: evaluation of a pilot study. Eur J Emerg Med 2018;25:191-8.

36 Chen J, Li J, Cao B, et al. Mediating effects of self-efficacy, coping, burnout, and social support between job stress and mental health among young Chinese nurses. J Adv Nurs 2020;76:163-73.

37 Fan JK, Mustard C, Smith PM. Psychosocial work conditions and mental health: Examining differences across mental illness and well-being outcomes. Ann Work Expo Health 2019;63:546-59.

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	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
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	6-7
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	N/A
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	8-9
		(b) Give reasons for non-participation at each stage	8-9
		(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	8-9
Outcome data	15*	Report numbers of outcome events or summary measures	10-13

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	8-9
		(*b*) Report category boundaries when continuous variables were categorized	8-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
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	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
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	17

*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

Association for combined exposure to job strain, shift work on mental health among Chinese railway workers: A cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-037544.R1
Article Type:	Original research
Date Submitted by the Author:	13-Jun-2020
Complete List of Authors:	Jiang, Yu; Fujian Medical University, public health Wu, Chuancheng; Fujian Medical University, Public health Hu, Tianqi; Fujian Medical University, Public health Chen, meilong; Fuzhou Railway Centers for Disease Control and Prevention, Occupational health Liu, Wei; Fujian Medical University, Public health Zhou, Yabing; Fujian Medical University, Humanities Chen, Zhibing; Fujian Medical University, Public health Xu, Xin; Fujian Medical University, Public health
Primary Subject Heading:	Occupational and environmental medicine
Secondary Subject Heading:	Occupational and environmental medicine
Keywords:	MENTAL HEALTH, OCCUPATIONAL & INDUSTRIAL MEDICINE, PUBLIC HEALTH

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.

Association for combined exposure to job strain, shift work on mental health among Chinese railway workers: A cross-sectional study

Jiang Yu[1,§*], Wu Chuancheng[1§], Hu Tianqi[1], Chen Meilong[2], Liu Wei[1], Zhou Yabing[3], Chen Zhibing[1], Xu Xin[1]

[§] These authors contribute equally to this work.

[1]*Department of Preventive Medicine, School of Public Health, Fujian Medical University, Fuzhou, Fujian, China*

[2]*Department of Occupational health, Fuzhou Railway Centers for Disease Control and Prevention, Fuzhou, Fujian, China*

[3]*Department of Humanities, Fujian Medical University, Fuzhou, Fujian, China*

Correspondence to

Dr. Jiang Yu,

School of Public Health,

Fujian Medical University, Fuzhou, Fujian 350012, China;

jiangyu@fjmu.edu.cn

Abstract

Objectives The aim of this study was to assess the effects of co-exposure to job strain and shift work on mental health in railway workers.

Design Cross-sectional study.

Participants A sample of 1,270 front-line railway workers were randomly selected from Fuzhou branch of the China Railway Nanchang Bureau Group.

Methods: The Symptom Checklist-90-Revised questionnaire was used to measure general mental

health. Job strain variables were derived from the Job Content Questionnaire (JCQ). Based on the records of the work schedule three months prior to the survey, the following three shift types were identified: Fixed day, fixed night, and rotating night shifts. Risks associated with mental health were assessed by carrying out logistic regression analysis which was adjusted for age, job tenure, smoking and exercise. Additionally, a crossover analysis was employed for the combined effects.

Results: High levels of job strain were linked to a higher risk of poor mental health (odds ratio [OR]=1.53, 95% confidence interval [CI]: 1.10-2.11). After adjusting for confounding factors, night shifts and rotating night shifts were significant risk factors for mental health (OR=2.21, 95% CI: 1.60–3.07; OR=2.36, 95% CI: 1.73–3.22). Compared to participants who experienced a low level of job strain and day shifts, those with a high level of job strain and who worked rotating shifts were at the highest risk of poor mental health (OR=4.68, 95% CI: 2.91–8.04), whereas the influence of a low level of job strain and rotating night shifts was not statistically significant.

Conclusion: Job strain and night shifts among workers were associated, both independently and in combination, with an increased risk of poor mental health. Our data suggest that job strain contributes to the risk of poor mental health by means of a combined effect with shift work.

Keywords: Mental health; Job strain; Shift work

Strengths and limitations of this study
►There are few studies of the effects of job strain and shift work, and their combined effect on general mental health.
►The following three shift types were identified: Fixed day, fixed night, and rotating night shifts.
►A randomly selected sample and analyses controlled by job tenure, smoking and exercise.
►Given the cross-sectional research design used, only statistical associations can be observed, and hence, strong causal claims are not strictly proven.
►Subjective assessment of job strain (questionnaire) did not allow a more objective evidence.

Introduction

Mental health disorders are a major public health concern, both globally and within China.[1] In fact, mental health (including substance abuse) affected more than one billion people globally in 2016, and caused 7% of all global burdens of disease as measured in Disability-Adjusted Life Years (DALYs), and the trend is still rising.[2 3] Mental disorders associated with chronic physical disease are more prevalent among specific occupational groups, and are a leading cause of absenteeism and long-term work incapacity.[4 5]

Many factors can influence mental health, including work-related stress.[6] Epidemiological studies have shown that job strain is linked to mental health and an increased risk of psychological disorders.[7 8] A large British cohort study assessed the prospective association between job strain and the onset of common mental disorders, and found that high job demands, low job control and high job strain remained significant independent predictors of the future onset of common mental disorders.[9] One study of healthy Swedish working men and women found that job strain was as strongly related to depressive symptoms among men as among women, and women reported higher levels of job strain than men.[10] Another study found that repeated job strain and low social support at work were associated with an increased risk of major depressive disorder, and after adjusting for earlier psychological distress, the results held.[11] These findings suggest that modifiable work-related risk factors might be an important factor for efforts to reduce the prevalence of mental disorders.

In addition to occupational stressors, shift work can increase the risk of mental health problems.[12] Since the industrial revolution, night shift work has become more and more common, and it is widespread within the services and fabricating industries as well as the transportation,

hospitality, manufacturing, and health care sectors.[13] Night shift work can be defined as a working schedule which involved working partly or entirely during night, at least three times per month.[14] [15] Studies have shown that long-term shifts can disrupt the 24-hour circadian rhythms and increase the risk of sleep disorders.[16] In addition, a close relationship has been found between shift work and many chronic diseases, such as cancer, metabolic disorders, cardiovascular diseases, and mental health disorders, etc.[17-21] On the one hand, night shifts are known to disturb circadian rhythms by affecting melatonin secretion, stress hormones and autoimmune functions, which leads to impaired psychological well-being. On the other hand, night shifts may also impair an individual's work-life balance and social interactions, which contributes to greater mental distress.[22 23]

China's total railway mileage reached 97,625 km by 2012, and is predicted to top 120,000 km by 2020, ranking second in the world after the United States. As the world's largest populated country and the fourth largest country by area, China has the highest rail transportation density in the world [39.95 million equated ton-km/km in 2012].[24] The increasing traffic volume results in a heavy workload for about two million railway workers in China. Except for the heavy workload, railway workers, especially those who work on the front lines, work irregular shift schedules.[25] Workers in transportation industries have higher rates of mental disorders, depression and physical health effects than workers in other occupations, including professional and managerial occupations.[26] There is increasing concern about the health and wellbeing of railway workers, which is related to the safety of the country's transportation infrastructure.

Although several studies have highlighted the role of job strain or shift work in mental health, the combined effect between job strain, shift work, and mental health in railway workers has,

however, received considerably less attention. We addressed this issue among railway workers in the Fuzhou region of Fujian Province in China. The study aimed to examine the main effect of shift work and job strain on mental health, and the effect of the combined exposure to shift work and job strain on mental health.

Methods

Study design and participants

This research was carried out as part of the Occupational Health Study of Railway Workers in China and was conducted between March and September 2019. The target population included front-line employees of the Fuzhou branch of the China Railway Nanchang Bureau Group Co. Ltd. in Fuzhou City, Fujian province, China. The administration bureau has eight subordinate units and about 20,000 employees, and covers all work related to the railway industry. In summary, we used a stratified sampling method (stratified in shifts) to enroll participants who had worked for a minimum of one year so that they could take part in an interview. A total of 1,862 workers were invited to participate. The exclusion criteria focused on participants' work experience, as well as their medical and medication history. Participants aged <20 or >60 years, who had been absent from work due to sick and occupational injuries, or who were stationed abroad, were excluded. Based on this criteria, 1,540 participants remained eligible. With the assistance of the administration bureau's managers, an announcement was forwarded to employees to explain that the survey was designed "to better understand how job strain and shift work affect mental health." Participants were selected randomly; participation was voluntary; responses were confidential; and participation did not affect health care benefits. Ultimately, 1,270 workers were included in the study (Fig.1). Once an individual was identified and their formal consent was obtained, a

face-to-face interview was conducted during the annual professional health examination. This interview was carried out by trained interviewers using a questionnaire that included sociodemographic, job strain, shift work and mental health components.

Exposure assessment

The Job Content Questionnaire (JCQ) is one of the most widely used instruments to estimate job strain, and it is based on the Job Demand-Control model.[27] It is believed that job strain stems from an imbalance between work-related demands and an individual's control. The JCQ is widely used in the field of job strain research. The Chinese version of the JCQ was developed by domestic scholars, and has high reliability and validity.[28] In our study, 22 items from the original 49-item JCQ were applied, and they consisted of three dimensions: job demand, job control, and workplace social support. Each item was scored using a four-point Likert-type scale which ranged from 'strongly disagree' to 'strongly agree,' with higher scores indicating a higher level of psychological job demands, job control and workplace social support. In line with previously published studies, the scores for these subscales were divided into tertiles (low, medium, and high scores).[9 29] A job strain measure was computed using a combination of the job demands and control subscales which were further classified into three levels of job strain including low, intermediate, and high levels of job strain.[9] In the present study, the Cronbach's alpha coefficients for demand latitude, job control and social support of the JCQ-22 were 0.81, 0.79, and 0.86, respectively.

Shift work categories: According to the work schedules record held by the branch which related to the three months prior to the interviews, we classified workers into day shifts, night

shifts, and rotating night shifts. Day shift workers worked only during the day, according to the schedules, and their working hours were from 8:00 a.m. or 9:00 a.m. to 8:00 p.m. or 9:00 p.m. Night shift workers worked only during the night, according to the nature of the work and the schedules, and their working hours were strictly controlled and operated from 10 p.m. or 11 a.m. to 6 a.m. (need avoid driving hours). Rotating night shift workers were carried out day and night shifts; at least five night shifts per month, followed by two days off. Descriptive statistics of the exposures are shown in Table 1.

Table 1. Descriptive statistics of the exposures

	All	
Exposures variable	n	%
Job strain		
Low	349	27.5
Medium	628	49.4
High	293	23.1
Shift types		
Day shift	300	23.6
Night shift	442	34.8
Rotating night shift	528	41.6

Outcome

We measured the general mental health of participants using the Symptom Checklist-90-Revised (SCL-90-R) which is a self-administrated questionnaire used to measure

psychological distress and psychological symptoms, and this questionnaire has been used in several community-based epidemiology studies.[30] It consists of 90 items across nine primary symptom domains: (a) somatization, (b) obsessive-compulsive, (c) interpersonal sensitivity, (d) depression, (e) anxiety, (f) hostility, (g) phobic anxiety, (h) paranoid ideation, and (i) psychoticism. Participants responses were measured using a five-point Likert-type scale ranging from 0 ("asymptomatic") to 4 ("very severe"). A total score of greater than 160 is a possible indication of mental health problems.[31] The Chinese version of the SCL-90-R has high reliability and validity, and can be used to measure psychological distress and psychological symptoms among the Chinese population. In the current study, Cronbach's alpha was 0.854. The internal reliabilities of all nine subscales were greater than 0.8, respectively.

Covariates

Several demographic, socioeconomic, occupational, and lifestyle factors have been shown to be associated with mental health. Therefore, such factors may represent potential confounding variables for the results of any combined exposure to mental health and job strain or shift work. We considered the following variables in the study: sex, age (<30, 30–40, 40–50, >50 years) and marital status (married/unmarried). Occupational factors included job tenure (<10, 10–20, >20 years). The following lifestyle factors were considered: alcohol consumption, no (never or rarely)/yes (daily or often); smoking, "no" (never or rarely) or "yes" (daily or occasionally); and exercise, which was assessed with the question: "During the past month, how many times have you exercised?" The choice of response included "no" (never or rarely) or "regularly" (three times or more per week, and exercise was at least 1 hour in duration in each occasion).

Statistical analysis

Analyses were carried out using SPSS for Windows v.20.0 (SPSS, Inc., Chicago, IL, USA). Data were summarized using frequencies for categorical data. Chi-square tests were used to compare demographic characteristics. Odds ratios (ORs) and 95% confidence intervals (CIs) were determined for the risk associated with mental health using logistic regression. The combined effect observed between job strain, shift work, and mental health was evaluated by carrying out a crossover analysis. All of the models were adjusted for age, job tenure, smoking and exercise. The tests were two-tailed and the significance level was set at $p<0.05$.

Patient and public involvement

Patients and the public were not involved in the design or planning of the study.

Results

The characteristics of 1,270 participants who took part in this study are shown in Table 2. Approximately 532 participants were identified as having mental health problems according to the cut-off score. Therefore, the prevalence of mental health problems among participants was 41.9% (532/1270). We found group differences with respect to the prevalence of mental health problems in the case of job tenure, smoking and exercise ($p<0.05$). Participants whose job tenure was <10 years were more likely to report poor mental health than those whose tenure was 10–20 years or >20 years (45.0% vs. 39.5% vs. 38.6%). Participants who smoked were more susceptible to mental health problems than those who did not smoke (50.9% vs. 36.3%). Participants who did not exercise were more susceptible to mental health problems than those who engaged in regular exercise (44.90% vs. 35.0%). No statistically significant associations were observed between mental health problems and other variables such as age, sex, marital status, and alcohol consumption ($p>0.05$).

Table 2. Prevalence of poor mental health according to participant characteristics

Characteristics	n	No. mental health problems	Prevalence	χ^2	p-value
Age (years)					
<30	552	228	41.3%	3.012	0.390
30–40	217	102	47.0%		
40–50	277	110	39.7%		
>50	224	92	41.1%		
Sex					
Male	1242	520	41.9%	0.011	0.916
Female	28	12	42.9%		
Job tenure (years)					
<10	720	324	45.0%	6.959	**0.031**
10–20	167	60	35.9%		
>20	383	148	38.6%		
Marital status					
Unmarried	404	180	44.6%	1.728	0.189
Married	866	352	40.6%		
Alcohol consumption					
Yes	961	404	42.0%	0.036	0.849
No	309	128	41.4%		
Smoking					
Yes	483	246	50.9%	26.178	**<0.001**

No	787	286	36.3%		
Exercise					
Regularly	386	135	35.0%	10.895	**0.001**
No	884	397	44.9%		

The results of unconditional logistic regression analyses of the relationship between mental health and job strain after adjusting for age, job tenure, smoking, and exercise are shown in Table 3. The risk of poor mental health was higher among those who experienced a high level of job strain compared to low levels of job strain (OR=1.80, 95% CI: 1.31–2.47). The significant association persisted after adjusting for all other confounding factors, and greater odds of exhibiting case-level symptoms of common mental disorders were associated with higher job demands (OR=2.28, 95% CI: 1.64–3.17), lower job control (OR=1.54, 95% CI: 1.18–2.02), lower social support (OR=2.00, 95% CI: 1.46–2.75), and a higher level of job strain (OR=1.53, 95% CI: 1.10–2.11).

Table 3. Odds ratios for mental health in relation to the different job strain exposures

		Model 1		Model 2	
Job demand	n (%)	OR (95% CI)	p value	OR (95% CI)	p value
Low	496 (39.1%)	1.00	—	1.00	—
Medium	519 (40.9%)	1.49 (1.08–2.06)	**0.016**	1.45 (1.04–2.03)	**0.030**
High	255 (20.0%)	2.54 (1.85–3.50)	**<0.001**	2.28 (1.64–3.17)	**<0.001**
Job control					

Low	585 (46.1%)	1.70 (1.31–2.21)	**<0.001**	1.54 (1.18–2.02)	**0.002**
Medium	279 (22.0%)	1.49 (1.09–2.04)	**0.013**	1.49 (1.08–2.06)	**0.008**
High	406 (31.9%)	1.00	—	1.00	—
Social support					
Low	540 (42.5%)	2.06 (1.52–2.79)	**<0.001**	2.00 (1.46–2.75)	**<0.001**
Medium	457 (36.0%)	1.33 (0.97–1.82)	0.078	1.30 (0.94–1.80)	0.109
High	273 (21.5%)	1.00	—	1.00	—
Job strain					
Low	349 (27.5%)	1.00	—	1.00	—
Medium	628 (49.4%)	1.04 (0.79–1.36)	0.781	0.99 (0.75–1.30)	0.932
High	293 (23.1%)	1.80 (1.31–2.47)	**0.009**	1.53 (1.10–2.11)	**0.011**

OR, odds ratio; CI, confidence interval.

Model 1 is crude. Model 2 is adjusted for age, job tenure, smoking and exercise

The results of multivariate analyses of the relationship between mental health and shift types after adjusting for age, job tenure, smoking, and exercise are shown in Table 4. The risk of poor mental health was higher among those who worked night shifts (OR=2.64, 95% CI: 1.91–3.66) and rotating night shifts (OR=3.18, 95% CI: 2.32–4.36) when compared to day shift workers. The significant association persisted after adjusting for all other confounding factors, and mental disorders were associated with shift types, especially night shifts (OR=2.21, 95% CI: 1.60–3.07) and rotating night shifts (OR=2.36, 95% CI: 1.73–3.22).

Table 4. Odds ratios for mental health in relation to the different shift types exposures

		Model 1		Model 2	
Shift types	n (%)	OR (95% CI)	p value	OR (95% CI)	p value
Day shift	300 (23.6%)	1.00	—	1.00	—
Night shift	442 (34.8%)	2.64 (1.91–3.66)	**<0.001**	2.21 (1.60–3.07)	**<0.001**
Rotating night shift	528 (41.6%)	3.18 (2.32–4.36)	<0.001	2.36 (1.73–3.22)	**<0.001**

OR, odds ratio; CI, confidence interval.

Model 1 was crude. Model 2 was adjusted for age, job tenure, smoking, and exercise.

To investigate the combined exposure to job strain and shift work with respect to mental health, participants were divided into high-, low-, or moderate-job-strain groups, and day-, night- or rotating night shift types (Table 5). The crossover analysis showed that compared to participants with low or moderate levels of job strain who worked day shifts, day shift workers with high levels of job strain were more likely to have poor mental health (OR=2.80, 95% CI: 1.95-4.02), as were participants with high levels of job strain who worked night shifts (OR=4.57, 95% CI: 2.78-7.52). Those with high levels of job strain who work rotating night shifts had the highest likelihood of experiencing mental health problems (OR=5.53, 95% CI: 3.45-8.88). Participants with low or moderate levels of job strain who worked night shifts were at risk of poor mental health (OR=2.33, 95% CI: 1.61-3.39). The combined effect to job strain and shift work remained significant after adjusting for confounding factors, including age, job tenure, smoking and exercise, which were associated with poor mental health (OR=2.52, 95% CI: 1.64-3.57 for high levels of job strain and the day shift; and OR=4.33, 95% CI: 2.63-7.14 for high levels of job strain and the night shift; and OR=4.68, 95% CI: 2.91-8.04 for high levels of job strain and the

rotating night shift when compared to lower or moderate levels of job strain and the day shift).

Table 5. The combined effect to job strain and shift types on mental health

Job strain	Shift types	OR (95% CI)	P	AOR[a] (95% CI)	p value
Low and medium	Day shift	1.00	—	1.00	—
Low and medium	Night shift	2.33 (1.61–3.39)	**<0.001**	2.06 (1.42–2.99)	**<0.001**
Low and medium	rotating night shift	1.16 (0.62–2.17)	0.651	0.90 (0.43–1.72)	0.935
High	Day shift	2.80 (1.95–4.02)	**<0.001**	2.52 (1.64–3.57)	**<0.001**
High	Night shift	4.57 (2.78–7.52)	**<0.001**	4.33 (2.63–7.14)	**<0.001**
High	rotating night shift	5.53 (3.45–8.88)	**<0.001**	4.68 (2.91–8.04)	**<0.001**

[a] Adjusted odds ratios (AOR) for age, job tenure, smoking, and exercise.

Discussion

This study investigated the potential relationship between job stress, shift work, psychological and behavioral factors, and mental health. This is the first study to examine a combined effect between job strain and shift types with respect to mental health among Chinese railway workers. This study's main findings show that job strain and shift work are correlated with mental health, and a combined exposure to high levels of job strain and rotating shifts were identified as effective predictors of poor mental health among railway workers.

The influence of work conditions on mental health has been extensively studied over the past decades. Specifically, the adverse effect of high levels of job strain on mental health problems has been widely accepted.[7] Indeed, in the present study, the multivariate logistic regression analyses revealed that workers with high levels of job strain, encompassing lower job control and higher

job demands, were at a greater risk of poor mental health than those who experienced low or moderate levels of stress. Some studies also suggest that exposure to chronic stressors, such as job strain, can cause dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and subsequent physiological changes that are involved in the pathophysiology of depression, including loss of neuroplasticity, inhibition of neurogenesis, and increased inflammation, which implies that stress disrupts normal mental health via HPA axis activation.[32]

Shift work is now very common in most countries. A higher proportion of shift work was observed in the US where 29% of employees reported that they did not work a regular day shift, and such figures related to data from 2004 (17.7%).[33] The high prevalence of shift work has led to concerns about its potential adverse impact on health. The current research indicated that shift work has an even clearer impact on mental health than job strain. Night shifts, especially rotating night shifts, were identified as a risk factor for psychological problems among front-line railway workers in China. Our findings are consistent with some previous studies which reported higher risks of mental health problems among night shift workers than day shift workers.[34] Interestingly, the role of rotating night shifts has been noticed. The sample population in this study largely included male front-line railway workers, and rotating night shifts were found to be associated with increased mental health symptoms than fixed night shifts. A study found that rotating night shifts were associated with greater health risks than permanent night shifts, suggesting that the former shift type might be implicated in greater disruptions to physiological rhythms, and workers may have less time to adapt to the circadian clock.[35]

Our findings offer new insight into the impact of job strain and night shifts on mental health. The results of this study suggest that a combined exposure to high levels of job strain and rotating

night shifts may occur in a multiplicative fashion. In other words, the combined effect (OR=5.53) was greatest, and the relationship was also confirmed by adjusting potential confounding factors. These results suggest that employers should consider strategies for reducing the mental health burden of shift workers, such as offering more job control and flexibility over shift schedules, reducing job strain, and providing more social support at work. Workplace policies, programs, and practices could promote awareness of the associated risk factors, and enable access to mental health services.[12] Moreover, the magnitude of the OR was not statistically significant for the subgroup who worked rotating night shifts when compared to those who worked day shifts, when there is low and moderate job strain. Although the mechanistic basis for this observation remains unclear, it may be linked to the coordinating role of low levels of job strain.[36 37] According to the Job Demand-Control model, low job strain means low job demand or high job control, and may include a high level of social support. Multiple studies suggest that these factors may act as a buffer in regulating mental health.[38 39]

Some limitations of the current study and recommendations for future efforts should be considered. First, both job strain and mental health were self-reported, which may lead to single/common source bias. Second, lifestyle factors, such as alcohol, smoking and exercise, may vary greatly, e.g. “never or rarely alcohol” vs. “daily or often.” This may lead to reporting bias, such that more participants reported “never” or “rarely” responses. Third, individual differences in terms of vulnerability to mental health could be expected. For instance, evening-type people who have a better ability to cope with shift work may have self-selected night jobs. Moreover, younger workers are more likely to be assigned night shifts or rotating night shifts. On the other hand, poor health conditions might cause workers to quit shift work, which could lead to a healthy worker

selection bias. Longitudinal studies, which follow workers' occupational paths, are needed to confirm the causal relationships between shift work and health outcomes, as well as to avoid selection effects.

Conclusion

Our study suggests that workers who experience job strain or who work night shifts were more likely to suffer from mental health problems than day shift workers. Furthermore, we found that among night shift workers, those who worked on the basis of a rotating night shift schedule were at a higher risk of sleep problems than those who worked fixed night shifts. While further studies are needed to fully understand the biological and social consequences of job strain, night shifts and rotating shift among different genders and different subgroups, we suggest that employers and occupational health practitioners should pay attention to the impacts of the combined exposure to job strain and shift work, and effects on workers' health and well-being. Furthermore, a suitable working schedule should be designed to minimize adverse health consequences.

Acknowledgement

The authors wish to acknowledge all of the participants in this study.

Contributors

JY participated in the study design, data collation, analysis, interpretation of the data and drafted the manuscript and tables. WC contributed to interpretation of the data, and participated the first draft of the article. HT, CM and LW assisted field investigation and collected the data. ZY, CZ

and XX contributed data curation and formal analysis. All authors critically revised the manuscript.

Funding

This research was funded by the Startup Fund for scientific research, Fujian Medical University (Grant numbers 2018QH1008), Fujian Medical University's Research Foundation for Talented Scholars (Grant number XRCZX2018011), and the 2019 Provincial Health Research Talent Training Program-Youth Research Project (Grant number 2019-1-59).

Conflicting interests

None declared.

Patient consent for publication

Not required.

Ethics approval

This study was approved by the ethics committees of Fujian Medical University (FJMU2019025).

Provenance and peer review

Not commissioned; externally peer reviewed.

Data availability statement

All data relevant to the study are included in the article or uploaded as supplementary information.

References

1 Huang Y, Wang Y, Wang H, et al. Prevalence of mental disorders in China: a cross-sectional epidemiological study. Lancet Psychiatry 2019; 6:211 – 224.

2 Rehm J, Shield KD. Global burden of disease and the impact of mental and addictive disorders.

Curr Psychiatry Rep 2019; 21:10.

3 Whiteford HA, Degenhardt L, Rehm J, et al. Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. Lancet 2013; 382:1575-86.

4 Rantonen O, Alexanderson K, Pentti J, et al. Trends in work disability with mental diagnoses among social workers in Finland and Sweden in 2005-2012. Epidemiol Psychiatr Sci 2017; 26:644-54.

5 Scott KM, Lim C, Al-Hamzawi A, et al. Association of mental disorders with subsequent chronic physical conditions: World Mental Health Surveys from 17 countries. JAMA Psychiatry 2016; 73:150-58.

6 Milner A, Aitken Z, Kavanagh A, et al. Persistent and contemporaneous effects of job stressors on mental health: a study testing multiple analytic approaches across 13 waves of annually collected cohort data. Occup Environ Med 2016; 73:787-93.

7 Madsen IEH, Nyberg ST, Magnusson Hanson LL, et al. Job strain as a risk factor for clinical depression: systematic review and meta-analysis with additional individual participant data. Psychol. Med 2017; 47:1342-56.

8 Theorell T, Hammarström A, Aronsson G, et al. A systematic review including meta-analysis of work environment and depressive symptoms. BMC Public Health 2015;15:738.

9 Harvey SB, Sellahewa DA, Wang MJ, et al. The role of job strain in understanding midlife common mental disorder: a national birth cohort study. Lancet Psychiatry 2018; 5:498-506.

10 Theorell T, Hammarström A, Gustafsson PE, et al. Job strain and depressive symptoms in men and women: a prospective study of the working population in Sweden. J Epidemiol Community

Health 2014; 68:78-82.

11 Stansfeld SA, Shipley MJ, Head J, et al. Repeated job strain and the risk of depression: longitudinal analyses from the Whitehall II study. Am J Public Health 2012; 102:2360-66.

12 Torquati L, Mielke GI, Brown WJ, et al. Shift work and poor mental health: A meta-analysis of longitudinal studies. Am J Public Health 2019; 109:e13-e20.

13 Alterman T, Luckhaupt S, Dahlhamer J, et al. Prevalence rates of work organization characteristics among workers in the US: Data from the 2010 National Health Interview Survey. Am J Ind Med 2013;56:647-59.

14 Kogevinas M, Espinosa A, Papantoniou K, et al. Prostate cancer risk decreases following cessation of night shift work. Int J Cancer 2019; 145:2597-99.

15 Lim YC, Hoe VCW, Darus A, et al. Association between night-shift work, sleep quality and metabolic syndrome. Occup Environ Med 2018; 75:716-23.

16 Wright KP Jr, Bogan RK, Wyatt JK. Shift work and the assessment and management of shift work disorder (SWD). Sleep Med Rev 2013;17:41-54.

17 Lim YC, Hoe VCW, Darus A, et al. Association between night-shift work, sleep quality and metabolic syndrome. Occup Environ Med 2018;75:716-23.

18 Jaradat Y, Birkeland Nielsen M, Kristensen P, et al. Job satisfaction and mental health of Palestinian nurses with shift work: a cross-sectional study. Lancet 2018;391 Suppl 2:S50.

19 Behrens T, Rabstein S, Wichert K et al. Shift work and the incidence of prostate cancer: a 10-year follow-up of a German population-based cohort study. Scand J Work Environ Health 2017;43:560-68.

20 Thomas C, Power C. Shift work and risk factors for cardiovascular disease: a study at age 45

years in the 1958 British birth cohort. Eur J Epidemiol 2010;25:305-14.

21 Torquati L, Mielke GI, Brown WJ, et al. Shift Work and Poor Mental Health: A Meta-Analysis of Longitudinal Studies. Am J Public Health 2019;109:e13-e20.

22 Ramin C, Devore EE, Wang W, et al. Night shift work at specific age ranges and chronic disease risk factors. Occup Environ Med 2015;72:100-7.

23 Moreno CRC, Marqueze EC, Sargent C, et al. Working time society consensus statements: Evidence-based effects of shift work on physical and mental health. Ind Health 2019; 57:139-157.

24 Qian M. China Railway Yearbook. China Railway Yearbook Editional Office, 2013, Beijing, China.

25 Zhang X, Chen G, Xu F, et al. Health-related quality of life and associated factors of frontline railway workers: a cross-sectional survey in the Ankang area, Shaanxi Province, China. Int J Environ Res Public Health 2016; 13:E1192.

26 Al-Dubai SA, Ganasegeran K, Elkalmi R, et al. Perceived stress among Malaysian railway workers. Malays J Med Sci 2016;23:38-43.

27 Karasek R, Brisson C, Kawakami N, et al. The job content questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol 1998;3:322-55.

28 Li J, Yang W, Liu P, et al. Psychometric evaluation of the Chinese (mainland) version of Job Content Questionnaire: a study in university hospitals. Ind Health 2004; 42:260-7.

29 Stansfeld SA, Clark C, Caldwell T, et al. Psychosocial work characteristics and anxiety and depressive disorders in midlife: the effects of prior psychological distress. Occup Environ Med 2008;65:634-42.

30 Derogatis LR. The SCL-90 Manual I: scoring, administration and procedures for the SCL-90. Baltimore (MD) 1977, Clinical Psychometric Research.

31 Liao J, Ma X, Gao B, et al. Psychological status of nursing survivors in China and its associated factors: 6 years after the 2008 Sichuan earthquake. Neuropsychiatr Dis Treat 2019;15:2301-11.

32 Lamers F, Vogelzangs N, Merikangas KR, et al. Evidence for a differential role of HPA-axis function, inflammation and metabolic syndrome in melancholic versus atypical depression. Mol Psychiatry 2013;18:692-99.

33 Alterman T, Luckhaupt SE, Dahlhamer JM, et al. Prevalence rates of work organization characteristics among workers in the US: data from the 2010 National Health Interview Survey. Am J Ind Med 2013;56:647-59.

34 Angerer P, Schmook R, Elfantel I, Li J. Night work and the risk of depression. Dtsch Arztebl Int 2017;114:404-11.

35 Muecke S. Effects of rotating night shifts: Literature review. J Adv Nurs 2005;50:433-9.

36 Lagerveld SE, Blonk RW, Brenninkmeijer V, et al. Work-focused treatment of common mental disorders and return to work: a comparative outcome study. J Occup Health Psychol 2012;17:220-34

37 Mache S, Bernburg M, Baresi L, Groneberg D. Mental health promotion for junior physicians working in emergency medicine: evaluation of a pilot study. Eur J Emerg Med 2018;25:191-8.

38 Chen J, Li J, Cao B, et al. Mediating effects of self-efficacy, coping, burnout, and social support between job stress and mental health among young Chinese nurses. J Adv Nurs 2020;76:163-73.

39 Fan JK, Mustard C, Smith PM. Psychosocial work conditions and mental health: Examining differences across mental illness and well-being outcomes. Ann Work Expo Health 2019;63:546-59.

Figure Legends:

Figure 1. Flow of excluded individuals in the cross-sectional study.

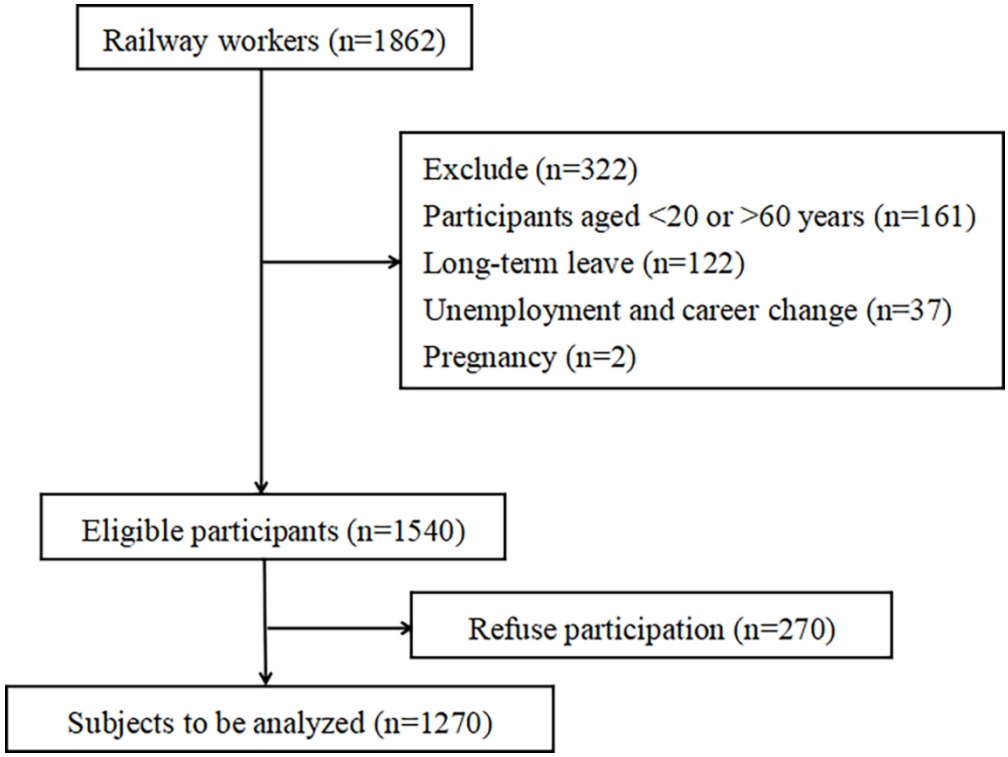

Figure 1. Flow of excluded individuals in the cross-sectional study.

120x90mm (300 x 300 DPI)

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	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
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	6-7
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	N/A
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	8-9
		(b) Give reasons for non-participation at each stage	8-9
		(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	8-9
Outcome data	15*	Report numbers of outcome events or summary measures	10-13

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	8-9
		(*b*) Report category boundaries when continuous variables were categorized	8-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
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	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
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	17

*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

Association for combined exposure to job strain, shift work on mental health among Chinese railway workers: A cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-037544.R2
Article Type:	Original research
Date Submitted by the Author:	04-Aug-2020
Complete List of Authors:	Jiang, Yu; Fujian Medical University, public health Wu, Chuancheng; Fujian Medical University, Public health Hu, Tianqi; Fujian Medical University, Public health Chen, meilong; Fuzhou Railway Centers for Disease Control and Prevention, Occupational health Liu, Wei; Fujian Medical University, Public health Zhou, Yabing; Fujian Medical University, Humanities Chen, Zhibing; Fujian Medical University, Public health Xu, Xin; Fujian Medical University, Public health
Primary Subject Heading:	Occupational and environmental medicine
Secondary Subject Heading:	Occupational and environmental medicine
Keywords:	MENTAL HEALTH, OCCUPATIONAL & INDUSTRIAL MEDICINE, PUBLIC HEALTH

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.

Association for combined exposure to job strain, shift work on mental health among Chinese railway workers: A cross-sectional study

Jiang Yu[1*], Wu Chuancheng[1], Hu Tianqi[1], Chen Meilong[2], Liu Wei[1], Zhou Yabing[3], Chen Zhibing[1], Xu Xin[1]

[1]*Department of Preventive Medicine, Fujian Provincial Key Laboratory of Environment Factors and Cancer, Key Laboratory of Environment and Health, School of Public Health, Fujian Medical University, Fuzhou, Fujian, China*

[2]*Department of Occupational health, Fuzhou Railway Centers for Disease Control and Prevention, Fuzhou, Fujian, China*

[3]*Department of Humanities, Fujian Medical University, Fuzhou, Fujian, China*

Correspondence to

Dr. Jiang Yu,

School of Public Health,

Fujian Medical University, Fuzhou, Fujian 350012, China;

jiangyu@fjmu.edu.cn

Abstract

Objectives: The aim of this study was to assess the effects of co-exposure to job strain and shift work on mental health in railway workers.

Design: Cross-sectional study.

Setting: One Railway Bureau Group in China.

Participants: A total of 1,270 front-line railway workers.

Outcome measures: The Symptom Checklist-90-Revised questionnaire was used to measure

general mental health. Job strain variables were derived from the Job Content Questionnaire (JCQ). Based on the records of the work schedule three months prior to the survey, the following three shift types were identified: Fixed day, fixed night, and rotating night shifts. Risks associated with mental health were assessed by carrying out logistic regression analysis which was adjusted for age, job tenure, smoking and exercise. Additionally, a crossover analysis was employed for the combined effects.

Results: High levels of job strain were linked to a higher risk of poor mental health (odds ratio [OR]=1.53, 95% confidence interval [CI]: 1.10-2.11). After adjusting for confounding factors, night shifts and rotating night shifts were significant risk factors for mental health (OR=2.21, 95% CI: 1.60–3.07; OR=2.36, 95% CI: 1.73–3.22). Compared to participants who experienced a low level of job strain and day shifts, those with a high level of job strain and who worked rotating shifts were at the highest risk of poor mental health (OR=4.68, 95% CI: 2.91–8.04), whereas the influence of a low level of job strain and rotating night shifts was not statistically significant.

Conclusion: Job strain and night shifts among workers were associated, both independently and in combination, with an increased risk of poor mental health. Our data suggest that job strain contributes to the risk of poor mental health by means of a combined effect with shift work.

Keywords: Mental health; Job strain; Shift work

Strengths and limitations of this study

- ► Our study shows the relationship of job strain and shift work on mental health in front-line railway workers.
- ► Our study included three shift types: Fixed day, fixed night, and rotating night shifts.
- ► A randomly selected sample and analyses controlled by job tenure, smoking and exercise.
- ► Given the cross-sectional research design used, only statistical associations can be observed, and hence, strong causal claims are not strictly proven.
- ► Subjective assessment of job strain (questionnaire) did not allow a more objective evidence.

Introduction

Mental health disorders are a major public health concern, both globally and within China.[1] In fact, mental health (including substance abuse) affected more than one billion people globally in 2016, and caused 7% of all global burdens of disease as measured in Disability-Adjusted Life Years (DALYs), and the trend is still rising.[2 3] Mental disorders associated with chronic physical disease are more prevalent among specific occupational groups, and are a leading cause of absenteeism and long-term work incapacity.[4 5]

Many factors can influence mental health, including work-related stress.[6] Epidemiological studies have shown that job strain is linked to mental health and an increased risk of psychological disorders.[7 8] A large British cohort study assessed the prospective association between job strain and the onset of common mental disorders, and found that high job demands, low job control and high job strain remained significant independent predictors of the future onset of common mental disorders.[9] One study of healthy Swedish working men and women found that job strain was as strongly related to depressive symptoms among men as among women, and women reported higher levels of job strain than men.[10] Another study found that repeated job strain and low social support at work were associated with an increased risk of major depressive disorder, and after adjusting for earlier psychological distress, the results held.[11] These findings suggest that modifiable work-related risk factors might be an important factor for efforts to reduce the prevalence of mental disorders.

In addition to occupational stressors, shift work can increase the risk of mental health problems.[12] Since the industrial revolution, night shift work has become more and more common, and it is widespread within the services and fabricating industries as well as the transportation,

hospitality, manufacturing, and health care sectors.[13] Night shift work can be defined as a working schedule which involved working partly or entirely during night.[14] Studies have shown that long-term shifts can disrupt the 24-hour circadian rhythms and increase the risk of sleep disorders.[15] In addition, a close relationship has been found between shift work and many chronic diseases, such as cancer, metabolic disorders, cardiovascular diseases, and mental health disorders, etc.[12,16-19] Night shifts are known to disturb circadian rhythms by affecting melatonin secretion, stress hormones and autoimmune functions, which leads to impaired psychological well-being. Moreover, night shifts may also impair an individual's work-life balance and social interactions, which contributes to greater mental distress.[20 21]

China's total railway mileage reached 97,625 km by 2012, and is predicted to top 120,000 km by 2020, ranking second in the world after the United States. As the world's largest populated country and the fourth largest country by area, China has the highest rail transportation density in the world [39.95 million equated ton-km/km in 2012].[22] The increasing traffic volume results in a heavy workload for about two million railway workers in China. Except for the heavy workload, the front line workers often have irregular working schedules.[23] Workers in transportation industries have higher rates of mental disorders, depression and physical health effects than workers in other occupations, including professional and managerial occupations.[24] There is increasing concern about the health and wellbeing of railway workers, which is related to the safety of the country's transportation infrastructure.

Although several studies have highlighted the role of job strain or shift work in mental health, the combined effect of job strain and shift work on mental health in railway workers has received considerably less attention. We addressed this issue among railway workers in the Fuzhou region

of Fujian Province in China. The study aimed to examine the main effect of shift work and job strain on mental health, and the effect of the combined exposure to shift work and job strain on mental health.

Methods

Study design and participants

This research was carried out as part of the Occupational Health Study of Railway Workers in China and was conducted between March and September 2019. The target population included front-line employees of the Fuzhou branch of the China Railway Nanchang Bureau Group Co. Ltd. in Fuzhou City, Fujian province, China. The administration bureau has eight subordinate units and about 20,000 employees, and covers all work related to the railway industry. In summary, we used a stratified sampling method (stratified in shifts) to randomly enroll participants who had worked for a minimum of one year so that they could take part in an interview. A total of 1,862 workers were invited to participate. Information about the study were collected by work records and self-reported health status. The exclusion criteria focused on participants' work experience, as well as their medical and medication history. Participants aged <20 or >60 years, who had been absent from work due to sick and occupational injuries, or who were stationed abroad, were excluded. Based on this criteria, 1,540 participants remained eligible. With the assistance of the administration bureau's managers, an announcement was forwarded to employees to explain that the survey was designed "to better understand how job strain and shift work affect mental health." Participants were selected randomly; participation was voluntary; responses were confidential; and participation did not affect health care benefits. Ultimately, 1,270 workers consented to participate in the study (Fig.1). Once an individual was identified and their formal consent was obtained, a

face-to-face interview was conducted during the annual professional health examination. This interview was carried out by trained interviewers using a questionnaire that included sociodemographic, job strain, shift work and mental health components.

Exposure assessment

The Job Content Questionnaire (JCQ) is one of the most widely used instruments to estimate job strain, and it is based on the Job Demand-Control model.[25] It is believed that job strain stems from an imbalance between work-related demands and an individual's control. The JCQ is widely used in the field of job strain research. The Chinese version of the JCQ was developed by domestic scholars, and has high reliability and validity.[26] In our study, 22 items from the original 49-item JCQ were applied, and they consisted of three dimensions: job demand, job control, and workplace social support. Each item was scored using a four-point Likert-type scale which ranged from 'strongly disagree' to 'strongly agree,' with higher scores indicating a higher level of psychological job demands, job control and workplace social support. In line with previously published studies, the scores for these subscales were divided into tertiles (low, medium, and high scores).[9 27] A job strain measure was computed using a combination of the job demands and control subscales, producing nine exposure categories which were further classified into three levels of job strain including low, intermediate, and high.[9] In the present study, the Cronbach's alpha coefficients for demand latitude, job control and social support of the JCQ-22 were 0.81, 0.79, and 0.86, respectively.

Shift work categories: According to the work schedules record held by the branch which related to the three months prior to the interviews, we classified workers into day shifts, night

shifts, and rotating night shifts. Day shift workers worked only during the day, according to the schedules, and their working hours were from 8:00 a.m. or 9:00 a.m. to 8:00 p.m. or 9:00 p.m. Night shift workers worked only during the night, according to the nature of the work and the schedules, and their working hours were strictly controlled and operated from 10 p.m. or 11 p.m. to 6 a.m. (need avoid driving hours). Rotating night shift workers was defined as at least five night shifts per month in addition to day shifts in that month. After consecutive night shifts, the schedule includes two days off. Descriptive statistics of the exposures are shown in Table 1.

Table 1. Descriptive statistics of the exposures

	All	
Exposures variable	n	%
Job strain		
Low	349	27.5
Medium	628	49.4
High	293	23.1
Shift types		
Day shift	300	23.6
Night shift	442	34.8
Rotating night shift	528	41.6

Outcome

We measured the general mental health of participants using the Symptom Checklist-90-Revised (SCL-90-R) which is a self-administrated questionnaire used to measure

psychological distress and psychological symptoms, and this questionnaire has been used in several community-based epidemiology studies.[28] It consists of 90 items across nine primary symptom domains: (a) somatization, (b) obsessive-compulsive, (c) interpersonal sensitivity, (d) depression, (e) anxiety, (f) hostility, (g) phobic anxiety, (h) paranoid ideation, and (i) psychoticism. Participants responses were measured using a five-point Likert-type scale ranging from 0 ("asymptomatic") to 4 ("very severe"). A total score of greater than 160 is a possible indication of mental health problems.[29] The Chinese version of the SCL-90-R has high reliability and validity, and can be used to measure psychological distress and psychological symptoms among the Chinese population.[30] In the current study, Cronbach's alpha was 0.854. The internal reliabilities of all nine subscales were greater than 0.8, respectively.

Covariates

Several demographic, socioeconomic, occupational, and lifestyle factors have been shown to be associated with mental health. Therefore, such factors may represent potential confounding variables for the results of any combined exposure to mental health and job strain or shift work. We considered the following variables in the study: sex, age (<30, 30–40, 40–50, >50 years) and marital status (married/unmarried). Occupational factors included job tenure (<10, 10–20, >20 years). The following lifestyle factors were considered: alcohol consumption, no (never or rarely)/yes (daily or often); smoking, "no" (never or rarely) or "yes" (daily or occasionally); and exercise, which was assessed with the question: "During the past month, how many times have you exercised?" The choice of response included "no" (never or rarely) or "regularly" (three times or more per week, and exercise was at least 1 hour in duration in each occasion).

Statistical analysis

Analyses were carried out using SPSS for Windows v.20.0 (SPSS, Inc., Chicago, IL, USA). Data were summarized using frequencies for categorical data. Chi-square tests were used to compare demographic characteristics. Odds ratios (ORs) and 95% confidence intervals (CIs) were determined for the risk associated with mental health using logistic regression. The combined effect of job strain and shift work on mental health was evaluated by carrying out a crossover analysis. All of the models were adjusted for age, job tenure, smoking and exercise. The tests were two-tailed and the significance level was set at $p<0.05$.

Patient and public involvement

Patients and the public were not involved in the design or planning of the study.

Results

The characteristics of 1,270 participants who took part in this study are shown in Table 2. Approximately 532 participants were identified as having mental health problems according to the cut-off score. Therefore, the prevalence of mental health problems among participants was 41.9% (532/1270). We found group differences with respect to the prevalence of mental health problems in the case of job tenure, smoking and exercise ($p<0.05$). Participants whose job tenure was <10 years were more likely to report poor mental health than those whose tenure was 10–20 years or >20 years (45.0% vs. 39.5% vs. 38.6%). Participants who smoked reported more mental health problems than than those who did not smoke (50.9% vs. 36.3%). Participants who did not exercise reported more mental health problems than those who engaged in regular exercise (44.90% vs. 35.0%). No statistically significant associations were observed between mental health problems and other variables such as age, sex, marital status, and alcohol consumption ($p>0.05$).

Table 2. Prevalence of poor mental health according to participant characteristics

Characteristics	n	No. mental health problems	Prevalence	χ^2	p-value
Age (years)					
<30	552	228	41.3%	3.012	0.390
30–40	217	102	47.0%		
40–50	277	110	39.7%		
>50	224	92	41.1%		
Sex					
Male	1242	520	41.9%	0.011	0.916
Female	28	12	42.9%		
Job tenure (years)					
<10	720	324	45.0%	6.959	**0.031**
10–20	167	60	35.9%		
>20	383	148	38.6%		
Marital status					
Unmarried	404	180	44.6%	1.728	0.189
Married	866	352	40.6%		
Alcohol consumption					
Yes	961	404	42.0%	0.036	0.849
No	309	128	41.4%		
Smoking					
Yes	483	246	50.9%	26.178	**<0.001**
No	787	286	36.3%		

Exercise					
Regularly	386	135	35.0%	10.895	**0.001**
No	884	397	44.9%		

The results of unconditional logistic regression analyses of the relationship between mental health and job strain after adjusting for age, job tenure, smoking, and exercise are shown in Table 3. The risk of poor mental health was higher among those who experienced a high level of job strain compared to low levels of job strain (OR=1.80, 95% CI: 1.31–2.47). The significant association persisted after adjusting for all other confounding factors, and greater odds of exhibiting case-level symptoms of common mental disorders were observed in relation to higher job demands (OR=2.28, 95% CI: 1.64–3.17), lower job control (OR=1.54, 95% CI: 1.18–2.02), lower social support (OR=2.00, 95% CI: 1.46–2.75), and a higher level of job strain (OR=1.53, 95% CI: 1.10–2.11).

Table 3. Odds ratios for mental health in relation to the different job strain exposures

		Model 1		Model 2	
Job demand	n (%)	OR (95% CI)	p value	OR (95% CI)	p value
Low	496 (39.1%)	1.00	—	1.00	—
Medium	519 (40.9%)	1.49 (1.08–2.06)	**0.016**	1.45 (1.04–2.03)	**0.030**
High	255 (20.0%)	2.54 (1.85–3.50)	**<0.001**	2.28 (1.64–3.17)	**<0.001**
Job control					
Low	585 (46.1%)	1.70 (1.31–2.21)	**<0.001**	1.54 (1.18–2.02)	**0.002**

Medium	279 (22.0%)	1.49 (1.09–2.04)	**0.013**	1.49 (1.08–2.06)	**0.008**
High	406 (31.9%)	1.00	—	1.00	—
Social support					
Low	540 (42.5%)	2.06 (1.52–2.79)	**<0.001**	2.00 (1.46–2.75)	**<0.001**
Medium	457 (36.0%)	1.33 (0.97–1.82)	0.078	1.30 (0.94–1.80)	0.109
High	273 (21.5%)	1.00	—	1.00	—
Job strain					
Low	349 (27.5%)	1.00	—	1.00	—
Medium	628 (49.4%)	1.04 (0.79–1.36)	0.781	0.99 (0.75–1.30)	0.932
High	293 (23.1%)	1.80 (1.31–2.47)	**0.009**	1.53 (1.10–2.11)	**0.011**

OR, odds ratio; CI, confidence interval.

Model 1 is crude. Model 2 is adjusted for age, job tenure, smoking and exercise

The results of multivariate analyses of the relationship between mental health and shift types after adjusting for age, job tenure, smoking, and exercise are shown in Table 4. The significant association persisted after adjusting for all other confounding factors, and mental disorders were associated with shift types, especially night shifts (OR=2.21, 95% CI: 1.60–3.07) and rotating night shifts (OR=2.36, 95% CI: 1.73–3.22).

Table 4. Odds ratios for mental health in relation to the different shift types exposures

		Model 1		Model 2	
Shift types	n (%)	OR (95% CI)	p value	OR (95% CI)	p value

Day shift	300 (23.6%)	1.00	—	1.00	—
Night shift	442 (34.8%)	2.64 (1.91–3.66)	**<0.001**	2.21 (1.60–3.07)	**<0.001**
Rotating night shift	528 (41.6%)	3.18 (2.32–4.36)	<0.001	2.36 (1.73–3.22)	**<0.001**

OR, odds ratio; CI, confidence interval.

Model 1 was crude. Model 2 was adjusted for age, job tenure, smoking, and exercise.

To investigate the combined exposure to job strain and shift work with respect to mental health, participants were divided into high-, low-, or moderate-job-strain groups, and day-, night- or rotating night shift types (Table 5). The crossover analysis showed that compared to participants with low or moderate levels of job strain who worked day shifts, day shift workers with high levels of job strain were more likely to have poor mental health (OR=2.80, 95% CI: 1.95-4.02), as were participants with high levels of job strain who worked night shifts (OR=4.57, 95% CI: 2.78-7.52). Those with high levels of job strain who work rotating night shifts had the highest likelihood of experiencing mental health problems (OR=5.53, 95% CI: 3.45-8.88). Participants with low or moderate levels of job strain who worked night shifts were at risk of poor mental health (OR=2.33, 95% CI: 1.61-3.39). The combined effect to job strain and shift work remained significant after adjusting for confounding factors, including age, job tenure, smoking and exercise, which were associated with poor mental health (OR=2.52, 95% CI: 1.64-3.57 for high levels of job strain and the day shift; and OR=4.33, 95% CI: 2.63-7.14 for high levels of job strain and the night shift; and OR=4.68, 95% CI: 2.91-8.04 for high levels of job strain and the rotating night shift when compared to lower or moderate levels of job strain and the day shift).

Table 5. The combined effect to job strain and shift types on mental health

		Model 1		Model 2	
Job strain	Shift types	OR (95% CI)	p value	OR (95% CI)	p value
Low and medium	Day shift	1.00	—	1.00	—
Low and medium	Night shift	2.33 (1.61–3.39)	**<0.001**	2.06 (1.42–2.99)	**<0.001**
Low and medium	rotating night shift	1.16 (0.62–2.17)	0.651	0.90 (0.43–1.72)	0.935
High	Day shift	2.80 (1.95–4.02)	**<0.001**	2.52 (1.64–3.57)	**<0.001**
High	Night shift	4.57 (2.78–7.52)	**<0.001**	4.33 (2.63–7.14)	**<0.001**
High	rotating night shift	5.53 (3.45–8.88)	**<0.001**	4.68 (2.91–8.04)	**<0.001**

Model 1 was crude. Model 2 was adjusted for age, job tenure, smoking, and exercise.

Discussion

This study investigated the potential relationship between job stress, shift work, psychological and behavioral factors, and mental health. This is the first study to examine a combined effect between job strain and shift types with respect to mental health among Chinese railway workers. This study's main findings show that job strain and shift work are correlated with mental health, and a combined exposure to high levels of job strain and rotating shifts were associated with poor mental health among railway workers.

The influence of work conditions on mental health has been extensively studied over the past decades. Specifically, the adverse effect of high levels of job strain on mental health problems has been widely accepted.[7] Indeed, in the present study, the multivariate logistic regression analyses revealed that workers with high levels of job strain, encompassing lower job control and higher job demands, were at a greater risk of poor mental health than those who experienced low or

moderate levels of strain. Some studies also suggest that exposure to chronic stressors, such as job strain, can cause dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and subsequent physiological changes that are involved in the pathophysiology of depression, including loss of neuroplasticity, inhibition of neurogenesis, and increased inflammation, which implies that stress disrupts normal mental health via HPA axis activation.[31]

Shift work is now very common in most countries.[32] The high prevalence of shift work has led to concerns about its potential adverse impact on health. The current research indicated that shift work has an even clearer impact on mental health than job strain. Night shifts, especially rotating night shifts, were identified as a risk factor for psychological problems among front-line railway workers in China. Our findings are consistent with a previous study which reported higher risks of mental health problems among night shift workers than day shift workers.[12 33] Interestingly, the role of rotating night shifts has been noticed. The sample population in this study largely included male front-line railway workers, and rotating night shifts were also found associated with increased mental health symptoms. A study found that rotating night shifts were associated with greater health risks than permanent night shifts, suggesting that the former shift type might be implicated in greater disruptions to physiological rhythms, and workers may have less time to adapt to the circadian clock.[34]

Our findings offer new insight into the impact of job strain and night shifts on mental health. The results of this study suggest that a combined exposure to high levels of job strain and rotating night shifts may occur in a additive fashion. In other words, the combined effect (OR=5.53) was greatest, and the relationship was also confirmed by adjusting potential confounding factors. These results suggest that employers should consider strategies for reducing the mental health

burden of shift workers, such as offering more job control, reducing job strain, and providing more social support at work. Workplace policies, programs, and practices could promote awareness of the associated risk factors, and enable access to mental health services.[12] Moreover, the magnitude of the OR was not statistically significant for the subgroup who worked rotating night shifts when compared to those who worked day shifts, when there is low and moderate job strain. This may suggests a mediating role for job strain in the shift work and mental health relationship.[12] According to the Job Demand-Control model, low job strain means low job demand or high job control, and may include a high level of social support. Multiple studies suggest that these factors may act as a buffer in regulating mental health.[35 36]

Some limitations of the current study and recommendations for future efforts should be considered. First, both job strain and mental health were self-reported, which may lead to single/common source bias and inflate the odds rations.[37] Second, lifestyle factors, such as alcohol, smoking and exercise, may vary greatly, e.g. "never or rarely alcohol" vs. "daily or often." This may lead to reporting bias, such that more participants reported "never" or "rarely" responses. Third, individual differences in terms of vulnerability to mental health could be expected. For instance, evening-type people who have a better ability to cope with shift work may have self-selected night jobs. Moreover, younger workers are more likely to be assigned night shifts or rotating night shifts. On the other hand, poor health conditions might cause workers to quit shift work, which could lead to a healthy worker selection bias. Longitudinal studies, which follow workers' occupational paths, are needed to confirm the causal relationships between shift work and health outcomes, as well as to avoid selection effects.

Conclusion

Our study suggests that workers who experience job strain or who work night shifts were more likely to suffer from mental health problems than day shift workers. Furthermore, we found that rotating night shift workers were also at a high risk of mental health problems. While further studies are needed to fully understand the biological and social consequences of job strain, night shifts and rotating shift among different genders and different subgroups, we suggest that employers and occupational health practitioners should pay attention to the impacts of the combined exposure to job strain and shift work, and effects on workers' health and well-being. Furthermore, a suitable working schedule should be designed to minimize adverse health consequences.

Acknowledgement

The authors wish to acknowledge all of the participants in this study.

Contributors

JY participated in the study design, data collation, analysis, interpretation of the data and drafted the manuscript and tables. WC contributed to interpretation of the data. HT, CM and LW assisted field investigation and collected the data. ZY, CZ and XX contributed data curation and formal analysis. All authors critically revised the manuscript.

Funding

This research was funded by the Startup Fund for scientific research, Fujian Medical University (Grant numbers 2018QH1008), Fujian Medical University's Research Foundation for Talented

Scholars (Grant number XRCZX2018011), and the 2019 Provincial Health Research Talent Training Program-Youth Research Project (Grant number 2019-1-59).

Conflicting interests

None declared.

Patient consent for publication

Not required.

Ethics approval

This study was approved by the ethics committees of Fujian Medical University (FJMU2019025).

Provenance and peer review

Not commissioned; externally peer reviewed.

Data availability statement

All data relevant to the study are included in the article or uploaded as supplementary information.

References

1 Huang Y, Wang Y, Wang H, et al. Prevalence of mental disorders in China: a cross-sectional epidemiological study. Lancet Psychiatry 2019; 6:211 – 224.

2 Rehm J, Shield KD. Global burden of disease and the impact of mental and addictive disorders. Curr Psychiatry Rep 2019; 21:10.

3 Whiteford HA, Degenhardt L, Rehm J, et al. Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. Lancet 2013; 382:1575-86.

4 Rantonen O, Alexanderson K, Pentti J, et al. Trends in work disability with mental diagnoses among social workers in Finland and Sweden in 2005-2012. Epidemiol Psychiatr Sci 2017;

26:644-54.

5 Scott KM, Lim C, Al-Hamzawi A, et al. Association of mental disorders with subsequent chronic physical conditions: World Mental Health Surveys from 17 countries. JAMA Psychiatry 2016; 73:150-58.

6 Milner A, Aitken Z, Kavanagh A, et al. Persistent and contemporaneous effects of job stressors on mental health: a study testing multiple analytic approaches across 13 waves of annually collected cohort data. Occup Environ Med 2016; 73:787-93.

7 Madsen IEH, Nyberg ST, Magnusson Hanson LL, et al. Job strain as a risk factor for clinical depression: systematic review and meta-analysis with additional individual participant data. Psychol. Med 2017; 47:1342-56.

8 Theorell T, Hammarström A, Aronsson G, et al. A systematic review including meta-analysis of work environment and depressive symptoms. BMC Public Health 2015;15:738.

9 Harvey SB, Sellahewa DA, Wang MJ, et al. The role of job strain in understanding midlife common mental disorder: a national birth cohort study. Lancet Psychiatry 2018; 5:498-506.

10 Theorell T, Hammarström A, Gustafsson PE, et al. Job strain and depressive symptoms in men and women: a prospective study of the working population in Sweden. J Epidemiol Community Health 2014; 68:78-82.

11 Stansfeld SA, Shipley MJ, Head J, et al. Repeated job strain and the risk of depression: longitudinal analyses from the Whitehall II study. Am J Public Health 2012; 102:2360-66.

12 Torquati L, Mielke GI, Brown WJ, et al. Shift work and poor mental health: A meta-analysis of longitudinal studies. Am J Public Health 2019; 109:e13-e20.

13 Alterman T, Luckhaupt S, Dahlhamer J, et al. Prevalence rates of work organization

characteristics among workers in the US: Data from the 2010 National Health Interview Survey. Am J Ind Med 2013;56:647-59.

14 Kogevinas M, Espinosa A, Papantoniou K, et al. Prostate cancer risk decreases following cessation of night shift work. Int J Cancer 2019; 145:2597-99.

15 Wright KP Jr, Bogan RK, Wyatt JK. Shift work and the assessment and management of shift work disorder (SWD). Sleep Med Rev 2013;17:41-54.

16 Lim YC, Hoe VCW, Darus A, et al. Association between night-shift work, sleep quality and metabolic syndrome. Occup Environ Med 2018;75:716-23.

17 Jaradat Y, Birkeland Nielsen M, Kristensen P, et al. Job satisfaction and mental health of Palestinian nurses with shift work: a cross-sectional study. Lancet 2018;391 Suppl 2:S50.

18 Behrens T, Rabstein S, Wichert K et al. Shift work and the incidence of prostate cancer: a 10-year follow-up of a German population-based cohort study. Scand J Work Environ Health 2017;43:560-68.

19 Thomas C, Power C. Shift work and risk factors for cardiovascular disease: a study at age 45 years in the 1958 British birth cohort. Eur J Epidemiol 2010;25:305-14.

20 Ramin C, Devore EE, Wang W, et al. Night shift work at specific age ranges and chronic disease risk factors. Occup Environ Med 2015;72:100-7.

21 Moreno CRC, Marqueze EC, Sargent C, et al. Working time society consensus statements: Evidence-based effects of shift work on physical and mental health. Ind Health 2019; 57:139-157.

22 Qian M. China Railway Yearbook. China Railway Yearbook Editional Office, 2013, Beijing, China.

23 Zhang X, Chen G, Xu F, et al. Health-related quality of life and associated factors of frontline

railway workers: a cross-sectional survey in the Ankang area, Shaanxi Province, China. Int J Environ Res Public Health 2016; 13:E1192.

24 Al-Dubai SA, Ganasegeran K, Elkalmi R, et al. Perceived stress among Malaysian railway workers. Malays J Med Sci 2016;23:38-43.

25 Karasek R, Brisson C, Kawakami N, et al. The job content questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol 1998;3:322-55.

26 Li J, Yang W, Liu P, et al. Psychometric evaluation of the Chinese (mainland) version of Job Content Questionnaire: a study in university hospitals. Ind Health 2004; 42:260-7.

27 Stansfeld SA, Clark C, Caldwell T, et al. Psychosocial work characteristics and anxiety and depressive disorders in midlife: the effects of prior psychological distress. Occup Environ Med 2008;65:634-42.

28 Derogatis LR. The SCL-90 Manual I: scoring, administration and procedures for the SCL-90. Baltimore (MD) 1977, Clinical Psychometric Research.

29 Liao J, Ma X, Gao B, et al. Psychological status of nursing survivors in China and its associated factors: 6 years after the 2008 Sichuan earthquake. Neuropsychiatr Dis Treat 2019;15:2301-11.

30 Chen S, Li L. Re-testing reliability, validity, and norm applicatility of SCL-90. Chin J Nerv Ment Dis 2003;29:323-7.

31 Lamers F, Vogelzangs N, Merikangas KR, et al. Evidence for a differential role of HPA-axis function, inflammation and metabolic syndrome in melancholic versus atypical depression. Mol Psychiatry 2013;18:692-99.

32 Wickwire EM, Geiger-Brown J, Scharf SM, et al. Shift Work and Shift Work Sleep Disorder: Clinical and Organizational Perspectives.Chest 2017 May;151:1156-1172.

33 Angerer P, Schmook R, Elfantel I, Li J. Night work and the risk of depression. Dtsch Arztebl Int 2017;114:404-11.

34 Muecke S. Effects of rotating night shifts: Literature review. J Adv Nurs 2005;50:433-9.

35 Chen J, Li J, Cao B, et al. Mediating effects of self-efficacy, coping, burnout, and social support between job stress and mental health among young Chinese nurses. J Adv Nurs 2020;76:163-73.

36 Fan JK, Mustard C, Smith PM. Psychosocial work conditions and mental health: Examining differences across mental illness and well-being outcomes. Ann Work Expo Health 2019;63:546-59.

37 Madsen IEH, Nyberg ST, Magnusson Hanson LL, et al. Job strain as a risk factor for clinical depression: systematic review and meta-analysis with additional individual participant data. Psychol Med 2017;47:1342-1356.

Figure Legends:

Figure 1. Flow of excluded individuals in the cross-sectional study.

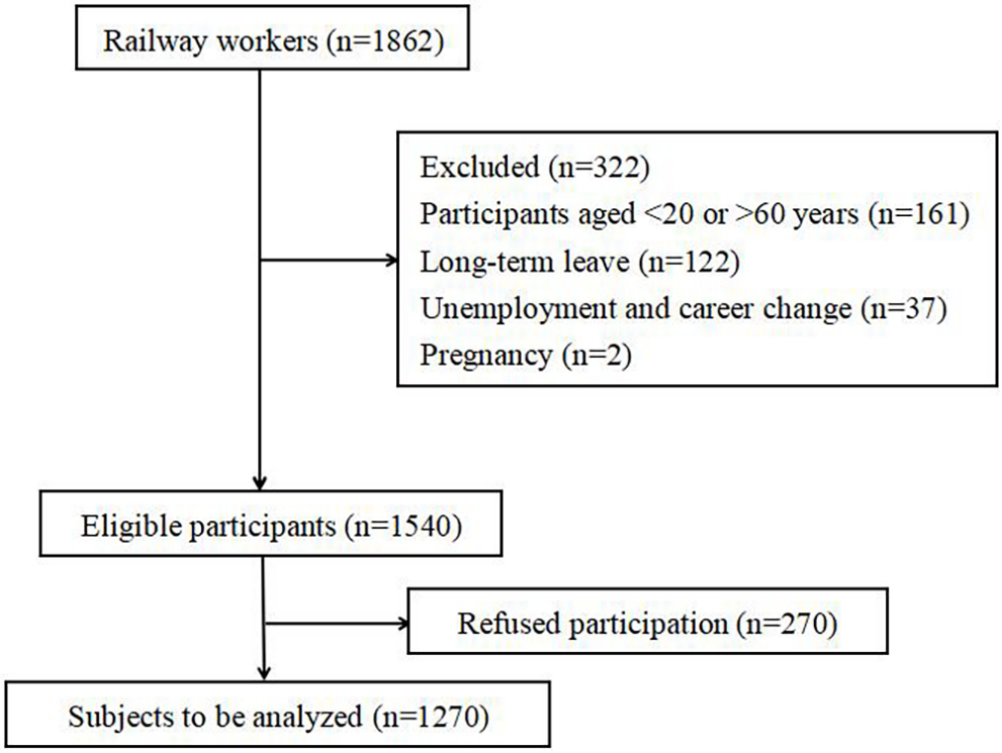

Figure 1. Flow of excluded individuals in the cross-sectional study.

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	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
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	6-7
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	N/A
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	8-9
		(b) Give reasons for non-participation at each stage	8-9
		(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	8-9
Outcome data	15*	Report numbers of outcome events or summary measures	10-13

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	8-9
		(*b*) Report category boundaries when continuous variables were categorized	8-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
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	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
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	17

*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

Association for combined exposure to job strain, shift work on mental health among Chinese railway workers: A cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-037544.R3
Article Type:	Original research
Date Submitted by the Author:	22-Sep-2020
Complete List of Authors:	Jiang, Yu; Fujian Medical University, public health Wu, Chuancheng; Fujian Medical University, Public health Hu, Tianqi; Fujian Medical University, Public health Chen, meilong; Fuzhou Railway Centers for Disease Control and Prevention, Occupational health Liu, Wei; Fujian Medical University, Public health Zhou, Yabing; Fujian Medical University, Humanities Chen, Zhibing; Fujian Medical University, Public health Xu, Xin; Fujian Medical University, Public health
Primary Subject Heading:	Occupational and environmental medicine
Secondary Subject Heading:	Occupational and environmental medicine
Keywords:	MENTAL HEALTH, OCCUPATIONAL & INDUSTRIAL MEDICINE, PUBLIC HEALTH

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.

Association for combined exposure to job strain, shift work on mental health among Chinese railway workers: A cross-sectional study

Jiang Yu[1*], Wu Chuancheng[1], Hu Tianqi[1], Chen Meilong[2], Liu Wei[1], Zhou Yabing[3], Chen Zhibing[1], Xu Xin[1]

[1]*Department of Preventive Medicine, Fujian Provincial Key Laboratory of Environment Factors and Cancer, Key Laboratory of Environment and Health, School of Public Health, Fujian Medical University, Fuzhou, Fujian, China*

[2]*Department of Occupational health, Fuzhou Railway Centers for Disease Control and Prevention, Fuzhou, Fujian, China*

[3]*Department of Humanities, Fujian Medical University, Fuzhou, Fujian, China*

Correspondence to

Dr. Jiang Yu,

School of Public Health,

Fujian Medical University, Fuzhou, Fujian 350012, China;

jiangyu@fjmu.edu.cn

Abstract

Objectives: The aim of this study was to assess the effects of co-exposure to job strain and shift work on mental health in railway workers.

Design: Cross-sectional study.

Setting: One Railway Bureau Group in China.

Participants: A total of 1,270 front-line railway workers.

Outcome measures: The Symptom Checklist-90-Revised questionnaire was used to measure

general mental health. Job strain variables were derived from the Job Content Questionnaire (JCQ). Based on the records of the work schedule three months prior to the survey, the following three shift types were identified: Fixed day, fixed night, and rotating night shifts. Risks associated with mental health were assessed by carrying out logistic regression analysis which was adjusted for age, job tenure, smoking and exercise. Additionally, a crossover analysis was employed for the combined effects.

Results: High levels of job strain were linked to a higher risk of poor mental health (odds ratio [OR]=1.53, 95% confidence interval [CI]: 1.10-2.11). After adjusting for confounding factors, night shifts and rotating night shifts were significant risk factors for mental health (OR=2.21, 95% CI: 1.60–3.07; OR=2.36, 95% CI: 1.73–3.22). Compared to participants who experienced a low level of job strain and day shifts, those with a high level of job strain and who worked rotating shifts were at the highest risk of poor mental health (OR=4.68, 95% CI: 2.91–8.04), whereas the influence of a low level of job strain and rotating night shifts was not statistically significant.

Conclusion: Job strain and night shifts among workers were associated, both independently and in combination, with an increased risk of poor mental health. Our data suggest that job strain contributes to the risk of poor mental health by means of a combined effect with shift work.

Keywords: Mental health; Job strain; Shift work

Strengths and limitations of this study

- ► Our study shows the relationship of job strain and shift work on mental health in front-line railway workers.
- ► Our study included three shift types: Fixed day, fixed night, and rotating night shifts.
- ► A randomly selected sample and analyses controlled by job tenure, smoking and exercise.
- ► Given the cross-sectional research design used, only statistical associations can be observed, and hence, strong causal claims are not strictly proven.
- ► Subjective assessment of job strain (questionnaire) did not allow a more objective evidence.

Introduction

Mental health disorders are a major public health concern, both globally and within China.[1] In fact, mental health (including substance abuse) affected more than one billion people globally in 2016, and caused 7% of all global burdens of disease as measured in Disability-Adjusted Life Years (DALYs), and the trend is still rising.[2 3] Mental disorders associated with chronic physical disease are more prevalent among specific occupational groups, and are a leading cause of absenteeism and long-term work incapacity.[4 5]

Many factors can influence mental health, including work-related stress.[6] Epidemiological studies have shown that job strain is linked to mental health and an increased risk of psychological disorders.[7 8] A large British cohort study assessed the prospective association between job strain and the onset of common mental disorders, and found that high job demands, low job control and high job strain remained significant independent predictors of the future onset of common mental disorders.[9] One study of healthy Swedish working men and women found that job strain was as strongly related to depressive symptoms among men as among women, and women reported higher levels of job strain than men.[10] Another study found that repeated job strain and low social support at work were associated with an increased risk of major depressive disorder, and after adjusting for earlier psychological distress, the results held.[11] These findings suggest that modifiable work-related risk factors might be an important factor for efforts to reduce the prevalence of mental disorders.

In addition to occupational stressors, shift work can increase the risk of mental health problems.[12] Since the industrial revolution, night shift work has become more and more common, and it is widespread within the services and fabricating industries as well as the transportation,

hospitality, manufacturing, and health care sectors.[13] Night shift work can be defined as a working schedule which involved working partly or entirely during night.[14] Studies have shown that long-term shifts can disrupt the 24-hour circadian rhythms and increase the risk of sleep disorders.[15] In addition, a close relationship has been found between shift work and many chronic diseases, such as cancer, metabolic disorders, cardiovascular diseases, and mental health disorders, etc.[12,16-19] Night shifts are known to disturb circadian rhythms by affecting melatonin secretion, stress hormones and autoimmune functions, which leads to impaired psychological well-being. Moreover, night shifts may also impair an individual's work-life balance and social interactions, which contributes to greater mental distress.[20 21]

China's total railway mileage reached 97,625 km by 2012, and is predicted to top 120,000 km by 2020, ranking second in the world after the United States. As the world's largest populated country and the fourth largest country by area, China has the highest rail transportation density in the world [39.95 million equated ton-km/km in 2012].[22] The increasing traffic volume results in a heavy workload for about two million railway workers in China. Except for the heavy workload, the front line workers often have irregular working schedules.[23] Workers in transportation industries have higher rates of mental disorders, depression and physical health effects than workers in other occupations, including professional and managerial occupations.[24] There is increasing concern about the health and wellbeing of railway workers, which is related to the safety of the country's transportation infrastructure.

Although several studies have highlighted the role of job strain or shift work in mental health, the combined effect of job strain and shift work on mental health in railway workers has received considerably less attention. We addressed this issue among railway workers in the Fuzhou region

of Fujian Province in China. The study aimed to examine the main effect of shift work and job strain on mental health, and the effect of the combined exposure to shift work and job strain on mental health.

Methods

Study design and participants

This research was carried out as part of the Occupational Health Study of Railway Workers in China and was conducted between March and September 2019. The target population included front-line employees of the Fuzhou branch of the China Railway Nanchang Bureau Group Co. Ltd. in Fuzhou City, Fujian province, China. The administration bureau has eight subordinate units and about 20,000 employees, and covers all work related to the railway industry. In summary, we used a stratified sampling method (stratified in shifts) to randomly select participants who had worked for a minimum of one year so that they could take part in an interview. Information about the study, with an invitation to participate, was orally passed on to the randomly selected workers by administration bureau' s managers in face-to-face meetings. Meanwhile, with the assistance of the managers, an announcement was forwarded to workers to explain that the survey was designed "to better understand how job strain and shift work affect mental health." A total of 1,862 workers were invited to participate. The exclusion criteria focused on participants' work experience, as well as their medical and medication history. Participants aged <20 or >60 years, who had been absent from work due to sick and occupational injuries, or who were stationed abroad, were excluded. Based on this criteria, 1,540 participants remained eligible. Participants was voluntary; responses were confidential; and participation did not affect health care benefits. Ultimately, 1,270 workers consented to participate in the study (Fig.1). Once an individual was identified and their

formal consent was obtained, a face-to-face interview was conducted during the annual professional health examination. This interview was carried out by trained interviewers using a questionnaire that included sociodemographic, job strain, shift work and mental health components.

Exposure assessment

The Job Content Questionnaire (JCQ) is one of the most widely used instruments to estimate job strain, and it is based on the Job Demand-Control model.[25] It is believed that job strain stems from an imbalance between work-related demands and an individual's control. The JCQ is widely used in the field of job strain research. The Chinese version of the JCQ was developed by domestic scholars, and has high reliability and validity.[26] In our study, 22 items from the original 49-item JCQ were applied, and they consisted of three dimensions: job demand, job control, and workplace social support. Each item was scored using a four-point Likert-type scale which ranged from 'strongly disagree' to 'strongly agree,' with higher scores indicating a higher level of psychological job demands, job control and workplace social support. In line with previously published studies, the scores for these subscales were divided into tertiles (low, medium, and high scores).[9 27] A job strain measure was computed using a combination of the job demands and control subscales, producing nine exposure categories which were further classified into three levels of job strain including low, intermediate, and high.[9] In the present study, the Cronbach's alpha coefficients for demand latitude, job control and social support of the JCQ-22 were 0.81, 0.79, and 0.86, respectively.

Shift work categories: According to the work schedules record held by the branch which

related to the three months prior to the interviews, we classified workers into day shifts, night shifts, and rotating night shifts. Day shift workers worked only during the day, according to the schedules, and their working hours were from 8:00 a.m. or 9:00 a.m. to 8:00 p.m. or 9:00 p.m. Night shift workers worked only during the night, according to the nature of the work and the schedules, and their working hours were strictly controlled and operated from 10 p.m. or 11 p.m. to 6 a.m. (need avoid driving hours). Rotating night shift workers was defined as at least five night shifts (not necessarily five consecutive nights) per month in addition to day shifts in that month. Note that if workers has three consecutive night shifts and above, the schedule includes the following two days off. Descriptive statistics of the exposures are shown in Table 1.

Table 1. Descriptive statistics of the exposures

	All	
Exposures variable	n	%
Job strain		
Low	349	27.5
Medium	628	49.4
High	293	23.1
Shift types		
Day shift	300	23.6
Night shift	442	34.8
Rotating night shift	528	41.6

Outcome

We measured the general mental health of participants using the Symptom Checklist-90-Revised (SCL-90-R) which is a self-administrated questionnaire used to measure psychological distress and psychological symptoms, and this questionnaire has been used in several community-based epidemiology studies.[28] It consists of 90 items across nine primary symptom domains: (a) somatization, (b) obsessive-compulsive, (c) interpersonal sensitivity, (d) depression, (e) anxiety, (f) hostility, (g) phobic anxiety, (h) paranoid ideation, and (i) psychoticism. Participants responses were measured using a five-point Likert-type scale ranging from 0 ("asymptomatic") to 4 ("very severe"). A total score of greater than 160 is a possible indication of mental health problems.[29] The Chinese version of the SCL-90-R has high reliability and validity, and can be used to measure psychological distress and psychological symptoms among the Chinese population.[30] In the current study, Cronbach's alpha was 0.854. The internal reliabilities of all nine subscales were greater than 0.8, respectively.

Covariates

Several demographic, socioeconomic, occupational, and lifestyle factors have been shown to be associated with mental health. Therefore, such factors may represent potential confounding variables for the results of any combined exposure to mental health and job strain or shift work. We considered the following variables in the study: sex, age (<30, 30–40, 40–50, >50 years) and marital status (married/unmarried). Occupational factors included job tenure (<10, 10–20, >20 years). The following lifestyle factors were considered: alcohol consumption, no (never or rarely)/yes (daily or often); smoking, "no" (never or rarely) or "yes" (daily or occasionally); and exercise, which was assessed with the question: "During the past month, how many times have you exercised?" The choice of response included "no" (never or rarely) or "regularly" (three times

or more per week, and exercise was at least 1 hour in duration in each occasion).

Statistical analysis

Analyses were carried out using SPSS for Windows v.20.0 (SPSS, Inc., Chicago, IL, USA). Data were summarized using frequencies for categorical data. Chi-square tests were used to compare demographic characteristics. Odds ratios (ORs) and 95% confidence intervals (CIs) were determined for the risk associated with mental health using logistic regression. The combined effect of job strain and shift work on mental health was evaluated by carrying out a crossover analysis. All of the models were adjusted for age, job tenure, smoking and exercise. The tests were two-tailed and the significance level was set at $p<0.05$.

Patient and public involvement

Patients and the public were not involved in the design or planning of the study.

Results

The characteristics of 1,270 participants who took part in this study are shown in Table 2. Approximately 532 participants were identified as having mental health problems according to the cut-off score. Therefore, the prevalence of mental health problems among participants was 41.9% (532/1270). We found group differences with respect to the prevalence of mental health problems in the case of job tenure, smoking and exercise ($p<0.05$). Participants whose job tenure was <10 years were more likely to report poor mental health than those whose tenure was 10–20 years or >20 years (45.0% vs. 39.5% vs. 38.6%). Participants who smoked reported more mental health problems than than those who did not smoke (50.9% vs. 36.3%). Participants who did not exercise reported more mental health problems than those who engaged in regular exercise (44.90% vs. 35.0%). No statistically significant associations were observed between mental health problems

and other variables such as age, sex, marital status, and alcohol consumption (p>0.05).

Table 2. Prevalence of poor mental health according to participant characteristics

Characteristics	n	No. mental health problems	Prevalence	χ^2	p-value
Age (years)					
<30	552	228	41.3%	3.012	0.390
30–40	217	102	47.0%		
40–50	277	110	39.7%		
>50	224	92	41.1%		
Sex					
Male	1242	520	41.9%	0.011	0.916
Female	28	12	42.9%		
Job tenure (years)					
<10	720	324	45.0%	6.959	**0.031**
10–20	167	60	35.9%		
>20	383	148	38.6%		
Marital status					
Unmarried	404	180	44.6%	1.728	0.189
Married	866	352	40.6%		
Alcohol consumption					
Yes	961	404	42.0%	0.036	0.849
No	309	128	41.4%		
Smoking					

Yes	483	246	50.9%	26.178	**<0.001**
No	787	286	36.3%		
Exercise					
Regularly	386	135	35.0%	10.895	**0.001**
No	884	397	44.9%		

The results of unconditional logistic regression analyses of the relationship between mental health and job strain after adjusting for age, job tenure, smoking, and exercise are shown in Table 3. The risk of poor mental health was higher among those who experienced a high level of job strain compared to low levels of job strain (OR=1.80, 95% CI: 1.31–2.47). The significant association persisted after adjusting for all other confounding factors, and greater odds of exhibiting case-level symptoms of common mental disorders were observed in relation to higher level of job strain (OR=1.53, 95% CI: 1.10–2.11), higher job demands (OR=2.28, 95% CI: 1.64–3.17), lower job control (OR=1.54, 95% CI: 1.18–2.02), and lower social support (OR=2.00, 95% CI: 1.46–2.75).

Table 3. Odds ratios for mental health in relation to the different job strain exposures

		Model 1		Model 2	
Variables	n (%)	OR (95% CI)	p value	OR (95% CI)	p value
Job strain					
Low	349 (27.5%)	1.00	—	1.00	—
Medium	628 (49.4%)	1.04 (0.79–1.36)	0.781	0.99 (0.75–1.30)	0.932
High	293 (23.1%)	1.80 (1.31–2.47)	**0.009**	1.53 (1.10–2.11)	**0.011**

Job demand					
Low	496 (39.1%)	1.00	—	1.00	—
Medium	519 (40.9%)	1.49 (1.08–2.06)	**0.016**	1.45 (1.04–2.03)	**0.030**
High	255 (20.0%)	2.54 (1.85–3.50)	**<0.001**	2.28 (1.64–3.17)	**<0.001**
Job control					
Low	585 (46.1%)	1.70 (1.31–2.21)	**<0.001**	1.54 (1.18–2.02)	**0.002**
Medium	279 (22.0%)	1.49 (1.09–2.04)	**0.013**	1.49 (1.08–2.06)	**0.008**
High	406 (31.9%)	1.00	—	1.00	—
Social support					
Low	540 (42.5%)	2.06 (1.52–2.79)	**<0.001**	2.00 (1.46–2.75)	**<0.001**
Medium	457 (36.0%)	1.33 (0.97–1.82)	0.078	1.30 (0.94–1.80)	0.109
High	273 (21.5%)	1.00	—	1.00	—

OR, odds ratio; CI, confidence interval.

Model 1 is crude. Model 2 is adjusted for age, job tenure, smoking and exercise

The results of multivariate analyses of the relationship between mental health and shift types after adjusting for age, job tenure, smoking, and exercise are shown in Table 4. The significant association persisted after adjusting for all other confounding factors, and mental disorders were associated with shift types, especially night shifts (OR=2.21, 95% CI: 1.60–3.07) and rotating night shifts (OR=2.36, 95% CI: 1.73–3.22).

Table 4. Odds ratios for mental health in relation to the different shift types exposures

	Model 1	Model 2

Shift types	n (%)	OR (95% CI)	p value	OR (95% CI)	p value
Day shift	300 (23.6%)	1.00	—	1.00	—
Night shift	442 (34.8%)	2.64 (1.91–3.66)	**<0.001**	2.21 (1.60–3.07)	**<0.001**
Rotating night shift	528 (41.6%)	3.18 (2.32–4.36)	<0.001	2.36 (1.73–3.22)	**<0.001**

OR, odds ratio; CI, confidence interval.

Model 1 was crude. Model 2 was adjusted for age, job tenure, smoking, and exercise.

To investigate the combined exposure to job strain and shift work with respect to mental health, participants were divided into high-, low-, or moderate-job-strain groups, and day-, night- or rotating night shift types (Table 5). The crossover analysis showed that compared to participants with low or moderate levels of job strain who worked day shifts, day shift workers with high levels of job strain were more likely to have poor mental health (OR=2.80, 95% CI: 1.95-4.02), as were participants with high levels of job strain who worked night shifts (OR=4.57, 95% CI: 2.78-7.52). Those with high levels of job strain who work rotating night shifts had the highest likelihood of experiencing mental health problems (OR=5.53, 95% CI: 3.45-8.88). Participants with low or moderate levels of job strain who worked night shifts were at risk of poor mental health (OR=2.33, 95% CI: 1.61-3.39). The combined effect to job strain and shift work remained significant after adjusting for confounding factors, including age, job tenure, smoking and exercise, which were associated with poor mental health (OR=2.52, 95% CI: 1.64-3.57 for high levels of job strain and the day shift; and OR=4.33, 95% CI: 2.63-7.14 for high levels of job strain and the night shift; and OR=4.68, 95% CI: 2.91-8.04 for high levels of job strain and the rotating night shift when compared to lower or moderate levels of job strain and the day shift).

Table 5. The combined effect to job strain and shift types on mental health

		Model 1		Model 2	
Job strain	Shift types	OR (95% CI)	p value	OR (95% CI)	p value
Low and medium	Day shift	1.00	—	1.00	—
Low and medium	Night shift	2.33 (1.61–3.39)	**<0.001**	2.06 (1.42–2.99)	**<0.001**
Low and medium	rotating night shift	1.16 (0.62–2.17)	0.651	0.90 (0.43–1.72)	0.935
High	Day shift	2.80 (1.95–4.02)	**<0.001**	2.52 (1.64–3.57)	**<0.001**
High	Night shift	4.57 (2.78–7.52)	**<0.001**	4.33 (2.63–7.14)	**<0.001**
High	rotating night shift	5.53 (3.45–8.88)	**<0.001**	4.68 (2.91–8.04)	**<0.001**

Model 1 was crude. Model 2 was adjusted for age, job tenure, smoking, and exercise.

Discussion

This study investigated the potential relationship between job stress, shift work, psychological and behavioral factors, and mental health. This is the first study to examine a combined effect between job strain and shift types with respect to mental health among Chinese railway workers. This study's main findings show that job strain and shift work are correlated with mental health, and a combined exposure to high levels of job strain and rotating shifts were associated with poor mental health among railway workers.

The influence of work conditions on mental health has been extensively studied over the past decades. Specifically, the adverse effect of high levels of job strain on mental health problems has been widely accepted.[7] Indeed, in the present study, the multivariate logistic regression analyses revealed that workers with high levels of job strain, encompassing lower job control and higher

job demands, were at a greater risk of poor mental health than those who experienced low or moderate levels of strain. Some studies also suggest that exposure to chronic stressors, such as job strain, can cause dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis and subsequent physiological changes that are involved in the pathophysiology of depression, including loss of neuroplasticity, inhibition of neurogenesis, and increased inflammation, which implies that stress disrupts normal mental health via HPA axis activation.[31]

Shift work is now very common in most countries.[32] The high prevalence of shift work has led to concerns about its potential adverse impact on health. The current research indicated that shift work has an even clearer impact on mental health than job strain. Night shifts, especially rotating night shifts, were identified as a risk factor for psychological problems among front-line railway workers in China. Our findings are consistent with a previous study which reported higher risks of mental health problems among night shift workers than day shift workers.[12 33] Interestingly, the role of rotating night shifts has been noticed. The sample population in this study largely included male front-line railway workers, and rotating night shifts were also found associated with increased mental health symptoms. A study found that rotating night shifts were associated with greater health risks than permanent night shifts, suggesting that the former shift type might be implicated in greater disruptions to physiological rhythms, and workers may have less time to adapt to the circadian clock.[34]

Our findings offer new insight into the impact of job strain and night shifts on mental health. The results of this study suggest that a combined exposure to high levels of job strain and rotating night shifts may occur in a additive fashion. In other words, the combined effect (OR=5.53) was greatest, and the relationship was also confirmed by adjusting potential confounding factors.

These results suggest that employers should consider strategies for reducing the mental health burden of shift workers, such as offering more job control, reducing job strain, and providing more social support at work. Workplace policies, programs, and practices could promote awareness of the associated risk factors, and enable access to mental health services.[12] Moreover, the magnitude of the OR was not statistically significant for the subgroup who worked rotating night shifts when compared to those who worked day shifts, when there is low and moderate job strain. This may suggests a mediating role for job strain in the shift work and mental health relationship.[12] According to the Job Demand-Control model, low job strain means low job demand or high job control, and may include a high level of social support. Multiple studies suggest that these factors may act as a buffer in regulating mental health.[35 36]

Some limitations of the current study and recommendations for future efforts should be considered. First, both job strain and mental health were self-reported, which may lead to single/common source bias and inflate the odds rations.[37] Second, lifestyle factors, such as alcohol, smoking and exercise, may vary greatly, e.g. “never or rarely alcohol” vs. “daily or often.” This may lead to reporting bias, such that more participants reported “never” or “rarely” responses. Third, individual differences in terms of vulnerability to mental health could be expected. For instance, evening-type people who have a better ability to cope with shift work may have self-selected night jobs. Moreover, younger workers are more likely to be assigned night shifts or rotating night shifts. On the other hand, poor health conditions might cause workers to quit shift work, which could lead to a healthy worker selection bias. Longitudinal studies, which follow workers’ occupational paths, are needed to confirm the causal relationships between shift work and health outcomes, as well as to avoid selection effects.

Conclusion

Our study suggests that workers who experience job strain or who work night shifts were more likely to suffer from mental health problems than day shift workers. Furthermore, we found that rotating night shift workers were also at a high risk of mental health problems. While further studies are needed to fully understand the biological and social consequences of job strain, night shifts and rotating shift among different genders and different subgroups, we suggest that employers and occupational health practitioners should pay attention to the impacts of the combined exposure to job strain and shift work, and effects on workers' health and well-being. Furthermore, a suitable working schedule should be designed to minimize adverse health consequences.

Acknowledgement

The authors wish to acknowledge all of the participants in this study.

Contributors

JY participated in the study design, data collation, analysis, interpretation of the data and drafted the manuscript and tables. WC contributed to interpretation of the data. HT, CM and LW assisted field investigation and collected the data. ZY, CZ and XX contributed data curation and formal analysis. All authors critically revised the manuscript.

Funding

This research was funded by the Startup Fund for scientific research, Fujian Medical University

(Grant numbers 2018QH1008), Fujian Medical University's Research Foundation for Talented Scholars (Grant number XRCZX2018011), and the 2019 Provincial Health Research Talent Training Program-Youth Research Project (Grant number 2019-1-59).

Conflicting interests

None declared.

Patient consent for publication

Not required.

Ethics approval

This study was approved by the ethics committees of Fujian Medical University (FJMU2019025).

Provenance and peer review

Not commissioned; externally peer reviewed.

Data availability statement

All data relevant to the study are included in the article or uploaded as supplementary information.

References

1 Huang Y, Wang Y, Wang H, et al. Prevalence of mental disorders in China: a cross-sectional epidemiological study. Lancet Psychiatry 2019; 6:211 – 224.

2 Rehm J, Shield KD. Global burden of disease and the impact of mental and addictive disorders. Curr Psychiatry Rep 2019; 21:10.

3 Whiteford HA, Degenhardt L, Rehm J, et al. Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. Lancet 2013; 382:1575-86.

4 Rantonen O, Alexanderson K, Pentti J, et al. Trends in work disability with mental diagnoses

among social workers in Finland and Sweden in 2005-2012. Epidemiol Psychiatr Sci 2017; 26:644-54.

5 Scott KM, Lim C, Al-Hamzawi A, et al. Association of mental disorders with subsequent chronic physical conditions: World Mental Health Surveys from 17 countries. JAMA Psychiatry 2016; 73:150-58.

6 Milner A, Aitken Z, Kavanagh A, et al. Persistent and contemporaneous effects of job stressors on mental health: a study testing multiple analytic approaches across 13 waves of annually collected cohort data. Occup Environ Med 2016; 73:787-93.

7 Madsen IEH, Nyberg ST, Magnusson Hanson LL, et al. Job strain as a risk factor for clinical depression: systematic review and meta-analysis with additional individual participant data. Psychol. Med 2017; 47:1342-56.

8 Theorell T, Hammarström A, Aronsson G, et al. A systematic review including meta-analysis of work environment and depressive symptoms. BMC Public Health 2015;15:738.

9 Harvey SB, Sellahewa DA, Wang MJ, et al. The role of job strain in understanding midlife common mental disorder: a national birth cohort study. Lancet Psychiatry 2018; 5:498-506.

10 Theorell T, Hammarström A, Gustafsson PE, et al. Job strain and depressive symptoms in men and women: a prospective study of the working population in Sweden. J Epidemiol Community Health 2014; 68:78-82.

11 Stansfeld SA, Shipley MJ, Head J, et al. Repeated job strain and the risk of depression: longitudinal analyses from the Whitehall II study. Am J Public Health 2012; 102:2360-66.

12 Torquati L, Mielke GI, Brown WJ, et al. Shift work and poor mental health: A meta-analysis of longitudinal studies. Am J Public Health 2019; 109:e13-e20.

13 Alterman T, Luckhaupt S, Dahlhamer J, et al. Prevalence rates of work organization characteristics among workers in the US: Data from the 2010 National Health Interview Survey. Am J Ind Med 2013;56:647-59.

14 Kogevinas M, Espinosa A, Papantoniou K, et al. Prostate cancer risk decreases following cessation of night shift work. Int J Cancer 2019; 145:2597-99.

15 Wright KP Jr, Bogan RK, Wyatt JK. Shift work and the assessment and management of shift work disorder (SWD). Sleep Med Rev 2013;17:41-54.

16 Lim YC, Hoe VCW, Darus A, et al. Association between night-shift work, sleep quality and metabolic syndrome. Occup Environ Med 2018;75:716-23.

17 Jaradat Y, Birkeland Nielsen M, Kristensen P, et al. Job satisfaction and mental health of Palestinian nurses with shift work: a cross-sectional study. Lancet 2018;391 Suppl 2:S50.

18 Behrens T, Rabstein S, Wichert K et al. Shift work and the incidence of prostate cancer: a 10-year follow-up of a German population-based cohort study. Scand J Work Environ Health 2017;43:560-68.

19 Thomas C, Power C. Shift work and risk factors for cardiovascular disease: a study at age 45 years in the 1958 British birth cohort. Eur J Epidemiol 2010;25:305-14.

20 Ramin C, Devore EE, Wang W, et al. Night shift work at specific age ranges and chronic disease risk factors. Occup Environ Med 2015;72:100-7.

21 Moreno CRC, Marqueze EC, Sargent C, et al. Working time society consensus statements: Evidence-based effects of shift work on physical and mental health. Ind Health 2019; 57:139-157.

22 Qian M. China Railway Yearbook. China Railway Yearbook Editional Office, 2013, Beijing, China.

23 Zhang X, Chen G, Xu F, et al. Health-related quality of life and associated factors of frontline railway workers: a cross-sectional survey in the Ankang area, Shaanxi Province, China. Int J Environ Res Public Health 2016; 13:E1192.

24 Al-Dubai SA, Ganasegeran K, Elkalmi R, et al. Perceived stress among Malaysian railway workers. Malays J Med Sci 2016;23:38-43.

25 Karasek R, Brisson C, Kawakami N, et al. The job content questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol 1998;3:322-55.

26 Li J, Yang W, Liu P, et al. Psychometric evaluation of the Chinese (mainland) version of Job Content Questionnaire: a study in university hospitals. Ind Health 2004; 42:260-7.

27 Stansfeld SA, Clark C, Caldwell T, et al. Psychosocial work characteristics and anxiety and depressive disorders in midlife: the effects of prior psychological distress. Occup Environ Med 2008;65:634-42.

28 Derogatis LR. The SCL-90 Manual I: scoring, administration and procedures for the SCL-90. Baltimore (MD) 1977, Clinical Psychometric Research.

29 Liao J, Ma X, Gao B, et al. Psychological status of nursing survivors in China and its associated factors: 6 years after the 2008 Sichuan earthquake. Neuropsychiatr Dis Treat 2019;15:2301-11.

30 Chen S, Li L. Re-testing reliability, validity, and norm applicatility of SCL-90. Chin J Nerv Ment Dis 2003;29:323-7.

31 Lamers F, Vogelzangs N, Merikangas KR, et al. Evidence for a differential role of HPA-axis function, inflammation and metabolic syndrome in melancholic versus atypical depression. Mol

Psychiatry 2013;18:692-99.

32 Wickwire EM, Geiger-Brown J, Scharf SM, et al. Shift Work and Shift Work Sleep Disorder: Clinical and Organizational Perspectives.Chest 2017 May;151:1156-1172.

33 Angerer P, Schmook R, Elfantel I, Li J. Night work and the risk of depression. Dtsch Arztebl Int 2017;114:404-11.

34 Muecke S. Effects of rotating night shifts: Literature review. J Adv Nurs 2005;50:433-9.

35 Chen J, Li J, Cao B, et al. Mediating effects of self-efficacy, coping, burnout, and social support between job stress and mental health among young Chinese nurses. J Adv Nurs 2020;76:163-73.

36 Fan JK, Mustard C, Smith PM. Psychosocial work conditions and mental health: Examining differences across mental illness and well-being outcomes. Ann Work Expo Health 2019;63:546-59.

37 Madsen IEH, Nyberg ST, Magnusson Hanson LL, et al. Job strain as a risk factor for clinical depression: systematic review and meta-analysis with additional individual participant data. Psychol Med 2017;47:1342-1356.

Figure Legends:

Figure 1. Flow of excluded individuals in the cross-sectional study.

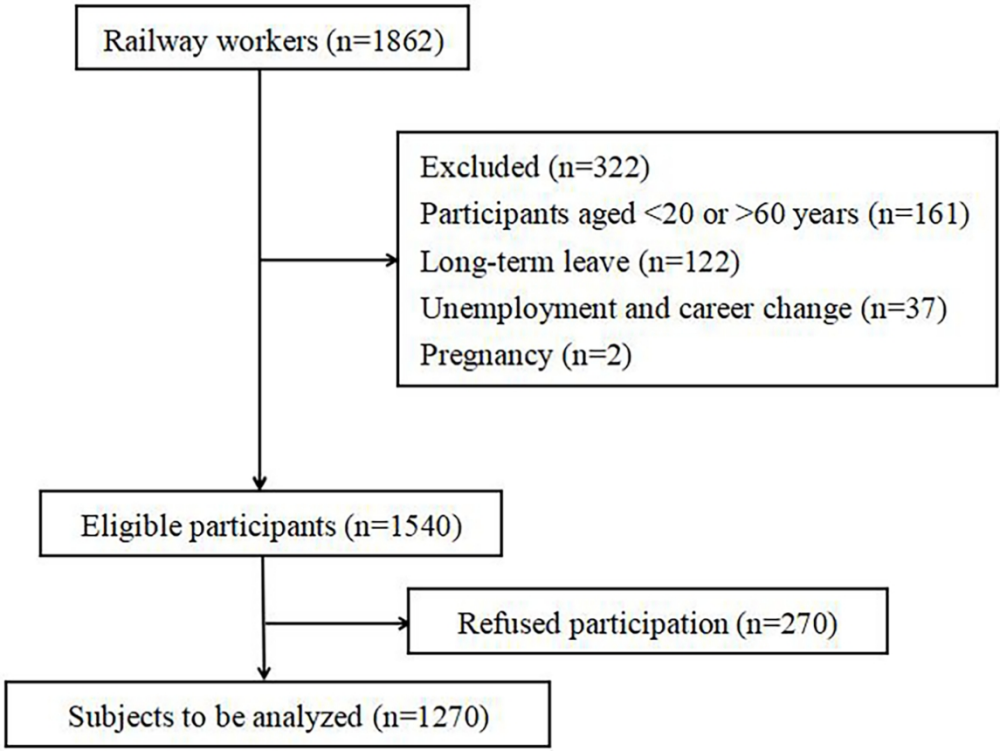

Figure 1. Flow of excluded individuals in the cross-sectional study.

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	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
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	7-9
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	9-10
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	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	10
		(*e*) Describe any sensitivity analyses	N/A

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	10-11
		(b) Give reasons for non-participation at each stage	10-11
		(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	10-11
		(b) Indicate number of participants with missing data for each variable of interest	10-11
Outcome data	15*	Report numbers of outcome events or summary measures	12-15
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	12-15
		(*b*) Report category boundaries when continuous variables were categorized	12-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	15
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
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	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
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	18

*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.