



BMJ Open Sleep problems of healthcare workers in tertiary hospital and influencing factors identified through a multilevel analysis: a cross-sectional study in China

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ABSTRACT

Objectives Sleep problems are common among healthcare workers, especially among those who work in tertiary hospitals; however, studies focusing on healthcare workers in tertiary hospitals in China are limited. Therefore, we aimed to examine the prevalence of sleep problems among tertiary hospital employees in China and identify associated factors.

Design Cross-sectional questionnaire survey study.

Setting The study was conducted in 317 departments at 33 tertiary hospitals in the Heilongjiang Province, China.

Participants The study included a representative sample of 4007 healthcare workers, including clinicians, medical technicians and office workers, who were selected using a multistage cluster sampling method. Ultimately, 3810 participants completed valid questionnaires, yielding a response rate of 95%.

Primary and secondary outcome measures Participants completed a structured questionnaire which collected data regarding demographics, sleep problems, employment, chronic pain and health-related behaviours. A two-level logistic regression model was constructed to examine determinants of sleep problems.

Results We found that nearly half of the respondents reported experiencing sleep problems. The two-level logistic model suggested a positive association of sleep problems with headache (OR=2.64, 95% CI=2.27 to 3.07), working hours (OR=1.41, 95% CI=1.20 to 1.66) and night shifts (OR=1.43, 95% CI=1.21 to 1.69). In contrast, regular diet (OR=0.44, 95% CI=0.36 to 0.53) and exercise (OR=0.65, 95% CI=0.53 to 0.80) protected the study population against sleep problems.

Conclusions We found that sleep problems are prominent among tertiary hospital employees in China. The risk factor most strongly associated with sleep problems was headaches. To alleviate sleep problems in this population, medical institutions and health policy makers should establish reasonable working schedules and night-shift work systems, while the healthcare workers themselves should pay attention to their chronic pain problems and engage in regular diet and exercise.

INTRODUCTION

Sleep problems are increasingly becoming a public health concern. Globally, it is estimated

Strengths and limitations of this study

- This was a multicentre study with a large sample size; specifically, we recruited 3810 healthcare workers from 317 departments at 33 tertiary hospitals in the Heilongjiang Province, China, using multi-stage stratified random sampling.
- Considering the hierarchical structure of the study sample, a two-level logistic model was applied to examine determinants of sleep problems in order to obtain more accurate and reliable results.
- Although the results of the study may not be generalisable to healthcare workers in other countries, the findings likely accurately reflect the sleep problems of many Chinese healthcare workers, particularly those working in tertiary public hospitals in China.
- Information regarding the exposure and outcome was obtained via a self-report questionnaire which may have introduced report bias.
- The cross-sectional design limited our ability to establish causal relationships based on the results.

that 7.6% of the population has sleep problems.¹ Common sleep problems include difficulty falling asleep, frequent night-time awakenings, parasomnias, noisy breathing, snoring and obstructive sleep apnoea.² In China, workers in a variety of occupations are at risk of sleep problems, although sleep problems are particularly evident among healthcare workers.³ Many scholars have reported a high prevalence of sleep problems among Chinese healthcare workers, ranging from 21% to 65.5%.⁴⁻⁶ In fact, it has been shown that sleep problems are common among healthcare workers worldwide, including clinicians, nurses, medical technicians and administrative staff.

For example, in a study by Hayashino *et al.*, 30.7% of Japanese healthcare workers reported having difficulty initiating sleep.⁷ Moreover, a study performed in Italy found that the prevalence of sleep disturbances

among healthcare workers was extremely high, even among healthy controls in the study, with 24.6% of workers reporting difficulties falling asleep and 31.7% experiencing frequent awakenings during the night.⁸ In a study in Iran, nearly 43% of healthcare workers reported different degrees of sleep problems.⁹

Paying special attention to sleep problems among healthcare workers is essential for several reasons. First, sleep problems can affect the health and safety of these workers. For instance, various studies have confirmed that sleep problems have a powerful influence on the risk of cardiovascular disease, immune disorders and cancer.^{10–12} Sun and colleagues reported a significant negative correlation between anxiety and sleep problems in healthcare workers.⁴ Moreover, Kling *et al* reported that sleep problems are associated with an increased risk of work injury.¹³ Second, sleep problems affect both the health of the healthcare workers and patient safety and the quality of medical services the healthcare workers provide. Indeed, there is clear evidence indicating that sleep deprivation caused by long working hours can affect both the health of healthcare workers and the safety of patients.¹⁴ Further, sleep deprivation, long working hours and working during the night have been found to lead to medical errors, such as increases in the rates of surgical complications, needlestick injuries, adverse drug events and misdiagnosis.^{15–18}

Currently, there is tremendous pressure on the healthcare system in China given the increasing size of the ageing population¹⁹ and the elevated incidence of chronic diseases such as cancer²⁰ and cardiovascular diseases.²¹ In response to the increasing demands on healthcare services, the workloads and hours worked by healthcare workers have likewise increased, which may also lead to more frequent sleep problems in these individuals. One prior study with healthcare workers indicated that long working hours were the critical determinant of sleep health.²² However, few studies have focused on the relationship between working hours and sleep problems in healthcare workers in China. Moreover, Kim *et al* suggested that frequent night shifts are likely to be an important factor affecting sleep problems among healthcare workers.²³

Furthermore, chronic pain, which is common among healthcare workers,²⁴ has been shown to be related to sleep problems,²⁵ although it remains unclear which specific site of chronic pain most greatly affects sleep problems. Health-related behaviours are also an important potential influencing factor. For example, research has shown that unhealthy diets are associated with sleep problems, while a healthy diet can effectively improve sleep quality.²⁶ A recent study conducted in Japan observed that healthcare workers who reported having trouble initiating sleep consumed more alcohol and exercised less.⁷ In addition, it has been noted that sleep health assessment should be multidimensional, with sleep duration being one of the most important aspects.^{27 28} Although sleep needs differ among individuals due to genetic and environmental

factors,²⁹ shorter sleep duration may increase the likelihood of sleep problems.³⁰

In 2009, China launched a nationwide systematic reform of healthcare services. Although the reform was successful in some areas, additional steps are required to reform the delivery of China's healthcare services. Particularly, primary healthcare facilities have not been able to perform a gate-keeping function, and most patients in China prefer to visit tertiary hospitals, especially tertiary public hospitals, even for common and minor illnesses. In 2016, there were approximately 3.27 billion patient visits to Chinese hospitals, 49.8% of which were visits to tertiary hospitals.³¹ A survey of the Chinese Medical Doctor Association in 2014 showed that 92% of healthcare workers in tertiary hospitals had to work overtime, and 72% of the healthcare workers who work >60 hours/week on average are employed in tertiary hospitals in China.³² Therefore, the sleep problems of healthcare workers in tertiary hospitals are of paramount importance. Nevertheless, population-based prevalence data on sleep problems among healthcare workers in tertiary hospitals in China are limited. Further, the relationships among sleep problems, work factors, health-related behaviours and chronic pain remain to be discovered in this population.

Therefore, the purposes of the present study were to investigate the prevalence of self-reported sleep problems among healthcare workers in tertiary public hospitals in China and to identify potential factors associated with sleep problems among these individuals. This study has several advantages. First, although it has been established that sleep problems are common among healthcare workers, relevant studies examining tertiary hospital employees in China are limited. Second, considering the hierarchical structure of the study sample, a two-level logistic model was applied to examine determinants of sleep problems in order to obtain more accurate and reliable results. Third, in contrast to previous reports,^{33–35} this was a multicentre study covering a large sample of healthcare workers in the Heilongjiang Province of China.

METHODS

Data collection and study population

This study took place in Heilongjiang Province, in North-east China, where there were 689 public hospitals in 2014, of which 82 were tertiary public hospitals.³⁶ The study included a representative sample of healthcare workers from tertiary hospitals, including clinicians (physicians, surgeons, paediatricians, gynaecologists, emergency doctors and so on), medical technicians (pharmacists, radiological technicians, laboratory physicians and so on) and office workers (administrative department personnel, finance personnel and so on), who were selected using a multistage cluster sampling method. First, 33 tertiary public hospitals were selected at random to serve as survey locations for this study and all selected hospitals participated (100% response rate). Second, the departments of each hospital were coded, and several

Table 1 Characteristics of questionnaire respondents and results of the univariate analysis

Variable	Total	Sleep problems		P value
	n=3810 (%)	No n=1964 (%)	Yes n=1846 (%)	
Department level				
Clinical department				0.001
Yes	3297 (86.5)	1658 (50.2)	1639 (49.7)	
No	513 (13.5)	306 (59.6)	207 (40.4)	
Individual level				
Age (years)				<0.001
<30	504 (13.2)	308 (61.1)	196 (38.9)	
30–40	2054 (53.9)	982 (47.8)	1072 (52.2)	
>40	1252 (32.9)	674 (53.8)	578 (46.2)	
Sex				0.279
Men	2455 (64.4)	1282 (52.2)	1173 (47.8)	
Women	1355 (35.6)	682 (50.3)	673 (49.7)	
Educational background				0.004
Bachelor's degree and below	1883 (49.4)	926 (49.2)	957 (50.8)	
Master's degree and above	1927 (50.6)	1038 (53.9)	889 (46.1)	
Job title				0.001
Junior titles and others	924 (24.3)	521 (48.8)	403 (51.2)	
Intermediate title	1287 (33.8)	622 (30.8)	665 (69.2)	
Senior title	1599 (42.0)	821 (51.3)	778 (48.7)	
Monthly salary				0.791
≤3000 yuan	2286 (60.0)	1112 (48.6)	1174 (51.4)	
>3000 yuan	1524 (40.0)	790 (51.8)	734 (48.2)	
One-way commute time				0.001
<30 min	2038 (53.5)	1097 (53.8)	941 (46.2)	
≥30 min	1772 (46.5)	867 (48.9)	905 (51.1)	
Regular diet at work				<0.001
Yes	934 (24.5)	682 (73.0)	252 (27.0)	
No	2876 (75.5)	1282 (44.6)	1594 (55.4)	
No	3063 (80.4)	1427 (34.2)	1636 (65.8)	
Work hours per week				<0.001
≥55	1964 (51.5)	850 (42.3)	1114 (56.7)	
<55	1846 (48.5)	1114 (60.3)	732 (39.7)	
Night shifts per month (times)				<0.001
≤5	2171 (57.0)	1270 (58.5)	901 (41.5)	
>5	1639 (43.0)	694 (42.3)	945 (57.7)	
Daily exercise				<0.001
Yes	685 (18.0)	452 (66.0)	233 (34.0)	
No	3125 (82.0)	1512 (48.4)	1613 (51.6)	
Headaches				<0.001
Yes	1698 (44.6)	601 (35.4)	1097 (64.6)	
No	2112 (55.4)	1363 (64.5)	749 (35.5)	
Neck and shoulder pain				<0.001
Yes	2664 (69.9)	1243 (46.7)	1421 (53.3)	

Continued

Table 1 Continued

Variable	Total	Sleep problems		P value
	n=3810 (%)	No n=1964 (%)	Yes n=1846 (%)	
No	1146 (30.1)	721 (62.9)	425 (37.1)	
Lumbar and back pain				<0.001
Yes	2441 (64.1)	1111 (45.5)	1330 (54.5)	
No	1369 (35.9)	853 (62.3)	516 (37.7)	
Knee pain				<0.001
Yes	975 (25.6)	340 (34.9)	635 (65.1)	
No	2835 (74.4)	1624 (57.3)	1211 (42.7)	

departments were randomly selected from each hospital. The sample size at each level was based on the proportion of the number of workers in the hospital at that level. In the final sample, 4007 healthcare workers from 317 departments were invited to participate in the study. The healthcare workers in the selected departments completed a self-administered questionnaire (see online supplementary additional file 1 for details). After the data cleaning process, incomplete or anomalous data (n=197) were excluded, leaving a final sample of 3810 participants (95% response rate).

Variables

A structured questionnaire was designed to obtain data regarding demographics, sleep problems, working conditions, chronic pain and health-related behaviours.

Outcome measure (dependent variable)

The main outcome was the presence of sleep problems, which was a binary variable (1=yes; 0=no). The presence of sleep problems was assessed from each participant's self-report. Participants were asked the question 'Overall, in the last 30 days, how much of a problem did you have with sleeping, such as falling asleep, waking up frequently during the night or waking up too early in the morning?' with the following five response options: none, mild, moderate, severe and extreme. Participants who answered 'extreme' and 'severe' were considered to have sleep problems. This definition was adopted by previous studies that used the same survey question to assess sleep problems.^{1 37}

Individual-level variables (independent variables)

Individual-level variables included sociodemographic indicators (age, sex, educational background, job title and monthly salary), working conditions (average weekly working hours, number of night shifts per month and one-way commute time), health-related behaviours (physical exercise and regularity of diet) and experience of chronic pain (headache, neck and shoulder pain, lumbar and back pain and knee pain).

Age was categorised into three groups (<30, 30–40 and >40 years) and job title was considered an ordinal

categorical variable (junior title or no title, intermediate job title and senior title). The median monthly salary of participants in this study was 3000 yuan. Therefore, we coded monthly salary as ≤3000 yuan (=0) and >3000 yuan (=1). Average weekly working hours were evaluated with the question: 'How much time do you work on average per week?' The median number of weekly working hours reported by participants in this study was 55. Hence, the response categories were 1 = ≥55 hours and 0 = <55 hours.

Herein, chronic pain was defined as any continuous or persistent intermittent pain experienced for a period longer than 3 months.³⁸ We asked participants whether they had experienced chronic pain that had not improved in the past 30 days in the following regions: headache, neck and shoulder, lumbar and back and knee. The response categories were 1=yes and 0=no. The coding of other individual-level variables is shown in online supplementary additional file 2.

Department-level variables (independent variable)

The participants' department type was a level 2 explanatory variable in our analysis because individuals in the same department are not independent of each other. Among the healthcare workers in the study, some practitioners were from clinical departments (including internal medicine, surgery, gynaecology, paediatrics and so on) or laboratory, pathology, radiology or other technicians. Moreover, administrative-department personnel also participated in the survey. Therefore, this study was based on the functional attributes of the department, and whether the participants were from a clinical department (1=yes, 0=no) was an explanatory variable.

Data analysis

In this study, we used two statistical methods. The χ^2 test was used to examine the independent associations between participant sleep problems and each independent variable. As the data were hierarchical, participants (level 1) were nested within departments (level 2) to create a two-level logistic model that was applied to assess associations between sleep problems and the study variables.

Intraclass correlation coefficients (ICC) for healthcare workers were calculated to assess clustering by department.³⁹ First, an empty model was constructed to verify whether our research model was applicable to the two-level logistic model. A significant ICC would suggest that a multilevel logistic regression model is appropriate. Subsequently, in model 1, the department-level explanatory variable was added to the empty model. Next, in model 2, the individual-level explanatory variables were added to model 1. Meanwhile, we needed to judge whether the two multicategory variables (age and job title) should be introduced into the model as dummy or grouped linear variables according to the fit of the model. The likelihood ratio (LR) χ^2 test can be used for model comparisons and the difference in -2 log-likelihood between two models is used for the LR χ^2 test.⁴⁰ A statistically significant difference in -2 log-likelihood between the two models indicated that the fit of the latter model was better.⁴¹ We also conducted subpopulation analyses to determine whether short sleep duration (Q15: 1=sleep duration ≤ 6 hours, 0=sleep duration >6 hours)⁴² significantly modified the observed associations.⁴³

The two-level binary logistic regression models were estimated with the GLIMMIXED and NLMIXED procedures of SAS V.9.4 (SAS Institute). All other analyses were conducted with SPSS V.21.0 (IBM Corp), and p values <0.05 were considered to reflect statistical significance.

Ethics approval

The study received permission and assistance from each hospital to contact their healthcare workers. All participants were informed that the study was voluntary and confidential and that they had the right to discontinue their participation or withdraw their consent at any time without obligation to state their reasons. Interviews

were conducted after the participants provided written informed consent. Survey data were collected using an anonymous questionnaire to protect the privacy of the participants (online supplementary additional file 3).

Patient and public involvement

No patients were involved.

RESULTS

Participant characteristics

The participants' general characteristics are shown in table 1. Overall, the participants were generally unable to maintain a regular diet (75.5%). The most common types of chronic pain were neck and shoulder pain (69.9%), and lumbar and back pain (64.1%). Sleep problems were reported by 48.5% of participants. The univariate analysis indicated that demographics (excluding sex and monthly salary), chronic pain and working conditions were all related to participants' sleep problems ($p < 0.05$).

Self-reported sleep duration

Most participants (46.7%) reported a sleep duration of approximately 6 hours/day regardless of department. Moreover, most of the 11.3% of respondents who reported sleeping less than 5 hours/day were working in clinical departments (figure 1).

Multilevel analysis

Table 2 presents the results from the multilevel analyses. The results of the empty model showed significant between-group variation (ICC=0.1181, $p < 0.001$). An ICC of 0.1181 indicated that approximately 12% of the total variation in the outcome variables was caused by variation between the departments.

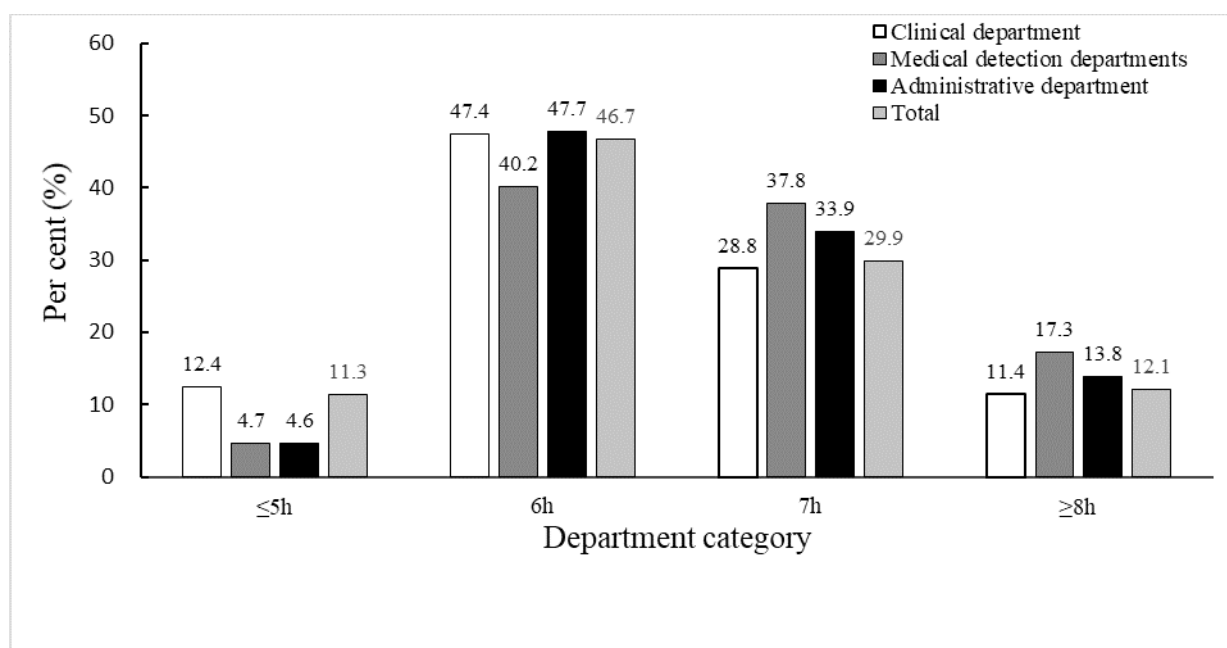


Figure 1 Subjective sleep duration (hours per night).

Table 2 Factors related to sleep problems: results from the two-level logistic regression analysis (n=3810)

Variable	Empty model	Model 1	Model 2
Department level			
Clinical department			
Yes		1.53 (1.15 to 2.04)*	1.07 (0.81 to 1.40)
No		1 (reference)	1 (reference)
Individual level			
Age (years)			
<30			0.87 (0.63 to 1.20)
30–40			1.06 (0.86 to 1.31)
>40			1 (reference)
Educational background			
Bachelor degree and below			0.87 (0.74 to 1.03)
Master's degree and above			1 (reference)
Job title			
Junior title or no title			0.71 (0.55 to 0.92)*
Intermediate title			0.87 (0.71 to 1.07)
Senior title			1 (reference)
One-way commute time			
<30 min			1.07 (0.92 to 1.24)
≥30 min			1 (reference)
Regular diet at work			
Yes			0.44 (0.36 to 0.53)**
No			1 (reference)
Daily exercise			
Yes			0.65 (0.53 to 0.80)**
No			1 (reference)
Work hours per week			
≥55			1.41 (1.20 to 1.66)**
<55			1 (reference)
Night shifts per month			
≤5			1.43 (1.21 to 1.69)**
>5			1 (reference)
Headache			
Yes			2.64 (2.27 to 3.07)**
No			1 (reference)
Neck and shoulder pain			
Yes			1.29 (1.09 to 1.52)*
No			1 (reference)
Lumbar and back pain			
Yes			1.36 (1.16 to 1.60)**
No			1 (reference)
Knee pain			
Yes			1.61 (1.34 to 1.93)**
No			1 (reference)
Sigma μ (SE)	0.4407 (0.092)	0.4061 (0.088)	0.2278 (0.070)
Intraclass correlation	0.1181**	0.1099**	0.0648**
–2 log-likelihood	5159.4	5150.9	4538.0

*P<0.01; **P<0.001.

Subsequently, the department-level explanatory variable was introduced. The results showed that the odds of having sleep problems was approximately 1.5 times greater among healthcare workers in clinical departments than among those in non-clinical departments (OR=1.53, 95% CI=1.15 to 2.04). After incorporating the department-level explanatory variable, the -2 log-likelihood declined from 5159.4 to 5150.9. The difference in -2 log-likelihood between model 1 and the empty model indicated that the fit of model 1 was better (LR=8.5, df=1, $p<0.01$).

In model 2, individual-level variables were added. The results showed that healthcare-worker sleep problems had an inverse association with regular diet (OR=0.44, 95% CI=0.36 to 0.53) and exercise (OR=0.65, 95% CI=0.53 to 0.80). The odds of having sleep problems were higher among participants with senior than with junior job titles (OR=0.71, 95% CI=0.55 to 0.92). Model 2 further suggested that chronic pain was positively associated with sleep problems. Specifically, participants with sleep problems were more likely to report having headaches (OR=2.64, 95% CI=2.27 to 3.03). Furthermore, working hours (OR=1.41, 95% CI=1.20 to 1.66) and night shifts (OR=1.43, 95% CI=1.21 to 1.69) were associated with sleep problems. The difference in -2 log-likelihood between model 2 and model 1 indicated that the fit of model 2 was better (LR=612, df=14, $p<0.001$). Meanwhile, department-level variables were also tested but showed no statistical significance.

Table 3 shows the results of the two-level logistic regression model for the subpopulation of healthcare workers with short sleep duration. In this subpopulation, the observed associations were mostly consistent with those identified with the two-level model comprising the total sample. However, in contrast to the analysis of the total sample, neck and shoulder pain ($p=0.128$) was not significantly associated with sleep problems in healthcare workers with short sleep durations.

Factors related to headaches

Table 4 shows factors related to headaches among respondents with sleep problems. We found that among the participants with headache, 62.4% worked ≥ 55 hours/week and 73.5% did not exercise daily.

Discussion

This study contributes to current knowledge on the extent of sleep problems among healthcare workers. We determined the prevalence of sleep problems experienced by the healthcare employees of tertiary public hospitals in the Heilongjiang Province, China and identified associated factors. In this study, more than 45% of the sample reported experiencing sleep problems, which is much higher than the prevalence reported for the general population of China (36.2%).³

Herein, the factor most strongly associated with sleep problems among healthcare workers was headaches. We found that 44.6% of participants reported experiencing headaches for longer than 3 months, which had not

improved in the past 30 days. Such findings are consistent with those of previous studies showing that headache is a very common symptom among healthcare workers. Sokolovic *et al* found that 61% of the healthcare workers they evaluated had experienced at least one type of headache in the previous 3 months.⁴⁴ A cross-sectional study with healthcare workers conducted in Enugu, South East Nigeria showed that 12% of the participants had severe headaches that affected their sleep.⁴⁵ From a clinical perspective, it has been suggested that the relationship between headaches and sleep problems may be bidirectional,⁴⁶ whereby headache treatment is crucial for relieving sleep problems, while sleep improvement is also likely to reduce headache symptoms in healthcare workers. In addition, we analysed factors related to the participants' headaches and found that among respondents with sleep problems, irregular diet, working overtime, lack of exercise and neck and shoulder, lumbar and back and knee pain were associated with headaches. These findings highlight the importance of addressing these factors to reduce the high incidence of headaches among healthcare workers.

Our study additionally confirmed the negative effects of other types of chronic pain on sleep, suggesting that chronic pain in different parts of the body increases the likelihood of sleep problems. A study by Andersen *et al* with healthcare workers also indicated that chronic musculoskeletal pain in one body region increases the risk of developing chronic pain in other pain-free body regions.²⁴ Therefore, when healthcare workers complain of chronic pain, they should be diagnosed and treated in a timely manner to reduce the risk of sleep problems and avoid the development of chronic pain in other body parts.

Our finding that night-shift work predicted a greater risk of sleep problems is consistent with the results of several previous studies.^{9 34} In hospitals, inpatient care usually requires round-the-clock services, which often translates to healthcare workers having to work extended shifts (especially night shifts) and long hours, which deprive them of sleep. Moreover, working during the night leads to misalignment between internal circadian rhythms and work-rest schedules, again resulting in fewer sleeping hours.⁴⁷ As such, determining effective means to minimise the negative effects of shift work on health workers' sleep is essential. Previous studies have suggested that timed bright lights and light-blocking goggles can promote circadian adaptation to shift work.^{48 49} However, more reasonable night-shift working schedules may be a better solution to alleviate the sleep problems of healthcare employees; our data suggest that the number of night shifts per month should be reduced at a reasonable level. Additionally, and in line with the assertions of some previous studies, we suggest that it would be optimal to allow for time off of sufficient duration between shifts⁵⁰ and to set a nap time to alleviate the high levels of sleepiness experienced while working during the night.^{50 51}

Table 3 Factors related to sleep problems: results from the two-level logistic regression analysis of healthcare workers with short sleep durations (≤ 6 hours; $n=2210$)

Variable	Empty model	Model 1	Model 2
Department level			
Clinical department			
Yes		1.47 (1.21 to 1.79)*	0.86 (0.59 to 1.25)
No		1 (reference)	1 (reference)
Individual level			
Age (years)			
<30			0.92 (0.60 to 1.42)
30–40			1.11 (0.84 to 1.46)
>40			1 (reference)
Educational background			
Bachelor degree and below			0.86 (0.69 to 1.06)
Master's degree and above			1 (reference)
Job title			
Junior title or no title			0.63 (0.45 to 0.88)**
Intermediate title			0.84 (0.63 to 1.11)
Senior title			1 (reference)
One-way commute time			
<30 min			1.13 (0.93 to 1.38)
≥ 30 min			1 (reference)
Regular diet at work			
Yes			0.53 (0.40 to 0.71)***
No			1 (reference)
Daily exercise			
Yes			0.74 (0.56 to 0.98)*
No			1 (reference)
Work hours per week			
≥ 55			1.32 (1.06 to 1.63)***
<55			1 (reference)
Night shifts per month			
≤ 5			1.45 (1.17 to 1.81)**
>5			1 (reference)
Headache			
Yes			2.58 (2.11 to 3.16)***
No			1 (reference)
Neck and shoulder pain			
Yes			1.19 (0.95 to 1.49)
No			1 (reference)
Lumbar and back pain			
Yes			1.29 (1.04 to 1.60)*
No			1 (reference)
Knee pain			
Yes			1.63 (1.29 to 2.05)***
No			1 (reference)
Sigma μ (SE)	0.3885 (0.100)	0.3842 (0.099)	0.2789 (0.098)
Intraclass correlation	0.1056***	0.1046***	0.07814***
-2 log-likelihood	2922.1	2920.5	2645.1

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 4 Factors related to headaches among respondents with sleep problems (n=1846)

Variable	Headache		P value
	Yes n=1097 (%)	No n=749 (%)	
Work hours per week			0.015
≥55	685 (62.4)	429 (57.3)	
<55	412 (37.6)	320 (42.7)	
Number of night shifts per month			0.173
5 times or less	525 (47.9)	376 (50.2)	
More than 5 times	572 (52.1)	373 (49.8)	
Do exercise every day			<0.001
Yes	120 (10.9)	113 (15.1)	
No	977 (89.1)	636 (84.9)	
Regular diet at work			<0.001
Yes	122 (11.12)	130 (17.36)	
No	975 (88.88)	619 (82.64)	
Neck and shoulder pain			<0.001
Yes	880 (80.2)	540 (72.1)	
No	217 (19.8)	209 (27.9)	
Lumbar and back pain			<0.001
Yes	833 (75.9)	496 (66.2)	
No	264 (24.1)	253 (33.8)	
Knee pain			<0.001
Yes	498 (45.4)	136 (18.2)	
No	559 (54.6)	613 (81.8)	

The present study also revealed that long working hours were a critical risk factor associated with sleep problems. A cross-sectional study in the USA reported that compensated working hours were consistently associated with sleep duration, such that as work duration increased, sleep duration decreased.⁵² In addition, the working hours of healthcare workers are evidently too long. According to the latest survey data collected in 2017, tertiary hospital employees in China work an average of 51.05 hours/week,⁵³ which is similar to the hours reported by our participants. Hale demonstrated that people working >50 hours/week were more likely to be short sleepers.⁵⁴ Many countries have clear rules limiting the maximum working hours of healthcare workers. For example, in 2009, the European Union specified a maximum of 48 hours of work per week and established rest periods for healthcare workers.⁵⁵ Although China's labour law specifies a maximum number of working hours, it does not apply to healthcare workers, and currently there are no established policies concerning the labour rights of healthcare workers.⁵⁶

Our findings confirmed that health-related behaviours play an important role in sleep problems. Indeed, our results showed that more than three-quarters of healthcare workers were unable to maintain a regular diet, and an irregular diet was significantly associated with sleep problems. Many healthcare workers do not have enough time to eat while working, and thus they order fast food from delivery services or simply delay their meals. However, research has revealed that short sleep duration is associated with higher caloric intake, mostly due to increased consumption of saturated fat.⁵⁷ We recommend that healthcare workers should maintain a regular diet and increase the intake of micronutrients such as tryptophan and vitamin B to improve sleep problems.⁵⁸ In addition, we also observed that participants who did not engage in regular exercise were more likely to experience sleep problems, which is consistent with the findings of previous research.⁵⁹ A randomised controlled trial found that improved sleep quality was evident after an exercise intervention and that physical activity is beneficial in terms of quality and duration of sleep.⁵⁸ For adults aged 18–64 years, the WHO recommends at least 150 min of moderate-intensity or at least 75 min of vigorous-intensity aerobic physical activity per week.⁶⁰

A study funded by the Chinese Medical Doctor Association found 46 cases of karoshi, or 'death by overwork', among Chinese healthcare workers between 2013 and 2015, most of whom were aged 30–39 years.⁶¹ Although healthcare workers in China's top-three hospitals treat numerous patients, few workers are mindful of their own health issues. Studies have shown that continuous exposure to factors such as lack of sleep, exercise and a regular diet, as was found here, may increase the risk of chronic diseases among healthcare workers.^{10 62 63} The fact that healthcare workers do not pay proper attention to their own health should be recognised by the government and society.

Overall, existing evidence indicates that it is important for healthcare workers to increase their sleep duration and reduce their workload. The effect that chronic pain, especially headache, has on healthcare worker sleep problems is of particular concern and requires attention. Furthermore, ensuring that workers engage in healthy behaviours is equally important. We make the following recommendations based on our findings: (1) hospitals should ensure that healthcare worker chronic pain in different body parts is diagnosed and treated in a timely manner; (2) healthcare workers should be aware of their own health issues and pay more attention to cultivating healthy behaviours, such as eating a regular diet and undergoing regular physical examinations; (3) more manageable working hours and night-shift work systems should be established and (4) health administrative departments should expand the scope of labour laws and formulate special regulations for the labour rights of healthcare workers.

Our study has some limitations of note. First, information regarding the exposure and outcome was obtained via a self-report questionnaire, which may have introduced report bias in these variables. In particular, we determined

sleep problems via subjective evaluations of the participants. Future research should incorporate validated scales and clinical diagnoses to support the results obtained via self-reports. Second, all participants were from the Heilongjiang Province, China and thus the study findings may not be generalisable to other populations. Moreover, the sample did not include nursing staff, and hence the results cannot be used to characterise all healthcare workers. Third, as this was a cross-sectional study, we cannot establish causal relationships based on the results. Fourth, only one subpopulation of healthcare workers was examined to test for effect modification. Finally, survey weights were not considered in this study, and the results were based on an unweighted analysis, the OR of which might be smaller than that when considering weight.⁶⁴ Therefore, sample weighting should be conducted in future analyses.

Conclusions

In summary, our findings suggest that nearly half of the healthcare workers in tertiary hospitals from the Heilongjiang Province in China have sleep problems. Chronic pain (headaches, knee pain, neck and shoulder pain and lumbar and back pain), long working hours and frequent night shifts were positively associated with sleep problems among healthcare workers. Of these, headaches were the most prominent risk factor for sleep problems in this population. However, a regular diet and daily exercise may reduce the likelihood of sleep problems. Most findings were not altered when analysing only participants with short sleep durations. These results indicate that to improve the sleep problems of healthcare workers, both medical institutions and health policy makers should work hand in hand to provide healthcare workers with reasonable work schedules, while the healthcare workers themselves should pay attention to their chronic pain problems and engage in regular diet and exercise.

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Contributors HL conducted calculations, analysed results and drafted the manuscript. QW and YH were responsible for the overall design of the research, organised and conducted the survey. MJ, NN and LL designed the analyses framework. ZK and LG revised the paper. JJL, MC, XT and TZ assisted with the literature review and data collection. All authors approved the current version of this manuscript for publications.

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