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**The association between shift work, sleep quality, and health-related quality of life among workers in the logistics industry**

Qingyuan Xu1, Yanzhuo Li1, Qiaochu Xu1, Yuxuan Wu1, Chengxiu Ling1, Kelvin P Jordan2 and Ying Chen1

**Affiliations:**

1. Wisdom Lake Academy of Pharmacy, Xi’an Jiaotong-Liverpool University, Suzhou, China.

2. School of Medicine, Keele University, Keele, United Kingdom.

**Corresponding author:** Ying Chen, Ying.Chen01@xjtlu.edu.cn, ORCID: 0000-0002-5919-743X, Wisdom Lake Academy of Pharmacy, Xi’an Jiaotong - Liverpool University, Suzhou, 215213, China.

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**Abstract**

The booming online shopping industry has accelerated the growth of logistic services, often subjecting workers to irregular schedules. This study aims to examine the association between night-shift work and health-related quality of life among logistics workers, with a special focus on the mediating role of sleep characteristics. A survey was conducted among logistics workers across China, who filled out an online questionnaire. The questionnaire collected information about shift work, sleep characteristics, health-related quality of life, various sociodemographic factors, and specific job categories. The Insomnia Severity Index measured sleep quality, while the 12-Item Short Form Health Survey assessed health-related quality of life, including the physical and mental components. Linear regression analysis and structural equation modeling were used to examine the proposed associations and conduct mediation analysis, respectively. Out of the 484 respondents, 352 (72.7%) worked night shifts. These workers were predominantly males, smokers, alcohol users, less educated, and those with longer working hours involved in goods transportation and distribution. Our results showed a considerable trend of declining general health when transitioning from day to night shifts. There was a negative association between the frequency of night shift work and physical health. Specifically, those who worked more than 12 night shifts a month reported poorer health compared to those working permanent daytime, after adjustments for confounding variables. Sleep quality emerged as a significant mediator in this relationship. Our findings underscore the need to prioritize improving sleep quality to enhance the health and well-being of logistics workers.

**Keywords:** Logistics worker, Night-shift work, Insomnia, Health Status, Population Survey, Occupational Health

**Introduction**

The recent surge in online shopping has propelled China to the forefront of the global e-commerce market [1]. The burgeoning online shopping market has fuelled a rapid expansion of logistics services in China [2]. In 2019, over 63.5 billion logistics parcels were delivered in China, with 70% originating from online shopping [3]. To meet consumers’ demand for speedy delivery, night-shift work has become an inevitable aspect of the logistics industry, leading to irregular work-rest schedules and diminished quality of life for workers [4].

Night shift work may be a risk to physical and mental health problems. Previous studies conducted in the UK have revealed that nurses engaged in night shifts for 10 years or more have a 1.18 times higher risk of developing coronary heart disease, compared with their counterparts who never work night shifts [5]. Moreover, night shift was reported to be associated with an increased risk of atrial fibrillation, chronic obstructive pulmonary disease, asthma, and type II diabetes [6-9]. Recent reviews have also identified mental health issues as a negative outcomes of night-shift work [10]. Studies from the UK and China suggested that those who work during the night may be more prone to anxiety and depression [11, 12].

In addition to health conditions, the night shift also appeared to be associated with sleep characteristics. Night-shift workers were found to sleep less than daytime-shift workers [13]. A survey conducted in Taiwan on female nurses, using the Pittsburgh Sleep Quality Index, found that nurses on night shifts tended to have poorer sleep quality compared to those working regular daytime hours [12]. Working at night often disrupts the normal circadian rhythms, leading to sleep issues [14, 15].

Despite the rapid growth of the logistics industry in China and globally, there has been insufficient research attention on the health condition of logistics workers, and no survey has explored the relationship between night-shift work and the physical and mental health of logistics workers. This study aims to examine the potential association between night shifts and decreased physical and mental health aspects of quality of life among logistics workers, and to assess whether certain sleep characteristics play as a mediator.

**Methods**

***Study participants***

This study was a population survey conducted in August 2023. The target population consisted of all logistics industry practitioners across China who were at least 18 years old. The Cochran formula was used to calculate the minimum sample size [16]. Three hundred and eighty-fifth was required, with a conservative population variance of 0.025, a 2-sided α of 0.05 and a sampling error of 0.05. Anticipating an effective response rate of 65%, a total of 592 survey questionnaires were sent out. This study used ‘SoJump’, the largest online survey platform in China, to draw samples, distribute questionnaires, and collect data from anonymous participants. In practice, 484 participants were recruited, yielding an actual response rate of 81.8%, which exceeded the minimum required sample size.

***Measurement of shift work***

In the survey, participants were asked whether their current work involves night shifts, options being ‘daytime shift only’, ‘night shift only’, and ‘both daytime and night shift’. Those who answered ‘night shift only’ and ‘both daytime and night shift’ were further asked the number of years they have worked night shifts and the average number of night shifts per month. This data was categorized as ‘years of night shift’ (options being ‘permanent daytime’, ‘1-5 years’, ‘6-10 years’ and ‘more than 10 years’) and ‘frequency of night shift’ (options being ‘permanent daytime’, ‘1-6 days per month’, ‘7-12 days per month’ and ‘more than 12 days per month’), respectively [6, 9].

***Measurement of health-related quality of life***

The Chinese version of the 12-Item Short Form Health Survey (SF-12) was used to measure the health-related quality of life among study participants. SF-12, a simplified version of the 36-Item Short Form Survey, has demonstrated good reliability and validity, making it suitable for assessing the Chinese population [17, 18]. The SF-12 assigned varying physical and mental weights to different questions, generating two standardized summary measurements: The Physical Component Summary (PCS) and the Mental Component Summary (MCS). Higher scores indicate better respondent health conditions [19].

***Measurement of sleep characteristics***

Sleep characteristics were measured by three aspects: sleep duration, nap duration, and sleep quality as measured by the Insomnia Severity Index (ISI) [20]. Sleep duration referred to the average daily regular sleep time reported by participants, while nap duration referred to the average daily short-period sleep time reported by participants in addition to the regular sleep time. The ISI was a 7-item self-report scale with a range of 0-28 points. It has been validated for its effectiveness in assessing the nature, severity, and impact of participants’ sleep quality, with higher scores indicating poorer sleep quality [21, 22].

***Covariates***

Several sociodemographic, behavioral, and occupational factors were also collected in this study [9, 13, 23]. These included gender, age, body height and weight (for calculating body mass index (BMI)), spouse/partner status, offspring status, cigarette smoking status, alcohol consumption status, physical exercise, income satisfaction level (‘very satisfied’, ‘satisfied’, ‘ordinary’, ‘dissatisfied’, ‘very dissatisfied’), education level (‘college degree or above’, ‘high school’, ‘junior high school or below’), geographical region of residence (‘East China’, ‘Northeast China’, ‘North China’, ‘Central China’, ‘South China’, ‘Southwest China’, ‘Northwest China’), and specific job type (‘motor vehicle driving’, ‘specialized vehicle driving’, ‘cargo distribution’, ‘household goods distribution’, ‘warehouse management’, ‘logistics supervision and protection’ and ‘others’).

***Statistical analysis***

Descriptive statistics were initially carried out on the sociodemographic and sleep characteristics of all participants, as well as participants categorized by shift work status (‘daytime shift only’, ‘night shift only’, and ‘both daytime and night shift’). All categorical variables were presented by percentages, while continuous variables were presented by means (with standard deviation (SD)) or medians (with interquartile range (IQR)) depending on their normality of data distribution. PCS and MCS scores of study participants were also described by mean (with SD) or median (with IQR) based on their shift work status, years of night shift (‘permanent daytime’, ‘1-5 years’, ‘6-10 years’, ‘more than10 years’), and frequency of night shift (‘permanent daytime’, ‘1-6 days per month’, ‘7-12 days per month’, ‘more than 12 days per month’).

Multivariable linear regression analyses were used to examine the association of shift work status, years of night shift, and frequency of night shift with either PCS or MCS score separately. Both unadjusted and adjusted results (accounting for all studied covariates) were presented. The coefficient estimates and corresponding *p*-values were reported. *P* values for the trend of ordinal variables in each model were also reported. Sleep variables were examined as potential mediators in the pathway between shift work characteristics and health-related quality of life measurements. The bootstrapping structural equation modeling was used to test the possible effects [24-26].

A *p*-value < 0.05 (two-tailed) indicated statistical significance, and all data analyses were carried out by R (version 4.3.1).

**Results**

***Descriptive statistics***

A total of 484 logistics workers from 28 provinces in China participated in the survey. The geographical distribution of these participants by province is shown in Supplementary Figure 1. Males occupied 58.9% of all participants, and the largest age category was ’31 to 35 years’ (37.6%) (Table 1). Of the participants, 66.5% worked both day and night shifts, while only 6.2% worked exclusively night shifts (Table 1). Among workers involving night shifts, the largest proportions of night shift years and frequency were ‘1-5 years’ (40.1%) and ‘7-12 days per month’ (40.3%), respectively.

Compared to participants working daytime shifts only, workers engaged in night shifts were predominantly male, smokers, alcohol users, less educated, and those with longer working hours involved in goods transportation and distribution. Participants who worked night shift only had the longest sleep duration (median, 8 hours 24 minutes) (Table 1). There was little difference in nap duration among different shift work groups. Compared to participants who worked permanently during the daytime, workers involving night shifts had worse sleep quality (ISI score, 6 vs. 10) (Table 1).

***Association of night shift with lower health-related quality of life***

PCS and MCS scores of study participants engaging in daytime shifts only were higher than those engaging in night shifts (Table 2). Participants who worked night shifts only, compared to those who worked both daytime and night shifts, had similar PCS scores but lower MCS scores (Table 2). As the years of night-shift work increased, both PCS and MCS scores showed a decreasing trend (Table 2). Along with the increase in the frequency of night-shift work, the PCS score gradually decreased, and workers engaging in night shift frequency of more than 12 days per month had the lowest MCS score (Table 2).

After accounting for sex, age, BMI, spouse/partner status, offspring status, cigarette smoking status, alcohol drinking status, physical exercise, income satisfaction level, education level, geographical region, and specific job type, our results indicated a trend towards deteriorating health, reflected in both PCS (for physical health) and MCS (for mental health) scores, when transitioning from working day shifts to a combination of day and night shifts, and eventually to night shifts only (Table 3). This trend especially reached statistical significance in terms of physical health (Table 3). Meanwhile, we found no significant difference in health outcomes related to the number of years spent working night shifts (Table 3). However, with respect to the frequency of night shift work, those working more than 7 (PCS: Regression coefficient -1.76, 95%CI -3.49 to -0.04) and 12 days a month (PCS: Regression coefficient -2.62, 95%CI -4.79 to -0.46) reported lower health-related quality of life compared to their counterparts not engaged in night shifts (Table 3). Notably, the trend of declining PCS scores with increasing frequency of night shifts was statistically significant (Table 3).

***Sleep quality as a mediator***

In addition to the association between night-shift work and worse sleep quality (measured by ISI) (Table 1), worse sleep quality was also associated with both PCS (r = -0.63, p < 0.01) and MCS scores (r = -0.57, p < 0.01). When sleep quality was included as an additional covariate in the original multivariable linear regression model (‘Adjusted model’, Table 3), the associations between night-shift characteristics and PCS and MCS scores disappeared (Supplementary Table 1).

Therefore, as a potential mediator, we formally examined the mediation effect of worse sleep quality on the associations of night shifts with PCS and MCS. For instance, compared with workers engaging in daytime work only, for each point of increase in ISI, PCS scores of workers participating in both daytime and night shifts (Regression coefficient -1.23, 95%CI -2.18 to -0.31) and workers working only at night (Regression coefficient -2.10, 95%CI -3.73 to -0.78) decreased significantly, due to the mediation effect. While the direct effect of shift work status on PCS was very small and statistically insignificant. These results indicated that sleep quality played a significant role as a mediator in the association of shift work status with PCS, accounting for more than 80% of the total effect (Table 4). Similar findings were also found where MCS was the outcome variable (Table 4). In addition, such medication effect was consistently observed when comparing workers with different years or frequency of night shifts (Table 4).

**Discussion**

This study found that night-shift work was associated with reduced health-related quality of life measured by SF-12 among the logistics workers. Workers engaged in only night shifts, as well as those working both daytime and night shifts, reported lower physical and mental health aspects of quality of life, compared to daytime workers. As the frequency of night shifts increased, particularly when exceeding 12 days a month, there was a considerable decline in the workers’ physical and mental status. Furthermore, this study also demonstrated that sleep quality significantly mediated the associations between shift work and PCS and MCS scores, suggesting that night shift led to worse physical and mental conditions among logistics workers by affecting their sleep quality. Previous evidence suggested that shift workers reported worse sleep than day workers, a trend that continues even into their retirement [27]. This underscores the importance of focusing on the mediating role of sleep quality.

Research into the relationship between night-shift work and health was carried out initially among nurses and was conducted in both developed and developing countries [28-31]. These studies found that night-shift work was associated with sleep quality and physical and mental health, however, none of them explored the possible mediating role of sleep quality. In recent years, this topic has been explored in other demographics, including the general population [32], resident physicians [33], police employees [34], manufacturing workers [23, 35, 36], and technology company employees [37]. Among these, several conducted mediation analyses for specific conditions. Sleep quality was found as a partial mediator in the association between night-shift work and depression in Chinese automobile manufacturing workers and South Korean Samsung employees [36, 37], and also in the association with gastroesophageal reflux disease among the UK biobank participants [38]. However, two studies on Canadian and Malaysian workers did not find sufficient evidence to support sleep quality as a mediating factor in the association between night-shift work and hypertension or metabolic syndrome [23, 39]. For overall health and well-being, the only literature conducted on Malaysian manufacturing workers supported sleep quality as a significant mediator [35]. Our study, conducted among logistics workers for the first time, further enriched the relevant research content.

The reported physical and mental components of life quality in logistics workers were lower than the general average level (PCS/MCS < 50), which may be due to long working hours and poor working conditions [40, 41]. Particularly, night shift work, which is an inevitable aspect of the logistics industry, could contribute to lower health-related quality of life due to the irregular work pattern that goes against a normal daytime schedule. Our results, with details on years and frequency of night-shift engagement, suggested that the more the night shift was participated in, the poorer the physical and mental health. These findings align with a recent meta-analysis of longitudinal studies on shift work and poor mental health [42].

Sleep quality now has been shown to be a key factor in the association between night-shift work and poorer health-related quality of life in logistics workers. As a potentially modifiable factor, interventions aimed at improving sleep quality could be useful and feasible. Organizations should prioritize improving the sleep quality of logistics workers in order to address issues related to health-related quality of life. The regular monitoring of sleep quality among night-shift logistics workers is important, and there is an urgent requirement for the development and implementation of relevant interventions. A better health-related quality of life is associated with increased productivity and a decreased risk of job-related incidents such as traffic accidents.

Our study has several strengths and limitations. One of the strengths is the use of a smartphone app platform, enabling us to efficiently and economically recruit participants from a specific employment sector nationwide. However, due to the app’s restrictions, individuals who had previously registered with the app and frequently accessed their mobile phones were more likely to be invited to our survey. Our study is cross-sectional in nature, therefore reverse impact whereby lower health-related quality of life leads to poorer sleep quality is possible. Our study is based on self-reported data, which is associated with possible data misclassification and subjective response. However, it is worth noting that we used validated tools for measuring sleep quality and health-related quality of life. To form a higher level of epidemiological evidence, longitudinal and interventional studies with objective measurements are required. In addition to sleep, other possible mediators such as lifestyle and dietary intake may also be involved. Shift workers are more likely to have unhealthy lifestyles and irregular food intake both in terms of patterns and nutrition. However, they were not studied in this paper. Although in this study, we included many covariates as potential confounding factors, other information such as chronotype and medication records of participants were not collected. Our study was performed in a middle-income setting with a relatively low regulation of employee benefits, so the generalizability of findings in other settings is yet to be assessed. Finally, the sample size of this study is not substantial, resulting in limited power for sub-categories with few participants.

In conclusion, our study established the association between night-shift work and reduced health-related quality of life among logistics workers. Notably, poor sleep quality emerged as a significant mediator, accounting for the majority of this relationship. A better understanding of regulatory pathways and identification of modifiable mediation factors could aid in the development of interventions to reduce the adverse health effects of night-shift work on logistics workers. Our findings underscore the importance of prioritizing improvements in sleep quality to enhance the health and well-being of logistics workers. There is an urgent need for the development of multidisciplinary interventions, considering the large number of workers and the dynamic change and expansion of the logistics industry.

**Declarations**

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

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**Ethics approval:** The researchers are provided with only the anonymous database where no individual participant can be identified. This study is approved by the Ethics Review Committee of Xi’an Jiaotong-Liverpool University (No. ER-LRR-0010000121120240924131512), and conducted in accordance with the principles of the Helsinki Declaration.

**Data availability statement:**

**Authors’ contribution statements:** Conceptualization: Ying Chen; Methodology: Qiaochu Xu, and Qingyuan Xu ; Formal analysis and investigation: Qingyuan Xu, Qiaochu Xu, and Yanzhuo Li; Writing - original draft preparation: Qingyuan Xu, and Ying Chen; Writing - review and editing: Yanzhuo Li, Yuxuan Wu, Qiaochu Xu, Chengxiu Ling, and Kelvin P Jordan; Supervision: Ying Chen, Chengxiu Ling, and Kelvin P Jordan.

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**Table 1. Characteristics description of survey participants**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Characteristics** | **Daytime shift only, n = 132 (27.3%)** | **Both daytime and night shifts, n = 322 (66.5%)** | **Night shift only, n = 30 (6.2%)** | ***p*-value** | **All participants, n = 484** |
| **Sex, n (%)** |  |  |  | 0.082 |  |
| Male | 68 (51.5) | 201 (62.4) | 16 (53.3) |  | 285 (58.9) |
|  Female | 64 (48.5) | 121 (37.6) | 14 (46.7) |  | 199 (41.1) |
| **Age, n (%)** |  |  |  | 0.714 |  |
|  18-25 years | 6 (4.5) | 18 (5.6) | 1 (3.3) |  | 25 (5.2) |
|  26-30 years | 45 (34.1) | 96 (29.8) | 12 (40.0) |  | 153 (31.6) |
|  31-35 years | 51 (38.6) | 119 (37.0) | 12 (40.0) |  | 182 (37.6) |
|  36-40 years | 19 (14.4) | 62 (19.3) | 5 (16.7) |  | 86 (17.8) |
|  41-45 years | 5 (3.8) | 18 (5.6) | 0 (0) |  | 23 (4.8) |
|  More than 45 years | 6 (4.5) | 9 (2.8) | 0 (0) |  | 15 (3.1) |
| **BMI, median (IQR)** | 21.5 (20.2 to 23.4) | 22.0 (20.2 to 23.8) | 21.8 (20.2 to 22.8) | 0.464 | 22.0 (20.2 to 23.4) |
| **Spouse or partner, n (%)** |  |  |  | 0.296 |  |
| Yes | 17 (12.9) | 43 (13.4) | 7 (23.3) |  | 67 (13.8) |
|  No | 115 (87.1) | 279 (86.6) | 23 (76.7) |  | 417 (86.2) |
| **Offspring, n (%)** |  |  |  | 0.510 |  |
|  Yes | 109 (82.6) | 260 (80.7) | 22 (73.3) |  | 391 (80.8) |
|  No | 23 (17.4) | 62 (19.3) | 8 (26.7) |  | 93 (19.2) |
| **Cigarette smoking, n (%)** |  |  |  | <0.001 |  |
| Yes | 20 (15.2) | 114 (35.4) | 10 (33.3) |  | 144 (29.8) |
| No | 112 (84.8) | 208 (64.6) | 20 (66.7) |  | 340 (70.2) |
| **Alcohol drinking, n (%)** |  |  |  | 0.003 |  |
| Yes | 17 (12.9) | 86 (26.7) | 10 (33.3) |  | 113 (23.3) |
| No | 115 (87.1) | 236 (73.3) | 20 (66.7) |  | 371 (76.7) |
| **Physical exercise, n (%)** |  |  |  | 0.124 |  |
| Yes | 87 (65.9) | 188 (58.4) | 22 (73.3) |  | 297 (61.4) |
| No | 45 (34.1) | 134 (41.6) | 8 (26.7) |  | 187 (38.6) |
| **Income satisfaction, n (%)** |  |  |  | 0.355 |  |
| Very satisfied | 5 (3.8) | 2 (0.6) | 1 (3.3) |  | 8 (1.7) |
| Satisfied | 46 (34.8) | 104 (32.3) | 11 (36.7) |  | 161 (33.3) |
| Ordinary | 62 (47.0) | 163 (50.6) | 16 (53.3) |  | 241 (49.8) |
| Dissatisfied | 18 (13.6) | 49 (15.2) | 2 (6.7) |  | 69 (14.3) |
| Very dissatisfied | 1 (0.2) | 4 (0.8) | 0 (0) |  | 5 (1.0) |
| **Education level, n (%)** |  |  |  | 0.009 |  |
| Junior high school | 2 (1.5) | 5 (1.6) | 0 (0) |  | 7 (1.4) |
| High school | 23 (17.4) | 105 (32.6) | 5 (16.7) |  | 133 (27.5) |
| College degree or above | 107 (81.1) | 212 (65.8) | 25 (83.3) |  | 344 (71.1) |
| **Geographic region, n (%)** |  |  |  | 0.252 |  |
| North China | 18 (13.6) | 52 (16.1) | 7 (23.3) |  | 77 (15.9) |
| Northeast China | 3 (2.3) | 15 (4.7) | 0 (0) |  | 18 (3.7) |
| East China | 52 (39.4) | 112 (34.8) | 7 (23.3) |  | 171 (35.3) |
| Central China | 19 (14.4) | 42 (13.0) | 2 (6.7) |  | 63 (13.0) |
| South China | 18 (13.6) | 59 (18.3) | 10 (33.3) |  | 87 (18.0) |
| Southwest China | 16 (12.1) | 33 (10.2) | 4 (13.3) |  | 53 (11.0) |
| Northwest China | 6 (4.5) | 9 (2.8) | 0 (0) |  | 15 (3.1) |
| **Specific job type, n (%)** |  |  |  | <0.001 |  |
| Motor vehicle driving | 18 (13.6) | 90 (28.0) | 9 (30.0) |  | 117 (24.2) |
| Specialized vehicle driving | 1 (0.8) | 7 (2.2) | 2 (6.7) |  | 10 (2.1) |
| Cargo distribution | 23 (17.4) | 71 (22.0) | 3 (10.0) |  | 97 (20.0) |
| Household goods distribution | 8 (6.1) | 26 (8.1) | 1 (3.3) |  | 35 (7.2) |
| Warehouse management | 32 (24.2) | 66 (20.5) | 6 (20.0) |  | 104 (21.5) |
| Supervision and protection | 27 (20.5) | 54 (16.8) | 2 (6.7) |  | 83 (17.1) |
| Others | 23 (17.4) | 8 (2.5) | 7 (23.3) |  | 38 (7.9) |
| **Years of night shift, n (%)** |  |  |  | — |  |
| Permanent daytime | 132 (100) | — | — |  | 132 (27.3) |
|  1-5 years | — | 174 (54.0) | 20 (66.7) |  | 194 (40.1) |
|  6-10 years | — | 117 (36.3) | 8 (26.7) |  | 125 (25.8) |
| More than 10 years | — | 31 (9.7) | 2 (6.7) |  | 33 (6.8) |
| **Frequency of night shift, n (%)** |  |  |  |  |  |
| Permanent daytime | 132 (100) | — | — | — | 132 (27.3) |
| 1-6 days per month | — | 68 (21.1) | 7 (23.4) |  | 75 (15.5) |
| 7-12 days per month | — | 183 (56.9) | 12 (40.0) |  | 195 (40.3) |
| More than 12 days per month | — | 71 (22.0) | 11 (36.7) |  | 82 (16.9) |
| **Sleep duration, median (IQR)** | 7.92 hours (7.05 to 8.78) | 7.55 hours (6.45 to 8.65) | 8.40 hours (6.40 to 10.40) | <0.001 | 7.70 hours (6.57 to 8.83) |
| **Nap duration, median (IQR)** | 0.58 hours (0.35 to 0.82) | 0.57 hours (0.33 to 0.80) | 0.57 hours (0.35 to 0.78) | 0.652 | 0.57 hours (0.33 to 0.80) |
| **ISI, mean (SD)** | 6 (5.7) | 10 (3.7) | 10 (5.1) | <0.001 | 9 (5.3) |

BMI, body mass index; IQR, interquartile range; SD, standard deviation, ISI, the Insomnia Severity Index.

**Table 2. Description of physical and mental components of SF-12 in all participants and by work shift characteristics**

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristics** | **n (%)** | **Physical component, mean (SD)** | **Mental component, mean (SD)** |
| **All participants** | 484 (100) | 47.4 (8.0) | 46.5 (9.5) |
| **Shift work status** |  |  |  |
|  Daytime shift only | 132 (27.3) | 48.8 (7.8) | 47.9 (10.2) |
|  Both daytime and night shifts | 322 (66.5) | 47.0 (6.4) | 46.1 (9.2) |
|  Night shift only | 30 (6.2) | 46.8 (8.2) | 44.4 (9.0) |
|  *p*-value | — | 0.005 | 0.034 |
| **Years of night shift** |  |  |  |
| Permanent daytime | 132 (27.3) | 48.8 (7.8) | 47.9 (10.2) |
|  1-5 years | 194 (40.1) | 47.0 (7.8) | 45.0 (9.5) |
|  6-10 years | 125 (25.8) | 46.9 (8.4) | 47.4 (8.4) |
| More than 10 years | 33 (6.8) | 45.7 (8.5) | 46.1 (8.3) |
| *p*-value | — | 0.030 | 0.020 |
| **Frequency of night shift** |  |  |  |
| Permanent daytime | 132 (27.3) | 48.8 (7.8) | 47.9 (10.2) |
| 1-6 days per month | 75 (15.5) | 48.6 (7.6) | 46.5 (9.3) |
| 7-12 days per month | 195 (40.3) | 46.7 (8.3) | 46.3 (8.9) |
| More than12 days per month | 82 (16.9) | 45.6 (7.5) | 44.7 (9.6) |
| *p*-value | — | 0.001 | 0.068 |

SF-12, the 12-Item Short Form Health Survey; SD, standard deviation.

**Table 3. Association of work shifts characteristics with PCS and MCS of SF-12**

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristics (exposure variable)** | **n (%)** | **Unadjusted model** | **Adjusted model** |
| Regression coefficient (95% confidence interval) | *p*-value | Regression coefficient (95% confidence interval) | *p*-value |
|  |  | ***Physical component summary (outcome variable)*** |
| **Shift work status** |  |  |  |  |  |
|  Daytime shift only | 132 (27.3) | Referent |  | Referent |  |
|  Both daytime and night shifts | 322 (66.5) | -2.00 (-3.62 to -0.38) | 0.016 | -1.42 (-3.03 to 0.18) | 0.082 |
| Night shift only | 30 (6.2) | -1.85 (-5.01 to 1.31) | 0.251 | -2.28 (-5.31 to 0.75) | 0.139 |
| Statistics for trend |  |  | 0.033 |  | 0.050 |
| **Years of night shift** |  |  |  |  |  |
| Permanent daytime | 132 (27.3) | Referent |  | Referent |  |
|  1-5 years | 194 (40.1) | -1.85 (-3.61 to -0.08) | 0.041 | -1.40 (-3.15 to 0.35) | 0.117 |
|  6-10 years | 125 (25.8) | -1.89 (-3.85 to 0.06) | 0.058 | -1.78 (-3.72 to 0.16) | 0.073 |
|  More than 10 years | 33 (6.8) | -3.16 (-6.21 to -0.11) | 0.042 | -1.29 (-4.36 to 1.77) | 0.407 |
| Statistics for trend |  |  | 0.021 |  | 0.111 |
| **Frequency of night shift** |  |  |  |  |  |
| Permanent daytime | 132 (27.3) | Referent |  | Referent |  |
| 1-6 days per month | 75 (15.5) | -0.23 (-2.48 to 2.02) | 0.842 | 0.01 (-2.15 to 2.18) | 0.991 |
| 7-12 days per month | 195 (40.3) | -2.12 (-3.88 to -0.36) | 0.018 | -1.76 (-3.49 to -0.04) | 0.045 |
| More than 12 days per month | 82 (16.9) | -3.27 (-5.46 to -1.08) | 0.004 | -2.62 (-4.79 to -0.46) | 0.018 |
| Statistics for trend |  |  | <0.001 |  | 0.006 |
|  |  | ***Mental component summary (outcome variable)*** |
| **Shift work status** |  |  |  |  |  |
| Daytime shift only | 132 (27.3) | Referent |  | Referent |  |
| Both daytime and night shifts | 322 (66.5) | -1.80 (-3.72 to 0.12) | 0.065 | -0.86 (-2.72 to 1.00) | 0.365 |
| Night shift only | 30 (6.2) | -3.53 (-7.29 to 0.22) | 0.065 | -3.13 (-6.63 to 0.37) | 0.079 |
| Statistics for trend |  |  | 0.026 |  | 0.098 |
| **Years of night shift** |  |  |  |  |  |
| Permanent daytime | 132 (27.3) | Referent |  | Referent |  |
| 1-5 years | 194 (40.1) | -2.90 (-4.98 to -0.81) | 0.007 | -1.62 (-3.64 to 0.40) | 0.115 |
| 6-10 years | 125 (25.8) | -0.56 (-2.87 to 1.76) | 0.637 | 0.10 (-2.14 to 0.34) | 0.931 |
| More than 10 years | 33 (6.8) | -1.69 (-5.29 to 1.92) | 0.358 | -2.13 (-5.66 to 1.41) | 0.238 |
| Statistics for trend |  |  | 0.601 |  | 0.603 |
| **Frequency of night shift** |  |  |  |  |  |
| Permanent daytime | 132 (27.3) | Referent |  | Referent |  |
| 1-6 days per month | 75 (15.5) | -1.49 (-4.17 to 1.20) | 0.278 | -0.93 (-3.45 to 1.59) | 0.469 |
| 7-12 days per month | 195 (40.3) | -1.59 (-3.68 to 0.50) | 0.136 | -0.96 (-2.97 to 1.09) | 0.208 |
| More than 12 days per month | 82 (16.9) | -3.23 (-5.84 to -0.62) | 0.015 | -1.68 (-4.20 to 0.84) | 0.190 |
| Statistics for trend |  |  | 0.019 |  | 0.197 |

PCS, Physical component summary; MCS, Mental component summary; SF-12, the 12-Item Short Form Health Survey; Adjusted Model: adjusted for age, sex, body mass index, spouse/partner status, offspring status, cigarette smoking status, alcohol drinking status, physical exercise, income satisfaction level, education level, geographical region and specific job type. For shift work status, when combining “Both daytime and night shifts” and “Night shift only”, the regression coefficient of the newly generated term on physical health was -1.52 (-3.09 to 0.06) with a *p* value of 0.059, and -1.10 (-2.92, 0.73) for mental health with a *p* value of 0.237,

**Table 4. Mediation effect of sleep quality (measured by ISI) on the associations of night shift with PCS and MCS of SF-12**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Characteristics (exposure variable)** | **Mediation effect (95% confidence interval)** | ***p*-value** | **Direct effect (95% confidence interval)** | ***p*-value** | **Total effect (95% confidence interval)** | ***p*-value** | **Proportion\*** |
|  | ***Sleep quality (mediator variable) | Physical component summary (outcome variable)*** |
| **Shift work status** |  |  |  |  |  |  |  |
| Daytime shift only | Referent |  | Referent |  | Referent |  |
| Both daytime and night shifts | -1.23 (-2.18 to -0.31) | 0.004 | -0.08 (-1.34 to 1.20) | 0.928 | -1.31 (-2.91 to 0.35) | 0.132 | 0.858 |
| Night shift only | -2.10 (-3.73 to -0.48) | 0.014 | -0.34 (-3.09 to 2.24) | 0.786 | -2.44 (-5.37 to 0.57) | 0.118 | 0.799 |
| **Years of night shift** |  |  |  |  |  |  |  |
| Permanent daytime | Referent |  | Referent |  | Referent |  |
| 1-5 years | -1.34 (-2.28 to -0.31) | 0.008 | 0.10 (-1.40 to 1.65) | 0.906 | -1.25 (-3.04 to 0.63) | 0.160 | 0.966 |
| 6-10 years | -1.10 (-2.20 to -0.06) | 0.046 | -0.58 (-2.28 to 1.05) | 0.490 | -1.68 (-3.66 to 0.26) | 0.106 | 0.622 |
| More than 10 years | -2.03 (-3.82 to -0.30) | 0.024 | 0.93 (-1.67 to 3.43) | 0.460 | -1.10 (-4.29 to 2.05) | 0.496 | 1.000 |
| **Frequency of night shift** |  |  |  |  |  |  |  |
| Permanent daytime | Referent |  | Referent |  | Referent |  |
| 1-6 days per month | -0.55 (-1.78 to 0.67) | 0.380 | 0.72 (-0.97 to 2.55) | 0.450 | 0.17 (-2.04 to 2.38) | 0.890 | — |
| 7-12 days per month | -1.67 (-2.67 to -0.76) | <0.001 | -0.04 (-1.52 to 1.30) | 0.974 | -1.72 (-3.36 to -0.09) | 0.042 | 0.956 |
| More than 12 days per month | -1.25 (-2.53 to -0.07) | 0.038 | -1.17 (-2.94 to 0.54) | 0.192 | -2.42 (-4.65 to -0.35) | 0.014 | 0.511 |
|  | ***Sleep quality (mediator variable) | Mental component summary (outcome variable)*** |
| **Shift work status** |  |  |  |  |  |  |  |
| Daytime shift only | Referent |  | Referent |  | Referent |  |
| Both daytime and night shifts | -1.17 (-2.13 to -0.28) | 0.006 | 0.37 (-1.33 to 2.01) | 0.662 | -0.80 (-2.67 to 0.98) | 0.422 | 0.915 |
| Night shift only | -2.02 (-3.76 to -0.42) | 0.022 | -0.88 (-3.95 to 2.28) | 0.538 | -2.90 (-6.27 to 0.55) | 0.114 | 0.641 |
| **Years of night shift** |  |  |  |  |  |  |  |
| Permanent daytime | Referent |  | Referent |  | Referent |  |
| 1-5 years | -1.27 (-2.26 to -0.34) | 0.006 | -0.35 (-2.08 to 1.50) | 0.694 | -1.63 (-3.55 to 0.31) | 0.108 | 0.723 |
| 6-10 years | -1.03 (-2.27 to 0.03) | 0.062 | 1.23 (-0.85 to 3.24) | 0.220 | 0.20 (-2.13 to2.45) | 0.826 | — |
| More than 10 years | -1.98 (-3.67 to -0.34) | 0.018 | -0.09 (-3.20 to 3.14) | 0.932 | -2.06 (-5.58 to 1.30) | 0.240 | 0.769 |
| **Frequency of night shift** |  |  |  |  |  |  |  |
| Permanent daytime | Referent |  | Referent |  | Referent |  |
| 1-6 days per month | -0.55 (-1.80 to 0.57) | 0.350 | -0.17 (-2.34 to 2.00) | 0.860 | -0.72 (-3.15 to 1.86) | 0.590 | — |
| 7-12 days per month | -1.65 (-2.74 to -0.73) | <0.001 | 0.63 (-1.15 to 2.47) | 0.500 | -1.02 (-2.95 to 0.97) | 0.310 | 1.000 |
| More than 12 days per month | -1.22 (-2.43 to -0.06) | 0.034 | -0.28 (-2.47 to 1.94) | 0.792 | -1.51 (-3.89 to 0.95) | 0.260 | 0.638 |

 ISI, the Insomnia Severity Index; PCS, Physical component summary; MCS, Mental component summary; SF-12, the 12-Item Short Form Health Survey; \*Describing the proportion of mediation effect to the total effect, i.e. mediation effect / (mediation effect + direct effect); Models adjusted for age, sex, body mass index, spouse/partner status, offspring status, cigarette smoking status, alcohol drinking status, physical exercise, income satisfaction level, education level, geographical region and specific job type.