Sleep Health 8 (2022) 521–527

Contents lists available at ScienceDirect

Sleep Health

Journal of the National Sleep Foundation

journal homepage: sleephealthjournal.org

Association between occupational exposure to chemical or physical factors and sleep disturbance: An analysis of the fifth Korean Working Conditions Survey

Seong-Sik Cho, MD, PhD[a], Mo-Yeol Kang, MD, PhD[b*]

[a] Department of Occupational and Environmental Medicine, College of Medicine, Dong-A University, Pusan, Republic of Korea

[b] Department of Occupational and Environmental Medicine, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea

A R T I C L E   I N F O

Article History:
Received 2 December 2021
Revised 12 May 2022
Accepted 7 June 2022

Keywords:
Sleep disturbances
Occupational exposure
Physical factors
Chemical factors
Korean Working Conditions Survey

A B S T R A C T

Objective: A range of risk factors in occupational environments can negatively affect the sleep of workers. Although psychosocial factors have been emphasized in various studies, few have reported on the relationship between physical or chemical exposure in the workplace and sleep disturbances. Thus, this study aimed to investigate the relationship between occupational exposure to physical or chemical factors and sleep disturbances.

Design: Cross-sectional study.

Setting: Data from the fifth Korean Working Conditions Survey (KWCS).

Participants: The target population of the fifth KWCS was economically active individuals aged 15 years or older in all Korean households in 2017, resulting in a total study population of 50,176 participants. After excluding the unemployed, full-time students, homemakers, and the retired, 36,996 employees were included in the current study.

Measurements: Exposure to occupational physical or chemical risk factors was assessed by multiplying the exposure scales of physical or chemical risk factors and weekly working hours. Sleep disturbance was estimated using the Minimal Insomnia Symptom Scale.

Results: In the fully adjusted logistic regression model, exposure to the following risk factors was positively associated with sleep disturbance: vibration (odds ratio [OR], 1.74)); noise (OR, 2.28); high temperatures (OR, 2.43); low temperatures (OR, 2.51); smoke, fume, and dust (OR, 2.12); vapors of solvents or thinners (OR, 3.78); chemical substances (OR, 3.78); and environmental smoking (OR, 5.03).

Conclusions: The results of this study provide evidence of a relationship between occupational exposure to physical or chemical factors and sleep disturbances.

Introduction

Sleep is a basic human need and occupies one-third of a person's life.[1] Obtaining adequate, restorative, and healthy sleep, characterized by appropriate timing, quantity, and quality/satisfaction, is essential for human health, social relationships, efficiency, safety, and well-being.[2] Poor sleep health is reflected in sleep disturbances and inadequate, fragmentary, unrecovered, or delayed sleep, which may be inconsistent with the internal circadian rhythm or social obligations. Recent evidence suggests that the prevalence of sleep disorders has increased significantly in many societies over the past decade, and is now the second most frequent health problem after pain, affecting almost all individuals at some point in their life.[3,4] According to global estimates, about one-third of the general adult population reports sleep disturbances, and approximately 6%-10% meet the Diagnostic and Statistical Manual (DSM-IV) criteria for insomnia.[5] Sleep disturbance is a particularly serious health problem for workers in industrialized countries. It has been estimated that approximately 18% and 23% of workers in Europe[6] and the United States,[7] respectively, suffer from sleep problems.

To date, a large and growing body of evidence supports the hypothesis that sleep disturbance can cause physical and mental health problems, such as cardiovascular disease,[8] hypertension,[9] obesity,[10] syncope and presyncope,[11] depression, and suicidal ideation.[12]

*Corresponding author: Mo-Yeol Kang, MD, PhD, Department of Occupational and Environmental Medicine, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, 222, Banpo-daero, Seocho-gu, Seoul 06591, Republic of Korea.

E-mail address: snaptoon@gmail.com (M.-Y. Kang).

https://doi.org/10.1016/j.sleh.2022.06.004

Persons who suffer from these disorders are much more likely to be absent from work.[13] This problem also incurs significant costs for employers and the community. Individuals with sleep disturbances have less self-confidence and lower job satisfaction in their workplace.[14] In fact, there is a higher accident and job error rate, and lower productivity among this population.[15]

Therefore, understanding the risk factors of sleep disturbance is important and could be used to create strategies to promote a healthier, safer, and more productive workforce. A range of risk factors in occupational environments can negatively affect the sleep of workers.[16] These factors include job stress, organizational factors, work schedules, psychosocial factors, and exposure to various chemicals or physical hazards.

Among these, psychosocial factors have been emphasized in various studies. For instance, Linton et al reviewed studies with prospective or randomized designs and suggested that the psychosocial work variables of social support at work, control, and organizational justice were related to fewer sleep disturbances, while high work demands, job strain, bullying, and effort-reward imbalance were related to more future sleep disturbances.[16] However, few studies have reported on the relationship between physical or chemical exposure in the workplace and sleep disturbances, even though a large number of workers may be exposed to an array of working conditions that include chemical and/or physical agents, and any one of which might influence sleep. This calls for a comprehensive study, using a representative sample, of general workers that elucidates the relationship between physical or chemical exposure in the workplace and sleep disturbances. Thus, this study aimed to investigate the relationship between occupational exposure to physical or chemical factors and sleep disturbances, using data that is representative of the general working population in Korea.

Methods

The fifth Korean Working Conditions Survey and study population

Data from the fifth Korean Working Conditions Survey (KWCS) were used in this study. The fifth KWCS was conducted by the Korean Occupational Safety and Health Agency (KOSHA). Its target population was economically active individuals aged 15 years or older in all Korean households in 2017. The survey aimed to monitor comprehensive working conditions and the safety and health of the Korean working population. The survey questionnaire included demographic characteristics of participants, various physical, chemical, ergonomic, and psychosocial work exposures, and the health status of workers, including sleep disturbance. The KWCS is comparable to the European Working Conditions Survey and the British Labour Force Survey in its basic structure and content of raw data, the questionnaire, and the user guide that is available online.

The sample design of the KWCS was a multi-stage probability proportion stratified cluster sample survey. First, census districts were selected using probability proportional to size systematic sampling to reflect the number of households in each census district. Second, in each selected census district, ten households were randomly chosen by systematic sampling. Finally, one eligible person in each household was randomly selected to be interviewed (eligible individuals were engaged in the labor market at the time of the survey). The survey was carried out from July to November 2017. Trained interviewers visited each household and administered the questionnaire through Computer Assisted Personal Interviewing. The survey weight of the fifth KWCS was estimated by sampling design-weight, adjustment weight for nonresponse rate, and adjustment weight for post-stratification.

The survey included the economically active population comprising employees, self-employed workers, and employers. However, the unemployed, full-time students, homemakers, and the retired were excluded from this study. The total study population of the fifth KWCS was 50,176 participants, while the eligible population (employees) in the current study was 36,996 (survey weighted).

Physical and chemical risk factor exposure

Exposure to occupational physical or chemical risk factors was assessed by multiplying the exposure scales of physical or chemical risk factors and weekly working hours. Participants were considered exposed to physical and chemical risk factors if their weekly exposure duration was 20 hours per week or more. Conversely, they were considered not exposed to physical and chemical risk factors if their weekly exposure duration was less than 20 hours per week. Exposure scales were classified as, all the time (1.0), almost all the time (0.95), around three-fourth of the time (0.75), around half the time (0.5), around one-fourth of the time (0.25), almost never (0.05), and never (0). Each exposure was scaled on the following descriptions: vibration “from hand tools, machinery, etc.,” noise “so loud that you would have to raise your voice to talk to people,” high temperatures that “make you perspire even when not working,” low temperatures “whether indoors or outdoors,” smoke, fume, powder, dust, or vapors from solvents and thinners that “you breathe in,” chemical products or substances “handled or been in direct contact with,” and environmental smoking or “tobacco smoke from other people.” For multiple exposures to physical and chemical risk factors, the number of factors whose exposure durations were the same or exceeding 20 hours per week was estimated.

Sleep disturbance

Sleep disturbance was estimated using the Minimal Insomnia Symptom Scale (MISS),[17] which consists of 3 items: “difficulty in falling asleep (difficulty initiating sleep),” “waking repeatedly during sleep (difficulty maintaining sleep),” and “waking up with a feeling of exhaustion and fatigue (nonrestorative sleep).” MISS was included in the fifth KWCS as part of the survey questionnaire. For each question, participants could describe the frequency of their sleep disturbance symptoms with a description that was assigned a numerical equivalent: “every day” (4 points), “sometimes a week” (3 points), “sometimes a month” (2 points), “rarely” (one point), “not at all” (no point), and “don’t know” and “decline” (both of which were considered as non-responses). The range of the total MISS score was 0-12. In this study, a score of 0-5 suggested no sleep disturbance, while a score of 6 or more suggested the presence of sleep disturbance.[17]

Other covariates

In this study, variables related to sleep disturbances were included in the analysis. Sex, age, and socioeconomic status (eg, educational level, income, occupation, employment status) were included. Working hours, shift work, and self-rated health status were considered covariates. Age was classified into 4 groups (15-39, 40-49, 50-59, and 60 or above years). Educational level was classified into 3 groups (middle school graduate or lower education, high school graduate, and college graduate or higher education). Income level was classified by quartile (lowest, lower-middle, upper-middle, and highest). Occupations were classified by the Korean Standard Classification of Occupations and divided into 4 groups: (1) the management/professional group (managers, professionals, and related practitioners), (2) the clerical worker group (office workers), (3) the service and sales worker group (service workers and salespersons), and (4) the manual worker group (blue-collar: skilled workers in agriculture, forestry and fishing, technicians and related craft workers, workers engaged in device/machine operation and assembly, and simple labor workers). Employment status classified according to the duration of employment contract was categorized into 3 groups: standard (at least one year or more), temporary (at least one month but less than one year), and daily (less than one month). Shift work was assessed by the question, "Do you work shifts?", to which the participants responded as either "yes" or "no", with the former also including night work. Weekly working hours were classified into 5 groups according to the number of hours worked per week (1-34, 35-40, 41-5, 53-60, and 61 hours or more). Job control was assessed by the question, "Can you influence decisions that are important for your work?". Options "Always," "Most of the time," or "Sometimes" were considered to not indicate low job control, whereas options "Rarely" or "Never" were considered to indicate low job control. Effort-reward imbalance was estimated by the question, "Considering all my efforts and achievements in my job, do I feel I get paid appropriately?". Options "Strongly agree," "Tend to agree," and "Neither agree nor disagree" were considered to indicate the absence of an effort-reward imbalance, whereas options "Tend to disagree" and "Strongly disagree" were considered to indicate the presence of an effort-reward imbalance.

Statistical analysis

Distribution of the general and occupational characteristics of participants grouped by the presence or absence of workplace exposure to physical and chemical factors is presented as numbers and percentages. Prevalence of sleep disturbance has been demonstrated across all participants with occupational exposure, and chi-square test was conducted using survey weighting. Survey-weighted logistic regression analysis was performed to explore the association between occupational exposure and sleep disturbance. Odds ratio (OR) and 95% confidence interval (CI) values were estimated for the unadjusted model; adjusted model 1 that included age, sex, and socioeconomic status; adjusted model 2 that included weekly working hours and shift work in addition to the above-mentioned variables; and fully adjusted model 3 that included low job control and effort-reward imbalance in addition to the previously mentioned variables. Furthermore, considering the multiple exposure conditions, additional analysis was conducted on the number of exposures and sleep disturbance for multiple physical or chemical exposures. Next, stratified analysis by shift work was conducted to explore the modifying effect of shift work on the relationship between chemical or physical exposure and sleep disturbances. All statistical analyses were carried out using Stata Version 16.1 (Stata Co, College Station, TX).

Table 1
Characteristics of the study population, grouped by presence or absence of occupational exposure to physical or chemical factors

Characteristics	Total		No exposure		Exposure [a]	
	n	%	*n*	%	*n*	%
Sex						
Male	20,995	56.7	11,124	53.0	9871	47.0
Female	16,001	43.3	11,821	73.9	4180	26.1
Age group						
15-39	16,104	43.5	10,844	67.3	5260	32.7
40-49	9361	25.3	5950	63.6	3411	36.4
50-59	7426	20.1	4019	54.1	3407	45.9
≥ 60	4104	11.1	2132	51.9	1972	48.1
Education						
Middle school or less	3191	8.6	1481	46.4	1710	53.6
High school	11,529	31.2	5814	50.5	5712	49.5
College or more	22,245	60.2	15,625	70.2	6620	29.8
Income						
Lowest	7260	21.0	4853	66.8	2407	33.2
Low middle	8128	23.4	5277	64.9	2851	35.1
High middle	9444	27.2	5463	57.8	3981	42.2
Highest	9872	28.4	5960	60.4	3912	39.6
Employment						
Regular	29,969	81.0	18,987	63.4	10,982	36.6
Temporary	5108	13.8	3232	63.3	1877	36.7
Daily	1919	5.2	727	37.9	1192	62.1
Occupation						
Professional & managerial	8775	23.8	6471	73.8	2303	26.2
Clerical (office work)	9041	24.5	7117	78.7	1924	21.3
Sales & service	7450	20.2	5282	70.9	2167	29.1
Manual	11,613	31.5	4020	34.6	7593	65.4
Weekly working hours						
1-34	3848	10.4	2700	70.2	1149	29.8
35-40	18,132	49.0	12,169	67.1	5963	32.9
41-52	10,132	27.4	5775	57.0	4358	43.0
53-60	3642	9.8	1696	46.6	1946	53.4
> 60	1241	3.4	606	48.8	635	51.2
Shift work						
No	32,607	88.1	20,614	63.2	11,992	36.8
Yes	4385	11.9	2330	53.1	2055	46.9
Low job control						
No	27,188	73.5	16,971	62.4	10,217	37.6
Yes	9791	26.5	5962	60.9	3829	39.1
Effort-reward imbalance						
No	32,345	88.2	20,379	63.0	11,966	37.0
Yes	4312	11.8	2310	53.6	2002	46.4

[a] Exposure (+): Exposure to one or more physical or chemical factors in the workplace.

Results

Table 1 shows the socio-demographic characteristics of participants grouped by the presence or absence of occupational exposure to physical or chemical factors. The proportion of exposure group was higher in males (47%) than females (26.1%). Higher proportions of workers were exposed to physical or chemical factors in older age groups. The proportion of exposure group was lowest (29.8%) among participants with a college degree or higher, and it was the highest (53.6%) among those with a middle school degree or less. Highest proportion of daily-contract workers (62.1%) were exposed to physical or chemical risks. Highest proportion of manual workers (65.4%) and lowest proportion of clerical workers (21.3%) were exposed to physical or chemical risks. Also, differences in exposure proportion were observed for weekly working hours, shift work, and effort-reward imbalance but not for low job control.

Table 2 demonstrates the prevalence of sleep disturbance among participants, grouped by their exposure to physical and chemical factors. All forms of workplace exposures studied were associated with an increase in the prevalence of sleep disturbance. Workers who were not exposed to any physical or chemical factors had a sleep disturbance prevalence of 6%, while those who were exposed had a sleep disturbance prevalence that ranged from 10% to 26%. In general, the prevalence of sleep disturbance was higher in the exposure to chemical hazards subgroups than in the exposure to physical hazards subgroups. Notably, the prevalence of sleep disturbance was the highest (25.9%) in workers exposed to environmental smoking.

Table 3 shows the prevalence of sleep disturbance according to the number of exposures to physical or chemical risk factors. The group not exposed to any physical nor chemical risk factors had the lowest prevalence of sleep disturbance (5.3%). As the number of exposures increased, the prevalence of sleep disturbance also increased, with the prevalence being highest among workers exposed to 8 risk factors.

Table 4 presents the association between workplace exposure and sleep disturbance by survey-weighted logistic regression analysis. Regardless of the specifics, all investigated physical and chemical factors resulted in an increased OR. In the fully adjusted model (model 3), the following exposures were positively associated with sleep disturbance: vibration (OR, 1.74; 95% CI, 1.41-2.14); noise (OR, 2.28; 95% CI, 1.83-2.85); high temperatures (OR, 2.43; 95% CI, 1.99-2.96); low temperatures (OR, 2.51; 95% CI, 2.04-3.09); smoke, fume, and dust

Table 2
Physical or chemical exposures in the workplace and prevalence of sleep disturbance

	Total		No sleep disturbance		Sleep disturbance		
	n	%	*n*	%	*n*	%	*p* value
Vibration							<.001
No	30,641	90.4	28,678	93.6	1962	6.4	
Yes	3255	9.6	2928	89.9	327	10.1	
Noise							<.001
No	31,165	93.3	29,282	94.0	1883	6.0	
Yes	2234	6.7	1952	87.4	282	12.6	
High temperatures							<.001
No	31,468	93.1	29,585	94.0	1883	6.0	
Yes	2339	6.9	2027	86.7	312	13.3	
Low temperatures							<.001
No	32,344	94.6	30,414	94.0	1930	6.0	
Yes	1861	5.4	1604	86.2	257	13.8	
Smoke, fume, dust, or powder							<.001
No	32,238	94.1	30,195	93.7	2043	6.3	
Yes	2038	5.9	1789	87.8	248	12.2	
Vapors of solvent or thinner							<.001
No	34,721	97.9	32,591	93.9	2130	6.1	
Yes	742	2.1	588	79.2	154	20.8	
Chemical products or substances							<.001
No	34,385	97.7	32,267	93.8	2118	6.2	
Yes	798	2.3	638	79.9	160	20.1	
Environmental smoking							<.001
No	33,163	98.3	31,145	93.9	2017	6.1	
Yes	564	1.7	418	74.1	146	25.9	

p was calculated using survey weighted chi-squared test.

(OR, 2.12; 95% CI, 1.71-2.63); vapors of solvents or thinners (OR, 3.78; 95% CI, 2.90-4.92); chemical substances (OR, 3.78; 95% CI, 2.96-4.84); and environmental smoking (OR, 5.03; 95% CI, 3.78-6.70). Among these exposures, environmental smoking had the highest OR. In addition, exposure to the vapors of solvents or thinners and exposure to chemical products or substances had relatively high ORs.

Table 5 shows the association between the number of exposures to physical or chemical risk factors and sleep disturbance. As the number of exposures increased, the ORs of sleep disturbance also increased, with the OR being highest among workers exposed to 8 risk factors.

Appendix Tables 1-3 show the associations between workplace exposure to the different physical or chemical factors and sleep-related symptoms, which constitute the MISS, difficulty in initiating sleep (Appendix Table 1), difficulty in maintaining sleep (Appendix Table 2), and nonrestorative sleep (Appendix Table 3). All investigated physical and chemical factors were associated with an increased risk of all sleep-related symptoms. Considering the amplitudes of the ORs, the effect of workplace exposure on sleep might be greater on difficulty in maintaining sleep and non-restorative sleep than on difficulty in initiating sleep. Appendix Table 4 shows the association between occupational physical or chemical exposures and sleep disturbance stratified by shift work. Regardless of shift work, all physical and chemical exposures increased the risk of sleep disturbance among shift workers. Appendix Table 5 presents the association between the number of occupational physical or chemical exposures and sleep disturbance stratified by shift work. As the number of exposures increased, the risk of sleep disturbance also gradually increased in both shift and nonshift work.

Table 3
Number of physical or chemical exposures in the workplace and prevalence of sleep disturbance

	Total		No sleep disturbance		Sleep disturbance	
	n	%	*n*	%	*n*	%
Number of exposures						
0	22,936	62.0	21,720	94.7	1216	5.3
1	5227	14.1	4836	92.5	391	7.5
2	3212	8.7	2967	92.4	245	7.6
3	2170	5.9	1980	91.2	190	8.8
4	1401	3.8	1262	90.2	138	9.8
5	978	2.7	877	89.7	101	10.3
6	522	1.4	445	85.1	78	14.9
7	342	0.9	276	80.6	66	19.4
8	196	0.5	146	74.4	50	25.6

Discussion

This study aimed to evaluate the association between exposure to physical or chemical factors in the workplace and sleep disturbances in a nationwide representative sample of the Korean working population. The findings suggest that exposure to vibration, noise, high or low temperatures, dust or fumes, solvent vapors, chemicals substances, and secondhand smoke is associated with sleep disturbances, such as problems in initiating and maintaining sleep and fatigue at awakening. After adjusting for age, sex, education, income level, occupation, employment type, working hours, shift work, and job stressors, the physical and chemical risk factors retained a statistically significant relationship with sleep disturbance. Hence, it could be concluded that these workplace risk factors contributed to the workers' sleep disturbance.

It may be difficult to compare the results of this study with those of previous studies because the study population and methods are different; however, results similar to ours have been found. For example, Bertrais et al assessed the association between a wide range of occupational risk factors and sleep problems, and investigated the cumulative effects of these exposures using data from the 2016 French Working Conditions Survey.[18] The results showed that exposure to most occupational risk factors, such as fumes and dust, noise, toxic and dangerous products, and biochemical substances, was associated with sleep problems; the prevalence ratio of sleep problems was also found to significantly increase with an increase in the number of exposures to physical work factors. Mokarami et al also

Table 4
Association between physical or chemical exposures and sleep disturbance by survey-weighted logistic regression analysis

	Unadjusted			Model 1[a]			Model 2[b]			Model 3[c]		
Exposure	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Vibration	1.63	1.38	1.93	1.73	1.40	2.13	1.72	1.39	2.12	1.74	1.41	2.14
Noise	2.25	1.86	2.71	2.29	1.84	2.86	2.28	1.83	2.85	2.28	1.83	2.85
High temperature	2.42	2.05	2.86	2.50	2.06	3.04	2.49	2.05	3.02	2.43	1.99	2.96
Low temperature	2.52	2.10	3.04	2.62	2.14	3.21	2.59	2.11	3.17	2.51	2.04	3.09
Smoke, fume, dust, etc.	2.05	1.71	2.46	2.10	1.69	2.59	2.10	1.69	2.60	2.12	1.71	2.63
Vapors of solvent, etc.	4.01	3.17	5.06	4.04	3.11	5.23	4.07	3.13	5.28	3.78	2.90	4.92
Chemical products	3.82	3.04	4.80	3.78	2.96	4.83	3.90	3.05	4.99	3.78	2.96	4.84
Environmental smoking	5.39	4.15	6.98	5.30	4.02	6.99	5.14	3.89	6.81	5.03	3.78	6.70

[a] Model 1: Adjusted for age, sex, education, income, occupation, and employment status.
[b] Model 2: Adjusted for age, sex, education, income, occupation, employment status, weekly working hours, and shift work.
[c] Model 3: Adjusted for age, sex, education, income, occupation, employment status, weekly working hours, shift work, low job control, and effort-reward imbalance.

suggested that environmental risk factors in the workplace, especially noise, heat stress, and respirable dust, are related to the employees' indices of sleep disturbance in a brick factory in Iran.[19] Moreover, the potential impact of workplace exposure to inhalational agents, especially solvents, on obstructive sleep apnea (OSA) has been reported in previous studies. Prolonged exposure to these pollutants can cause sleep disturbances, especially sleep apnea syndromes.[20] The results of a meta-analysis by Schwartz et al confirmed that exposure to solvents increases the risk of OSA.[21]

Although the mechanisms by which physical or chemical risk factors cause sleep disturbances remain unclear, there are several plausible explanations for these findings. First, exposure to certain types of occupational risk factors (eg, noise, thermal discomfort, and poor air quality) could promote stress reactions that, in turn, could impair sleep via increased activation of the hypothalamic-pituitary-adrenal axis and rumination.[22] Some studies have reported that chronic exposure to noise or vibration can continuously stimulate the autonomic nervous system, causing persistent central autonomic arousal and stimulation of sympathetic activity.[23] However, there have been few studies on the effects of noise, vibration, and temperature exposure during work on sleep after work. Second, exposure to heat and chemicals can affect the nervous system directly or indirectly and cause long-term neurobehavioral effects, including sleep disturbance.[24,25] Third, sleep problems could be caused by psychological factors. Thus, health concerns or anxiety can be influenced by direct exposure to handling hazardous substances, and increased stress by recognizing the poor working conditions associated with hazardous substance exposure can lead to sleep disturbances.[26] Fourth, exposure to a variety of risk factors can affect a worker's overall health status including chronic illness that may also lead to sleep disturbances.[27] Another possible explanation is that poor sleep affects perceptions of the working environment, which is not plausible in the current cross-sectional context, given that our research utilized self-reporting measures. Individuals with poor sleep due to other factors (eg, poor health, loneliness, isolation, family environment, lack of sleep) may be more emotionally responsive, which can affect their subjective assessment of the working environment.[28,29]

With respect to shift work, it is well demonstrated that shift workers experience high levels of sleep disturbance.[29] As shown in Table 1, the proportion of exposure group was significantly higher in the shift workers. This may suggest that shift work can explain the higher likelihood of exposure and sleep disturbance. However, it is unclear to what degree shift work influences the relationship between occupational exposure to physical or chemical factors and sleep disturbances. Stratified analysis by shift work did not reveal any significant differences in relationship, depending on whether shift work is performed (Appendix Tables 4 and 5). Similarly, in a previous study of steel shift workers characterized by an identical physical, chemical, and mental working load during 3 different shifts, the working periods were constantly characterized by higher indexes of cardiac sympathetic modulation compared with the sleep time; no specific sleep disturbance was reported by the workers although the study did not aim to investigate sleep quality.[30] The combining or modifying effect of shift work on the relationship between physical or chemical exposure and sleep is rife for further research.

The strengths of the current study include the use of a nationwide representative survey of the working population, assessment of sleep disturbance using a validated tool, and the examination of various occupational exposures that have seldom been explored in the literature. However, the following limitations were recognized in our

Table 5
Association between number of physical or chemical exposures and sleep disturbance by survey-weighted logistic regression analysis

	Unadjusted			Model 1[a]			Model 2[b]			Model 3[c]		
Number of exposures	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
1	1.45	1.23	1.70	1.55	1.30	1.85	1.54	1.28	1.84	1.54	1.28	1.84
2	1.47	1.22	1.78	1.64	1.34	2.02	1.62	1.32	2.00	1.60	1.30	1.98
3	1.72	1.37	2.15	1.89	1.46	2.44	1.86	1.43	2.41	1.82	1.40	2.36
4	1.95	1.51	2.52	2.22	1.66	2.97	2.20	1.64	2.94	2.16	1.61	2.89
5	2.05	1.53	2.75	2.37	1.72	3.27	2.36	1.70	3.26	2.27	1.64	3.14
6	3.12	2.22	4.38	4.01	2.79	5.78	4.02	2.80	5.78	3.82	2.64	5.54
7	4.29	3.03	6.09	5.26	3.57	7.75	5.30	3.60	7.82	5.06	3.39	7.55
8	6.16	4.12	9.20	7.55	4.91	11.61	7.58	4.92	11.68	7.23	4.71	11.09

[a] Model 1: Adjusted for age, sex, education, income, occupation, and employment status.
[b] Model 2: Adjusted for age, sex, education, income, occupation, employment status, weekly working hours, and shift work.
[c] Model 3: Adjusted for age, sex, education, income, occupation, employment status, weekly working hours, shift work, low job control, and effort-reward imbalance.

study. First, as the study design was cross-sectional, a causal relationship could not be verified. Furthermore, given the healthy worker effect, we could not exclude the possibility that workers with sleep problems may have changed jobs or left the labor market because of their occupational exposures, which may lead to an underestimation of the true associations. Second, information on symptoms and exposures was obtained using self-administered questionnaires; this method relies on the accuracy of the responders' memory and may be subject to recall bias. Third, there is a lack of detailed workplace risk factor evaluation. We were not able to confirm the exposure root, quantity, duration, or whether protective equipment was being worn; although, it is expected that these factors may have distinct health effects. Fourth, this study evaluated sleep disturbances with a particular focus on occupational exposure without considering key confounding factors such as sleep medication use, history of mental illness (eg, major depressive disorder, anxiety disorder), and other health behaviors (eg, smoking, alcohol drinking, exercise), because the information provided in this survey did not include these variables.

In conclusion, the results of the current study provide evidence of a relationship between occupational exposure to physical or chemical factors and sleep disturbances. In future studies, improving upon the limitations of our study, a causal relationship should be confirmed by using a longitudinal study design and an objective assessment method, and by gathering detailed information about exposure and confounders.

From a public health viewpoint, it is important to tackle workers' sleep problems as they negatively impact their health, quality of life, and work performance. Based on the current findings, interventional programs to improve sleep and prevent sleep disturbances need to be tailored for workers exposed to various kinds of chemical and physical exposures. Improving the workplace environment by, for example, lowering the intensity and duration of workers' exposure to physical and chemical hazards would be a useful preventive strategy. It also requires proper training in self-protection. In addition, identifying and managing other risk factors that may affect the sleep health of workers are necessary to improve workers' sleep health.

Declaration of conflict of interest

All authors declare no competing interests.

Funding

This research is supported by the National Research Foundation of Korea (NRF-2021R1C1C1007796).

Ethics statement

The fifth Korean Working Conditions Survey contains anonymous data and is open to the public. Written informed consent and review of the study protocol were waived by the Dong-A Institutional Review Board (Approval No: 2-1040709-AB-N-01-202104-HR-020-02).

Data sharing

The KWCS data and the user's guide are available at https://oshri.kosha.or.kr/oshri/researchField/downWorkingEnvironmentSurvey.do

Author contribution

SSC conceived and designed the study. SSC analyzed the data. SSC and MYK were involved in interpreting the results and discussion. SSC and MYK drafted the manuscript. All authors reviewed, approved, and agreed to submit the final version of the manuscript for publication.

Acknowledgment

This research is supported by the National Research Foundation of Korea (NRF-2021R1C1C1007796).

The authors appreciate the Occupational Safety and Health Research Institute (OSHRI) for providing the raw data of the fifth Korean Working Conditions Survey.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.sleh.2022.06.004.

References

1. Chandola T, Ferrie JE, Perski A, Akbaraly T, Marmot MG. The effect of short sleep duration on coronary heart disease risk is greatest among those with sleep disturbance: a prospective study from the Whitehall II cohort. *Sleep*. 2010;33(6):739–744. https://doi.org/10.1093/sleep/33.6.739.
2. Magnavita N, Garbarino S. Sleep, health and wellness at work: a scoping review. *Int J Environ Res Public Health*. 2017;14(11):1347. https://doi.org/10.3390/ijerph14111347.
3. Chaput J-P, Yau J, Rao DP, Morin CM. Prevalence of insomnia for Canadians aged 6 to 79. *Health Rep*. 2018;29(12):16–20.
4. Chung S, Cho SW, Jo M-W, Youn S, Lee J, Sim CS. The prevalence and incidence of insomnia in Korea during 2005 to 2013. *Psychiatry Investig*. 2020;17(6):533–540. https://doi.org/10.30773/pi.2019.0218.
5. Ohayon MM. Epidemiological overview of sleep disorders in the general population. *Sleep Med Res*. 2011;2(1):1–9. https://doi.org/10.17241/smr.2011.2.1.1.
6. Dregan A, Armstrong D. Cross-country variation in sleep disturbance among working and older age groups: an analysis based on the European Social Survey. *Int Psychogeriatr*. 2011;23(9):1413–1420. https://doi.org/10.1017/S1041610211000664.
7. Kessler RC, Berglund PA, Coulouvrat C, et al. Insomnia and the performance of US workers: results from the America insomnia survey. *Sleep*. 2011;34(9):1161–1171. https://doi.org/10.5665/SLEEP.1230.
8. Sofi F, Cesari F, Casini A, Macchi C, Abbate R, Gensini GF. Insomnia and risk of cardiovascular disease: a meta-analysis. *Eur J Prev Cardiol*. 2014;21(1):57–64. https://doi.org/10.1177/2047487312460020.
9. Jarrin DC, Alvaro PK, Bouchard M-A, Jarrin SD, Drake CL, Morin CM. Insomnia and hypertension: a systematic review. *Sleep Med Rev*. 2018;41:3–38. https://doi.org/10.1016/j.smrv.2018.02.003.
10. Muscogiuri G, Barrea L, Annunziata G, et al. Obesity and sleep disturbance: the chicken or the egg? *Crit Rev Food Sci Nutr*. 2019;59(13):2158–2165. https://doi.org/10.1080/10408398.2018.1506979.
11. Magnavita N, Di Prinzio RR, Arnesano G, et al. Association of occupational distress and low sleep quality with syncope, presyncope, and falls in workers. *Int J Environ Res Public Health*. 2021;18(23):12283.
12. Kang M-Y, Kwon H-J, Choi K-H, Kang C-W, Kim H. The relationship between shift work and mental health among electronics workers in South Korea: a cross-sectional study. *PLoS One*. 2017;12(11): e0188019.
13. Ishibashi Y, Shimura A. Association between work productivity and sleep health: a cross-sectional study in Japan. *Sleep Health*. 2020;6(3):270–276.
14. Park JB, Nakata A, Swanson NG, Chun H. Organizational factors associated with work-related sleep problems in a nationally representative sample of Korean workers. *Int Arch Occup Environ Health*. 2013;86(2):211–222. https://doi.org/10.1007/s00420-012-0759-3.
15. Uehli K, Mehta AJ, Miedinger D, et al. Sleep problems and work injuries: a systematic review and meta-analysis. *Sleep Med Rev*. 2014;18(1):61–73. https://doi.org/10.1016/j.smrv.2013.01.004.
16. Linton SJ, Kecklund G, Franklin KA, et al. The effect of the work environment on future sleep disturbances: a systematic review. *Sleep Med Rev*. 2015;23:10–19.
17. Broman J-E, Smedje H, Mallon L, Hetta J. The minimal insomnia symptom scale (MISS). *Ups J Med Sci*. 2008;113(2):131–142. https://doi.org/10.3109/2000-1967-221.
18. Bertrais S, André N, Bèque M, Chastang JF, Niedhammer I. Associations between multiple occupational exposures and sleep problems: results from the national French Working Conditions survey. *J Sleep Res*. 2020;30(3):e13101. https://doi.org/10.1111/jsr.13101.
19. Mokarami H, Gharibi V, Kalteh HO, Kujerdi MF, Kazemi R. Multiple environmental and psychosocial work risk factors and sleep disturbances. *Int Arch Occup Environ Health*. 2020;93(5):623–633. https://doi.org/10.1007/s00420-020-01515-8.
20. Viaene M, Vermeir G, Godderis L. Sleep disturbances and occupational exposure to solvents. *Sleep Med Rev*. 2009;13(3):235–243. https://doi.org/10.1016/j.smrv.2008.07.003.
21. Schwartz DA, Vinnikov D, Blanc PD. Occupation and obstructive sleep apnea: a meta-analysis. *J Occup Environ Med*. 2017;59(6):502–508. https://doi.org/10.1097/JOM.0000000000001008.

22. Buckley TM, Schatzberg AF. On the interactions of the hypothalamic-pituitary-adrenal (HPA) axis and sleep: normal HPA axis activity and circadian rhythm, exemplary sleep disorders. *J Clin Endocrinol Metab*. 2005;90(5):3106–3114. https://doi.org/10.1210/jc.2004-1056.
23. Lee S, Lee W, Roh J, Won J-U, Yoon J-H. Symptoms of nervous system related disorders among workers exposed to occupational noise and vibration in Korea. *J Occup Environ Med*. 2017;59(2):191–197. https://doi.org/10.1097/JOM.0000000000000935.
24. Patel AV, Mihalik JP, Notebaert AJ, Guskiewicz KM, Prentice WE. Neuropsychological performance, postural stability, and symptoms after dehydration. *J Athl Train*. 2007;42(1):66–75.
25. Shih H-T, Yu C-L, Wu M-T, et al. Subclinical abnormalities in workers with continuous low-level toluene exposure. *Toxicol Ind Health*. 2011;27(8):691–699. https://doi.org/10.1177/0748233710395348.
26. Heo Y-S, Chang S-J, Park S-G, et al. Association between workplace risk factor exposure and sleep disturbance: analysis of the 2nd Korean Working Conditions Survey. *Ann Occup Environ Med*. 2013;25(1):41. https://doi.org/10.1186/2052-4374-25-41.
27. Taylor DJ, Mallory LJ, Lichstein KL, Durrence HH, Riedel BW, Bush AJ. Comorbidity of chronic insomnia with medical problems. *Sleep*. 2007;30(2):213–218. https://doi.org/10.1093/sleep/30.2.213.
28. Magee C, Gopaldasani V, Bakand S, Coman R. The physical work environment and sleep: a latent class analysis. *J Occup Environ Med*. 2019;61(12):1011–1018. https://doi.org/10.1097/JOM.0000000000001725.
29. Åkerstedt T, Garefelt J, Richter A, et al. Work and sleep—a prospective study of psychosocial work factors, physical work factors, and work scheduling. *Sleep*. 2015;38(7):1129–1136. https://doi.org/10.5665/sleep.4828.
30. Furlan R, Barbic F, Piazza S, Tinelli M, Seghizzi P, Malliani A. Modifications of cardiac autonomic profile associated with a shift schedule of work. *Circulation*. 2000;102(16):1912–1916.