safety

MDPI

Article

A Study on the Relationship between Work-Related Health Problems and the Working Conditions of Electronics Industry Workers in South Korea

Sul A. Won [1], Jae Wook Choi [2,3] and Kyung Hee Kim [3,*]

[1] Department of Public Health, Graduate School, Korea University, 73 Goryeodae-ro, Seongbuk-gu, Seoul 02841, Republic of Korea; wonsula@naver.com
[2] Department of Preventive Medicine, College of Medicine, Korea University, 73 Goryeodae-ro, Seongbuk-gu, Seoul 02841, Republic of Korea; shine@korea.ac.kr
[3] Institute for Environmental Health, Korea University, 73 Goryeodae-ro, Seongbuk-gu, Seoul 02841, Republic of Korea
* Correspondence: kyonghee80@korea.ac.kr

Abstract: Background: The electronics industry has characteristics, such as the continuous occurrence of new hazards and risk factors due to rapid technological changes, the occurrence of safety and health blind spots due to the outsourcing of work, trade secrets, and a lack of information, so research is needed from a safety and health perspective. This study sought to determine the relationship between work-related health problems and the working conditions of electronics industry workers. Methods: The study subjects were 3354 workers in the electronics industry from the raw data of the 4th to 6th Korean Working Condition Survey (KWCS). The variables were divided into general, occupational, and working environment characteristics, and a logistic regression analysis was conducted to determine the relationship between work-related health problems and working conditions. Results: Among the general and occupational characteristics, gender, education, night work, and working time appropriateness were analyzed as effect factors. In terms of working environment characteristics, physical work risk, musculoskeletal work risk, possibility of risk to work, subjective health impact, and working environment satisfaction were found to have effects on work-related health problems. Conclusions: The results of this study are meaningful in that they identified the effect factors of work-related health problems in the working conditions of workers in the electronics industry, where prior studies are lacking. Therefore, improvements, such as the management of night workers, appropriate working time, reduction in exposure to work risk factors, and improvement in working environment satisfaction, appear to be necessary.

Keywords: work-related health problems; working conditions; working environment; electronics industry; working condition survey

Citation: Won, S.A.; Choi, J.W.; Kim, K.H. A Study on the Relationship between Work-Related Health Problems and the Working Conditions of Electronics Industry Workers in South Korea. *Safety* **2024**, *10*, 49. https://doi.org/10.3390/safety10020049

Academic Editor: Raphael Grzebieta

Received: 25 January 2024
Revised: 27 May 2024
Accepted: 29 May 2024
Published: 31 May 2024

1. Introduction

The electronics industry, which leads Korea's industrial development, is developing rapidly, and this development can affect the health and safety of workers.

As of 2023, in South Korea, there are 3.74 million people employed in manufacturing, of which 22% (801,121 people) work in the electronics industry [1]. According to the 2021 industrial accident statistics announced by the Ministry of Employment and Labor (MoEL), the number of occupational diseases reached a total of 20,435, with the manufacturing industry accounting for 7444 (36.4%), of which the electronics industry accounted for 329 (4.4%). There were a total of 1252 deaths due to occupational diseases, with the manufacturing industry accounting for 328 (26.1%), of which the electronics industry accounted for 23 (7.0%) [2].

Occupational accidents and diseases have a fatal socioeconomic impact on workers and companies, and despite many improvements, the prevention of occupational accidents and diseases is considered an important issue worldwide.

According to data from the International Labor Organization (ILO), each year, more than 2.78 million workers worldwide die from work-related accidents or diseases, and about 374 million non-fatal work-related injuries occur [3].

In the UK, in 2022/23, around 1.8 million workers had a disease they believed was caused or worsened by work, 135 workers died in work-related accidents, and about 561,000 workers suffered work-related injuries. In addition, there was a loss of about 36.8 million working days due to work-related diseases and injuries, which is equivalent to 1.31 lost working days per worker for one year [4]. For manufacturing workers, about 92,000 cases (2.9% of all manufacturing workers) of work-related diseases (40% musculoskeletal diseases, 40% stress, depression, anxiety, etc.) occurred every year, and about 54,000 work-related injuries occurred [5].

In the United States, 373,300 work-related injuries and diseases were reported in the entire manufacturing industry in 2020, of which 23,400 work-related injuries and diseases related to absence occurred among maintenance and repair workers [6,7].

The electronics industry consists of various processes, so there are health hazards caused by various chemicals and facilities in each process [8]. In addition, it has characteristics, such as the continuous occurrence of new harmful and risk factors due to rapid technological change, the occurrence of safety and health blind spots due to the outsourcing of work, trade secrets, and lack of information [9,10], and a lot of research in the context of safety and health is needed.

Existing research related to the electronics industry has been conducted with a focus on measurable exposure, which can overlook unknown risks, so it is necessary to identify potential risk factors and prepare management measures.

Accordingly, this study aims to analyze the relationship between the work-related health problems and working conditions of electronics industry workers using the 4th–6th Korean Working Condition Survey conducted by the Occupational Safety and Health Research Institute (OSHRI). The derived research results could contribute to creating safe working conditions that can prevent work-related health problems for workers in the electronics industry and use them as a basis for establishing occupational safety and health policies.

2. Materials and Methods

2.1. Study Subjects

This study used raw data from the Korean Working Condition Survey (KWCS), conducted by the Occupational Safety and Health Research Institute. KWCS was a benchmarking survey of the European Working Conditions Survey (EWCS) conducted by the Eurofound under the European Union. It is a survey that provides an overall understanding of the work environment, work type, industry, exposure to risk factors, and employment stability. The KWCS was first conducted with the approval of Statistics Korea in 2006 (1st) and has been conducted in 2010 (2nd), 2011 (3rd), 2014 (4th), 2017 (5th), and 2020 (6th). In this study, the results of the 4th, 5th, and 6th survey were used.

The target population of this survey can be defined as “employed people aged 15 or older in all households residing in Korea at the time of the survey”. However, considering the realistic aspects of the survey, islands, dormitory, special social facilities, hotel, and foreigner survey areas were excluded.. The survey method was conducted as a 1:1 interview through household visits, and the survey tool was TAPI (Tablet PC-Assisted Personal Interviewing) using an electronic questionnaire on-board tablet PC instead of a paper questionnaire. In addition, to increase the reliability of the data, samples were extracted using a stratified sampling method, and subjects who fit the category of ‘employed’ were selected from the extracted households.

The subjects of this study were selected through the following procedures. Frist, out of the 150,750 total survey samples from the 4th to 6th KWCS, 93,922 wage workers who responded to question 3 of Q5 (employment status) of the questionnaire were selected.

Wage workers are workers who explicitly or implicitly sign employment contracts with an individual, household, or business and receives wages, salary, daily wages, or in kind in return for their work, including regular, temporary, and daily workers, who have been paid for more than an hour in the past week.

Next, among wage workers, 3354 workers in the electronics industry were selected as final research subjects in questions Q3 (major classification) and Q4 (medium classification) of the questionnaire.

The electronics industry was classified into major classification C. Manufacturing (10~34), medium classification, 26. Manufacture of electronic components, computer, visual, sounding and communication equipment, 27. Manufacture of medical, precision and optical instruments, watch and clocks, 28. Manufacture of electrical equipment [11] according to the Korea Standard of Industry Classification.

2.2. Ethical and Legal Considerations

This study corresponds to research using information disclosed to the general public in accordance with Article 13 (Human Subjects Research Exempted from Institutional Review Board) of the "Enforcement Rules of the Bioethics and Safety Act". Therefore, it was approved by the Institutional Review Board of the Korea University (KUIRB-2024-0028-01).

2.3. Study Method

2.3.1. Variable Definition

Variables that could affect work-related health problems were extracted from the Korean Working Condition Survey and selected by dividing into general, occupational, and working environment characteristics of the study subjects.

As general characteristics, gender, age, education, and income were selected as variables. Gender was classified into male and female, and age was classified into under 30s, 30s, 40s, and over 50s. Education was classified as lower than high school and college above, and income was classified as less than KRW 2 million, KRW 2 to 3.99 million, and more than KRW 4 million.

As occupational characteristics, employment status, night work, shift work, working time appropriateness, and workplace scale were selected as variables. Employment status was classified into regular workers, temporary workers, and daily workers, and night work and shift work was classified into "no"; working at least once was classified into "yes". Working time appropriateness was classified into "appropriate" or "inappropriate" in response to the question, "Is your working time appropriate for family life or social life outside of work?", and workplace scale was classified into less than 50 workers, 50–299 workers, and more than 300 workers.

As working environment characteristics, physical work risk, musculoskeletal work risk, psychological work risk, possibility of risk to work, subjective health impact, working environment satisfaction, provide health, and safety information were selected as variables. Physical work risk, musculoskeletal work risk, and psychological work risk were classified into exposure, and the possibility of risk to work was classified into "yes" and "no" in response to the question, "Do you think what you are doing is harmful to your health or dangerous to safety?". Subjective health impact was classified into "positive impact" and "negative impact" in response to the question, "How do you think your work affects your health?". Working environment satisfaction was classified into "satisfaction" and "non-satisfaction", and providing health and safety information was classified into "yes" and "no".

Work-related health problems were assessed by asking, "In the past year, have you had any of the following health problems?". The answers to the questions include the following: A. low back pain (back pain); B. upper extremity muscle pain, such as shoulder,

neck, arm, elbow, wrist, and hand; C. lower extremity muscle pain, such as hip, leg, knee, and foot, D. headache, eye fatigue; E. anxiety; F. general fatigue; G. other health problems. After answering "yes" to the upper question, it was defined as answering "yes" at least once to the question "if yes, was it caused by your work?"

2.3.2. Data Analysis

For the statistical analysis in this study, we used the SPSS for windows version 23.0 program to analyze the data. First, trends in work-related health problems were identified among 3354 electronics industry workers during the 4th to 6th KWCS. Second, the 4th to 6th KWCSs were classified, and general, occupational, working environment characteristics were identified through frequency analysis and cross-analysis. Third, a logistic regression analysis was conducted to determine the relationship between work-related health problems and working conditions. The statistical significance level was set at 0.05 for a two-sided test. Logistic regression analysis is a method to identify the relationship between one or more independent variables. Using this analysis method, we analyzed the relationship between the dependent variable of work-related health problems and the independent variables of general, occupational, working environment characteristics.

3. Results

3.1. Trend of Increase and Decrease in Work-Related Health Problems among Electronics Industry Workers in the 4th to 6th Working Condition Survey

As a result of analyzing the raw data from the 4th to 6th working condition surveys in Figure 1, the number of workers who responded that they had work-related health problems in the electronics industry showed a decreasing trend but increased in the 6th survey conducted in 2020. The result of the gender comparison also showed that work-related health problems decreased in the 5th survey for both males and females compared to the 4th survey but tended to increase in the 6th survey. This change in trend can be seen as a result of a change in social awareness related to work-related health problems, as the number of approved industrial accidents in the electronics industry has been increasing since 2017. In addition, it is believed that the efficiency of industrial accident prevention projects has decreased due to the impact of the COVID-19 pandemic, and work-related health problems have tended to increase due to rapid changes in the industrial ecosystem.

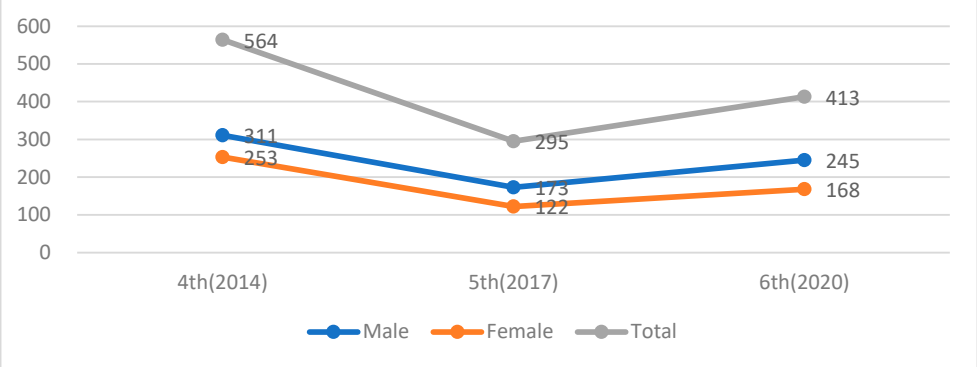

Figure 1. Time-series analysis of work-related health problems by gender.

3.2. Characteristics of Workers in the Electronics Industry

Looking at the general and occupational characteristics of electronics industry workers in the 4th to 6th working condition surveys in Table 1, it can be seen that gender characteristics accounted for 64.3% of males compared to 35.7% of females. In the case of age, those in their 30s accounted for 33.2%, followed by 30.5% in their 40s, 20.7% over 50s, and 15.6% under 30s. In the case of education, 61.2% were educated to college and above compared to 38.8% with lower than high school, and in the case of income, KRW 2 to 3.99 million was

the most common at 56.1%, followed by 22.9% with less than KRW 2 million and 21% with more than KRW 4 million.

In terms of the employment status among occupational characteristics, regular workers were the most common at 92.8%, and in the case of night work and shift work, "no" accounted for 87.8% and 87.3%, respectively. In the case of working time appropriateness, "appropriate" accounted for 80.0%, and for the workplace scale, 50–299 workers were the most at 37.5%, followed by 35.1% with less than 50 workers and 27.4% with more than 300 workers.

Table 1. General and occupational characteristics of the electronics industry workers.

Variables/Category		2014 (4th) (*n* = 1320)	2017 (5th) (*n* = 879)	2020 (6th) (*n* = 1155)	Total (*n* = 3354)	x^2 (*p*)
Gender	Male	820 (62.1)	590 (67.1)	746 (64.6)	2156 (64.3)	5.819
	Female	500 (37.9)	289 (32.9)	409 (35.4)	1198 (35.7)	(0.055)
Age	<30	228 (17.3)	134 (15.2)	161 (13.9)	523 (15.6)	17.475 (0.008)
	30–39	448 (33.9)	311 (35.4)	356 (30.8)	1115 (33.2)	
	40–49	377 (28.6)	276 (31.4)	370 (32.0)	1023 (30.5)	
	≥50	267 (20.2)	158 (18.0)	268 (23.2)	693 (20.7)	
Education	Lower than high school	585 (44.6)	319 (36.3)	393 (34.1)	1297 (38.8)	31.789 (<0.001)
	College above	727 (55.4)	560 (63.7)	761 (65.9)	2048 (61.2)	
Income (won)	Less than 200	463 (35.8)	155 (18.4)	124 (11.3)	742 (22.9)	233.582 (<0.001)
	200–399	652 (50.4)	483 (57.4)	678 (61.7)	1813 (56.1)	
	More than 400	179 (13.8)	203 (24.1)	296 (27.0)	678 (21.0)	
Employment status	Regular	1182 (90.0)	825 (93.9)	1099 (95.2)	3106 (92.8)	35.809 (<0.001)
	Temporary	94 (7.2)	48 (5.5)	47 (4.1)	189 (5.6)	
	Daily	38 (2.9)	6 (0.7)	9 (0.8)	53 (1.6)	
Night work	No	1124 (85.9)	780 (88.7)	1030 (89.3)	2934 (87.8)	7.822 (0.020)
	Yes	185 (14.1)	99 (11.3)	123 (10.7)	407 (12.2)	
Shift work	No	1129 (86.4)	754 (85.8)	1029 (89.5)	2912 (87.3)	7.619 (0.022)
	Yes	177 (13.6)	125 (14.2)	121 (10.5)	423 (12.7)	
Working time appropriateness	Appropriate	996 (76.1)	699 (79.5)	977 (84.9)	2672 (80.0)	29.462 (<0.001)
	Inappropriate	312 (23.9)	180 (20.5)	174 (15.1)	666 (20.0)	
Workplace scale	Less than 50	609 (46.8)	77 (8.8)	473 (42.1)	1159 (35.1)	392.789 (<0.001)
	50–299	409 (31.4)	500 (57.1)	327 (29.1)	1236 (37.5)	
	More than 300	283 (21.8)	298 (34.1)	323 (28.8)	904 (27.4)	

Looking at the working environment characteristics of electronics industry workers in Table 2, "non-exposure" to physical work risk was 56.4% compared to "exposure" 43.6%, and in the case of musculoskeletal work risk, "exposure" was 89.4% compared to "non-exposure" 10.6%. In the case of psychological work risk, "non-exposure" was 80.9% compared to "exposure" 19.1%, and in the case of subjective health impact, "negative impact" was 57.3% compared to a "positive impact" of 42.7%. In the case of work environment satisfaction, "satisfaction" of 81.5% was found compared to "non-satisfaction" of 18.5%, and in the case of providing health and safety information, 78.5% were provided compared to 21.5% with no provision.

Table 2. Working environment characteristics of the electronics industry workers.

Variables/Category		2014 (4th) (*n* = 1320)	2017 (5th) (*n* = 879)	2020 (6th) (*n* = 1155)	Total (*n* = 3354)	x^2 (*p*)
Physical work risk	Non-exposure	722 (54.8)	453 (51.5)	715 (61.9)	1890 (56.4)	24.025
	exposure	595 (45.2)	426 (48.5)	440 (38.1)	1461 (43.6)	(<0.001)
Musculoskeletal work risk	Non-exposure	291 (22.1)	13 (1.5)	52 (4.5)	356 (10.6)	305.858
	exposure	1025 (77.9)	866 (98.5)	1103 (95.5)	2994 (89.4)	(<0.001)
Psychological work risk	Non-exposure	1060 (81.0)	680 (77.4)	963 (83.4)	2703 (80.9)	11.717
	exposure	248 (19.0)	199 (22.6)	192 (16.6)	639 (19.1)	(0.003)
Possibility of risk to work	No	1159 (88.7)	804 (91.7)	1030 (90.0)	2993 (89.9)	5.029
	Yes	148 (11.3)	73 (8.3)	115 (10.0)	336 (10.1)	(0.074)
Subjective health impact	Positive impact	132 (36.6)	123 (41.4)	157 (48.9)	412 (42.7)	14.692
	Negative impact	229 (63.4)	174 (58.6)	150 (48.9)	553 (57.3)	(<0.001)
Working environment satisfaction	Satisfaction	1000 (78.2)	685 (78.1)	1005 (87.8)	2690 (81.5)	45.875
	Non-satisfaction	279 (21.8)	192 (21.9)	140 (12.2)	611 (18.5)	(<0.001)
Provide health and safety Information	Yes	938 (74.5)	683 (78.1)	941 (83.3)	2562 (78.5)	27.737
	No	321 (25.5)	191 (12.9)	188 (16.7)	700 (21.5)	(<0.001)

3.3. General, Occupational, and Working Environment Characteristics of Workers According to Work-Related Health Problems

As a result of classifying the characteristics of the study subjects according to work-related health problems, in general characteristics, males (64.7%, 57.3%) were more likely to have work-related health problems than females (35.3%, 42.7%) in both groups, without and with work-related health problems in Table 3. In the case of education in both groups, college and above (62.3%, 53.9%) was higher than lower than high school.

Among the occupational characteristics, in the case of night work, "no" (89.8%, 84.6%) was higher than "yes" (10.2%, 15.4%) in both groups, and in the case of working time appropriateness, "appropriate" (83.1%, 72.3%) was higher than "inappropriate" in both groups. In the case of the workplace scale, less than 50 workers (45.8%, 37.2%) were the highest in both groups, followed by 50–299 workers (36.0%, 36.7%) and more than 300 workers (18.2%, 26.2%).

Among the working environment characteristics, in the case of physical work risk, the group without work-related health problems had higher "non-exposure" (58.1%) than "exposure" (41.9%), but the group with work-related health problems had higher "exposure" (52.8%) than "non-exposure" (47.2%). In the case of the possibility of risk to work, "no" (89.8%, 83.6%) was higher than "yes" (10.2%, 16.4%) in both groups, and in the case of subjective health impact, "negative impact" (50.9%, 74.0%) was higher than "positive impact" (49.1%, 26.0%) in both groups. In the case of working environment satisfaction, "satisfaction" (88.8%, 74.6%) was higher than "non-satisfaction" (11.2%, 25.4%) in both groups, without and with work-related health problems.

Table 3. Work-related health problems according to the general, occupational, and working environment characteristics.

Variables/Category		No (*n* = 215)	Yes (*n* = 1272)	x^2 (*p*)
Gender	Male	139 (64.7)	729 (57.3)	4.078
	Female	76 (35.3)	543 (42.7)	(0.043)
Age	<30	22 (10.2)	142 (11.2)	
	30–39	57 (26.5)	389 (30.6)	1.999
	40–49	78 (36.3)	433 (34.0)	(0.573)
	≥50	58 (27.0)	308 (24.2)	

Table 3. *Cont.*

Variables/Category		No (n = 215)	Yes (n = 1272)	x^2 (p)
Education	Lower than high school	81 (37.7)	584 (46.1)	5.222
	College above	134 (62.3)	684 (53.9)	(0.022)
Income (KRW)	Less than 200	45 (21.7)	343 (27.9)	3.702
	200–399	114 (55.1)	641 (52.2)	(0.157)
	More than 400	48 (23.2)	245 (19.9)	
Employment status	Regular	201 (93.9)	1158 (91.0)	2.063
	Temporary	10 (4.7)	82 (6.4)	(0.357)
	Daily	3 (1.4)	32 (2.5)	
Night work	No	193 (89.8)	1074 (84.6)	3.881
	Yes	22 (10.2)	195 (15.4)	(0.049)
Shift work	No	191 (90.5)	1085 (85.7)	3.571
	Yes	20 (9.5)	181 (14.3)	(0.059)
Working time appropriateness	Appropriate	177 (83.1)	916 (72.3)	11.017
	Inappropriate	36 (16.9)	351 (27.7)	(0.001)
Workplace scale	Less than 50	98 (45.8)	466 (37.2)	8.172
	50–299	77 (36.0)	460 (36.7)	(0.017)
	More than 300	39 (18.2)	328 (26.2)	
Physical work risk	Non-exposure	125 (58.1)	600 (47.2)	8.858
	exposure	90 (41.9)	672 (52.8)	(0.003)
Musculoskeletal work risk	Non-exposure	24 (11.2)	93 (7.3)	3.763
	exposure	191 (88.8)	1179 (92.7)	(0.052)
Psychological work risk	Non-exposure	167 (78.0)	1020 (80.4)	0.628
	exposure	47 (22.0)	249 (19.6)	(0.428)
Possibility of risk to work	No	193 (89.8)	1058 (83.6)	5.282
	Yes	22 (10.2)	207 (16.4)	(0.022)
Subjective health impact	Positive impact	28 (49.1)	124 (26.0)	13.374
	Negative impact	29 (50.9)	353 (74.0)	(<0.001)
Working environment satisfaction	Satisfaction	191 (88.8)	936 (74.6)	20.852
	Non-satisfaction	24 (11.2)	319 (25.4)	(<0.001)
Provide health and safety information	Yes	155 (74.2)	963 (77.9)	1.436
	No	54 (25.8)	273 (22.1)	(0.231)

3.4. Related Factors of Work-Related Health Problems through Logistic Regression Analysis

As a result of logistic regression analysis conducted to examine factors related to groups with work-related health problems in Table 4, gender and education were significantly correlated in general characteristics ($p < 0.05$).

Females were 1.362-times more likely to experience work-related health problems than males, and for education, those who graduated from lower than high school were 1.497-times higher than those who were educated to college and above. However, in the case of age and income, there was no significant correlation with work-related health problems.

The occupational characteristics were significantly correlated in night work, working time appropriateness, and workplace scale ($p < 0.05$). In the case of night work, the group with night work was 1.608-times more likely to experience work-related health problems than the group without night work. In the case of the working time appropriateness, it was 1.831-times higher in "inappropriate" than "appropriate", and in the case of workplace scale, it was 1.665-times higher in more 300 workers than in less than 50 workers, but it was not significant in 50–299 workers. In addition, there was no significant correlation between employment status and shift work with work-related health problems.

Working environment characteristics were significantly correlated in physical work risk, musculoskeletal work risk, possibility of risk to work, subjective health impact, and working environment satisfaction ($p < 0.05$). In the case of physical work risk and musculoskeletal work risk, the exposure group was 1.556-times and 1.610-times more likely to experience work-related health problems than the non-exposure group. The possibility

of risk to work was 1.716-times higher in the group considered dangerous than in the non-risk group, and the subjective health impact was 2.182-times more likely to experience work-related health problems in negative impacts than in positive impacts. In the case of working environment satisfaction, the non-satisfaction group was 2.648-times more likely to experience work-related health problems than the satisfaction group. However, there was no significant correlation between psychological work risk and the provision of health and safety information with work-related health problems.

Table 4. Factors associated with work-related health problems.

Variables/Category		OR	95%CI	*p*-Value
Gender	Male	1		
	Female	1.362	1.008–1.841	0.044 *
Age	<30	1		
	30–39	1.419	0.810–2.484	0.221
	40–49	1.568	1.023–2.404	0.039 *
	≥50	1.236	0.837–1.824	0.287
Education	College above	1		
	Lower than high school	1.497	1.046–2.143	0.027 *
Income (KRW)	More than 400	1		
	200–399	1.493	0.963–2.315	0.073
	Less than 200	1.102	0.762–1.592	0.606
Employment status	Regular	1		
	Temporary	1.881	0.888–3.985	0.099
	Daily	2.055	0.615–6.871	0.242
Night work	No	1		
	Yes	1.608	1.008–2.566	0.046 *
Shift work	No	1		
	Yes	1.593	0.979–2.592	0.061
Working time appropriateness	Appropriate	1		
	Inappropriate	1.831	1.251–2.679	0.002 *
Workplace scale	Less than 50	1		
	50–299	1.197	0.862–1.661	0.283
	More than 300	1.665	1.116–2.483	0.012 *
Physical work risk	Non-exposure	1		
	exposure	1.556	1.161–2.084	0.003 *
Musculoskeletal work risk	Non-exposure	1		
	exposure	1.610	1.002–2.589	0.049 *
Psychological work risk	Non-exposure	1		
	exposure	0.856	0.602–1.219	0.389
Possibility of risk to work	No	1		
	Yes	1.716	1.078–2.734	0.023 *
Subjective health impact	Positive impact	1		
	Negative impact	2.182	1.186–4.015	0.012 *
Working environment satisfaction	Satisfaction	1		
	Non-satisfaction	2.648	1.162–6.033	0.020 *
Provide health and safety information	Yes	1		
	No	0.718	0.368–1.402	0.332

OR, odds ratio; 95%CI, 95% confidence interval; * *p*-value < 0.05.

4. Discussion

This study analyzed the relationship between work-related health problems and the working conditions of electronics industry workers through the 4th to 6th Korean Working Condition Surveys, conducted by the Occupational Safety and Health Research Institute.

As a result of this study, gender, education, night work, working time appropriateness, physical work risk, musculoskeletal work risk, possibility of risk to work, subjective health impact, and working environment satisfaction were analyzed as effect factors of work-related health problems.

In the case of gender, it was confirmed that females are more likely to experience work-related health problems than males. According to previous studies in Korea, females play multiple roles such as domestic work in addition to economic activities, and this is related to the increase in the frequency of job-related risk exposure due to the increase in female economic activity [12]. Even overseas, a study on semiconductor manufacturing line workers in Taiwan reported that female workers perform household tasks during recovery time after work compared to males, which affects work-related fatigue in females compared to males [13]. In addition, according to a study on Chinese female workers in the electronics industry, about 52% of female workers were exposed to one or more occupational risks, and more than 60% reported occupational diseases, such as low back pain, eye fatigue, hearing loss, and dizziness/headache [14]. Therefore, it is necessary to prevent and manage work-related fatigue and exposure to the work-related risks of female workers in the electronics industry.

Among the occupational characteristics, it was confirmed that night work was more likely to experience work-related health problems. As a result of a study investigating the relationship between night work and sleep quality among domestic electronics industry workers, it was confirmed that poor sleep quality due to night work was 2.61- and 1.33-times higher for both males and females than for day workers, respectively [15]. In addition, if they answered that the working time was inappropriate, they were more likely to experience work-related health problems, which is consistent with a report that work-related health problems increase as working time increases, and long working times increase work accidents and diseases, regardless of age, sex, occupation, and industry [16].

Among the working environment characteristics, it was confirmed that those exposed to physical work risk and musculoskeletal work risk were more likely to experience work-related health problems. The result of a study on the impact of absenteeism among domestic workers also reported that among physical factors, vibration, noise, and low-temperature exposure were highly related to absenteeism, and that inappropriate working posture and moving heavy objects were also impacts [17]. In addition, a study on the health impact of manufacturing workers showed that with a longer exposure to vibration, noise, temperature, inhalation of smoke dust, dangerous substances, etc., the more negative the impact on health [18]. In a study on Chinese electronics manufacturing workers, 40.6% of the subjects showed musculoskeletal symptoms, and it was reported that the causes were working times, long working times, and repetitive work in standing or sitting positions [19]. Looking at the characteristics of the electronics industry, workers are exposed to chemical, physical, and ergonomic factors, as well as maintenance work, work with heavy objects, and work in high places, so additional detailed research on work risk factors is necessary.

Subjective health impact and working environment satisfaction were also found to be factors affecting work-related health problems. Subjective health status is an indicator of the overall health level [20], and reliability has been secured through many studies and is used for health evaluation [21]. The finding that the probability of experiencing work-related health problems is twice as high in the case of negative impacts suggests the need to further study factors affecting the subjective health impact in the electronics industry. In addition, according to previous studies in Korea, work stress, subjective health status, and physical and mental health status affect working environment satisfaction [22]. Based on these previous research results, additional research on working environment

satisfaction, safety culture, worker's safety consciousness, and safety behavior, as well as physical factors in the electronics industry, is considered necessary.

The limitations of this study are as follows. First, because the work-related diseases in the KWCS questionnaire were analyzed by grouping them into one variable, "work-related health problems", the risk factors for each disease may have been underestimated. Second, because physical diseases and mental diseases were analyzed as one variable, they may affect the related factors. Third, since quantitative variables such as chemical usage and exposure level were not used, we cannot identify the direct cause of diseases such as cancer and reproductive problems. So far, occupational health for workers in the electronics industry has been studied to a limited extent in developed countries, and research on the direct causes of diseases is lacking. Therefore, epidemiological studies are continuously needed to identify the direct causes of reproductive problems and an increased risk of cancer [23].

Nevertheless, the significance of this study is that, unlike previous studies that conducted cross-sectional research, we utilized large-scale data to identify the characteristics of work-related health problems among workers in the electronics industry. In addition, it is meaningful in that it identified areas that require prevention as well as potential risk factors affecting work-related health problems in the electronics industry's working conditions, where prior research is lacking.

Work-related health problems cause enormous economic and social loss, not only to individuals but also to companies and countries. Considering that night work, physical work risk factors, musculoskeletal work risk factors, subjective health impact, and working environment satisfaction can affect work-related health problems, the personal, occupational, and working environment characteristics of workers should be considered. By identifying and managing them, we can expect to reduce work-related health problems.

In the future, based on the results of this study, it is necessary to prepare measures to prevent work-related health problems in electronics industry workers and conduct research on detailed factors to manage potential risk factors, in addition to chemical exposure.

5. Conclusions

This study used working condition survey data from a nationwide survey of workers to determine the relationship between the working conditions and work-related health problems of electronics industry workers. Based on this, an attempt was made to contribute to creating safe working conditions that can prevent work-related health problems and to be used as a basis for establishing occupational safety and health policies. In order to prevent work-related health problems, it is believed that improvements, such as the management of night workers, appropriate working time, a reduction in exposure to physical and musculoskeletal risk factors, and improvement in working environment satisfaction, will be necessary, and these can be used as basic data for future research in related fields.

Author Contributions: Conceptualization, K.H.K. and J.W.C.; methodology, S.A.W.; data curation, S.A.W.; writing—original draft preparation, S.A.W.; writing—review and editing, J.W.C.; supervision, K.H.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Korea University (KUIRB-2024-0028-01).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data were obtained from the Occupational Safety and Health Research Institute (OSHRI) and are available from the authors with the permission of the 4th to 6th surveys.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Ministry of Employment and Labor (MoEL). Employment Statistics by Industry/Size. 2023. Available online: http://laborstat.moel.go.kr (accessed on 21 August 2023).
2. Korean Statistical Information Service (KOSIS). Occupational Diseases Accident and Death Status. 2021. Available online: http://kosis.kr/index (accessed on 21 August 2023).
3. International Labour Organization (ILO). *Quick Guide on Sources and Uses of Statistics on Occupational Safety and Health*; International Labour Organization (ILO): Geneva, Switzerland, 2020; pp. 5–9. Available online: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/publication/wcms_759401.pdf (accessed on 30 August 2023).
4. Health Safety Executive (HSE). Historical Picture Statistics in Great Britain, 2023. 2023. Available online: https://www.hse.gov.uk/statistics/assets/docs/historical-picture.pdf (accessed on 29 November 2023).
5. Health Safety Executive (HSE). HSE Statistics 21/22 in the Manufacturing Industry in Great Britain. 2023. Available online: https://www.ecoonline.com/blog/hse-statistics-21-22-in-the-manufacturing-industry-in-great-britain (accessed on 30 August 2023).
6. Bureau of Labor Statistics (BLS). Injuries, Illnesses, and Fatalities Manufacturing, 2016–2020. 2022. Available online: https://www.bls.gov/iif/snapshots/isn-manufacturing-2016-20.htm (accessed on 21 August 2023).
7. Bureau of Labor Statistics (BLS). Injuries, Illnesses, and Fatalities Maintenance and Repair Workers, General, 2016–2020. 2022. Available online: https://www.bls.gov/iif/snapshots/osn-maintenance-and-repair-workers-general-2016-20.htm (accessed on 21 August 2023).
8. KOSHA. *Health Management Guide for Semiconductor Industry Workers*; Korea Occupational Safety & Health Agency (KOSHA): Ulsan, Republic of Korea, 2012; p. 4. Available online: https://www.kosha.or.kr/kosha/report/notice.do?mode=view&boardNo=505&articleNo=363969&attachNo (accessed on 29 May 2024).
9. Lim, J.W. Hazardous working conditions problem of the high-tech industries and its solution: Learning from the SAMSUNG semiconductor case. *Labor Law Rev.* **2015**, *39*, 51–88.
10. Son, M.I.; Yun, J.W.; Hwang, Y.S.; Park, M.J.; Choi, M.S.; Lee, M.Y.; Paek, D.M. Exposure of Carcinogens in Electronics Industries and Strategy for Control of Carcinogens: Using Work Environment Measurement Database (2013–2017) in Korea. *Korean Ind. Hyg. Assoc. J.* **2022**, *32*, 302.
11. Korean Statistical Classification (KSC). Korean Standard Industrial Classification (KSIC) Classification List. 2017. Available online: https://kssc.kostat.go.kr:8443/ksscNew_web/ekssc/main/main.do (accessed on 21 August 2023).
12. Hong, E.Y.; Kim, S.D. Health status and affecting factors related to job among Korean women employees. *J. Korea Acad.-Ind. Coop. Soc.* **2012**, *13*, 4107–4118.
13. Lin, Y.C.; Hsieh, H.I.; Chen, Y.C.; Chen, P.C. Risk for work-related fatigue among the employees on semiconductor manufacturing lines. *Asia-Pac. J. Public Health* **2015**, *27*, 1805–1818. [CrossRef] [PubMed]
14. Yu, W.; Lao, X.Q.; Pang, S.; Zhou, J.; Zhou, A.; Zou, J.; Mei, L.; Yu, I.T.-s. A survey of occupational health hazards among 7610 female workers in China's electronics industry. *Arch. Environ. Occup. Health* **2013**, *68*, 190–195. [CrossRef] [PubMed]
15. Jung, H.S.; Seo, B.S.; Kim, S.G.; Kim, W.S.; Han, B.S.; Jung, J.S.; Park, S.Y.; Park, H.J.; Son, U.I.; Son, H.S.; et al. Comparison of the decline in sleep quality between night and day workers in an electronics industry. *Ann. Occup. Environ. Med.* **2015**, *11*, 266–267.
16. Beak, E.M.; Jung, H.S. A study on factors impacting work-related health problems in different work-hour groups. *Korean Ind. Hyg. Assoc. J.* **2019**, *29*, 383.
17. Choi, S.Y.; Lee, S.J. Impact of Korean workers experience of exposure to the physical work factors on absence. *J. Korea Soc. Comput. Inf.* **2017**, *22*, 149–156.
18. Kim, H.G.; Seo, Y.R.; Cho, G.Y. The effect of working environment of manufacturing workers on health condition. *J. Korean Data Inf. Sci. Soc.* **2018**, *29*, 1555–1563.
19. Yin, Y.; Di, N.; Guo, W.; Ding, W.; Jia, N.; Wang, Z.; Yang, F. Multi-Site Musculoskeletal Symptoms in the Electronics Manufacturing Industry in China: A Cross-Sectional Study. *Int. J. Environ. Res. Public Health* **2022**, *19*, 13315. [CrossRef] [PubMed]
20. Lee, Y.W. Effects of the working environment on subjective health status. *Korean Ind. Hyg. Assoc. J.* **2017**, *27*, 210. [CrossRef]
21. Choi, E.S.; Jeon, G.S. The Impacts of Psychosocial Work Conditions on Self-rated Health among Korean Workers. *Korean J. Occup. Health Nurs.* **2016**, *25*, 300–310. [CrossRef]
22. Kim, S.G.; Jeon, Y.G. The Effects of Job Stress and Subjective Health Status on Satisfaction on Workplace Environment. *Crisisonomy* **2020**, *16*, 67–81. [CrossRef]
23. Bailar, J.C., III; LaDou, J. Occupational cancer and reproductive outcomes in the semiconductor industry: The need for an international epidemiologic study. *Eur. J. Oncol.* **2009**, *14*, 69–78.