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## Original Article

# The Relationship Between Frequency of Injuries and Workplace Environment in Korea: Focus on Shift Work and Workplace Environmental Factors ☆



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## ABSTRACT

**Background:** The purpose of this study was to investigate the effect of shift work on occupational safety in various industrial sectors. The study analyzes the effects of shift work on the health of workers by considering factors such as the workplace environment and welfare.

**Methods:** Focusing on the 4<sup>th</sup> Korean Working Conditions Survey, this study used an ordinary least-square multiple regression analysis. The dependent variable was the annual frequency of injuries reported by workers. Independent variables were categorized as demographic, shift work, workplace environment, and welfare variables. The analysis was conducted on two levels: 1) Shift work and nonshift work groups were compared, and 2) Shift work was compared with fixed and rotating shifts.

**Results:** For the entire group, age, a low level of education, work hours, and daily and dispatch work negatively impacted the frequency of injuries. Shift work was negatively affected by workplace environment and welfare factors. In the shift group, the frequency of injuries was lower than that of regular workers, and the higher the autonomy in the choice of work hours, the lower the frequency of injuries. Furthermore, shift workers in Korea have more extended work hours (49.25 h/week) than other workers (46.34 h/week).

**Conclusion:** Overall, welfare factors such as workplace satisfaction and work–life balance reduced the frequency of injuries. The effect of shift work was limited, but it was confirmed that shift worker autonomy could reduce the frequency of injuries.

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## 1. Introduction

Describing the 19<sup>th</sup>-century British work environment, Marx mentions shift work including night work. The rationalization for night work, which was regarded as a dimension of useless instinct, was to maximize productivity [1]. This “time squeeze” requires being awake constantly, changes modern people’s perception of time, and permanently creates tension in the modern society [2].

Nowadays, stores with bright lights can be found throughout cities at all hours. One element essential for 24-hour stores is a shift work system. The issues pertaining to shift work are closely related

to problems in the work environment, such as long hours, disturbances of the daily cycle, and the problem of autonomy in the choice of work hours.

The purpose of this study is to investigate the effect of shift work on occupational safety in various occupations. The study analyzes the effects of shift work on the health of workers by considering factors such as workplace environment and welfare. There are two research objectives. First, we explore the effects of shift work and workplace environment in Korea. This study is exploratory rather than heuristic, so as to reflect the reality that shift work has spread to include workers in a wide range of occupations in Korea. Second,

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this study seeks to exploit the advantages of research using a large-scale sample. Previous studies on shift work and the risk of worker injury in Korea were limited to small groups of shift workers. To accomplish the objectives of the study, the Korean Working Conditions Survey was used as a data set.

According to the International Labor Organization, shift work is a work-time organizational scheme in which an individual worker can do more work by handing over work to another worker in the workplace [3]. The European Council Directive defines shift work as a pattern in which workers work in the same workplace. According to this definition, shift labor includes not only the arrangement of working hours but also the arrangement of working spaces [4]. The International Agency for Research on Cancer (IARC) recommends classifying shift work as unstable and nonstandard work [5]. The definition of night work, considered the most problematic type of shift work, is as follows. The European Council Directive stipulates that night shifts involve night duties for at least 3 h during total work hours. Each member country has its own national law pertaining to nighttime standards [4].

Shift workers who work at night tend to wake up longer than those who work during the day. Night workers are awake for about 20 h, and weekly workers are awake for 15 h. This is because nighttime sleepers are less likely to sleep in the daytime, and the effects of the bio-cycle reduce the time spent sleeping [6]. The absolute sleep time of shift workers, including night workers, is longer than that of nonshift workers; however, it is associated with health problems such as drowsiness and persistent fatigue during work [7]. The time spent reading and dispensing prescriptions is 83% higher for night-duty nurses than those who work in the day [8]. Regarding occupational injuries, there are fewer cases for those working in fixed night shifts than for those working in other types of shift. However, for both groups, drowsiness and insomnia are not statistically significant [9]. Specifically, compared with fixed night-shift workers, rotating shift workers often complain about disturbances in relationships with their family or friends and physical problems such as drowsiness during the week [10].

Research on the health effects of shift work, including night shifts, generally focuses on identifying problems in shift workers' quality of sleep. Sleep is closely related to the physiological phenomena of the body. If our bodies are infected with an illness and exposed to excessive fatigue, the immune system induces us to fall asleep quickly [11,12]. This is because the immune system is activated while the body is in a sleep state and triggers antibodies such as leukocytes and lymph, promoting an immune response against various infections. Therefore, sleeping is a behavior that can actively resist an illness that is already present and plays a role in developing preventive immunity, which can eliminate disease-causing pathogens. Regarding quality of life, sleep disorders including insomnia are closely related to workers' health [13,14]. In 2010, the IARC pointed out the possibility that shift work could be a limited risk factor for cancer. A study on the carcinogenicity of shift work by the IARC in 2007 determined that this type of work is probably carcinogenic [3].

The working time capability theory explains long-term work, an issue pertaining to shift work, and the reduction of workers' use of time. According to this theory, shifts are a type of work in which the user organizes the worker's working time in such a way to maximize the production capacity of production facilities [15]. The theory of working time capability addresses the concept of workers' time sovereignty to explain why shift work causes long work hours and inadequate rest. Time sovereignty is directly linked to workers' ability to balance the workplace and home or to choose work cycles that fit their biorhythms. When time sovereignty is secured, the worker may more aggressively look for the side effects of shift work [16].

## 2. Materials and methods

### 2.1. Data source

The data used in this study came from the 4<sup>th</sup> Korean Working Conditions Survey conducted by the Korea Occupational Safety and Health Research Institute in 2014. The total sample consisted of 50,007 people, of which 3,536 responded that they had engaged in shift work. The sample for this survey was the economically active nationwide population aged over 15.

### 2.2. Measurement

The dependent variable used in the analysis was the frequency of injuries. The frequency was calculated by summing the frequency of responses to the questionnaire's (kQ69) "1-year health problem" question. This question asked whether they had experienced a physical health problem continuously for 1 y (K to N) such as an accident, physical health problem (A to J), or a psychological health problem such as anxiety or insomnia (yes or no). The researchers constructed the variables by adding the items that the respondents had experienced for 1 y. The frequency of injuries experienced by workers in the workplace is also a proxy for measuring the health of workers.

The independent variables were classified into four types as follows: 1) Sociodemographic variables were gender, age, education, income, and status of the worker. Gender was a nominal variable that was converted into a dummy variable (male = 1, female = 0). Age and income were continuous, discrete variables. Income was based on monthly income, and a natural logarithm was used for the analysis because income did not follow a normal distribution. Education was categorized as "higher than elementary school," "middle school," "high school," and "college education" and was replaced by an ordinal variable (elementary school = 1, college = 4). Finally, the status of the worker was categorized as a regular, temporary, or daily worker and was converted into a dummy variable (the reference variable was a regular worker).

2) Shift work was indicated by respondents answering "Yes" to the question on whether they worked shifts. The type of shift work was measured using a questionnaire with options for fixed and rotating shifts included in the subquestions. The type of shift work was used as a nominal variable, and all were replaced with dummy variables. In the analysis of the entire group, the reference variable was the nonshift work group, and in the analysis of the shift work group, the reference variable was the fixed shift group.

3) The group of work environment variables consisted of workplace safety and wage payment methods. Here, work hours and night work were discrete continuous variables. Work hours were measured as the total work hours per week, and night work as the number of workdays during which a worker worked for a full night during the month. Time sovereignty refers to autonomy in determining the work schedule. Time sovereignty was measured on a 4-point Likert scale (1 = the company decides the whole schedule, 5 = worker decides the whole schedule). Employment type, which refers to the payment of wages, was a nominal variable categorized as direct employment, dispatch work, or outsourcing. This variable was converted into a dummy variable (the reference variable was direct employment). Safety information vulnerability was measured on a 4-point Likert scale (1 = well informed, 5 = not informed); it refers to the availability of safety-related information in the workplace. The need for protective gear was a nominal variable and was used as a dummy variable (0 = not needed, 1 = needed).

4) The welfare factor was the level of subjective recognition of the level of welfare provided by the workplace. Here, workplace

**Table 1**  
Descriptive statistics

Variables		Shift work			
		Yes (N = 3,201)		No (N = 27,238)	
		Mean	Median	Mean	Median
Age (years)		40.5	40	39.3	40
		No.	%	No.	%
Gender	Female	1,133	35.4%	13,720	50.4%
	Male	2,068	64.6%	13,518	49.6%
Education	Elementary school	119	3.8%	1,626	6.0%
	Middle school	287	9.1%	1,884	7.0%
	High school	1,645	52.2%	9,952	36.8%
	College or higher	1,102	35.0%	13,582	50.2%
Employment status	Regular	2,346	73.7%	19,616	72.5%
	Temporary	735	23.1%	5,075	18.7%
	Daily	102	3.2%	2,377	8.8%
Occupation*	1. Managers	32	1.0%	564	2.1%
	2. Professionals	150	4.7%	2,309	8.5%
	3. Engineering professionals	169	5.3%	1,397	5.1%
	4. Clerks	210	6.6%	7,512	27.6%
	5. Service	612	19.1%	3,602	13.2%
	6. Sales	482	15.1%	3,407	12.5%
	7. Skilled agricultural	1	0.0%	128	0.5%
	8. Craft and trades	386	12.1%	2,519	9.3%
	9. Operating & assembling	474	14.8%	1,403	5.2%
	10. Elementary	658	20.6%	4,332	15.9%
	11. Armed forces	23	0.7%	52	0.2%
No. of injuries (per year)		1.5	1	1.3	1

\* Korean Standard Classification of Occupations.

satisfaction (1 = Very unsatisfied, 5 = Very satisfied) and work–life balance (1 = Very balanced, 5 = Not balanced) were measured on a 4–point Likert scale. These variables were included to help us understand shift work, the work environment, and the relation of workplace welfare with the frequency of injuries.

2.3. Statistical analysis

In this study, an ordinary least-square multiple regression analysis based on a linear model was used to verify the effect of shift work on health. The statistical package used by the researchers for the analysis is IBM’s SPSS version 24. Only employed workers

were included in the analysis; self-employed and unpaid family workers were excluded. In the case of self-employed or unpaid family workers, it is difficult to analyze the characteristics of workplace environment factors and types of employment.

The dependent variable was the frequency of injuries per year as reported by the employees. The independent variables can be classified into four groups. The first group of variables was the sociodemographic variables such as gender and age. The second group of variables contained those indicating the type of shift work. The third group of variables was related to workplace environments such as working time and employment type, and the fourth to welfare factors such as job satisfaction and work–life balance.

The analysis was conducted in two stages. During the first stage, the effects of shift work were analyzed. To determine the effects of shift work, we compared the shift work group with the control group (those who were not engaged in shift work) (Table 2). To determine the effects of shift work type, for the second group, fixed shifts were set as the reference variable (Table 3).

To examine the effect of each variable group, the independent variables were entered in four steps. In the first step (Model 1), the effect of the demographic variables on the dependent variables was analyzed. In the second step (Model 2), the effects of shift work were analyzed. In the third step (Model 3), the work environment was added, and its relationship with the frequency of injuries was analyzed. In the fourth step (Model 4), factors pertaining to the welfare of the workplace were added, and the relationship between all other variables and dependent variables was analyzed. The significance level was 0.05. This study examined the variance inflation factor (<5) and entered explanatory variables after confirming that multicollinearity was not an issue. See Table 1 for descriptive statistics of the key variables.

3. Results

The results of the analysis of the whole group, including shift workers and the control group, are reported in Table 2. The coefficient value given below is for the results reported in the analysis (Model 4), in which all variables were input.

Among the sociodemographic variables, the statistically significant ones were gender (-0.126), age (0.185), and education

**Table 2**  
Multiple regression analysis of factors affecting number of injuries (Total sample)

Groups of independent variables	No. of injuries (DV)	Model 1 R <sup>2</sup> = 0.066 N = 21,415		Model 2 R <sup>2</sup> = 0.068 N = 21,415		Model 3 R <sup>2</sup> = 0.085 N = 19,546		Model 4 R <sup>2</sup> = 0.104 N = 19,044	
		Std. coeff.	SE	Std. coeff.	SE	Std. coeff.	SE	Std. coeff.	SE
Sociodemographic variables	Gender	-0.095***	0.022	-0.099***	0.022	-0.123***	0.024	-0.126***	0.024
	Age	0.175***	0.001	0.174***	0.001	0.176***	0.001	0.185***	0.001
	Education	-0.102***	0.016	-0.100***	0.016	-0.061***	0.017	-0.048***	0.017
	Income	0.040***	0.021	0.041***	0.021	-0.011	0.024	0.002	0.024
	Status (temporary)	-0.014	0.031	-0.014	0.031	-0.011	0.032	-0.023***	0.032
	Status (daily)	0.043***	0.043	0.047***	0.043	0.040***	0.045	0.017*	0.046
Shift work	Shift work (fixed)			0.023***	0.051	0.011	0.053	0.004	0.054
	Shift work (rotated)			0.034***	0.049	0.014	0.054	0.010	0.054
Working environment	Work hours					0.078***	0.001	0.031***	0.001
	Night work					0.006	0.003	-0.004	0.003
	Time sovereignty					-0.002	0.015	0.002	0.015
	Employment type (dispatched)					0.016*	0.076	0.017*	0.077
	Employment type (outsourced)					0.007	0.061	0.006	0.062
	Safety information vulnerability					-0.010	0.013	-0.029***	0.013
	Need for protective gear					-0.110	0.027	-0.091***	0.028
Workplace welfare	Workplace satisfaction							-0.107***	0.020
	Work–life imbalance							0.086***	0.018

\*p < .050, \*\*p < .01, \*\*\*p < .001.

DV, dependent variable; SE, standard error.

**Table 3**  
Multiple regression analysis of factors affecting number of injuries (shift work group)

Groups of independent variables	No. of Injuries (DV)	Model 1 R <sup>2</sup> = 0.055 N = 2,171		Model 2 R <sup>2</sup> = 0.058 N = 2,171		Model 3 R <sup>2</sup> = 0.063 N = 2,035		Model 4 R <sup>2</sup> = 0.085 N = 1,969	
		Std. Coeff.	SE	Std. Coeff.	SE	Std. Coeff.	SE	Std. Coeff.	SE
Sociodemographic variables	Gender	0.075***	0.075	0.075***	0.075	-0.143***	0.080	-0.141***	0.081
	Age	0.003***	0.003	0.003***	0.003	0.210***	0.003	0.228***	0.003
	Education	0.046	0.046	0.046	0.046	-0.001	0.049	0.009	0.049
	Income	0.070	0.070	0.070	0.070	0.029	0.077	0.038	0.077
	Status (temporary)	0.092***	0.092	0.092***	0.092	-0.062*	0.096	-0.062*	0.097
	Status (daily)	0.198	0.198	0.198	0.198	-0.032	0.208	-0.036	0.208
Shift work	Shift work (rotated)			0.068	0.068	0.017	0.072	0.015	0.072
Working environment	Work hours					0.042	0.003	0.003	0.003
	Night work					-0.002	0.007	-0.018	0.007
	Time sovereignty					0.060**	0.054	0.062**	0.055
	Employment type (dispatched)					-0.005	0.183	-0.001	0.186
	Employment type (outsource)					-0.030	0.146	-0.022	0.147
	Safety information vulnerability					0.066**	0.045	0.051*	0.046
	Need for protective gear					-0.114***	0.082	-0.099***	0.082
Workplace welfare	Workplace satisfaction							-0.104***	0.062
	Work–life imbalance							0.102***	0.055

\* $p < .050$ , \*\* $p < .01$ , \*\*\* $p < .001$ .

DV, dependent variable; SE, standard error.

(-0.048). Regarding the status of workers, temporary work (-0.023) and daily work (0.017) were statistically significant. As for men and women, the higher the age and the lower the education level, the more positive the correlation with the frequency of injuries. Temporary and daily workers demonstrated negative (-) and positive (+) effects, respectively, when all variables were included. The standardized coefficient of these variables was the largest for age (0.185).

Shift work variables were statistically significant in the second step (Model 2) for both fixed and cyclic shifts. However, this statistical significance disappeared in the third (Model 3) and fourth steps (Model 4) when the workplace environment and welfare factors were added. In the second step (Model 2), both types were positively (+) correlated with the dependent variables, and cyclic shifts (0.034) had a slightly greater effect than fixed ones (0.023).

Statistically significant variables in both analyses including the nonshift worker group (Table 2) and only-shift worker group (Table 3) were safety information vulnerability (-0.029) and need for protective gear (-0.091). Both variables were negatively (-) correlated with the dependent variables. These two variables were not significant in Model 3 but had a significant effect in Model 4 when the welfare factors were added. The variables that demonstrated statistical significance only in the analysis that included nonshift workers were dispatch work (0.017) and work hours (0.031). These two variables were positively (+) correlated with the dependent variables.

All workplace welfare factor variables demonstrated statistically significant effects. Workplace satisfaction negatively (-0.107) affected the dependent variables, and work–life balance had a positive (0.086) effect.

The second analysis used only-shift workers. For the demographic variables, gender and age were statistically significant, as in the first analysis. However, unlike the first analysis, only temporary employment status had a more negative (-0.062) effect than a regular job. In this analysis, the results for daily workers were not statistically significant.

Unlike the first analysis, rotating shift work in the shift group did not have a statistically significant effect. In the previous analysis, the addition of the shift work variable had a positive (+) effect on the dependent variable. However, in the analysis including only-shift workers, rotating shift work did not have a significant effect compared with fixed shift work.

Among the work environment factors, safety information vulnerability (0.051) and need for protective gear (-0.099) remained statistically significant. However, unlike the previous analysis, a positive (+) correlation emerged: the frequency of injuries increased when less information on safety was provided.

Finally, variables related to the welfare of the workplace yielded the same results as in the previous analysis. Both workplace satisfaction (-0.104) and work–life imbalance (0.102) had the same effects as found in the previous analysis. Both variables were statistically significant.

#### 4. Discussion

Shift work had a limited correlation with the frequency of injuries. Shift work had a negative effect on the frequency of injuries only when the workplace environment and welfare factors were excluded. The statistical significance of shift work was confirmed when it was applied to the sociodemographic variables (Model 2). Both fixed and rotating shifts had statistically significant effects. There was no difference in the type of shift work in the shift work group. Therefore, it was confirmed that the statistical significance of shift work disappeared when the environmental and welfare factors were introduced.

The workplace environment and welfare factors were strongly correlated with the frequency of injuries. Long-term work negatively affects workers' health, and welfare factors in the workplace reportedly alleviate the incidence of injuries. In the analysis of the workplace environment variables for the whole sample, time sovereignty was significantly correlated with the frequency of injuries for shift workers. The analysis of the whole group confirmed that the longer the period of work, the higher the frequency of injuries. However, workers who worked in shifts worked on average 5 hours more per week than those who did not do shift work (shift = 48 hours, nonshift = 43 h). Welfare factors were statistically significant in both analyses. In particular, these factors were negatively correlated with the frequency of injuries. Furthermore, it was confirmed that welfare factors such as workplace satisfaction and work–life balance could mitigate the negative effects of the frequency of injuries.

The effect of work status and employment type was also confirmed. There was the possibility that regular workers would

have a higher incidence of injuries than temporary workers, and dispatch workers would have a higher incidence of injuries than those directly employed. However, the status of workers elicited unique results. In the case of the whole group, the frequency of injuries to regular workers was higher than that of temporary workers. However, the incidence of injuries for daily workers was higher than that for regular workers. This indicates that daily workers may be the most vulnerable group. Within the shift work group, work status differed from that of the whole group. Similar to the whole group, the incidence of injuries was lower than that of regular workers. However, statistically significant results were not obtained for daily workers. This was confirmed by the fact that regular workers had longer working hours than temporary workers (regular = 46 h, temporary = 38 h, daily = 36 h). The rate at which shift work was performed also differed. Of the total group, 23.1% of temporary workers performed shift work. On the other hand, temporary workers who did not work in shifts accounted for 18.7% of all workers. In the case of employment type, the analysis of the whole group indicated that dispatch workers were more exposed to risk than those who were directly employed. Among the shift workers, the dispatch workers were exposed to more risks. 3.5% of dispatched shift workers suffered more than one health problem per year. On the other hand, only 1.5% of dispatch workers report health problem, who did not have shift work.

Finally, we confirmed the continuous effect of demographic factors. The consistent results from both types of the analysis indicated that older males with a lower level of education were more vulnerable to the risk of disease.

These results suggest that shift work has a limited effect on the frequency of injuries experienced by workers. Among the types of shift work, rotating shift work demonstrated a stronger effect than fixed shift work. This implies that rotating shifts with uncertain job schedules may have more negative consequences for health. The effects of the variables related to the work environment were more significant than shift work. In particular, the variables associated with the welfare of workers mitigated the negative effects of shift work and the work environment on health. Along with this, the vulnerability of the older group with a lower level of education was confirmed. These results suggest that intensive management and intervention for older, less-educated men working in shifts are needed.

To summarize, there is a limited correlation between the health of Korean workers and shift work. Factors that have a more sustained effect on workers' health were gender, age, education level, work status, and employment type. In particular, it was confirmed that long work hours negatively affect the health of workers.

## 5. Conclusion

This study confirmed that satisfactory working conditions could effectively relieve the negative effects of shift work. In workplaces where shift work is essential, it is important to consider improving the workplace environment to make it more worker-friendly. It may also be possible to shorten the shift cycle to reduce long work hours or arrange the work in such a way that there is little fluctuation in the shift cycle.

This study was exploratory and conducted an analysis of shift work and health. It addressed the limitations of previous research by focusing on the effects of shift work on health using a sample drawn from various industries. Furthermore, the effects of gender and age were significant, confirming the necessity of constructing new categories based on these factors. Although the dependent variable, frequency of injury, was used as a proxy for the health of workers, it could not be defined as a variable directly related to health. In future research, it will be necessary to formulate variables

with their interaction in mind to examine the moderating effect of the work environment.

Workers must also be guaranteed dignity as members of society. The guarantee of dignity includes the recognition of the individual and legal protection against the social harm that may be associated with an individual's experience. Demands for the rights to health and labor, such as restricting long work hours, ensuring a natural sleep cycle, and restoring time sovereignty, are not simply guarantees of rest but a minimum normative request to ensure the healthy lives of workers. In a follow-up study, the relationship between the rights of workers and their time sovereignty, which is restricted by shift work, should be considered. However, in sleep medicine or the mass media, fatigue and drowsiness are seen as negatively affecting productivity, rather than structural social factors, wherein night shifts and shift work cause workers to experience fatigue or drowsiness [17–19].

At last, the limitations of this study are as follows. First, it did not track time-varying factors related to workers' health issues. Owing to the use of longitudinal data, this study could only use 1-year data on workers' health and workplace environments. In subsequent studies, the researchers need to use a continuous data set, such as panel data, to determine the causal effect between health and workplace environments. Second, it is necessary to use variables that define health more specifically. In this study, frequency of injuries was used as a proxy variable for health, but in follow-up studies, it will be necessary to identify subjective health status and other specific disease content.

## Conflicts of interest

There is no conflict of interest to report in this study.

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