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Association between job stress and occupational injuries among Korean firefighters: a nationwide cross-sectional study

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ABSTRACT

Objective: We aimed to assess the nature of association between job stress and occupational injuries among firefighters in Korea.

Design: Cross-sectional study.

Setting: We conducted a nationwide survey using self-reported questionnaires in South Korea.

Participants: A survey was conducted among 30 630 firefighters; 25 616 (83.6%) responded. Our study included firefighters who were 20–59 years old. Individuals with <12 months of current job experience and those with missing data were excluded; ultimately, 14 991 firefighters were analysed.

Results: Among fire suppression personnel, high job demands (OR=1.49, 95% CI 1.25 to 1.77), high interpersonal conflicts (OR=1.18, 95% CI 1.02 to 1.37), a poor organisational system (OR=1.33, 95% CI 1.14 to 1.55), and a negative workplace environment (OR=1.41, 95% CI 1.21 to 1.64) were associated with the occurrence of occupational injury; high job demands (OR=1.22, 95% CI 1.01 to 1.47) were also associated with the frequency of injuries. Among emergency medical services personnel, high job demands (OR=1.26, 95% CI 1.03 to 1.54), high interpersonal conflicts (OR=1.40, 95% CI 1.19 to 1.66), a poor organisational system (OR=1.55, 95% CI 1.30 to 1.85), lack of reward (OR=1.43, 95% CI 1.21 to 1.69) and a negative workplace environment (OR=1.30, 95% CI 1.10 to 1.54) were associated with the occurrence of occupational injury; low job control (OR=1.20, 95% CI 1.04 to 1.38), high interpersonal conflicts (OR=1.18, 95% CI 1.03 to 1.36), lack of reward (OR=1.17, 95% CI 1.02 to 1.35) and a negative workplace climate (OR=1.16, 95% CI 1.01 to 1.34) were also associated with a greater number of injuries. Among officers, high job demands (OR=1.96, 95% CI 1.35 to 2.85) and a negative workplace environment (OR=1.54, 95% CI 1.13 to 2.10) were associated with the occurrence of occupational injuries; however, there was no significant correlation between job stress and the number of injuries.

Conclusions: High job stress among firefighters was associated with both the occurrence of occupational injury, and also with an increased frequency of injuries. Therefore, job stress should be addressed to prevent occupational injuries among firefighters.

Strengths and limitations of this study

- This is a nationwide study including a large number of firefighters of Korea.
- There have been only a few systematic studies of the association between job stress and occupational injury among firefighters. This study showed that high job stress is related to both the occurrence of occupational injury, and to the frequency of occupational injuries in Korean firefighters.
- Owing to cross-sectional design, this study could not establish a causal relationship, and were only able to identify the association between job stress and occupational injuries.
- There was possibility that the result was biased by using self-reported questionnaires and missing some potential confounders.

INTRODUCTION

Firefighters are responsible for the safety of citizens, and perform functions that include fire suppression and emergency medical services (EMS). As such, they are exposed to physical or chemical hazards that lead to high rates of occupational injuries.[1–3] According to a report by the National Fire Protection Association, 18 500 cases of exposure to hazards were reported and 63 350 injuries occurred in the line of duty, in the USA in 2014.[4] According to another report, firefighters responsible for fire suppression had a 1.4–7.4-fold higher risk of non-fatal injuries than did workers in other industries.[5]

Factors that affect occupational injury among firefighters have been investigated. A study by Fabio *et al*[6] showed that such injuries

were influenced by work environments such as the number of alarms, grades of fire, number of structural floors at the scene, work intensity, civilian injury, time of incident and number of pumpers. Other studies reported that obesity was associated with increased injuries among firefighters.[7 8]

Various factors affecting occupational injury have been reported for other occupations, including long working hours[9] and shift work.[10 11] Individual characteristics such as obesity[8 12 13] and moderate or heavy alcohol consumption[14 15] also play a role. Separately, other researchers also examined whether psychological factors such as negative affectivity,[16] depression symptoms[17] and mental illness[18] were risk factors for occupational injuries. In terms of job stress. Recent studies have shown that occupational injury is associated with excessive workload, high cognitive demands and low job satisfaction, high intragroup conflict, job insecurity,[19] low decision latitude, conflicts with the supervisor or colleagues,[20] lack of organisational support,[21] poor physical environment, unfair reward and treatment,[22] verbal abuse and low predictability,[23] and organisational injustice.[24]

Despite a plethora of studies, there have been only a few systematic investigations to identify factors influencing occupational injuries among firefighters. In this study, which is based on a survey of all Korean firefighters, we aimed to investigate the existence of a correlation between job stress and occupational injury among firefighters.

METHODS

Study participants and methods

This cross-sectional study was conducted via a survey targeting firefighters in South Korea between July and November 2007. To explain the questionnaire and increase the response rate, the survey was conducted in coordination with the health managers at each fire station. A questionnaire was mailed to 30 630 firefighters; 25 615 (83.6%) responded. The self-reporting structured questionnaires were used to investigate the characteristics of participants, frequency of occupational injury during the previous 12 months and job stress at the current place of employment. Hence, 5165 respondents who had <12 months' experience in the current task job were excluded. We also excluded 5310 firefighters with missing basic data (sex, age, marital status, smoking status, alcohol consumption, frequency of exercise, education, current job category, current job experience, occupational exposures or job stress). Ultimately, data of 14 991 firefighters who were 20–59 years old were analysed. All participants provided written informed consent for their participation.

Occupational characteristics and injury

In the survey, participants were asked to reply to the question; "How many times have you experienced injury in the workplace that required medical care during the past 12 months?" Hence, occupational injuries in this study were restricted only to events related to the firefighters' duties. Furthermore, minor injuries that is, those that did not require medical care, were excluded. Occupational injuries within the previous 12 months were recorded because only a few such injuries occurred within shorted durations. Firefighters included all workers employed at a fire department and its related services, including: fire suppression (extinguishing a fire), paramedics (providing emergency medical care), rescue workers (rescuing people who are trapped or in medical emergencies), special investigators (investigating a cause of fire), informatics training officers (training other firefighters) and others.[25] These jobs were categorised into fire suppression, EMS (includes paramedics and rescue), and officers (including administrators, special investigators, and communicational and informational system operators).

Job stress

Job stress was identified according to the short form of the Korean Occupational Stress Scale (KOSS-SF), which was a structured questionnaire to estimate the job stress of Korean employees.[26] KOSS-SF was based on the most commonly used job stress questionnaires such as the Job Content Questionnaire, National Institute of Occupational Safety and Health job stress questionnaire and Occupational Stress Index. This scale is comprised of 7 subscales and 24 items: job demands (4 items), job control (4 items), interpersonal conflict (3 items), job insecurity (2 items), organisational system (4 items), lack of reward (3 items) and workplace environment (4 items). Each item allowed four possible responses: 'strongly disagree', 'disagree', 'agree' or 'strongly agree'. Subscale scores were the sum of each item, which was then converted into 100 points. Cronbach's α coefficient for each subscale was calculated to evaluate the internal reliability of the KOSS-SF, which ranged between 0.51 and 0.82. In this study, Cronbach's α coefficient for subscales of job stress ranged from 0.55 to 0.77. The KOSS-SF also showed acceptable validity by analysing internal consistency and factor analysis;[26] it also recommended using scores dichotomised around the median for the total study population. Therefore, the scores of each job stress were dichotomised at the median of the total firefighters (table 1).[26]

Occupational exposure

Firefighters have been exposed to various hazards that are directly linked to occupational injury. To clarify the effects of numerous such exposures, participants were asked whether or not they have experienced the following 12 hazardous conditions and/or exposure to materials in the workplace at least once: overload (lifting a heavy object repetitively), inadequate posture (working in an uncomfortable posture for a long time), lack of lighting (working in darkness), excessive heat or cold (working in an excessively hot or cold environment),

Table 1 Reference values and contents of KOSS-SF

Job stress subscales	Range of score*	Mean±SD† (male)	Mean±SD† (female)	Cronbach's α†	Contents	Questions
Job demands	0–100	59.7±16.0	61.1±17.2	0.69	Time pressure	Owing to my workload, I always feel time pressure‡
					Increasing workload	My job has become increasingly overbearing‡
					Excessive work	My work requires long lasting concentration§
					Multiple functions	I have to do various jobs simultaneously‡
Job control	0–100	51.7±14.7	49.4±13.0	0.55	Non-creative work	My work requires creativity§
					Skill underutilisation	My work requires a high level of skill or knowledge§
					Little or no decision-making	I can make my own decisions in my job and have influence over the work§
					Low control	I can control my pace of work and time schedule§
Interpersonal conflict	0–100	40.6±14.3	39.3±13.9	0.66	Inadequate supervisor support	My supervisor is helpful in getting the job done§
					Inadequate coworker support	My coworker is helpful in getting the job done§
					Lack of emotional support	I have someone who understands my difficulties at work§
Job insecurity	0–100	51.6±17.9	56.4±17.2	0.57	Uncertainty	My future is uncertain because the current situation of my company is unstable‡
					Negative changes to my job	Undesirable changes (ie, downsizing) will come to my job.
Organisational system	0–100	55.5±16.5	54.3±15.4	0.77	Unfair organisational policy	The organisational policy of my company is fair and reasonable§
					Unsatisfactory organisational support	My company provides me with sufficient organisational support§
					Interdepartmental conflict	Departments cooperate each other without conflicts§
					Limitation of communication	I have opportunities and channels to talk about my ideas§
Reward	0–00	50.3±16.5	51.0±15.2	0.73	Unsatisfactory salary	My salary is not commensurate with my effort and work performance§
					Future ambiguity	I believe that I will be given more rewards from my company if I work hard§
					Interruption of opportunity	I am provided with the opportunity to develop my capacity§
Workplace environment	0–100	47.0±15.8	49.2±16.5	0.68	Collective culture	Dining out after work makes me uncomfortable‡
					Inconsistency of job order	I am asked to do my work with irrational principles or inconsistency‡
					Authoritarian climate	My company climate is authoritative and hierarchical‡
					Gender discrimination	I am at a disadvantage because I am a woman‡

*The subscale scores were the sum of each item, which was converted into 100 points; a higher score means higher job stress.
†Mean, SD and Cronbach's α were the values used in this study.
‡Each question allowed four possible responses: 'strongly disagree', 'disagree', 'agree' or 'strongly agree', which is given a score from 1 to 4.
§Each question allowed four possible responses: 'strongly disagree', 'disagree', 'agree' or 'strongly agree', which is given a score from 4 to 1.
KOSS-SF, Short form of Korean Occupational Stress Scale.

noise (exposed to loud noise at work), vibration (exposed to vibration at work), dust (exposed to metallic dust, welding fume, grain dust, asbestos or other agents at work), organic solvents (exposed to organic solvents such as thinner, gasoline, light oil, kerosene oil, normal hexane, benzene, trichloroethylene and unknown organic solvents at work), other chemical agents (exposed to chemical agents such as chloroform, carbon tetrachloride, dimethylformamide, carbon disulfide, pesticide, urethane, epoxy resin and other unknown chemical agents at work), metals (exposed to metals such as lead, chrome, nickel, mercury, cadmium, aluminium and other unknown metals at work), biological agents (exposed to biological agents such as blood and other droplets or fluids at work) and radiation (exposed to non-destructive radiation at work).

Other confounding variables

Smokers were categorised as current smokers, ex-smokers and never smokers. The Alcohol Use Disorders Identification Test (AUDIT)[27] was used to identify hazardous drinkers among firefighters. Participants were categorised into hazardous drinkers (AUDIT score ≥8) versus non-hazardous drinkers (AUDIT score <8).[28] Regular physical activity was divided into exercising either <3 times or ≥3 times per week. Education levels were categorised into <12 years of schooling versus ≥12 years (high school or above). Marital status was categorised as married and living with a spouse versus other (never married, divorced, etc).

Statistical methods

All study participants were divided into two groups: those who had experienced occupational injury during the previous 12 months and those who had not. Injuries according to occupational and demographic characteristics were compared by using the χ^2 test and Cochran-Armitage trend test. Distribution of the numbers of injuries during the previous 12 months according to current job was also analysed. Job demands and job control were examined for analysing job stress; this analysis was conducted by stratifying the duties of firefighters into fire suppression, EMS and officers as mentioned above.

Association between job stress and occurrence of occupational injury was identified through a multivariate logistic regression model with adjustment for potential confounders that affect occupational injury on univariate analysis, including sex, age group, marital status, smoking status, hazardous drinking and occupational exposures. Some workers had one or more occupational injuries during the previous 12 months; hence, we tested whether job stress is related to the number of occupational injuries as well. The number of occupational injuries is counted variables that were commonly analysed by Poisson regression model, negative binomial regression model. In this study, the distribution of the number of injuries was overdispersed and zero-inflated. Thus, we selected a zero-inflated negative binomial regression model to handle the distribution.[29 30] The model was used to analyse the association between job stress and the number of occupational injuries; using this method, the incidence rate ratios (IRRs) and 95% CIs were calculated by adjusting all confounding variables. In this study, p values below 0.05 were considered statistically significant. Statistical analysis was performed using the SAS V.9.2 software (SAS Institute, Cary, North Carolina, USA.)

RESULTS

General characteristics

Over a period of 12 months 1757 participants comprising 14 349 men and 642 women experienced occupational injury (11.72%). There were significant differences between injured versus not injured personnel with respect to sex, age, marriage status, smoking status, hazardous drinking, current job and occupational exposures (table 2).

Distribution of the number of injuries by current job

The number of firefighters who experienced injuries in the previous 12 months included 840 fire suppression personnel, 723 EMS workers and 194 officers (table 3). As some firefighters were injured more than once, there were 5580 injury incidents; 2691 among fire suppression personnel, 2226 in EMS workers and 663 among officers. Including firefighters who never experienced injuries, the mean number of injuries was highest among EMS workers and lowest among officers; however, after excluding non-injured firefighters, that order was reversed (table 4).

Analysis of occupational injury according to job stress

ORs were calculated using a multivariate logistic regression model to identify the association between job stress and the occurrence of occupational injury. Among fire suppression personnel, high job demands, high interpersonal conflicts, a poor organisational system and a negative workplace environment were related to the occurrence of injury. Among EMS personnel, high job demands, high interpersonal conflicts, a poor organisational system, low rewards and a negative workplace environment were related to injury incidents. Among officers, high job demands and a negative workplace environment were associated with injury (table 4).

The IRRs of the number of occupational injuries were calculated by a zero-inflated negative binomial regression model comparing participants with high job stress to low job stress. Among fire suppression personnel, high job demands were associated with an increased number of injuries. Among EMS personnel, low job control, high interpersonal conflicts, low rewards and a negative workplace environment were related to an increased number of injuries. There were no correlations between the factors investigated and injury among officers (table 4).

Table 2 General characteristics of participants stratified by occupational injury

Characteristics	Not injured n (%)	Injured* n (%)	p Value†
Number of participants	13 234 (88.28)	1757 (11.72)	
Sex			
Male	12 657 (88.21)	1692 (11.79)	0.200
Female	577 (89.88)	65 (10.12)	
Age group (years)			
20–29	1042 (86.12)	168 (13.88)	<0.001‡
30–39	5846 (86.66)	900 (13.34)	
40–49	4998 (89.57)	582 (10.43)	
50–59	1348 (92.65)	107 (7.35)	
Marriage status			
With spouse	11 215 (88.63)	1439 (11.37)	0.002
Other	2019 (86.39)	318 (13.61)	
Smoking status			
Current smokers	5220 (88.61)	671 (11.39)	0.003
Never smokers	1022 (85.24)	177 (14.76)	
Former smokers	6992 (88.50)	909 (11.50)	
Hazardous drinking			
AUDIT <8	5291 (89.06)	650 (10.94)	0.016
AUDIT ≥8	7943 (87.77)	1107 (12.23)	
Frequency of exercise (times/week)			
<3	5689 (88.28)	755 (11.72)	0.989
≥3	7545 (88.28)	1002 (11.72)	
Education (years)			
≤12	5019 (88.66)	642 (11.34)	0.260
>12	8215 (88.05)	1115 (11.95)	
Current job			
Fire suppression	6621 (88.74)	840 (11.26)	<0.001
EMS	3432 (82.60)	723 (17.40)	
Officer	3181 (94.25)	194 (5.75)	
Current job experience (years)			
1–4	6196 (88.73)	787 (11.27)	<0.916‡
5–9	2496 (87.00)	373 (13.00)	
10–14	2532 (87.40)	365 (12.60)	
≥15	2010 (89.65)	232 (10.35)	
Overload			
Exposed	8284 (84.66)	1501 (15.34)	<0.001
Not exposed	4950 (95.08)	256 (4.92)	
Inadequate posture			
Exposed	7086 (84.19)	1331 (15.81)	<0.001
Not exposed	6148 (93.52)	426 (6.48)	
Lack of lighting			
Exposed	6495 (83.95)	1242 (16.05)	<0.001
Not exposed	6739 (92.90)	515 (7.10)	
Excessive heat or cold			
Exposed	6260 (83.88)	1203 (16.12)	<0.001
Not exposed	6974 (92.64)	554 (7.36)	
Noise			
Exposed	6921 (84.22)	1297 (15.78)	<0.001
Not exposed	6313 (93.21)	460 (6.79)	
Vibration			
Exposed	4725 (82.79)	982 (17.21)	<0.001
Not exposed	8509 (91.65)	775 (8.35)	
Dust			
Exposed	7137 (84.49)	1310 (15.51)	<0.001
Not exposed	6097 (93.17)	447 (6.83)	
Organic solvent			
Exposed	5209 (83.22)	1050 (16.78)	<0.001
Not exposed	8025 (91.90)	707 (8.10)	

Continued

Table 2 Continued

Characteristics	Not injured n (%)	Injured* n (%)	p Value†
Other chemical agents			
Exposed	5237 (83.03)	1070 (16.97)	<0.001
Not exposed	7997 (92.09)	687 (7.91)	
Metals			
Exposed	3759 (82.02)	824 (17.98)	<0.001
Not exposed	9475 (91.04)	933 (8.96)	
Biological agents			
Exposed	4381 (81.49)	995 (18.51)	<0.001
Not exposed	8853 (92.07)	762 (7.93)	
Radiation			
Exposed	1350 (80.94)	318 (19.06)	<0.001
Not exposed	11 884 (89.20)	1439 (10.80)	

*Participants that underwent medical treatment due to the occupational injury for past 12 months.
†p Values calculated using the χ^2 test.
‡p Values for trend calculated using the Cochran-Armitage trend test.
AUDIT, Alcohol Use Disorders Identification Test.

Table 3 Distribution of the number of injuries by current job

		Number of injuries*					
Current job	Participants (n)	Total injuries	Mean±SD[9]	Median[9]	Mean±SD (except zero)	Median (except zero)	Maximum
Total firefighters	14 991	5580	0.37±2.23	0	3.18±5.80	2	90
Fire suppression	7461	2691	0.36±2.53	0	3.20±6.93	1	90
Emergency medical services	4155	2226	0.54±2.09	0	3.08±4.17	2	40
Officers	3375	663	0.20±1.57	0	3.42±5.66	1	50

*Participants who underwent medical treatment owing to occupational injury in the prior 12 months.

DISCUSSION

This study showed that excessive job stress is related to the occurrence and the frequency of occupational injuries in Korean firefighters. Many recent studies have investigated occupational injury due to physical and chemical exposure, as well as psychological factors including job stress. However, the association between job stress and occupational injuries among firefighters has rarely been examined. Our study is meaningful because it is a nationwide survey involving the entire firefighter force of Korea; moreover, it reveals an association between job stress and the frequency of occupational injuries in Korean firefighters after adjusting for confounding variables.

In this study, high job demands were associated with the occurrence of occupational injury regardless of the nature of the current job. In a study of small-to-medium sized Korean manufacturing enterprises, workers with highly demanding jobs had a greater risk of occupational injury.[31] A study from Japan also showed that high quantitative workloads, high variance in workload and high cognitive demands were associated with occupational injury in men working in small-to-medium sized manufacturing enterprises. Among female workers, high quantitative workloads and high cognitive demands correlated with a greater risk of occupational workplace injury.[19] The results of our study suggest that firefighters, who have high-risk jobs, also experience a greater risk of occupational injury corresponding to higher job demands.

Low job control (ie, the ability to make decisions) was found not to be significantly associated with occupational injury among firefighters. Murata *et al*[32] showed no statistically significant effects of job control on occupational injury among blue-collar workers. Nakata *et al*[19] showed that female workers in small-to-medium sized manufacturing enterprises had a higher risk of occupational injury when they had less job control. Although low job control was associated with the number of occupational injuries among EMS personnel in our study, it was not associated with the occurrence of occupational injury in either sex.

High interpersonal conflicts were associated with the occurrence of occupational injury in fire suppression and EMS personnel. A study of Finish hospital personnel showed that problems in interpersonal relationships and conflicts during collaborations at work were related to occupational injury.[33] Another study of Japanese small-to-medium sized manufacturing enterprises workers showed that female employees with high

Table 4 Occurrence of occupational injury (logistic regression model) and number of injuries (zero-inflated negative binomial regression model) according to job stress scales

Job stress scale*	OR† (95% CI)	IRR‡ (95% CI)
Total firefighters		
Job demands (high)	1.42 (1.25 to 1.60)	1.08 (0.95 to 1.22)
Job control (low)	0.93 (0.84 to 1.04)	0.97 (0.90 to 1.10)
Interpersonal conflicts (high)	1.26 (1.13 to 1.39)	1.06 (0.96 to 1.17)
Job insecurity (high)	0.83 (0.74 to 0.93)	0.91 (0.81 to 1.01)
Organisational system (poor)	1.39 (1.24 to 1.54)	1.02 (0.92 to 1.13)
Rewards (low)	1.05 (0.90 to 1.22)	1.09 (0.98 to 1.20)
Workplace environment (negative)	1.35 (1.22 to 1.50)	1.06 (0.96 to 1.18)
Fire suppression		
Job demands (high)	1.49 (1.25 to 1.77)	1.22 (1.01 to 1.47)
Job control (low)	0.92 (0.79 to 1.06)	0.89 (0.76 to 1.03)
Interpersonal conflicts (high)	1.18 (1.02 to 1.37)	0.97 (0.83 to 1.12)
Job insecurity (high)	0.73 (0.61 to 0.87)	0.93 (0.78 to 1.12)
Organisational system (poor)	1.33 (1.14 to 1.55)	1.00 (0.85 to 1.17)
Rewards (low)	1.13 (0.97 to 1.31)	1.10 (0.94 to 1.27)
Workplace environment (negative)	1.41 (1.21 to 1.64)	0.99 (0.85 to 1.16)
Emergency medical services		
Job demands (high)	1.26 (1.03 to 1.54)	1.05 (0.88 to 1.25)
Job control (low)	1.02 (0.85 to 1.21)	1.20 (1.04 to 1.38)
Interpersonal conflicts (high)	1.40 (1.19 to 1.66)	1.18 (1.03 to 1.36)
Job insecurity (high)	0.88 (0.74 to 1.04)	0.90 (0.78 to 1.04)
Organisational system (poor)	1.55 (1.30 to 1.85)	1.12 (0.96 to 1.29)
Rewards (low)	1.43 (1.21 to 1.69)	1.17 (1.02 to 1.35)
Workplace environment (negative)	1.30 (1.10 to 1.54)	1.16 (1.01 to 1.34)
Officers		
Job demands (high)	1.96 (1.35 to 2.85)	0.70 (0.48 to 1.04)
Job control (low)	1.06 (0.77 to 1.47)	0.91 (0.67 to 1.24)
Interpersonal conflicts (high)	1.22 (0.90 to 1.65)	0.85 (0.60 to 1.19)
Job insecurity (high)	0.78 (0.56 to 1.09)	0.93 (0.67 to 1.30)
Organisational system (poor)	1.28 (0.94 to 1.75)	0.81 (0.61 to 1.09)
Rewards (low)	1.12 (0.82 to 1.52)	0.78 (0.58 to 1.06)
Workplace environment (negative)	1.54 (1.13 to 2.10)	0.86 (0.64 to 1.16)

*All job stress scales were compared to their counterparts.
†OR and 95% CI were calculated using a logistic regression model adjusted for sex, age group, marriage status, smoking status, hazardous drinking and occupational exposures.
‡IRR and 95% CI were calculated using a zero-inflated negative binomial regression model adjusted for sex, age group, marriage status, smoking status, hazardous drinking and occupational exposures.
IRR, incidence rate ratio.

intragroup conflicts at the workplace had a higher risk of occupational injury.[19] In both our previous and current studies, high interpersonal conflicts appear to be an important factor contributing to occupational injury, although the nature of the job was different.

In this study, high job insecurity was associated with a lower occurrence of occupational injury among fire suppression personnel. There were 47 deaths of firefighters actively on the job between 1998 and 2007, which constituted 22% of all causes of death among firefighters. Additionally, the average age of death of retired firefighters was 58.8 years during the same period.[34] Therefore, our reported rate of occupational injury could be underestimated if certain firefighters were unable to respond to our questionnaires because of disabilities or other medical reasons. Since we had no information on non-respondents, we could not assess the presence of the bias. However, considering the dangers of fire suppression, it is possible that the occurrences of injuries were underestimated in our study. Probst and Brubaker[35] reported that workers in insecure jobs underwent more occupational injuries than those in secure jobs. Nakata *et al*[19] showed that high job insecurity was associated with an increased risk of occupational injury among male workers in small-to-medium sized manufacturing enterprises. To clarify the association between job insecurity and the occurrence of occupational injury among firefighters, further studies that consider biases inherent in their designs are necessary.

A poor organisational system was associated with the occurrence of occupational injury in fire suppression and EMS personnel. Recently, a 1-year follow-up prospective study in Spain was conducted to investigate any association between job stress related to organisational support and occupational injuries.[21] Lack of organisational support was evaluated by questionnaires and then

estimated by index, severity and frequency; all were positively correlated with the risk of occupational injury. In the same context, our current results show that lack of organisational support in firefighters was also related to occupational injury.

A study in Hong Kong revealed that injuries among construction workers were influenced by emotional stress, which included unfair rewarding policies.[22] In our study, the lack of a reward was also associated with the occurrence of occupational injury among fire suppression and EMS personnel. Rewards were an important factor for predicting workers' safety and health with respect to the effort-reward model. In a cross-sectional survey of 11 636 Dutch workers, participants with high efforts and low rewards had a significantly higher risk of emotional exhaustion, psychosomatic symptoms, physical symptoms and job dissatisfaction (OR 3.23 to 15.43).[36] Although jobs vary by nature, the lack of rewards ought to be considered a factor affecting occupational injury.

A national representative survey in France reported that various adverse workplace practices such as verbal abuse, physical violence, low predictability and bullying, as well as psychological demands and low decision latitude, were related to occupational injuries.[23] Furthermore, an important study revealed that organisational injustices such as supervisors' abuse of power can affect both workers' rights as well as their health and safety.[24] That study also revealed qualitative data regarding the association between the level of power abuse and risk of occupational injuries. Such aspects can equally apply to the firefighting profession in terms of workplace climate.

The association between job stress scales and the number of occupational injuries using the zero-inflated negative binomial model significantly differed by current job duties. For fire suppression, only high job demands were associated with an increased number of occupational injuries. Among EMS personnel, low job control, high interpersonal conflict, lack of reward and a negative workplace environment were related to the number of occupational injuries. However, there were no statistically significant results for officers. Since the association between job stress and the number of occupational injuries has rarely been researched, there are few published data to compare our results to. Nevertheless, considering the different results according to job duties, our statistical method may be useful to estimate the differences in associations between job stress and occupational injuries in various jobs.

Our study had some limitations. First, because the study was conducted using a self-reported survey, recall or reporting bias may have occurred. However, because severe cases of injuries are more easily remembered, the fact that our study design surveyed only injuries that required medical care may have minimised recall bias. Self-reported surveys also carry a bias resulting from the lack of incorporation of non-respondents' data. Moreover, since workers who are hospitalised, retired or deceased cannot respond to the survey, a bias towards healthier workers may have occurred. If we were able to incorporate the data of non-respondents somehow, it is possible that our final results would be different. Second, confounding variables such as working patterns, hours of duty, sleep patterns and types of injury were not included, although these may have an influence on the relationship between job stress and occupational injuries. Third, because the study design was cross-sectional, we could not establish a causal relationship and were only able to identify the association between job stress and occupational injuries. For example, the results of our study could be interpreted as the number of occupational injuries themselves having an impact on job stress. Thus, careful interpretation of our data is required. However, the advantage of this study is that it was based on a nationwide survey that included the entire firefighter force in Korea.

In summary, our study revealed increased occurrence and frequency rates of occupational injuries due to job stress among firefighters. Although there were differences in injury rates according to current job duties, we found that high job demands, high interpersonal conflicts, a poor organisational system, lack of rewards and a negative workplace environment were factors associated with the occurrence of occupational injuries. As for the frequency of occupational injuries, fire suppression personnel with high job demands experienced a greater number of occupational injuries. In EMS workers, low job control, high interpersonal conflicts, lack of rewards and a negative workplace environment were associated with an increased number of occupational injuries. This study exposes the job stress factors that should be ameliorated to prevent occupational injuries among firefighters. Our results can be used to better address job stress and hence to minimise occupational injuries among firefighters.

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