



Risk of Cerebro-Cardiovascular Diseases among Police Officers and Firefighters: A Nationwide Retrospective Cohort Study

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Purpose: Police officers and firefighters are exposed to risk factors for cerebro-cardiovascular diseases, and the actual risk is expected to increase compared with other occupational groups. The present study aimed to estimate the risks of cerebro-cardiovascular diseases in police officers and firefighters compared to other occupational groups.

Materials and Methods: Using the National Health Insurance Service data, we constructed a retrospective cohort of public officers. Three-year consecutive health insurance registration data were used to identify police officers and firefighters. Cerebro-cardiovascular diseases consisted of acute myocardial infarction, other ischemic heart disease, cardiac arrhythmia, and stroke. We compared the incidences of cerebro-cardiovascular diseases between each of the two occupational groups (police officers and firefighters) and other public officers by calculating standardized incidence ratios (SIRs).

Results: SIRs and 95% confidence intervals of all cerebro-cardiovascular diseases for police officers and firefighters were 1.71 (1.66–1.76) and 1.22 (1.12–1.31), respectively, as compared with all public officers. The incidence ratios remained significantly higher compared to general and education officers. Subgroup analyses for myocardial infarction, stroke, and cardiac arrhythmia exhibited significant increases in incidence ratios among police officers and firefighters.

Conclusion: This study suggests that both police officers and firefighters are at high risk of cerebro-cardiovascular diseases. Therefore, medical protection measures for these occupational groups should be improved.

Key Words: Cardiovascular diseases, firefighters, police officers

INTRODUCTION

Police officers and firefighters are essential occupations to

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maintain security for a country and society, and they are hired as public employees by governments in most of the countries, including the Republic of Korea. The numbers of police officers and firefighters have been gradually increasing every year and, in 2019, reached 122913 and 60994, respectively. Since shift work is mandatory to secure societies among police officers and firefighters, they are simultaneously exposed to various occupational risk factors. Police officers are known to be at high risk for mental health problems, such as anxiety, due to accident scene experiences and firearm violence.^{1,2} In the Republic of Korea, a high prevalence of post-traumatic stress disorder was found among police officers.³ Besides, police officers are highly likely to be exposed to noise from rooftop work and siren use,⁴ as well as to particulate matter.⁵ Particularly, police officers frequently work near traffic roads, particles of which increase various health risks.⁶ In addition to these risks,

exposure to smoke in fire scenes is one of the important occupational risk factors among firefighters.⁷ For example, inhalation of or skin exposure to polycyclic aromatic hydrocarbons in fire scenes can cause numerous health problems.⁸

The above-mentioned exposures, such as shift work, emotional stress, and physical or chemical factors, are directly and indirectly related to a variety of health problems, particularly cerebro-cardiovascular diseases. Shift work is a well-known risk factor for cardiovascular diseases, and its underlying mechanisms may include the variation in physiological circadian rhythm, changes in meal time, and interrupted sleep.⁹ Emotional stress due to occupational factors is also one of the risk factors for cerebro-cardiovascular diseases. Previous studies targeting several occupations have consistently reported moderate or strong associations between job exposure stress (measured by different evaluation tools) and incident cerebro-cardiovascular diseases.¹⁰ Noise may increase the risk for hypertension, as well as the incidence of cardiovascular diseases and related mortality.¹¹ Furthermore, numerous studies have demonstrated compelling relationships between long- or short-term exposures to ambient air pollution and cerebro-cardiovascular diseases.^{12,13}

Given that police officers and firefighters are exposed to the above-mentioned risk factors for cerebro-cardiovascular diseases, they may be at higher risks for the diseases compared with other occupations. Especially, the risk of cerebro-cardiovascular diseases among police officers and firefighters might be much higher due to co-exposures to various risk factors. Hence, the present study aimed to quantify the risk for cerebro-cardiovascular disease among police officers and firefighters, using health insurance claims data.

MATERIALS AND METHODS

Data source

A unified national health insurance system is operated in the Republic of Korea. It is mandatory for citizens and foreigners residing in the Republic of Korea to join the national health insurance system. The National Health Insurance Service, the operating party of national health insurance, provides national health insurance claims data (from 2002) for research purposes.¹⁴ National health insurance claims data include eligibility, age, sex, area of residence, occupation, income, and type of insurance, as well as detailed clinical information such as diagnosis code (based on the 10th revision of International Classification of Diseases, ICD-10), procedure, and prescription (as per fee-for-service operated in the Republic of Korea). The present study constructed a cohort using the occupation codes of the national health insurance claims data. The present study was approved by the Institutional Review Board at Yonsei University Health System (No. 2017-2957-001). Since the data were de-identified, the requirement for informed writ-

ten consent was waived.

Study population

The study population consisted of police officers and firefighters, who are public employees. We first selected all public employees from the national health insurance claims data. The category of public employees comes with a variety of subcategories (e.g., general service, technical service, national security, education, and law). Police officers and firefighters were chosen as separate groups of interest, and all public employees were as their comparator. Education officers were also included as a comparator due to their similar work characteristics and evenly lower occupational risks. Since education officers could be identified from 2006 due to data availability, we used the national health insurance claims data from 2006 to 2017. The first observation date was January 1, 2007, as the year of 2006 was used as a washout period to exclude individuals who already developed diseases of interest. We identified the above occupation groups who remained in their occupations for 3 consecutive years (e.g., 2007–2009, 2008–2010, and 2009–2011). All individuals who had diseases of interest 1 year prior to observation start were excluded. Considering that cerebro-cardiovascular diseases can occur following short-term exposures, those who developed diseases of interest within the 3 consecutive years for the identification purpose were included. The observation period ended at a case occurrence or December 31, 2017.

Disease definitions

Diseases of interest were acute myocardial infarction (ICD-10, I21–I22), other ischemic heart disease (I20; I23–I25), conduction disorder and cardiac arrhythmia (I44–I49), and stroke, including intracerebral hemorrhage and infarction (I60–I63). We defined the development of each disease of interest as first admission with the relevant diagnosis codes during the observation period.

Statistical analysis

We compared the numbers of disease occurrence in police officers and firefighters versus education officers or all public employees, using direct standardization of age (5-year intervals). Based on the age-stratified numbers of disease occurrence in the comparators, the age-stratified numbers of disease occurrence in police officers and firefighters were estimated. Considering possible sex imbalances among police officers, firefighters, and the comparators, sex-stratified analyses were performed. We calculated standardized incidence ratio (SIR) as the ratio of the observed number over the estimated number. To calculate 95% confidence interval (CI), we used mid-p test under the assumption of Poisson distribution, in line with previous literature on estimating standardized mortality ratio among occupational groups.^{15,16} The estimation of SIR was conducted for the total observation period as well as on the an-

nual basis. Statistical significance was defined when 95% CI crossed one. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA).

RESULTS

Characteristics of study population

Among a total of 1146073 public employees, 105219 police officers, 27493 firefighters, 659734 education and general officers were included (Table 1). Person-years of observation were 9566453, 905631, 237432, and 5604293 in all public employees, police officers, firefighters, and education and general officers, respectively.

Standardized incidence ratios

The numbers of overall cerebro-cardiovascular diseases were greater in both police officers and firefighters than those of expected case in the other occupations (Tables 2 and 3). For over-

all cerebro-cardiovascular disease, the SIR (95% CI) was 1.71 (1.66–1.76) in police officers and 1.22 (1.12–1.31) in firefighters, respectively, when compared with all public employees. Compared to education and general officers, the SIR (95% CI) was 2.10 (2.04–2.17) in police officers and 1.51 (1.39–1.63) in firefighters. In police officers, the SIRs (95% CIs) for myocardial infarction, stroke, and arrhythmia were 1.51 (1.36–1.66), 1.25 (1.16–1.34), 2.04 (1.90–2.19), respectively, when compared with all public officers. The SIRs were higher compared to general and education officers. In firefighters, the SIRs (95% CIs) for myocardial infarction, stroke, and arrhythmia were 1.54 (1.23–1.90), 1.18 (1.01–1.38), 1.52 (1.27–1.80), respectively, when compared with all public officers. The SIRs were higher compared to general and education officers.

Sex-stratified analysis

After stratification by sex, the SIRs for overall cerebro-vascular disease in police officers were still significantly higher (Table 4). Among male workers, firefighters did not show a significant-

Table 1. Distribution of Person-Years among Study Participants

	Police officers (n=105219)	Firefighters (n=27493)	General or education officers (n=659734)	All public officers (n=1146073)
Total person-years	905631	237432	5604293	9566453
Age in 2006 (yr)				
25–29	100697	29779	835920	1393562
30–34	159133	48265	976414	1723447
35–39	231988	64476	1005736	1879347
40–44	178814	47708	968090	1667181
45–49	116179	28637	932809	1529356
50–54	109863	16708	629102	1050773
55–59	8956	1860	230792	292257
60–64	-	-	25429	30529
65 or over (excluded)	-	-	325	3049

Table 2. Case Numbers and SIRs of Police Officers Compared to All Public Officers or General and Education Officers

Disease	Police officers Identified cases	Comparison to all public officers		Comparison to general and education officers	
		Expected cases	SIR (95% CI)	Expected cases	SIR (95% CI)
Overall	4009	2348	1.71 (1.66–1.76)	1907	2.10 (2.04–2.17)
Myocardial infarction	385	256	1.51 (1.36–1.66)	195	1.98 (1.78–2.18)
Stroke of any type	756	605	1.25 (1.16–1.34)	507	1.49 (1.39–1.60)
Cardiac arrhythmia	776	380	2.04 (1.90–2.19)	302	2.57 (2.39–2.76)

SIR, standardized incidence ratio; CI, confidence interval.

Table 3. Case Numbers and SIRs of Firefighters Compared to All Public Officers or General and Education Officers

Disease	Firefighters Identified cases	Comparison to all public officers		Comparison to general and education officers	
		Expected cases	SIR (95% CI)	Expected cases	SIR (95% CI)
Overall	639	525	1.22 (1.12–1.31)	424	1.51 (1.39–1.63)
Myocardial infarction	88	57	1.54 (1.23–1.90)	43	2.07 (1.66–2.55)
Stroke of any type	160	136	1.18 (1.01–1.38)	114	1.40 (1.19–1.63)
Cardiac arrhythmia	135	89	1.52 (1.27–1.80)	70	1.93 (1.61–2.28)

SIR, standardized incidence ratio; CI, confidence interval.

Table 4. Sex-Stratified SIRs of Police Officers and Firefighters

Disease	Sex	Identified cases	Comparison to all public officers		Comparison to general and education officers	
			Expected cases	SIR (95% CI)	Expected cases	SIR (95% CI)
Police officers						
Overall	Male	3964	2765	1.43 (1.39–1.48)	2399	1.65 (1.60–1.70)
	Female	45	25	1.80 (1.32–2.41)	23	1.98 (1.45–2.65)
Myocardial infarction	Male	385	344	1.12 (1.01–1.24)	300	1.29 (1.16–1.42)
	Female	0	0.4	-	0.4	-
Stroke of any type	Male	744	704	1.06 (0.98–1.14)	643	1.16 (1.08–1.24)
	Female	12	8	1.52 (0.79–2.66)	7	1.65 (0.85–2.88)
Cardiac arrhythmia	Male	756	437	1.73 (1.61–1.86)	361	2.09 (1.95–2.25)
	Female	20	8	2.60 (1.59–4.02)	7	2.88 (1.76–4.44)
Firefighters						
Overall	Male	627	628	1.00 (0.92–1.08)	546	1.15 (1.06–1.24)
	Female	12	6	2.12 (1.10–3.71)	5	2.34 (1.21–4.08)
Myocardial infarction	Male	87	79	1.10 (0.88–1.36)	68	1.28 (1.02–1.58)
	Female	1	0.1	12.15 (0.31–67.72)	0.1	11.48 (0.29–63.95)
Stroke of any type	Male	156	160	0.98 (0.83–1.14)	148	1.05 (0.90–1.23)
	Female	4	1.8	2.20 (0.60–5.64)	1.7	2.40 (0.65–6.14)
Cardiac arrhythmia	Male	131	103	1.27 (1.06–1.51)	85	1.54 (1.29–1.83)
	Female	4	1.8	2.26 (0.62–5.79)	1.6	2.51 (0.68–6.43)

SIR, standardized incidence ratio; CI, confidence interval.

ly higher risk compared to all public officers (SIR, 1.00; 95% CI, 0.92–1.08), but showed a significantly higher risk when compared with general and education officers (SIR, 1.15; 95% CI, 1.06–1.24). The SIR (95% CI) for the overall cerebro-cardiovascular disease in female workers was 1.98 (1.45–2.65) among police officers and 2.34 (1.21–4.08) among firefighters, compared to general and education officers. However, SIR was not calculable for myocardial infarction in female workers, as there was no case in police officers and only one case in firefighters. All SIRs of myocardial infarction, stroke, and arrhythmia were higher in female workers than in male workers, but statistical significance was not guaranteed due to the limited case numbers in female workers.

DISCUSSION

The present study investigated the risk for cerebro-cardiovascular diseases among police officers and firefighters using a cohort based on healthcare insurance claims data. Both police officers and firefighters exhibited higher incidences of cerebro-cardiovascular diseases, including myocardial infarction, stroke, and arrhythmia, compared to total public officers. When compared with education and general officers, even higher incidences of cerebro-cardiovascular diseases were found among police officers and firefighters.

Previous studies have investigated mortality from ischemic heart disease and acute myocardial infarction among police officers in United States. A case-control study using death certificate data found that police officers aged <65 years were at a

2.1-fold increased risk for mortality from acute myocardial infarction compared to those who were not police officers,¹⁷ which was consistent with our study. Han, et al.¹⁸ estimated the risks of 17 disease categories, including angina pectoris (ICD-10, I20), acute myocardial infarction (I21), and cerebrovascular disease (I63), in police officers and fire fighters using the healthcare insurance claims data from 2003 to 2014. They found increased hazard ratios (estimated from survival analyses) for the three disease categories among police officers, but only the risk for acute myocardial infarction was statistically significant. In contrast, the present study observed higher SIRs of all cerebro-cardiovascular diseases among firefighters. This discrepancy may be due to the expansion of disease definitions and the reliability of occupation data (based on 3 consecutive years) in our study.

Healthy worker effect is an important issue to be considered, as police officers and firefighters are generally required to be healthier than other populations.¹⁹ A recent Spanish study following firefighters for 10 years found increased risks for a few rare malignancies, but not for cardiovascular diseases.²⁰ The increased risks for cerebro-cardiovascular diseases among police officers and firefighters observed in the current study might be attributed to the aforementioned factors, such as shift work, job stress, and air pollution exposures. These factors may affect the occurrence of cerebro-cardiovascular disease itself, as well as its mediators. In a 2015 Taiwanese study, the prevalence of metabolic syndrome among male police officers was 24.5%, and those of metabolic syndrome and central obesity were higher in police officers who had a high sleep disturbance score.²¹ Sleep disturbance and central obesity may

be the mediators of cerebro-cardiovascular diseases among police officers and firefighters and, hence, intervention targeting these modifiable factors has a potential to reduce the risk for cerebro-cardiovascular disease in police officers and firefighters.

Numerous studies targeting several shift-working occupations have suggested appropriate cycles for shift work. Although “appropriate shift period” may not exist,²² there could be various efforts to reduce overnight shift days and shift period, to eliminate permanent overnight shift work, and to choose clockwise shift work.²³ Police officers working outdoors are exposed to environmental pollutants. Therefore, police officers may experience health benefits from reducing air pollution exposures, which leads to a decline in cardiovascular events in the general population.²⁴ Firefighters may be at risk of cardiovascular disease associated with exposures to gaseous pollutants and particles generated from combustion. Wearing personal protective gears can block exposures to combustion products, but a recent randomized trial showed that the use of personal protective gears reduced working proficiency.²⁵ Given that an increase in workload (e.g., fire suppression, rescue, and first aid) is a risk factor for cardiovascular disease,²⁶ wearing personal protective gears might increase the risk of cardiovascular disease. A recent study of 201 police officers demonstrated that subjects with better physical fitness (versus poorer physical fitness) had lower levels of cardiovascular risk indicators among those with high effort-reward imbalance.²⁷ Therefore, in addition to reducing job stress, intervention on external factors (e.g., reducing workload and improving physical fitness) may be important for decreasing the risk of cardiovascular disease in firefighters. Overall medical cost is higher in firefighters compared to the general population, and the cost for cerebro-cardiovascular disease is much higher.²⁸ Since inherent occupational risk cannot be totally under control in police officers and firefighters, the occupational risks mentioned in the present study and previous studies need to be comprehensively accepted. In this context, cerebro-cardiovascular events in those occupations may need to be rapidly compensated as disasters on duty, and this approach may be applicable for tertiary prevention.

The present study had several limitations to be noted. First, the police officers and firefighters identified in this study might not have remained within their occupations. We constructed a fixed cohort of police officers and firefighters using the 3-year consecutive health insurance registration data in order to minimize misclassification of temporary workers as the occupational risk groups. Although constructing a dynamic cohort might be useful to address the issue of occupational changes as in a previous study,²⁹ the present study only included public officers, whose turnover rate is relatively low. Second, it is possible that the risk ratio estimated in this study was underestimated due to the healthy worker effect and biased by competing risk.³⁰ Police officers and firefighters are at extremely

high risk of occupational injuries and, in turn, competing risk of cerebro-cardiovascular events may exist, which was not considered in our analysis. Particularly, the risk ratio of cerebro-cardiovascular disease was lower in firefighters than in police officers in the present study, which might be attributed to the higher risk of occupational injuries and resulting loss of job continuity in firefighters. Third, there is an issue of diagnostic misclassification, as the present study used healthcare utilization data.³¹ However, the definition of cerebro-cardiovascular disease was based on admission data, and this may not have differentially affected the exposure and non-exposure groups in our study. More precise case definitions considering not only the ICD codes but also the diagnostic tools, interventions, and medications could be applied to improve validity in future studies using the national health insurance claims data.

In conclusion, the present study showed that both police officers and firefighters were at higher risk of cerebro-cardiovascular diseases, including myocardial infarction, stroke, and arrhythmia, compared to public officers. This highlights the need for improving cerebro-cardiovascular health and related occupational protection strategies for police officers and firefighters.

AUTHOR CONTRIBUTIONS

Conceptualization: Jinha Yoon. **Data curation:** Woo-Ri Lee and Ki-Bong Yoo. **Formal analysis:** Woo-Ri Lee and Ki-Bong Yoo. **Funding acquisition:** Jinha Yoon. **Investigation:** Jongjin Lee, Woo-Ri Lee, and Ki-Bong Yoo. **Methodology:** Jongjin Lee and Jinha Yoon. **Project administration:** Jongjin Lee. **Resources:** Jinha Yoon. **Software:** Woo-Ri Lee and Ki-Bong Yoo. **Supervision:** Jinha Yoon. **Validation:** Jaelim Cho and Jinha Yoon. **Visualization:** Jongjin Lee. **Writing—original draft:** Jongjin Lee, Jaelim Cho, and Jinha Yoon. **Writing—review & editing:** Jaelim Cho and Jinha Yoon. **Approval of final manuscript:** all authors.

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