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# Do police officers and firefighters have a higher risk of disease than other public officers?: a 13-year nationwide cohort study

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## ABSTRACT

**Objectives:** The work of public officials involves repeated and long-term exposure to heavy workloads, high job strain, and workplace violence, all of which negatively impact physical and mental health. This study aimed to evaluate and compare the incidences of diseases among different categories of public officials in Korea, in order to further understand the health risks associated with these occupations.

**Design:** A cohort study using the National Health Insurance data

**Participants:** We collated claims data between 2002 and 2014 for 860,221 public officials.

**Primary and secondary outcome measures:** Age-standardized rates were calculated using the direct standardization method, and hazard ratios (HRs) were calculated using the Cox Proportional Hazard regression models.

**Results:** Overall, we found that police officers and fire fighters had a higher incidence of a range of diseases when compared to national and regional government officers (NRG). The most prominent HRs were observed among police officers for angina pectoris (HR: 1.52, 95% confidence interval [CI]: 1.49-1.54), acute myocardial infarction (HR: 1.84, 95% CI: 1.77-1.92), and cerebrovascular disease (HR: 1.36, 95% CI: 1.31-1.40). Firefighters were more susceptible to physical ailments and were at a significantly higher risk for stress disorders (HR: 1.40, 95% CI: 1.26-1.56) than NRGs.

**Conclusion:** Compared to NRGs, police officers had higher HRs for all measured diseases, except for stress disorders. While firefighters had higher HRs for almost all diseases examined, public education officers had a higher HR for stress disorders, when compared to NRGs.

**Keywords:** public officer, police officer, firefighter, cohort, hazard ratios

**Strengths and limitations of the study**

- This study was the largest cohort study based on nationwide follow-up data including all Korean public officials. We included a comprehensive set of various health problems potentially related to job as well as cardiovascular disorders.
- The incidences and hazard ratios for diseases among various categories of public officers are different. Police officers had the highest risk for cardiovascular diseases. They also were at a high risk of mental disorders except for stress disorders. Firefighters also had higher risks of cardiovascular diseases, musculoskeletal and mental disorders. Public education officers had a higher risk for stress disorders
- A limitation of the study was that incidences of some disease could be underestimated or overestimated because our study used claimed data.

## INTRODUCTION

The broad category of "public officials" comprises of individuals in a range of government-overseen positions and public sector employment. As a percentage of total employment across the Organization for Economic Co-operation and Development countries, the employment rate for public officials rose slightly between 2009 and 2013, from 21.1% to 21.3%.[1] In Korea and in many developed countries, positions at public offices are regarded as prestigious occupations, albeit uniquely stressful.[2 3] The work of public officials is fundamental to the maintenance of society, and it is therefore important to understand any afflictions or ailments associated with this category of individuals.

The work of public officials involves repeated and long-term exposure to heavy workloads, high job strain, or workplace violence, all of which have a potentially negative impact on physical and mental health. This is particularly true for police officers and firefighters who, in addition to workplace stress also deal with physical, chemical, biological, and psychological hazards while on duty.[4-7] For these reasons, research shows that firefighters and police officers have higher mortality and morbidity rates compared to the general population, particularly for cardiovascular diseases (CVD). The incidence of cardiovascular diseases has been reported to be higher among police officers than in the general civilian population (31.4% vs. 18.4%).[8] Similarly, a study involving American firefighters found that CVD was the primary cause of death in the line of duty, accounting for approximately 45% of the on-duty fatalities.[9]

Considerable research on the health of public officials has been conducted in many Western countries, focusing mainly on cardiovascular diseases, chronic diseases, and mental disorders. However, comparable research in Asian countries is scarce. Using a large, nationwide dataset based on insurance claims, this study aimed to evaluate the differences in the incidence rates of specific diseases among different categories of public officials in Korea, in order to develop the understanding of health risks associated with these occupations.

## SUBJECTS AND METHODS

### Data Source

The study population consisted of public officials, including police officers, firefighters, public educational officials (PEOs), and national and regional government officers (NRGs), with claims data between 2002 and 2014, which was collected from the National Health Insurance Service (NHIS) using their customized database service.

The Korean National Health Insurance (NHI) program covers almost 100% of the Korean population and the database contains information on demographic characteristics, hospital admissions, ambulatory care, principal diagnosis, comorbidities (using the International Classification of Disease's 10th revision (ICD-10)), procedures, and prescriptions regarding all inpatients and outpatients. The date of death was ascertained from death certificates collected from the Korean National Statistical Office. Patients who were alive on December 31st, 2014, or after were not considered deceased for the purposes of this study.

### Study subjects and identification

We identified 860,221 public officials as the study population based on occupation codes. We then collected all patient claims data between 2002 and 2014, and dates of death, through the NHIS customized database service. We defined each disease based on its ICD-10 and procedure codes. We identified patients with alcoholic liver disease (ICD-10 K70), peptic ulcer (K25-K28), dyslipidemia (E78 with prescription), diabetes mellitus (DM) (E10-E14 with prescription), type II DM (E11), hypertension (I10-I15 or I30 with prescription), angina pectoris (I20), acute myocardial infarction (I21), cerebrovascular diseases (I63), admission due to injury (S00-T98 and document code of 'hospital admission'), low back pain (M543-M545 and document code of 'hospital admission'), lumbar disc herniation (M51), soft tissue diseases in shoulder region (M75), mental illness (F00-F99), mood disorders (F30-F39), sleep disorders (G47 or F51) and stress disorders (F43.0-F43.1). In order to designate new cases of diseases (incidence), we used a one year wash out period between January

1st, 2002 and December 31st, 2002.

**Statistical analysis**

The demographic characteristics of the study subjects were expressed as means and standard deviations for continuous variables, or as percentages for categorical variables. Age-standardized rates (ASRs) were calculated by the direct standardization method, using the person-years of NRG officers as the standard population. We calculated person-years as the time after the one year wash out period, January 1st, 2003, to the end of observation or death. In order to calculate person-years by age group (10-year intervals), we divided each individual's person-years by age group and then summed up all person-years for each respective age group.

We calculated hazard ratios (HRs) using the Cox Proportional Hazards regression models with adjustments for age and sex. All analyses were performed using the SAS Enterprise Guide (SAS Institute, Inc., Cary, NC). The results were considered statistically significant when the P value was less than 0.05.

## RESULTS

**Study population**

A total of 860,221 public officers were included in this study and were followed up for a total of 10,017,374 person-years. The overall mean length of follow-up was 11.6 years, and the mean age was 39.55 ± 9.06 years. The total proportion of male to female public officials was 63.7% to 36.3%, respectively. The proportions of different public officials were as follows: police officers, 10.8% (1,073,302 person-years); firefighters, 2.7% (272,189 person-years); PEOs, 39.4% (3,973,058 person-years); and NRG officers, 47.1% (4,698,825 person-years) (Table 1).

Table 1. Characteristics of Public officials

| Characteristics | All officials | Person-year |
|---|---|---|
| Total, number (%) | 860,221 | 10,017,374 |
| Men | 547,808 (63.7) | 6,315,940 |
| Women | 312,413 (36.3) | 3,701,434 |
| Age, mean ± SD, years | 39.55 ± 9.06 | 10,017,374 |
| Type of public officials, number (%) | | |
| Police officer | 92,545 (10.8) | 1,073,302 |
| Firefighter | 23,356 (2.7) | 272,189 |
| Public educational official | 338,857 (39.4) | 3,973,058 |
| National and regional government officer | 405,463 (47.1) | 4,698,825 |

**Incidence rate**

ASRs broken down by sex and public official type are shown in Table 2. Among men with alcoholic liver disease, NRG officers showed the highest ASR for incidence with 1,180.0 cases per 100,000 person-years, followed by police officers (1,177.1), PEOs (1,060.1), and firefighters (857.8). Among women with alcoholic liver disease, firefighters showed the highest ASR with 164.9 cases per 100,000 person-years. Among men with peptic ulcers, the highest ASR was for PEOs (5,245.8), followed by police officers (5,166.8); among women with peptic ulcers, firefighters showed the highest ASR (4,852.4), followed by NRG officers (4,847.5).

The highest incidence of dyslipidemia in both sexes was found among police officers (Men: 2,673.1, Women: 1,115.1), while the lowest incidence was seen in firefighters among men (1,955.5) and PEOs among women (995.3). Among men, the incidence rates for DM and type II DM were highest among NRGs (942.0 and 943.2 respectively), followed by police officers. Among women, DM and type II DM rates were highest among firefighters, followed by police officers. Hypertension rates in men were highest among NRGs (2,457.8) and lowest among firefighters (1,924.2), while in women they were highest among police officers (875.0) and lowest among firefighters (742.0).

For both sexes, angina pectoris and cerebrovascular diseases were highest among police officers.

Acute myocardial infarction in men was highest among police officers, followed by firefighters, while in women the highest rates were observed among firefighters, followed by police officers. Admission due to injury, low back pain, and lumbar disc herniation were highest among firefighters for both sexes, followed by police officers (both sexes). For both sexes, PEOs had the highest rate of mental illness. Finally, for both sexes, firefighters and PEOs had the highest rates of stress disorders, while firefighters and police officers had the highest rates of mood and sleep disorders.

Table 2. Age-standardized cause-specific incidence rate by public officials

| | Men (per 100,000 person-years) | | | | | Women (per 100,000 person-years) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Police | Firefighter | PEO | NRG | IRD | Police | Firefighter | PEO | NRG | IRD |
| Alcoholic liver disease | 1,177.1 | 857.8 | 1,060.1 | 1,180.8 | -3.7 | 161.5 | 166.9 | 141.7 | 163.9 | -2.4 |
| Peptic ulcer | 5,166.8 | 4,869.6 | 5,245.8 | 5,090.6 | 76.2 | 4,598.4 | 4,851.4 | 4,804.4 | 4,847.5 | -249.1 |
| Dyslipidemia | 2,673.1 | 1,955.5 | 2,207.8 | 2,358.9 | 314.2 | 1,115.1 | 1,087.6 | 995.3 | 1,030.1 | 85.0 |
| Diabetes mellitus | 915.2 | 699.4 | 821.2 | 942.0 | -26.8 | 237.3 | 254.9 | 171.0 | 233.9 | 3.4 |
| Type II diabetes mellitus | 918.5 | 703.0 | 822.5 | 943.2 | -24.7 | 238.1 | 254.9 | 170.2 | 233.1 | 5.0 |
| Hypertension | 2,329.6 | 1,924.2 | 2,401.6 | 2,457.8 | -128.2 | 875.0 | 741.0 | 753.8 | 846.8 | 28.2 |
| Angina pectoris | 1,648.3 | 1,186.5 | 1,251.5 | 1,256.7 | 391.6 | 673.5 | 668.5 | 549.1 | 557.0 | 116.5 |
| Acute myocardial infarction | 342.2 | 216.8 | 200.6 | 208.1 | 134.1 | 87.6 | 93.9 | 63.8 | 70.7 | 16.9 |
| Cerebrovascular diseases | 530.5 | 431.4 | 477.8 | 496.7 | 33.8 | 239.3 | 208.5 | 184.3 | 213.1 | 26.2 |
| Admission due to injury | 1,714.2 | 1,854.2 | 1,322.7 | 1,323.3 | 390.9 | 1,008.9 | 1,508.6 | 743.8 | 854.1 | 154.8 |
| Low back pain | 377.3 | 383.4 | 248.4 | 249.4 | 127.9 | 322.6 | 448.6 | 215.7 | 250.0 | 72.6 |
| Lumbar disc herniation | 2,358.1 | 2,552.2 | 2,208.6 | 2,111.6 | 246.5 | 2,113.3 | 2,666.5 | 1,970.3 | 1,986.8 | 126.5 |
| Soft tissue diseases in shoulder region | 3,061.6 | 2,987.1 | 2,928.5 | 2,724.8 | 336.8 | 2,250.8 | 2,761.2 | 2,201.7 | 2,263.3 | -12.5 |
| Mental illness | 3,569.1 | 3,543.4 | 3,627.4 | 3,571.8 | -2.7 | 3,648.5 | 3,861.0 | 3,883.7 | 3,828.7 | -180.2 |
| Mood disorder | 1,273.3 | 1,339.2 | 1,215.6 | 1,262.0 | 11.3 | 1,378.6 | 1,619.9 | 1,375.2 | 1,390.8 | -12.2 |
| Sleep disorder | 1,362.5 | 1,328.0 | 1,285.8 | 1,350.0 | 12.5 | 1,312.1 | 1,547.7 | 1,275.3 | 1,319.5 | -7.4 |
| Stress disorder | 95.1 | 132.6 | 98.6 | 98.5 | -3.4 | 141.6 | 244.3 | 169.6 | 140.0 | 1.6 |

PEO; Public educational official, NRG; National and regional government officer, IRD; Incidence rate difference between police and national or regional government officer

*shoulder disease including adhesive capsulitis of shoulder, rotator cuff syndrome, bicipital tendinitis, calcific tendinitis of shoulder, impingement syndrome of shoulder, bursitis of shoulder and so on

**Differences in hazard ratios for incident diseases by public official type**

To investigate the difference in HRs for each incident disease by the type of public official, we conducted a survival analysis using a Cox proportional model adjusted for age and sex. The results of this analysis are shown in Table 3.

The following results were statistically significant: Police officers (HR: 1.25, 95% confidence interval (CI): 1.23-1.27) had a greater risk of dyslipidemia compared to NRGs; police officers (HR: 1.19, 95% CI: 1.18-1.20) and firefighters (HR: 1.13, 95% CI: 1.11-1.15) had a greater risk of peptic ulcer compared to NRGs, while PEOs (HR: 0.97, 95% CI: 0.96-0.98) had a lower risk. Compared to NRGs, police officers and fire fighters had a greater risk of angina pectoris and acute myocardial infarction (police officer HR: 1.52, 95% CI: 1.49-1.54; HR: 1.84, 95% CI: 1.77-1.92 and firefighter HR: 1.06, 95% CI: 1.02-1.10; HR: 1.21, 95% CI: 1.10-1.32). For cerebrovascular diseases, police officers had a higher HR compared to NRGs, while firefighters and PEOs had lower HRs relative to NRGs. Both firefighters and police officers had a greater risk of admission due to injury, low back pain, lumbar disc herniation, and soft disease in the shoulder region relative to NGRs, with firefighters having the highest HRs for all these conditions. Finally, both firefighters and police officers had a higher risk of mental illnesses, mood disorders, and sleep disorders compared to NRGs, while PEOs had a lower risk of incidence.

Table 3. Differences in hazard ratios for incident diseases by public official type

| | Hazard Ratio (95% CI) | | | |
|---|---|---|---|---|
| | NRG | Police | Firefighter | PEO |
| Alcoholic liver disease | 1(ref.) | 1.10(1.07-1.12) | 0.80(0.76-0.83) | 0.82(0.81-0.83) |
| Peptic ulcer | 1(ref.) | 1.19(1.18-1.20) | 1.13(1.11-1.15) | 0.97(0.96-0.98) |
| Dyslipidemia | 1(ref.) | 1.25(1.23-1.27) | 0.89(0.86-0.92) | 0.89(0.88-0.90) |
| Diabetes mellitus | 1(ref.) | 1.05(1.02-1.08) | 0.73(0.69-0.77) | 0.77(0.75-0.78) |
| Type II diabetes mellitus | 1(ref.) | 1.05(1.03-1.07) | 0.85(0.82-0.88) | 0.85(0.85-0.86) |
| Hypertension | 1(ref.) | 1.05(1.03-1.07) | 0.85(0.82-0.88) | 0.85(0.85-0.86) |
| Angina pectoris | 1(ref.) | 1.52(1.49-1.54) | 1.06(1.02-1.10) | 0.93(0.92-0.94) |
| Acute myocardial infarction | 1(ref.) | 1.84(1.77-1.92) | 1.21(1.10-1.32) | 0.89(0.86-0.92) |
| Cerebrovascular diseases | 1(ref.) | 1.36(1.31-1.40) | 0.97(0.90-1.04) | 0.87(0.85-0.89) |
| Admission due to injury | 1(ref.) | 1.41(1.39-1.43) | 1.58(1.53-1.63) | 0.95(0.93-0.96) |
| Low back pain | 1(ref.) | 1.47(1.41-1.52) | 1.52(1.43-1.63) | 0.96(0.93-0.99) |
| Lumbar disc herniation | 1(ref.) | 1.20(1.18-1.22) | 1.43(1.39-1.46) | 1.00(0.99-1.01) |
| Soft tissue diseases in shoulder region | 1(ref.) | 1.20(1.18-1.21) | 1.26(1.24-1.29) | 1.00(0.99-1.01) |
| Mental illness | 1(ref.) | 1.07(1.06-1.09) | 1.11(1.08-1.13) | 0.98(0.98-0.99) |
| Mood disorder | 1(ref.) | 1.03(1.01-1.05) | 1.12(1.08-1.16) | 0.96(0.95-0.97) |
| Sleep disorder | 1(ref.) | 1.06(1.04-1.08) | 1.04(1.01-1.08) | 0.94(0.92-0.95) |
| Stress disorder | 1(ref.) | 1.00(0.93-1.07) | 1.40(1.26-1.56) | 1.11(1.07-1.15) |

PEO; Public educational official, NRG; National and regional government officer, CI; confidence interval, ref; reference. All models adjusted for age and sex.

## DISCUSSION

This is the first Korean population-based analysis of disease incidence among public officials using nation-wide data and is based on one of the largest cohorts used for this type of study to date.

Overall, we found that police officers and fire fighters had higher incidences of a range of diseases, compared to NRGs. Police officers also had higher hazard ratios for all measured diseases, except for stress disorders, when compared to NRGs. Similarly, when compared to NRGs, firefighters also had higher hazard ratios for peptic ulcer, angina pectoris, acute myocardial infarction, admissions due to injury, low back pain, lumbar disc herniation, soft tissue diseases involving the shoulder region, mental illness, mood disorders, sleep disorders, and stress disorders. Finally, the PEOs had a higher hazard ratio for stress disorders when compared to NRGs.

The most prominent HRs in this study were observed among police officers with regards to angina pectoris, acute myocardial infarction, and cerebrovascular diseases. Among men, police officers had the highest incidences of all the three diseases. While women police officers had the highest incidences of angina pectoris and cerebrovascular disease, they had the second highest incidence of acute myocardial infarction. Even after adjusting for age and sex, police officers continued to have higher incidences of cerebrocardiovascular ailments with significantly high hazard ratios for all conditions, compared to NRGs.

A number of western studies have found that police officers had several risk factors for CVD, including personal factors such as smoking, alcohol consumption, hypertension, obesity, DM, or dyslipidemia, and work-related factors, such as night duties, high job stress, workplace violence, and long work shifts.[10-13] Our research shows that the higher HRs among police officers compared to NRGs for other diseases such as alcoholic liver disease, DM, and dyslipidemia were also associated with these risk factors suggesting that these are serious risk factors. We did not collect socioeconomic or demographic variables, except for age and sex, and therefore, were unable to ascertain the presence or absence of these risk factors among Korean public officers.

In view of the high incidence of cerebrocardiovascular diseases among police officers, it is important to establish preventative measures to reduce their risk for these diseases. We assumed that

the distribution of socioeconomic variables, such as education level, income, or regional characteristics would also be comparable among public officers, due to regulations on the working conditions and employment packages for these public officers. Therefore, the higher HR for CVDs among police officers may be associated with working conditions, such as long working hours, night work and poor sleep, or job-related stress. Several studies have suggested a correlation between shift work and cardiovascular disease or other negative health outcomes.[14 15] A meta-analysis found longer working hours were associated with cerebrocardiovascular diseases.[16] A study involving police officers in Buffalo, New York, found that 28% of police officers worked afternoon shifts and 22% worked night shifts. The study also found that 54% of all police officers suffered from poor sleep quality: 44% for day shifts, 60% for afternoon shifts, and 69% for night shifts.[17] Furthermore, police officers deal with a variety of civil complaints, increasing their exposure to violent situations which increase the job-related stress. Shift work, night shifts, and higher workloads are more prevalent among both police officers and firefighters than among NRGs and education officials. This is consistent with our findings of higher CVD HRs in police officers and firefighters.

This study also found higher HRs for low back pain, lumbar disc herniation, and soft tissue diseases in the shoulder region among the firefighters, compared to NRGs. These findings coincide with previous research which found that low back pain was the most common work-related musculoskeletal disorder among firefighters in Korea.[18] Additionally, one study suggested that a primary contributing risk factor for low back pain in firefighters was stress.[19] This conclusion is supported by our findings, which show that firefighters in Korea are at a significantly higher risk for stress disorders than NRGs. A common hypothesis regarding the association between stress and injury is that the severity of muscle strain and, therefore, the likelihood of injury, increases with stress which in turn can further heighten the awareness of the musculoskeletal symptoms or hamper their management.[20 21] Firefighters are required to move heavy equipment and engage in demanding physical activity as part of their work. This, combined with higher levels of stress, may explain the

high levels of back pain among firefighters.

Furthermore, our research found that compared to NRGs, police officers also had higher HRs for low back pain, lumbar disc herniation, and soft tissue diseases of the shoulder. Police officers and firefighters were both found to have significantly high HRs for hospital admissions due to injury, with firefighters having the highest HRs compared to NRGs. This coincides with the findings of a study of American emergency responders which found high rates of injury in both firefighters (7.4 cases per 100 full-time equivalent firefighters) and police officers (8.5 cases per 100 full-time equivalent police officers).[22] As previously observed, police officers and firefighters are exposed to a variety of environmental, physical, and chemical hazards leading to relatively higher rates of injury.[4-6]

Police work and firefighting are generally regarded as high-risk and high-stress occupations. Firefighters and police officers spend significant time working outside their workplaces and managing unpredictable and urgent situations. These factors contribute to the high-stress work environment reported by a number of studies.[23] It is generally accepted that high levels of stress affect all areas of health and that stress can exacerbate pre-existing ailments. An American study found that stress was a potential factor for negative health outcomes among police officers.[24] Additionally, several studies have noted that factors, such as a lack of sleep, job insecurity, workplace conflicts, physical environment, levels of alcohol consumption, and organization systems, contributed to the stress of firefighters.[25 26] Other studies have suggested that the inherent risk associated with the job, high workloads, shift work, and the police administrative system contribute to the stress experienced by police officers. This is consistent with our finding of high HRs for a considerable number of diseases among police officers and firefighters.[24 27]

Both police officers and firefighters were found to have similar high hazard ratios for cerebrocardiovascular and musculoskeletal diseases, as well as for mental, mood, and sleep disorders. However, police officers, unlike firefighters, did not have a significantly higher hazard ratio for stress

disorders compared to NRGs. This could be due to the organizational culture of police work in Korea, and more research is required in this area. In Korea, candidates for jobs as police officers need to pass a very competitive official examination and mental health checkup, including a clinical psychology test. Once selected, the police officers may feel pressured to maintain their psychological health to maintain their careers and for promotions within the workplace, which can lead to underreporting of psychological diseases, such as stress disorders. An anonymous study found that the prevalence of stress related psychological symptoms, particularly post-traumatic stress disorder (PTSD), remains high among police officers in Korea. According to this study, 41.1% of a study population of 3,000 South Korean police officers were at high risk for developing PTSD.[7]

Finally, another interesting finding of our study was the higher HR for stress disorders among the PEOs compared to NRGs. For all other diseases measured in our study, the HRs in PEOs were lower than the reference or were not significant. This suggests the presence of specific psychological stressors in public education work. PEOs usually are required to care for students and their parents, and the education culture in Korea is competitive, with suicide among adolescents representing a significant social problem. Therefore, the emotional demands could potentially be severe, aggravating the distress.

There were a number of limitations in our study. First, because our study used only ICD-10 codes and procedure codes to identify each disease, incidences could be overestimated. However, incidences of some diseases such as mental disorders could also be underestimated due to underreporting in response to workplace culture. For example, some police officers may feel reluctant to receive treatments for a variety of reasons, including fear of losing eligibility for promotions or fear of losing their jobs. Another limitation was that the public officials were divided into four categories and compared. It is likely that there are additional subgroups within each category which may show different rates of incidence. For example, while we compared firefighters and NRGs, we did not compare different types of firefighting work to each other. We recommend more research on the

specific characteristics, risk factors, and incidences of diseases for specific subgroups within each field.

**Contributor ship statement**

IK and SH planned the study. MH and SP analyzed the data. JHP abstracted the variables and established the dataset. MH drafted the article. All authors interpreted the results, critically revised the article and approved the final version.

**Competing interests**

The authors declare that they have no competing interests.

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**Data sharing statement**

Extra data is available by emailing Inah Kim.

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STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | page | Recommendation |
|---|---|---|---|
| **Title and abstract** | 1 | 2 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract |
| | | 2 | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found |
| | | | **Introduction** |
| Background/rationale | 2 | 4 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | 4 | State specific objectives, including any prespecified hypotheses |
| | | | **Methods** |
| Study design | 4 | 5 | Present key elements of study design early in the paper |
| Setting | 5 | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | 5 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | 5 | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 | 5 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8* | 5 | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group |
| Bias | 9 | 5 | Describe any efforts to address potential sources of bias |
| Study size | 10 | 5 | Explain how the study size was arrived at |
| Quantitative variables | 11 | 5 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods | 12 | 6 | (*a*) Describe all statistical methods, including those used to control for confounding |
| | | 6 | (*b*) Describe any methods used to examine subgroups and interactions |
| | | - | (*c*) Explain how missing data were addressed |
| | | 6 | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | - | (*e*) Describe any sensitivity analyses |

Continued on next page

| | | | |
|---|---|---|---|
| | | **Results** | |
| Participants | 13* | 6 | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| | | - | (b) Give reasons for non-participation at each stage |
| | | - | (c) Consider use of a flow diagram |
| Descriptive data | 14* | 6-7 | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| | | - | (b) Indicate number of participants with missing data for each variable of interest |
| | | 6-7 | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15* | *7-9* | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | - | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | - | *Cross-sectional study*—Report numbers of outcome events or summary measures |
| Main results | 16 | 7-11 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included |
| | | - | (*b*) Report category boundaries when continuous variables were categorized |
| | | 9 | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | - | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| | | **Discussion** | |
| Key results | 18 | 11-12 | Summarise key results with reference to study objectives |
| Limitations | 19 | 15 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | 12-14 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | 15 | Discuss the generalisability (external validity) of the study results |
| | | **Other information** | |
| Funding | 22 | 16 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

# Do police officers and firefighters have a higher risk of disease than other public officers?: a 13-year nationwide cohort study



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# Do police officers and firefighters have a higher risk of disease than other public officers?: a 13-year nationwide cohort study

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**Keywords:** public officer, police officer, firefighter, cohort, hazard ratios

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## ABSTRACT

**Objectives:** The work of public officers involves repeated and long-term exposure to heavy workloads, high job strain, and workplace violence, all of which negatively impact physical and mental health. This study aimed to evaluate and compare the incidences of diseases among different categories of public officers in Korea, in order to further understand the health risks associated with these occupations.

**Design:** A cohort study using the National Health Insurance data.

**Participants:** We collated claims data between 2002 and 2014 for 860,221 public officers.

**Primary and secondary outcome measures:** Age-standardized rates were calculated using the direct standardization method, and hazard ratios (HRs) were calculated using the Cox Proportional Hazard regression models.

**Results:** Overall, we found that police officers and firefighters had a higher incidence of a range of diseases when compared to national and regional government officers (NRG). The most prominent HRs were observed among police officers for angina pectoris (HR: 1.52, 95% confidence interval [CI]: 1.49-1.54), acute myocardial infarction (HR: 1.84, 95% CI: 1.77-1.92), and cerebrovascular disease (HR: 1.36, 95% CI: 1.31-1.40). Firefighters were more susceptible to physical ailments and were at a significantly higher risk for traumatic stress disorders (HR: 1.40, 95% CI: 1.26-1.56) than NRGs.

**Conclusion:** Compared to NRGs, police officers had higher HRs for all measured diseases, except for traumatic stress disorders. While firefighters had higher HRs for almost all diseases examined, public education officers had a higher HR for traumatic stress disorders, when compared to NRGs.

**Keywords:** public officer, police officer, firefighter, cohort, hazard ratios

## Strengths and limitations of the study

- This study is the largest cohort study based on nationwide follow-up data including all

Korean public officers.

- We have included a comprehensive set of various health problems potentially related to job as well as cardiovascular disorders.
- A limitation of the study is that incidences of some diseases could have been underestimated or overestimated because our study used claims data.

## INTRODUCTION

The broad category of "public officers" comprises of individuals in a range of government-overseen positions and public sector employment. As a percentage of total employment across the Organization for Economic Co-operation and Development countries, the employment rate for public officers rose slightly between 2009 and 2013, from 21.1% to 21.3%.[1] In Korea and in many developed countries, positions at public offices are regarded as prestigious occupations, albeit uniquely stressful.[2 3] The work of public officers is fundamental to the maintenance of society, and it is therefore important to understand any afflictions or ailments associated with this category of individuals.

The work of public officers involves repeated and long-term exposure to heavy workloads, high job strain, or workplace violence, all of which have a potentially negative impact on physical and mental health. This is particularly true for police officers and firefighters who, in addition to workplace stress also deal with physical, chemical, biological, and psychological hazards while on duty.[4-7] For example, in the USA in particular, studies have shown police officers to have a shorter life expectancy than the general population.[8] For the reasons above, research shows that firefighters and police officers have higher mortality and morbidity rates compared to the general population, particularly for cardiovascular diseases (CVD). The incidence of cardiovascular diseases has been reported to be higher among police officers than in the general civilian population (31.4% vs. 18.4%).[9] Similarly, a study involving American firefighters found that CVD was the primary cause of death in the line of duty, accounting for approximately 45% of the on-duty fatalities.[10]

Considerable research on the health of public officers has been conducted in many Western countries, focusing mainly on cardiovascular diseases, chronic diseases, and mental disorders. However, comparable research in Asian countries is scarce. Using a large, nationwide dataset based on insurance claims, this study aimed to evaluate the differences in the incidence rates of specific diseases among different categories of public officers in Korea, in order to develop an understanding of health risks associated with these occupations.

## SUBJECTS AND METHODS

### Data Source

The study population consisted of public officers, including police officers, firefighters, public educational officers (PEOs), and national and regional government officers (NRGs), with claims data between 2002 and 2014, which was collected from the National Health Insurance Service (NHIS) using their customized database service.

The Korean National Health Insurance (NHI) program covers almost 100% of the Korean population and the database contains information on demographic characteristics, hospital admissions, ambulatory care, principal diagnosis, comorbidities (using the International Classification of Disease's 10th revision (ICD-10)), procedures, and prescriptions regarding all inpatients and outpatients. The date of death was ascertained from death certificates collected from the Korean National Statistical Office. Patients who were alive on December 31st, 2014, or after were not considered deceased for the purposes of this study.

### Study subjects and identification

We identified 860,221 public officers as the study population based on occupation codes. We then collected all patient claims data between 2002 and 2014, and dates of death, through the NHIS customized database service. We defined each disease based on its ICD-10 and procedure codes. We identified patients with alcoholic liver disease (ICD-10 K70), peptic ulcer (K25-K28), dyslipidemia (E78 with prescription), diabetes mellitus (DM) (E10-E14 with prescription), type II DM (E11), hypertension (I10-I15 or I30 with prescription), angina pectoris (I20), acute myocardial infarction (I21), cerebrovascular diseases (I63), admission due to injury (S00-T98 and document code of 'hospital admission'), lower back pain (M543-M545 and document code of 'hospital admission'), lumbar disc herniation (M51), soft tissue diseases in shoulder region (M75), mental illness (F00-F99), mood disorders (F30-F39), sleep disorders (G47 or F51) and traumatic stress disorders (F43.0-F43.1).

In order to designate new cases of diseases (incidence), we used a one year washout period between January 1st, 2002 and December 31st, 2002.

### Statistical analysis

The demographic characteristics of the study subjects were expressed as means and standard deviations for continuous variables, or as percentages for categorical variables. Age-standardized rates (ASRs) were calculated by the direct standardization method, using the person-years of NRG officers as the standard population. We calculated person-years as the time after the one year washout period, January 1st, 2003, to the end of observation or death. In order to calculate person-years by age group (10-year intervals), we divided each individual's person-years by age group and then summed up all person-years for each respective age group.

We calculated hazard ratios (HRs) using the Cox Proportional Hazards regression models with adjustments for age and sex. All analyses were performed using the SAS Enterprise Guide (SAS Institute, Inc., Cary, NC). The results were considered statistically significant when the P value was less than 0.05.

## RESULTS

### Study population

A total of 860,221 public officers were included in this study and were followed up for a total of 10,017,374 person-years. The overall mean length of follow-up was 11.6 years, and the mean age was 39.55 ± 9.06 years. The total proportion of male to female public officers was 63.7% to 36.3%, respectively. The proportions of different public officers were as follows: police officers, 10.8% (1,073,302 person-years); firefighters, 2.7% (272,189 person-years); PEOs, 39.4% (3,973,058 person-years); and NRG officers, 47.1% (4,698,825 person-years) (Table 1).

Table 1. Characteristics of Public officers

| Characteristics | All officers | Person-year |
|---|---|---|
| Total, number (%) | 860,221 | 10,017,374 |
| Men | 547,808 (63.7) | 6,315,940 |
| Women | 312,413 (36.3) | 3,701,434 |
| Age, mean ± SD, years | 39.55 ± 9.06 | 10,017,374 |
| Type of public officers, number (%) | | |
| Police officer | 92,545 (10.8) | 1,073,302 |
| Firefighter | 23,356 (2.7) | 272,189 |
| Public educational officer | 338,857 (39.4) | 3,973,058 |
| National and regional government officer | 405,463 (47.1) | 4,698,825 |

**Incidence rate**

ASRs broken down by sex and public officer type are shown in Table 2. Among men with the alcoholic liver disease, NRG officers showed the highest ASR for incidence with 1,180.0 cases per 100,000 person-years, followed by police officers (1,177.1), PEOs (1,060.1), and firefighters (857.8). Among women with the alcoholic liver disease, firefighters showed the highest ASR with 164.9 cases per 100,000 person-years. Among men with peptic ulcers, the highest ASR was for PEOs (5,245.8), followed by police officers (5,166.8); among women with peptic ulcers, firefighters showed the highest ASR (4,852.4), followed by NRG officers (4,847.5).

The highest incidence of dyslipidemia in both sexes was found among police officers (Men: 2,673.1, Women: 1,115.1), while the lowest incidence was seen in firefighters among men (1,955.5) and PEOs among women (995.3). Among men, the incidence rates for DM and type II DM were highest among NRGs (942.0 and 943.2 respectively), followed by police officers. Among women, DM and type II DM rates were highest among firefighters, followed by police officers. Hypertension rates in men were highest among NRGs (2,457.8) and lowest among firefighters (1,924.2), while in women they were highest among police officers (875.0) and lowest among firefighters (742.0).

For both sexes, angina pectoris and cerebrovascular diseases were highest among police officers. Acute myocardial infarction in men was highest among police officers, followed by firefighters, while in women the highest rates were observed among firefighters, followed by police officers. Admission due to injury, lower back pain, and lumbar disc herniation were highest among firefighters for both sexes, followed by police officers (both sexes). For both sexes, PEOs had the highest rate of mental illness. Finally, for both sexes, firefighters and PEOs had the highest rates of traumatic stress disorders, while firefighters and police officers had the highest rates of mood and sleep disorders.

Table 2. Age-standardized cause-specific incidence rate by public officers

| | Men (per 100,000 person-years) | | | | | Women (per 100,000 person-years) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Police | Firefighter | PEO | NRG | IRD | Police | Firefighter | PEO | NRG | IRD |
| Alcoholic liver disease | 1,177.1 | 857.8 | 1,060.1 | 1,180.8 | -3.7 | 161.5 | 161.9 | 141.7 | 163.9 | -2.4 |
| Peptic ulcer | 5,166.8 | 4,869.6 | 5,245.8 | 5,090.6 | 76.2 | 4,598.4 | 4,851.4 | 4,804.4 | 4,847.5 | -249.1 |
| Dyslipidemia | 2,673.1 | 1,955.5 | 2,207.8 | 2,358.9 | 314.2 | 1,115.1 | 1,087.6 | 995.3 | 1,030.1 | 85.0 |
| Diabetes mellitus | 915.2 | 699.4 | 821.2 | 942.0 | -26.8 | 237.3 | 251.9 | 171.0 | 233.9 | 3.4 |
| Type II diabetes mellitus | 918.5 | 703.0 | 822.5 | 943.2 | -24.7 | 238.1 | 253.9 | 170.2 | 233.1 | 5.0 |
| Hypertension | 2,329.6 | 1,924.2 | 2,401.6 | 2,457.8 | -128.2 | 875.0 | 741.0 | 753.8 | 846.8 | 28.2 |
| Angina pectoris | 1,648.3 | 1,186.5 | 1,251.5 | 1,256.7 | 391.6 | 673.5 | 668.5 | 549.1 | 557.0 | 116.5 |
| Acute myocardial infarction | 342.2 | 216.8 | 200.6 | 208.1 | 134.1 | 87.6 | 93.9 | 63.8 | 70.7 | 16.9 |
| Cerebrovascular diseases | 530.5 | 431.4 | 477.8 | 496.7 | 33.8 | 239.3 | 205.5 | 184.3 | 213.1 | 26.2 |
| Admission due to injury | 1,714.2 | 1,854.2 | 1,322.7 | 1,323.3 | 390.9 | 1,008.9 | 1,508.6 | 743.8 | 854.1 | 154.8 |
| Lower back pain | 377.3 | 383.4 | 248.4 | 249.4 | 127.9 | 322.6 | 448.6 | 215.7 | 250.0 | 72.6 |
| Lumbar disc herniation | 2,358.1 | 2,552.2 | 2,208.6 | 2,111.6 | 246.5 | 2,113.3 | 2,666.5 | 1,970.3 | 1,986.8 | 126.5 |
| Soft tissue diseases in shoulder region | 3,061.6 | 2,987.1 | 2,928.5 | 2,724.8 | 336.8 | 2,250.8 | 2,761.2 | 2,201.7 | 2,263.3 | -12.5 |
| Mental illness | 3,569.1 | 3,543.4 | 3,627.4 | 3,571.8 | -2.7 | 3,648.5 | 3,864.0 | 3,883.7 | 3,828.7 | -180.2 |
| Mood disorder | 1,273.3 | 1,339.2 | 1,215.6 | 1,262.0 | 11.3 | 1,378.6 | 1,619.9 | 1,375.2 | 1,390.8 | -12.2 |
| Sleep disorder | 1,362.5 | 1,328.0 | 1,285.8 | 1,350.0 | 12.5 | 1,312.1 | 1,547.7 | 1,275.3 | 1,319.5 | -7.4 |
| Traumatic stress disorder | 95.1 | 132.6 | 98.6 | 98.5 | -3.4 | 141.6 | 244.3 | 169.6 | 140.0 | 1.6 |

PEO; Public educational officer, NRG; National and regional government officer, IRD; Incidence rate difference between police and national or regional government officer

*shoulder disease including adhesive capsulitis of shoulder, rotator cuff syndrome, bicipital tendinitis, calcific tendinitis of shoulder, impingement syndrome of shoulder, bursitis of shoulder and so on

**Differences in hazard ratios for incident diseases by public officer type**

To investigate the difference in HRs for each incident disease by the type of public officer, we conducted a survival analysis using a Cox proportional model adjusted for age and sex. The results of this analysis are shown in Table 3.

The following results were statistically significant: Police officers (HR: 1.25, 95% confidence interval (CI): 1.23-1.27) had a greater risk of dyslipidemia compared to NRGs; police officers (HR: 1.19, 95% CI: 1.18-1.20) and firefighters (HR: 1.13, 95% CI: 1.11-1.15) had a greater risk of peptic ulcer compared to NRGs, while PEOs (HR: 0.97, 95% CI: 0.96-0.98) had a lower risk. Compared to NRGs, police officers and firefighters had a greater risk of angina pectoris and acute myocardial infarction (police officer HR: 1.52, 95% CI: 1.49-1.54; HR: 1.84, 95% CI: 1.77-1.92 and firefighter HR: 1.06, 95% CI: 1.02-1.10; HR: 1.21, 95% CI: 1.10-1.32). For cerebrovascular diseases, police officers had a higher HR compared to NRGs, while firefighters and PEOs had lower HRs relative to NRGs. Both firefighters and police officers had a greater risk of admission due to injury, lower back pain, lumbar disc herniation, and soft disease in the shoulder region relative to NRGs, with firefighters having the highest HRs for all these conditions. Finally, both firefighters and police officers had a higher risk of mental illnesses, mood disorders, and sleep disorders compared to NRGs, while PEOs had a lower risk of incidence.

Table 3. Differences in hazard ratios for incident diseases by public officer type

| | Hazard Ratio (95% CI) | | | |
|---|---|---|---|---|
| | NRG | Police | Firefighter | PEO |
| Alcoholic liver disease | 1(ref.) | 1.10(1.07-1.12) | 0.80(0.76-0.83) | 0.82(0.81-0.83) |
| Peptic ulcer | 1(ref.) | 1.19(1.18-1.20) | 1.13(1.11-1.15) | 0.97(0.96-0.98) |
| Dyslipidemia | 1(ref.) | 1.25(1.23-1.27) | 0.89(0.86-0.92) | 0.89(0.88-0.90) |
| Diabetes mellitus | 1(ref.) | 1.05(1.02-1.08) | 0.73(0.69-0.77) | 0.77(0.75-0.78) |
| Type II diabetes mellitus | 1(ref.) | 1.05(1.03-1.07) | 0.85(0.82-0.88) | 0.85(0.85-0.86) |
| Hypertension | 1(ref.) | 1.05(1.03-1.07) | 0.85(0.82-0.88) | 0.85(0.85-0.86) |
| Angina pectoris | 1(ref.) | 1.52(1.49-1.54) | 1.06(1.02-1.10) | 0.93(0.92-0.94) |
| Acute myocardial infarction | 1(ref.) | 1.84(1.77-1.92) | 1.21(1.10-1.32) | 0.89(0.86-0.92) |
| Cerebrovascular diseases | 1(ref.) | 1.36(1.31-1.40) | 0.97(0.90-1.04) | 0.87(0.85-0.89) |
| Admission due to injury | 1(ref.) | 1.41(1.39-1.43) | 1.58(1.53-1.63) | 0.95(0.93-0.96) |
| Lower back pain | 1(ref.) | 1.47(1.41-1.52) | 1.52(1.43-1.63) | 0.96(0.93-0.99) |
| Lumbar disc herniation | 1(ref.) | 1.20(1.18-1.22) | 1.43(1.39-1.46) | 1.00(0.99-1.01) |
| Soft tissue diseases in shoulder region | 1(ref.) | 1.20(1.18-1.21) | 1.26(1.24-1.29) | 1.00(0.99-1.01) |
| Mental illness | 1(ref.) | 1.07(1.06-1.09) | 1.11(1.08-1.13) | 0.98(0.98-0.99) |
| Mood disorder | 1(ref.) | 1.03(1.01-1.05) | 1.12(1.08-1.16) | 0.96(0.95-0.97) |
| Sleep disorder | 1(ref.) | 1.06(1.04-1.08) | 1.04(1.01-1.08) | 0.94(0.92-0.95) |
| Traumatic stress disorder | 1(ref.) | 1.00(0.93-1.07) | 1.40(1.26-1.56) | 1.11(1.07-1.15) |

PEO; Public educational officer, NRG; National and regional government officer, CI; confidence interval, ref; reference. All models adjusted for age and sex.

## DISCUSSION

This is the first Korean population-based analysis of disease incidence among public officers using nation-wide data and is based on one of the largest cohorts used for this type of study to date.

Overall, we found that police officers and firefighters had higher incidences of a range of diseases, compared to NRGs. Police officers also had higher hazard ratios for all measured diseases, except for traumatic stress disorders, when compared to NRGs. Similarly, when compared to NRGs, firefighters also had higher hazard ratios for peptic ulcer, angina pectoris, acute myocardial infarction, admissions due to injury, lower back pain, lumbar disc herniation, soft tissue diseases involving the shoulder region, mental illness, mood disorders, sleep disorders, and traumatic stress disorders. Finally, the PEOs had a higher hazard ratio for traumatic stress disorders when compared to NRGs.

The most prominent HRs in this study were observed among police officers with regards to angina pectoris, acute myocardial infarction, and cerebrovascular diseases. Among men, police officers had the highest incidences of all the three diseases. While women police officers had the highest incidences of angina pectoris and cerebrovascular disease, they had the second highest incidence of acute myocardial infarction. Even after adjusting for age and sex, police officers continued to have higher incidences of cerebro-cardiovascular ailments with significantly high hazard ratios for all conditions, compared to NRGs.

A number of western studies have found that police officers had several risk factors for CVD, including personal factors such as smoking, alcohol consumption, hypertension, obesity, DM, or dyslipidemia, and work-related factors, such as night duties, high job stress, workplace violence, and long work shifts.[11-14] Our research shows that the higher HRs among police officers compared to NRGs for other diseases such as alcoholic liver disease, DM, and dyslipidemia were also associated with these risk factors suggesting that these are serious risk factors. We did not collect socioeconomic or demographic variables, except for age and sex, and therefore, were unable to ascertain the presence or absence of these risk factors among Korean public officers.

In view of the high incidence of cerebro-cardiovascular diseases among police officers, it is important to establish preventative measures to reduce their risk for these diseases. We assumed that the distribution of socioeconomic variables, such as education level, income, or regional

characteristics would also be comparable among public officers, due to regulations on the working conditions and employment packages for these public officers. Therefore, the higher HR for CVD among police officers may be associated with working conditions, such as long working hours, night work and poor sleep, or job-related stress. Several studies have suggested a correlation between shift work and cardiovascular disease or other negative health outcomes.[15 16] A meta-analysis found longer working hours were associated with cerebro-cardiovascular diseases.[17] A study involving police officers in Buffalo, New York, found that 28% of police officers worked afternoon shifts and 22% worked night shifts. The study also found that 54% of all police officers suffered from poor sleep quality: 44% for day shifts, 60% for afternoon shifts, and 69% for night shifts.[18] Furthermore, police officers deal with a variety of civil complaints, increasing their exposure to violent situations which increase the job-related stress. Shift work, night shifts, and higher workloads are more prevalent among both police officers and firefighters than among NRGs and education officers. This is consistent with our findings of higher CVD HRs in police officers and firefighters.

This study also found higher HRs for lower back pain, lumbar disc herniation, and soft tissue diseases in the shoulder region among the firefighters, compared to NRGs. These findings coincide with previous research which found that lower back pain was the most common work-related musculoskeletal disorder among firefighters in Korea.[19] Additionally, one study suggested that a primary contributing risk factor for lower back pain in firefighters was stress.[20] A common hypothesis regarding the association between stress and injury is that the severity of muscle strain and, therefore, the likelihood of injury, increases with stress which in turn can further heighten the awareness of the musculoskeletal symptoms or hamper their management.[21 22] Firefighters are required to move heavy equipment and engage in demanding physical activity as part of their work. This, combined with higher levels of stress, may explain the high levels of back pain among firefighters. Additionally, firefighters are often not fit enough to deal with the physical demands of emergency situations. Some studies have suggested that physical check-up programs similar to those used for athletes may be necessary to achieve a higher $VO_2$ max and to improve the overall

health.[23-26]

Furthermore, our research found that compared to NRGs, police officers also had higher HRs for lower back pain, lumbar disc herniation, and soft tissue diseases of the shoulder. Police officers and firefighters were both found to have significantly high HRs for hospital admissions due to injury, with firefighters having the highest HRs compared to NRGs. This coincides with the findings of a study of American emergency responders which found high rates of injury in both firefighters (7.4 cases per 100 full-time equivalent firefighters) and police officers (8.5 cases per 100 full-time equivalent police officers).[27] As previously observed, police officers and firefighters are exposed to a variety of environmental, physical, and chemical hazards leading to relatively higher rates of injury.[4-6]

Police work and firefighting are generally regarded as high-risk and high-stress occupations. Firefighters and police officers spend significant time working outside their workplaces and managing unpredictable and urgent situations. These factors contribute to the high-stress work environment reported by a number of studies.[28] It is generally accepted that high levels of stress affect all areas of health and that stress can exacerbate pre-existing ailments. An American study found that stress was a potential factor for negative health outcomes among police officers.[8] Additionally, several studies have noted that factors, such as a lack of sleep, job insecurity, workplace conflicts, physical environment, levels of alcohol consumption, and organization systems, contributed to the stress of firefighters.[29 30] Other studies have suggested that the inherent risk associated with the job, high workloads, shift work, and the police administrative system contribute to the stress experienced by police officers. This is consistent with our finding of high HRs for a considerable number of diseases among police officers and firefighters.[8 31]

Both police officers and firefighters were found to have similar high hazard ratios for cerebrocardiovascular and musculoskeletal diseases, as well as for mental, mood, and sleep disorders. However, police officers, unlike firefighters, did not have a significantly higher hazard ratio for traumatic stress disorders compared to NRGs. This could be due to the organizational culture of police

work in Korea, and more research is required in this area. In Korea, candidates for jobs as police officers need to pass a very competitive official examination and mental health checkup, including a clinical psychology test. Once selected, the police officers may feel pressured to maintain their psychological health to maintain their careers and for promotions within the workplace, which can lead to underreporting of psychological diseases, such as traumatic stress disorders. An anonymous study found that the prevalence of stress-related psychological symptoms, particularly post-traumatic stress disorder (PTSD), remains high among police officers in Korea. According to this study, 41.1% of a study population of 3,000 South Korean police officers were at high risk for developing PTSD.[7]

Finally, another interesting finding of our study was the higher HR for traumatic stress disorders among the PEOs compared to NRGs. For all other diseases measured in our study, the HRs in PEOs were lower than the reference or were not significant. PEOs usually are required to care for students and their parents, and the education culture in Korea is competitive, with suicide among adolescents representing a significant social problem. Therefore, the emotional demands could be severe or distressing for the PEOs, and could potentially produce traumatic effects.

There were a number of limitations in our study. First, because our study used only ICD-10 codes and procedure codes to identify each disease, incidences could be overestimated. However, incidences of some diseases such as mental disorders could also be underestimated due to underreporting in response to workplace culture. For example, some police officers may feel reluctant to receive treatments for a variety of reasons, including fear of losing eligibility for promotions or fear of losing their jobs. Another limitation was that the public officers were divided into four categories and compared. It is likely that there are additional subgroups within each category which may show different rates of incidence. For example, while we compared firefighters and NRGs, we did not compare different types of firefighting work to each other. Likewise, the category ‘police officer’ includes very different sub-fields of police work each with different sets of risk factors. For instance, the most common health risk for the majority of police officers is low physical activity due to the sedentary nature of their work, yet this is not true for the special forces.[32 33] Additionally, this

study did not account for the regional differences, which may also influence the risk of death or injury.[34-36] Lastly, a final limitation of our study could be its inability to account for a "healthy worker effect." Compared to other public officers, firefighters and police officers have to meet more stringent health-related selection criteria due to the physical demands of their job. Therefore, police officers and firefighters may depending on their sub-field of work, be in better general health than the average population, including other public officers. Similarly, comparing firefighters and police officers to other public officers may lead to an under-appreciation of the severity of risk factors that they encounter. We recommend more research on the specific characteristics, risk factors, and incidences of diseases for specific subgroups within each field.

**Contributor ship statement**

IK and SH planned the study. MH and SP analyzed the data. JHP abstracted the variables and established the dataset. MH drafted the article. All authors interpreted the results, critically revised the article and approved the final version.

**Competing interests**

The authors declare that they have no competing interests.

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**Data sharing statement**

Extra data is available by emailing Inah Kim.

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STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | page | Recommendation |
|---|---|---|---|
| **Title and abstract** | 1 | 2 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract |
| | | 2 | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found |
| | | | **Introduction** |
| Background/rationale | 2 | 4 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | 4 | State specific objectives, including any prespecified hypotheses |
| | | | **Methods** |
| Study design | 4 | 5 | Present key elements of study design early in the paper |
| Setting | 5 | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | 5 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | 5 | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 | 5 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8* | 5 | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group |
| Bias | 9 | 5 | Describe any efforts to address potential sources of bias |
| Study size | 10 | 5 | Explain how the study size was arrived at |
| Quantitative variables | 11 | 5 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods | 12 | 6 | (*a*) Describe all statistical methods, including those used to control for confounding |
| | | 6 | (*b*) Describe any methods used to examine subgroups and interactions |
| | | - | (*c*) Explain how missing data were addressed |
| | | 6 | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | - | (*e*) Describe any sensitivity analyses |

Continued on next page

| | | | |
|---|---|---|---|
| | | **Results** | |
| Participants | 13* | 6 | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| | | - | (b) Give reasons for non-participation at each stage |
| | | - | (c) Consider use of a flow diagram |
| Descriptive data | 14* | 6-7 | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| | | - | (b) Indicate number of participants with missing data for each variable of interest |
| | | 6-7 | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15* | 7-9 | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | - | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | - | *Cross-sectional study*—Report numbers of outcome events or summary measures |
| Main results | 16 | 7-11 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included |
| | | - | (*b*) Report category boundaries when continuous variables were categorized |
| | | 9 | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | - | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| | | **Discussion** | |
| Key results | 18 | 11-12 | Summarise key results with reference to study objectives |
| Limitations | 19 | 15 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | 12-14 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | 15 | Discuss the generalisability (external validity) of the study results |
| | | **Other information** | |
| Funding | 22 | 16 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

# Do police officers and firefighters have a higher risk of disease than other public officers?: a 13-year nationwide cohort study in South Korea



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# Do police officers and firefighters have a higher risk of disease than other public officers?: a 13-year nationwide cohort study in South Korea

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**Keywords:** public officer, police officer, firefighter, cohort, hazard ratios

**Word Count**: 3,253

## ABSTRACT

**Objectives:** The work of public officers involves repeated and long-term exposure to heavy workloads, high job strain, and workplace violence, all of which negatively impact physical and mental health. This study aimed to evaluate and compare the incidences of diseases among different categories of public officers in Korea, in order to further understand the health risks associated with these occupations.

**Design:** A cohort study using the National Health Insurance data.

**Participants:** We collated claims data between 2002 and 2014 for 860,221 public officers.

**Primary and secondary outcome measures:** Age-standardized rates were calculated using the direct standardization method, and hazard ratios (HRs) were calculated using the Cox Proportional Hazard regression models.

**Results:** Overall, we found that police officers and firefighters had a higher incidence of a range of diseases when compared to national and regional government officers (NRG). The most prominent HRs were observed among police officers for angina pectoris (HR: 1.52, 95% confidence interval [CI]: 1.49-1.54), acute myocardial infarction (HR: 1.84, 95% CI: 1.77-1.92), and cerebrovascular disease (HR: 1.36, 95% CI: 1.31-1.40). Firefighters were more susceptible to physical ailments and were at a significantly higher risk for traumatic stress disorders (HR: 1.40, 95% CI: 1.26-1.56) than NRGs.

**Conclusion:** Compared to NRGs, police officers had higher HRs for all measured diseases, except for traumatic stress disorders. While firefighters had higher HRs for almost all diseases examined, public education officers had a higher HR for traumatic stress disorders, when compared to NRGs.

**Keywords:** public officer, police officer, firefighter, cohort, hazard ratios

**Strengths and limitations of the study**

- This study is the largest cohort study based on nationwide follow-up data including all Korean public officers.
- We have included a comprehensive set of various health problems potentially related to job as well as cardiovascular disorders.
- A limitation of the study is that incidences of some diseases could have been underestimated or overestimated because our study used claims data.

## INTRODUCTION

The broad category of "public officers" comprises of individuals in a range of government-overseen positions and public sector employment. As a percentage of total employment across the Organization for Economic Co-operation and Development countries, the employment rate for public officers rose slightly between 2009 and 2013, from 21.1% to 21.3%.[1] In Korea and in many developed countries, positions at public offices are regarded as prestigious occupations, albeit uniquely stressful.[2 3] The work of public officers is fundamental to the maintenance of society, and it is therefore important to understand any afflictions or ailments associated with this category of individuals.

The work of public officers involves repeated and long-term exposure to heavy workloads, high job strain, or workplace violence, all of which have a potentially negative impact on physical and mental health. This is particularly true for police officers and firefighters who, in addition to workplace stress also deal with physical, chemical, biological, and psychological hazards while on duty.[4-8] For example, in the USA in particular, studies have shown police officers to have a shorter life expectancy than the general population.[9] For the reasons above, research shows that firefighters and police officers have higher mortality and morbidity rates compared to the general population, particularly for cardiovascular diseases (CVD). The incidence of cardiovascular diseases has been reported to be higher among police officers than in the general civilian population (31.4% vs. 18.4%).[10] Similarly, a study involving American firefighters found that CVD was the primary cause of death in the line of duty, accounting for approximately 45% of the on-duty fatalities.[11]

Considerable research on the health of public officers has been conducted in many Western countries, focusing mainly on cardiovascular diseases, chronic diseases, and mental disorders. However, comparable research in Asian countries is scarce. Using a large, nationwide dataset based on insurance claims, this study aimed to evaluate the differences in the incidence rates of specific diseases among different categories of public officers in Korea, in order to develop an understanding of health risks associated with these occupations.

## SUBJECTS AND METHODS

### Data Source

The study population consisted of public officers, including police officers, firefighters, public educational officers (PEOs), and national and regional government officers (NRGs), with claims data between 2002 and 2014, which was collected from the National Health Insurance Service (NHIS) using their customized database service.

The Korean National Health Insurance (NHI) program covers almost 100% of the Korean population and the database contains information on demographic characteristics, hospital admissions, ambulatory care, principal diagnosis, comorbidities (using the International Classification of Disease's 10th revision (ICD-10)), procedures, and prescriptions regarding all inpatients and outpatients. The date of death was ascertained from death certificates collected from the Korean National Statistical Office. Patients who were alive on December 31st, 2014, or after were not considered deceased for the purposes of this study.

### Study subjects and identification

We identified 860,221 public officers as the study population based on occupation codes. We then collected all patient claims data between 2002 and 2014, and dates of death, through the NHIS customized database service. We defined each disease based on its ICD-10 and procedure codes. We identified patients with alcoholic liver disease (ICD-10 K70), peptic ulcer (K25-K28), dyslipidemia (E78 with prescription), diabetes mellitus (DM) (E10-E14 with prescription), type II DM (E11), hypertension (I10-I15 or I30 with prescription), angina pectoris (I20), acute myocardial infarction (I21), cerebrovascular diseases (I63), admission due to injury (S00-T98 and document code of 'hospital admission'), lower back pain (M543-M545 and document code of 'hospital admission'), lumbar disc herniation (M51), soft tissue diseases in shoulder region (M75), mental illness (F00-F99), mood disorders (F30-F39), sleep disorders (G47 or F51) and traumatic stress disorders (F43.0-F43.1).

In order to designate new cases of diseases (incidence), we used a one year washout period between January 1st, 2002 and December 31st, 2002.

### Statistical analysis

The demographic characteristics of the study subjects were expressed as means and standard deviations for continuous variables, or as percentages for categorical variables. Age-standardized rates (ASRs) were calculated by the direct standardization method, using the person-years of NRG officers as the standard population. We calculated person-years as the time after the one year washout period, January 1st, 2003, to the end of observation or death. In order to calculate person-years by age group (10-year intervals), we divided each individual's person-years by age group and then summed up all person-years for each respective age group.

We calculated hazard ratios (HRs) using the Cox Proportional Hazards regression models with adjustments for age and sex. All analyses were performed using the SAS Enterprise Guide (SAS Institute, Inc., Cary, NC). The results were considered statistically significant when the P value was less than 0.05.

## RESULTS

### Study population

A total of 860,221 public officers were included in this study and were followed up for a total of 10,017,374 person-years. The overall mean length of follow-up was 11.6 years, and the mean age was 39.55 ± 9.06 years. The total proportion of male to female public officers was 63.7% to 36.3%, respectively. The proportions of different public officers were as follows: police officers, 10.8% (1,073,302 person-years); firefighters, 2.7% (272,189 person-years); PEOs, 39.4% (3,973,058 person-years); and NRG officers, 47.1% (4,698,825 person-years) (Table 1).

Table 1. Characteristics of Public officers

| Characteristics | All officers | Person-year |
|---|---|---|
| Total, number (%) | 860,221 | 10,017,374 |
| Men | 547,808 (63.7) | 6,315,940 |
| Women | 312,413 (36.3) | 3,701,434 |
| Age, mean ± SD, years | 39.55 ± 9.06 | 10,017,374 |
| Type of public officers, number (%) | | |
| Police officer | 92,545 (10.8) | 1,073,302 |
| Firefighter | 23,356 (2.7) | 272,189 |
| Public educational officer | 338,857 (39.4) | 3,973,058 |
| National and regional government officer | 405,463 (47.1) | 4,698,825 |

**Incidence rate**

ASRs broken down by sex and public officer type are shown in Table 2. Among men with the alcoholic liver disease, NRG officers showed the highest ASR for incidence with 1,180.0 cases per 100,000 person-years, followed by police officers (1,177.1), PEOs (1,060.1), and firefighters (857.8). Among women with the alcoholic liver disease, firefighters showed the highest ASR with 164.9 cases per 100,000 person-years. Among men with peptic ulcers, the highest ASR was for PEOs (5,245.8), followed by police officers (5,166.8); among women with peptic ulcers, firefighters showed the highest ASR (4,852.4), followed by NRG officers (4,847.5).

The highest incidence of dyslipidemia in both sexes was found among police officers (Men: 2,673.1, Women: 1,115.1), while the lowest incidence was seen in firefighters among men (1,955.5) and PEOs among women (995.3). Among men, the incidence rates for DM and type II DM were highest among NRGs (942.0 and 943.2 respectively), followed by police officers. Among women, DM and type II DM rates were highest among firefighters, followed by police officers. Hypertension rates in men were highest among NRGs (2,457.8) and lowest among firefighters (1,924.2), while in women they were highest among police officers (875.0) and lowest among firefighters (742.0).

For both sexes, angina pectoris and cerebrovascular diseases were highest among police officers. Acute myocardial infarction in men was highest among police officers, followed by firefighters, while in women the highest rates were observed among firefighters, followed by police officers. Admission due to injury, lower back pain, and lumbar disc herniation were highest among firefighters for both sexes, followed by police officers (both sexes). For both sexes, PEOs had the highest rate of mental illness. Finally, for both sexes, firefighters and PEOs had the highest rates of traumatic stress disorders, while firefighters and police officers had the highest rates of mood and sleep disorders.

Table 2. Age-standardized cause-specific incidence rate by public officers

| | Men (per 100,000 person-years) | | | | | Women (per 100,000 person-years) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Police | Firefighter | PEO | NRG | IRD | Police | Firefighter | PEO | NRG | IRD |
| Alcoholic liver disease | 1,177.1 | 857.8 | 1,060.1 | 1,180.8 | -3.7 | 161.5 | 161.9 | 141.7 | 163.9 | -2.4 |
| Peptic ulcer | 5,166.8 | 4,869.6 | 5,245.8 | 5,090.6 | 76.2 | 4,598.4 | 4,851.4 | 4,804.4 | 4,847.5 | -249.1 |
| Dyslipidemia | 2,673.1 | 1,955.5 | 2,207.8 | 2,358.9 | 314.2 | 1,115.1 | 1,087.6 | 995.3 | 1,030.1 | 85.0 |
| Diabetes mellitus | 915.2 | 699.4 | 821.2 | 942.0 | -26.8 | 237.3 | 251.9 | 171.0 | 233.9 | 3.4 |
| Type II diabetes mellitus | 918.5 | 703.0 | 822.5 | 943.2 | -24.7 | 238.1 | 253.9 | 170.2 | 233.1 | 5.0 |
| Hypertension | 2,329.6 | 1,924.2 | 2,401.6 | 2,457.8 | -128.2 | 875.0 | 741.0 | 753.8 | 846.8 | 28.2 |
| Angina pectoris | 1,648.3 | 1,186.5 | 1,251.5 | 1,256.7 | 391.6 | 673.5 | 668.5 | 549.1 | 557.0 | 116.5 |
| Acute myocardial infarction | 342.2 | 216.8 | 200.6 | 208.1 | 134.1 | 87.6 | 93.9 | 63.8 | 70.7 | 16.9 |
| Cerebrovascular diseases | 530.5 | 431.4 | 477.8 | 496.7 | 33.8 | 239.3 | 205.5 | 184.3 | 213.1 | 26.2 |
| Admission due to injury | 1,714.2 | 1,854.2 | 1,322.7 | 1,323.3 | 390.9 | 1,008.9 | 1,508.6 | 743.8 | 854.1 | 154.8 |
| Lower back pain | 377.3 | 383.4 | 248.4 | 249.4 | 127.9 | 322.6 | 448.6 | 215.7 | 250.0 | 72.6 |
| Lumbar disc herniation | 2,358.1 | 2,552.2 | 2,208.6 | 2,111.6 | 246.5 | 2,113.3 | 2,666.5 | 1,970.3 | 1,986.8 | 126.5 |
| Soft tissue diseases in shoulder region | 3,061.6 | 2,987.1 | 2,928.5 | 2,724.8 | 336.8 | 2,250.8 | 2,761.2 | 2,201.7 | 2,263.3 | -12.5 |
| Mental illness | 3,569.1 | 3,543.4 | 3,627.4 | 3,571.8 | -2.7 | 3,648.5 | 3,864.0 | 3,883.7 | 3,828.7 | -180.2 |
| Mood disorder | 1,273.3 | 1,339.2 | 1,215.6 | 1,262.0 | 11.3 | 1,378.6 | 1,619.9 | 1,375.2 | 1,390.8 | -12.2 |
| Sleep disorder | 1,362.5 | 1,328.0 | 1,285.8 | 1,350.0 | 12.5 | 1,312.1 | 1,547.7 | 1,275.3 | 1,319.5 | -7.4 |
| Traumatic stress disorder | 95.1 | 132.6 | 98.6 | 98.5 | -3.4 | 141.6 | 244.3 | 169.6 | 140.0 | 1.6 |

PEO; Public educational officer, NRG; National and regional government officer, IRD; Incidence rate difference between police and national or regional government officer

*shoulder disease including adhesive capsulitis of shoulder, rotator cuff syndrome, bicipital tendinitis, calcific tendinitis of shoulder, impingement syndrome of shoulder, bursitis of shoulder and so on

**Differences in hazard ratios for incident diseases by public officer type**

To investigate the difference in HRs for each incident disease by the type of public officer, we conducted a survival analysis using a Cox proportional model adjusted for age and sex. The results of this analysis are shown in Table 3.

The following results were statistically significant: Police officers (HR: 1.25, 95% confidence interval (CI): 1.23-1.27) had a greater risk of dyslipidemia compared to NRGs; police officers (HR: 1.19, 95% CI: 1.18-1.20) and firefighters (HR: 1.13, 95% CI: 1.11-1.15) had a greater risk of peptic ulcer compared to NRGs, while PEOs (HR: 0.97, 95% CI: 0.96-0.98) had a lower risk. Compared to NRGs, police officers and firefighters had a greater risk of angina pectoris and acute myocardial infarction (police officer HR: 1.52, 95% CI: 1.49-1.54; HR: 1.84, 95% CI: 1.77-1.92 and firefighter HR: 1.06, 95% CI: 1.02-1.10; HR: 1.21, 95% CI: 1.10-1.32). For cerebrovascular diseases, police officers had a higher HR compared to NRGs, while firefighters and PEOs had lower HRs relative to NRGs. Both firefighters and police officers had a greater risk of admission due to injury, lower back pain, lumbar disc herniation, and soft disease in the shoulder region relative to NRGs, with firefighters having the highest HRs for all these conditions. Finally, both firefighters and police officers had a higher risk of mental illnesses, mood disorders, and sleep disorders compared to NRGs, while PEOs had a lower risk of incidence.

Table 3. Differences in hazard ratios for incident diseases by public officer type

| | Hazard Ratio (95% CI) | | | |
|---|---|---|---|---|
| | NRG | Police | Firefighter | PEO |
| Alcoholic liver disease | 1(ref.) | 1.10(1.07-1.12) | 0.80(0.76-0.83) | 0.82(0.81-0.83) |
| Peptic ulcer | 1(ref.) | 1.19(1.18-1.20) | 1.13(1.11-1.15) | 0.97(0.96-0.98) |
| Dyslipidemia | 1(ref.) | 1.25(1.23-1.27) | 0.89(0.86-0.92) | 0.89(0.88-0.90) |
| Diabetes mellitus | 1(ref.) | 1.05(1.02-1.08) | 0.73(0.69-0.77) | 0.77(0.75-0.78) |
| Type II diabetes mellitus | 1(ref.) | 1.05(1.03-1.07) | 0.85(0.82-0.88) | 0.85(0.85-0.86) |
| Hypertension | 1(ref.) | 1.05(1.03-1.07) | 0.85(0.82-0.88) | 0.85(0.85-0.86) |
| Angina pectoris | 1(ref.) | 1.52(1.49-1.54) | 1.06(1.02-1.10) | 0.93(0.92-0.94) |
| Acute myocardial infarction | 1(ref.) | 1.84(1.77-1.92) | 1.21(1.10-1.32) | 0.89(0.86-0.92) |
| Cerebrovascular diseases | 1(ref.) | 1.36(1.31-1.40) | 0.97(0.90-1.04) | 0.87(0.85-0.89) |
| Admission due to injury | 1(ref.) | 1.41(1.39-1.43) | 1.58(1.53-1.63) | 0.95(0.93-0.96) |
| Lower back pain | 1(ref.) | 1.47(1.41-1.52) | 1.52(1.43-1.63) | 0.96(0.93-0.99) |
| Lumbar disc herniation | 1(ref.) | 1.20(1.18-1.22) | 1.43(1.39-1.46) | 1.00(0.99-1.01) |
| Soft tissue diseases in shoulder region | 1(ref.) | 1.20(1.18-1.21) | 1.26(1.24-1.29) | 1.00(0.99-1.01) |
| Mental illness | 1(ref.) | 1.07(1.06-1.09) | 1.11(1.08-1.13) | 0.98(0.98-0.99) |
| Mood disorder | 1(ref.) | 1.03(1.01-1.05) | 1.12(1.08-1.16) | 0.96(0.95-0.97) |
| Sleep disorder | 1(ref.) | 1.06(1.04-1.08) | 1.04(1.01-1.08) | 0.94(0.92-0.95) |
| Traumatic stress disorder | 1(ref.) | 1.00(0.93-1.07) | 1.40(1.26-1.56) | 1.11(1.07-1.15) |

PEO; Public educational officer, NRG; National and regional government officer, CI; confidence interval, ref; reference. All models adjusted for age and sex.

## DISCUSSION

This is the first Korean population-based analysis of disease incidence among public officers using nation-wide data and is based on one of the largest cohorts used for this type of study to date.

Overall, we found that police officers and firefighters had higher incidences of a range of diseases, compared to NRGs. Police officers also had higher hazard ratios for all measured diseases, except for traumatic stress disorders, when compared to NRGs. Similarly, when compared to NRGs, firefighters also had higher hazard ratios for peptic ulcer, angina pectoris, acute myocardial infarction, admissions due to injury, lower back pain, lumbar disc herniation, soft tissue diseases involving the shoulder region, mental illness, mood disorders, sleep disorders, and traumatic stress disorders. Finally, the PEOs had a higher hazard ratio for traumatic stress disorders when compared to NRGs.

The most prominent HRs in this study were observed among police officers with regards to angina pectoris, acute myocardial infarction, and cerebrovascular diseases. Among men, police officers had the highest incidences of all the three diseases. While women police officers had the highest incidences of angina pectoris and cerebrovascular disease, they had the second highest incidence of acute myocardial infarction. Even after adjusting for age and sex, police officers continued to have higher incidences of cerebro-cardiovascular ailments with significantly high hazard ratios for all conditions, compared to NRGs.

A number of western studies have found that police officers had several risk factors for CVD, including personal factors such as smoking, alcohol consumption, hypertension, obesity, DM, or dyslipidemia, and work-related factors, such as night duties, high job stress, workplace violence, and long work shifts.[12-15] Our research shows that the higher HRs among police officers compared to NRGs for other diseases such as alcoholic liver disease, DM, and dyslipidemia were also associated with these risk factors suggesting that these are serious risk factors. We did not collect socioeconomic or demographic variables, except for age and sex, and therefore, were unable to ascertain the presence or absence of these risk factors among Korean public officers.

In view of the high incidence of cerebro-cardiovascular diseases among police officers, it is important to establish preventative measures to reduce their risk for these diseases. We assumed that the distribution of socioeconomic variables, such as education level, income, or regional

characteristics would also be comparable among public officers, due to regulations on the working conditions and employment packages for these public officers. Therefore, the higher HR for CVD among police officers may be associated with working conditions, such as long working hours, night work and poor sleep, or job-related stress. Several studies have suggested a correlation between shift work and cardiovascular disease or other negative health outcomes.[16 17] A meta-analysis found longer working hours were associated with cerebro-cardiovascular diseases.[18] A study involving police officers in Buffalo, New York, found that 28% of police officers worked afternoon shifts and 22% worked night shifts. The study also found that 54% of all police officers suffered from poor sleep quality: 44% for day shifts, 60% for afternoon shifts, and 69% for night shifts.[19] Furthermore, police officers deal with a variety of civil complaints, increasing their exposure to violent situations which increase the job-related stress. Shift work, night shifts, and higher workloads are more prevalent among both police officers and firefighters than among NRGs and education officers. This is consistent with our findings of higher CVD HRs in police officers and firefighters.

This study also found higher HRs for lower back pain, lumbar disc herniation, and soft tissue diseases in the shoulder region among the firefighters, compared to NRGs. These findings coincide with previous research which found that lower back pain was the most common work-related musculoskeletal disorder among firefighters in Korea.[20] Additionally, one study suggested that a primary contributing risk factor for lower back pain in firefighters was stress.[21] A common hypothesis regarding the association between stress and injury is that the severity of muscle strain and, therefore, the likelihood of injury, increases with stress which in turn can further heighten the awareness of the musculoskeletal symptoms or hamper their management.[22 23] Firefighters are required to move heavy equipment and engage in demanding physical activity as part of their work. This, combined with higher levels of stress, may explain the high levels of back pain among firefighters. Additionally, firefighters are often not fit enough to deal with the physical demands of emergency situations. Some studies have suggested that physical check-up programs similar to those used for athletes may be necessary to achieve a higher $VO_2$ max and to improve the overall

health.[24-27]

Furthermore, our research found that compared to NRGs, police officers also had higher HRs for lower back pain, lumbar disc herniation, and soft tissue diseases of the shoulder. Police officers and firefighters were both found to have significantly high HRs for hospital admissions due to injury, with firefighters having the highest HRs compared to NRGs. This coincides with the findings of a study of American emergency responders which found high rates of injury in both firefighters (7.4 cases per 100 full-time equivalent firefighters) and police officers (8.5 cases per 100 full-time equivalent police officers).[28] As previously observed, police officers and firefighters are exposed to a variety of environmental, physical, and chemical hazards leading to relatively higher rates of injury.[4-6] Particularly for firefighters, chemicals hazards including the inhalation of fire smoke, asbestos, diesel exhaust, and other chemicals are of concern.[8]

Police work and firefighting are generally regarded as high-risk and high-stress occupations. Firefighters and police officers spend significant time working outside their workplaces and managing unpredictable and urgent situations. These factors contribute to the high-stress work environment reported by a number of studies.[29] It is generally accepted that high levels of stress affect all areas of health and that stress can exacerbate pre-existing ailments. An American study found that stress was a potential factor for negative health outcomes among police officers.[9] Additionally, several studies have noted that factors, such as a lack of sleep, job insecurity, workplace conflicts, physical environment, levels of alcohol consumption, and organization systems, contributed to the stress of firefighters.[30 31] Other studies have suggested that the inherent risk associated with the job, high workloads, shift work, and the police administrative system contribute to the stress experienced by police officers. This is consistent with our finding of high HRs for a considerable number of diseases among police officers and firefighters.[9 32]

Both police officers and firefighters were found to have similar high hazard ratios for cerebrocardiovascular and musculoskeletal diseases, as well as for mental, mood, and sleep disorders.

However, police officers, unlike firefighters, did not have a significantly higher hazard ratio for traumatic stress disorders compared to NRGs. This could be due to the organizational culture of police work in Korea, and more research is required in this area. In Korea, candidates for jobs as police officers need to pass a very competitive official examination and mental health checkup, including a clinical psychology test. Once selected, the police officers may feel pressured to maintain their psychological health to maintain their careers and for promotions within the workplace, which can lead to underreporting of psychological diseases, such as traumatic stress disorders. An anonymous study found that the prevalence of stress-related psychological symptoms, particularly post-traumatic stress disorder (PTSD), remains high among police officers in Korea. According to this study, 41.1% of a study population of 3,000 South Korean police officers were at high risk for developing PTSD.[7]

Finally, another interesting finding of our study was the higher HR for traumatic stress disorders among the PEOs compared to NRGs. For all other diseases measured in our study, the HRs in PEOs were lower than the reference or were not significant. PEOs usually are required to care for students and their parents, and the education culture in Korea is competitive, with suicide among adolescents representing a significant social problem. Therefore, the emotional demands could be severe or distressing for the PEOs, and could potentially produce traumatic effects.

There were a number of limitations in our study. First, because our study used only ICD-10 codes and procedure codes to identify each disease, incidences could be overestimated. However, incidences of some diseases such as mental disorders could also be underestimated due to underreporting in response to workplace culture. For example, some police officers may feel reluctant to receive treatments for a variety of reasons, including fear of losing eligibility for promotions or fear of losing their jobs. Another limitation was that the public officers were divided into four categories and compared. It is likely that there are additional subgroups within each category which may show different rates of incidence. For example, while we compared firefighters and NRGs, we did not compare different types of firefighting work to each other. Likewise, the category ‘police officer’ includes very different sub-fields of police work each with different sets of risk factors. For instance,

the most common health risk for the majority of police officers is low physical activity due to the sedentary nature of their work, yet this is not true for the special forces.[33 34] Additionally, this study did not account for the regional differences, which may also influence the risk of death or injury.[35-37] Lastly, a final limitation of our study could be its inability to account for a "healthy worker effect." Compared to other public officers, firefighters and police officers have to meet more stringent health-related selection criteria due to the physical demands of their job. Therefore, police officers and firefighters may depending on their sub-field of work, be in better general health than the average population, including other public officers. Similarly, comparing firefighters and police officers to other public officers may lead to an under-appreciation of the severity of risk factors that they encounter. We recommend more research on the specific characteristics, risk factors, and incidences of diseases for specific subgroups within each field.

**Contributor ship statement**

IK and SH planned the study. MH and SP analyzed the data. JHP abstracted the variables and established the dataset. MH drafted the article. All authors interpreted the results, critically revised the article and approved the final version.

**Competing interests**

The authors declare that they have no competing interests.

**Ethics approval**

Institutional Review Board of Hanyang University (IRB No: HYI-15-213-4)

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**Data sharing statement**

Extra data is available by emailing Inah Kim.

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STROBE Statement—checklist of items that should be included in reports of observational studies

| | Item No | page | Recommendation |
|---|---|---|---|
| **Title and abstract** | 1 | 2 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract |
| | | 2 | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found |
| | | | **Introduction** |
| Background/rationale | 2 | 4 | Explain the scientific background and rationale for the investigation being reported |
| Objectives | 3 | 4 | State specific objectives, including any prespecified hypotheses |
| | | | **Methods** |
| Study design | 4 | 5 | Present key elements of study design early in the paper |
| Setting | 5 | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection |
| Participants | 6 | 5 | (*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br>*Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls<br>*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants |
| | | 5 | (*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed<br>*Case-control study*—For matched studies, give matching criteria and the number of controls per case |
| Variables | 7 | 5 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable |
| Data sources/ measurement | 8* | 5 | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group |
| Bias | 9 | 5 | Describe any efforts to address potential sources of bias |
| Study size | 10 | 5 | Explain how the study size was arrived at |
| Quantitative variables | 11 | 5 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why |
| Statistical methods | 12 | 6 | (*a*) Describe all statistical methods, including those used to control for confounding |
| | | 6 | (*b*) Describe any methods used to examine subgroups and interactions |
| | | - | (*c*) Explain how missing data were addressed |
| | | 6 | (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed<br>*Case-control study*—If applicable, explain how matching of cases and controls was addressed<br>*Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy |
| | | - | (*e*) Describe any sensitivity analyses |

Continued on next page

| | | | |
|---|---|---|---|
| | | **Results** | |
| Participants | 13* | 6 | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed |
| | | - | (b) Give reasons for non-participation at each stage |
| | | - | (c) Consider use of a flow diagram |
| Descriptive data | 14* | 6-7 | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders |
| | | - | (b) Indicate number of participants with missing data for each variable of interest |
| | | 6-7 | (c) *Cohort study*—Summarise follow-up time (eg, average and total amount) |
| Outcome data | 15* | 7-9 | *Cohort study*—Report numbers of outcome events or summary measures over time |
| | | - | *Case-control study*—Report numbers in each exposure category, or summary measures of exposure |
| | | - | *Cross-sectional study*—Report numbers of outcome events or summary measures |
| Main results | 16 | 7-11 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included |
| | | - | (*b*) Report category boundaries when continuous variables were categorized |
| | | 9 | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period |
| Other analyses | 17 | - | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses |
| | | **Discussion** | |
| Key results | 18 | 11-12 | Summarise key results with reference to study objectives |
| Limitations | 19 | 15 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias |
| Interpretation | 20 | 12-14 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence |
| Generalisability | 21 | 15 | Discuss the generalisability (external validity) of the study results |
| | | **Other information** | |
| Funding | 22 | 16 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based |

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.