



## Original Article

## Cancer Incidence by Occupation in Korea: Longitudinal Analysis of a Nationwide Cohort

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## ABSTRACT

**Background:** We performed this study to investigate the inequalities in site-specific cancer incidences among workers across different occupations in Korea.

**Methods:** Subjects included members of the national employment insurance. Incident cancers among 8,744,603 workers were followed from 1995 to 2007. Occupational groups were classified according to the Korean Standard Occupational Classification. Age-standardized incidence rate ratios were calculated.

**Results:** We found that men in service/sales and blue-collar occupations had elevated rates of esophageal, liver, laryngeal, and lung cancer. Among women, service/sales workers had elevated incidences of cervical cancer. Male prostate cancer, female breast, corpus uteri, and ovarian cancers, as well as male and female colorectal, kidney, and thyroid cancer showed lower incidences among workers in lower socioeconomic occupations.

**Conclusions:** Substantial differences in cancer incidences were found depending on occupation reflecting socioeconomic position, in the Korean working population. Cancer prevention policy should focus on addressing these socioeconomic inequalities.

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## 1. Introduction

Cancer is the leading cause of death in developed countries. In Korea, more than 200,000 individuals were newly diagnosed with cancer in 2014, and 28.6% of all-cause mortalities were attributable to cancer [1].

It is well known that occupation can be an important risk factor for cancer. Although certain occupations involve exposure to carcinogens [2], occupational classifications have been used more broadly to identify differences in socioeconomic status (SES) [3]. Moreover, the association between SES and cancer incidence has been extensively investigated in Western settings [4–7]. Overall, malignancies that exemplify socioeconomic inequalities in cancer risk (i.e., those that are more likely to occur in lower SES groups) are lung, stomach, and cervical cancer, the incidences of which are mainly explained by socioeconomic inequalities in behavioral risks (smoking, drinking, and vaccination) [8]. However, with some exceptions, higher SEP tends to be associated with a higher risk of

breast and prostate cancer, which may be partly explained by reproductive behaviors (e.g., overall fertility and age at first child-birth) as well as overdiagnoses [7,9,10].

In contrast to Western settings, evidence of the association between SES and cancer incidence remains scarce in Asian countries, including Korea. Although some previous studies have investigated the association between SES and cancer mortality [11–14], few studies have explored socioeconomic inequalities in cancer incidence in Korea. In a previous study on income inequalities of cancer incidence using Korean Cancer Registry and National Health Insurance data, stomach, liver, pancreas, and lung cancer among men and liver, lung and cervix cancer among women showed negative income gradient (higher incidence in lower-income), and male prostate, female colon cancer showed positive income gradient [15]. However, to the authors' belief, there has been no study investigated occupational inequalities in cancer incidence in Korea. In the neighboring developed country of Japan, two case-control studies suggested a higher risk for stomach and lung cancers

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among lower SES occupational classes as well as a higher risk for breast cancer among women of higher SES [16,17]. Although Korea is classified as a developed country, the relative poverty ratio remains high owing to large income gaps [18]. A comprehensive national cancer prevention strategy is required to reduce the overall cancer incidence/mortality as well to reduce or eliminate health inequalities.

The aim of the present study was to assess the role of occupational differences in the incidence of cancer in Korea. Using a large cohort comprising nearly 9 million Korean workers with a longitudinal design, we sought to determine whether overall and specific cancer incidence risks vary between occupations that reflect different SES.

## 2. Materials and methods

### 2.1. Data source

Employment insurance data from 1995 to 2000, which included 11,435,937 workers in Korea, were probed to extract our cohort. According to the Employment Insurance Act, employed workers have been required to join the employment insurance program in Korea since 1995. Details regarding the data source has been described previously [14].

### 2.2. Cohort identification

The cohort comprised Korean employees who were enrolled in employment insurance between 1995 and 2000. We restricted our study to workers aged  $\geq 15$  and  $< 60$  years because individuals under 15 years of age are ineligible for employment per the Korean Labor Standard Act, while workers 60 years and over were not subject to Employment Insurance when the program began in 1995. We also excluded workers previously diagnosed with cancer before enrollment. The occupational group assigned to each subject assumed continuous employment in the same category between 1995 and 2000; therefore, workers who switched categories or those for whom no occupational category was recorded were excluded from the cohort. Ultimately, 8,744,603 workers (62.6% male and 37.4% female) were analyzed in the current study (Table 1).

The occupation of each participant was coded by the Korean Standard Classification of Occupation (KSCO) (Table 1). We also collapsed occupations into four occupational groups to compare site-specific cancer incidence across occupations. These categories basically followed previous work using Korean data [19,20], taking into account distribution of education and average income. Employers or self-employed in the classification scheme were not considered because our data consists of all employed workers. Also, agricultural, forestry, and fishery workers were added to “blue-collar workers,” because their number was too small to analyze separately. Group 1 (managers and professionals) showed the highest income according to the national survey; therefore, we used Group 1 as the reference group and assumed Group 3 (service and sales worker) and Group 4 (blue-collar workers) as lowest SES occupations [21] (Table 1). Education distribution across the KSCO is presented in Appendix (Supplementary fig. 1).

### 2.3. Cancer incidence follow-up and incidence rate calculation

The main endpoint of our study was the first ever cancer diagnosis as registered in the Korea Central Cancer Registry (KCCR). All cancer incidences (including type of cancer and date of diagnosis), which were coded based on the International Classification of Disease 10th revision (ICD-10) as malignant neoplasms

**Table 1**  
Number of subjects, person-years, and incident cancer cases by occupational groups and sex

Occupational groups	KSCO* (average monthly wage in 2005)†			Male			Female			Total		
	n (%)	Person-years	Cancer	n (%)	Person-years	Cancer	n (%)	Person-years	Cancer	n (%)	Person-years	Cancer
Professional and manager (Group 1)	308,799 (5.6)	3,802,261	14,223	308,799 (5.6)	3,802,261	14,223	25,252 (0.8)	286,273	886	334,051 (3.8)	4,088,534	15,109
2. Professionals (2101 USD)	208,121 (3.8)	2,429,804	3,833	208,121 (3.8)	2,429,804	3,833	134,527 (4.1)	1,458,345	2,116	342,648 (3.9)	3,888,149	5,949
3. Technicians and Associate Professionals (1734 USD)	558,202 (10.2)	6,293,696	10,146	558,202 (10.2)	6,293,696	10,146	181,313 (5.5)	1,937,765	2,820	739,515 (8.5)	8,231,461	12,966
4. Clerks (1569 USD)	1,310,538 (24.0)	15,503,025	23,940	1,310,538 (24.0)	15,503,025	23,940	1,218,793 (37.2)	13,683,821	15,363	2,529,331 (28.9)	29,186,846	39,303
5. Service and Sale Workers (1115 USD and 1241 USD)	497,937 (9.1)	5,544,334	8,153	497,937 (9.1)	5,544,334	8,153	461,995 (14.1)	5,025,703	7,524	959,932 (11.0)	10,570,037	15,677
6. Agricultural, Forestry, and Fishery Workers (1450 USD)	20,766 (0.4)	236,060	658	20,766 (0.4)	236,060	658	2,415 (0.1)	25,837	66	23,181 (0.3)	261,897	724
7. Craft and Related Trades Workers (1415 USD)	1,388,037 (25.4)	16,094,152	30,471	1,388,037 (25.4)	16,094,152	30,471	507,641 (15.5)	5,877,190	10,675	1,895,678 (21.7)	21,971,342	41,146
8. Plant, Machine Operators, and Assemblers (1366 USD)	395,772 (7.2)	4,693,367	10,512	395,772 (7.2)	4,693,367	10,512	87,801 (2.7)	1,006,110	1,600	483,573 (5.5)	5,699,477	12,112
9. Elementary Occupations (927 USD)	784,000 (14.3)	8,219,247	32,469	784,000 (14.3)	8,219,247	32,469	652,694 (20.0)	7,129,858	20,065	1,436,694 (16.4)	15,349,105	52,534
Total	5,472,172 (100.0)	62,815,946	134,405	5,472,172 (100.0)	62,815,946	134,405	3,272,431 (100.0)	36,430,903	61,115	8,744,603 (100.0)	99,246,849	195,520

\* KSCO=Korean Standard Classification of Occupations.

† National statistics reported from Survey on labor conditions by employment type.

(C00–C97), were registered in the KCCR, and we merged the cohort dataset with KCCR data from 1995 to 2007. In the present study, recurrent cancer diagnoses were excluded, while second primary cancers in the same individuals were considered new diagnoses. The average follow-up period was 11.3 years.

Age-standardized incident rates (ASRs) for each occupational group were calculated by direct standardization. The year 2000 resident population registry of the Korea National Statistical Office was used as the population standard. To compare incident rates by SES, age-standardized rate ratios (SRRs) were calculated (stratified by sex) using Group 1 (managers and professionals) as the reference group.

#### 2.4. Ethics statement

This study was approved by the institutional review boards of the Occupational Safety and Health Research Institute, Korea Occupational Safety and Health Agency, Ulsan, Korea.

### 3. Results

In total, 8,744,603 individuals were eligible for analysis (Table 1). Among men, crafts and related traders (25.4%) and clerks (24.0%) were the most common occupational group, while clerks (37.2%) were most common in women. Male and female agricultural, forestry, and fishery workers (0.4% and 0.1%, respectively) as well as female legislators, senior officials, and managers (0.8%) accounted for a very small proportion of the cohort. During the follow-up period, 195,520 cancer cases (0.2% of the study population) were detected.

ASRs categorized by sex and KSCO are shown in Tables 2 and 3. The ASRs for all cancers were 378.3 per 100,000 among male subjects and 355.4 per 100,000 among female subjects. The leading

cancer sites among men were the stomach (97.0), colon/rectum (60.7), liver (47.1), and lung (44.1 per 100,000); those among women were the breast (58.0), thyroid (57.0), stomach (54.6) and colon/rectum (46.0 per 100,000).

Sex-specific SRRs for each occupational group for overall and specific cancer types are shown in Figs. 1 and 2, separately, with managers/professionals (Group 1) used as reference.

Male service/sales workers (Group 3) and blue-collar workers (Group 4) showed an elevated incidence of esophageal, liver, laryngeal, and lung cancer compared to professional and managerial workers (Group 1), which reflect socioeconomic inequalities in lifestyle such as smoking and drinking.

In contrast, colorectal, prostate, kidney, and thyroid cancer showed lower incidence rates in occupations related to lower SES. The incidences of these cancers are known to be related to screening and overdiagnosis.

For women, only the incidence of cervical cancer was elevated among service/sales workers (but not in blue-collar workers) relative to the reference group. Cancers of the breast, corpus uteri, ovary, kidney, and thyroid were less common in lower SES occupations (service and sales, blue-collar workers) than in the reference group, although incidence rates among clerical workers were higher than or similar to those of the reference group.

### 4. Discussion

Substantial inequalities in cancer incidence were identified by occupation, especially among men, in the Korean working population. Occupational inequalities were most evident for cancers in organs associated with smoking (lung, larynx, stomach, and esophagus), alcohol consumption (esophagus and liver), and reproductive history (breast, corpus uteri, and ovary), as well as utilization of screening (thyroid, kidney, prostate, and breast).

**Table 2**  
Age-standardized cancer incidence rate by occupation (males, per 100,000)

Cancer site	Group 1			Group 2	Group 3	Group 4				Total
	KSCO1	KSCO 2	KSCO 3	KSCO4	KSCO5	KSCO6	KSCO7	KSCO8	KSCO 9	
All cancer(C00–C97)	392.3	393.5	406.9	407.9	376.8	321.1	388.1	378.7	357.8	378.3
Lip, oral cavity, and pharynx (C00–C14)	6.3	7.1	10.8	8.5	12.3	2.7	8.6	6.9	7.9	8.1
Esophagus (C15)	4.9	5.0	9.4	5.4	6.9	2.8	7.3	6.7	9.2	7.2
Stomach (C16)	88.8	90.8	102.3	97.7	84.2	86.2	109.5	93.7	94.6	97.0
Colon, rectosigmoid junction, rectum (C18–C20)	70.3	75.0	70.2	71.5	65.1	52.9	59.3	66.4	50.9	60.7
Liver and intrahepatic bile ducts (C22)	46.4	46.7	47.7	46.6	50.4	42.7	47.9	45.3	50.0	47.1
Gallbladder, other and unspecified parts of biliary tract (C23–C24)	8.3	7.2	8.7	8.1	6.8	5.8	8.8	5.9	7.5	7.8
Pancreas (C25)	7.7	8.6	7.9	8.0	7.1	6.9	6.9	6.0	7.7	7.4
Larynx (C32)	5.4	4.2	5.9	4.9	6.9	3.0	7.2	6.6	6.8	6.4
Trachea, bronchus, and lung (C33–C34)	32.4	29.5	46.1	39.6	45.2	42.5	45.4	45.5	50.2	44.1
Mesothelioma (C45)	0.1	0.1	0.1	0.1	0.1	0.4	0.4	0.0	0.2	0.2
Breast (C50)	0.4	0.4	0.3	0.2	0.3	0.3	0.2	0.2	0.3	0.3
Prostate (C61)	41.6	28.2	13.9	30.3	17.4	25.2	17.0	21.5	14.0	20.4
Testis (C62)	0.2	0.4	0.6	0.7	0.6	0.0	0.5	0.5	0.6	0.6
Kidney (C64)	13.1	15.3	13.5	14.0	10.8	3.5	8.2	11.5	6.4	9.7
Bladder (C67)	15.3	16.2	13.0	14.3	11.3	10.1	15.5	19.2	11.6	13.5
Brain and other parts of central nervous system (C70–C72)	2.8	3.9	3.0	3.1	3.4	4.4	3.3	2.0	3.3	3.1
Thyroid gland (C73)	13.5	17.6	12.6	16.4	7.9	3.3	8.3	6.2	4.9	10.1
Hodgkin lymphoma (C81)	0.5	1.5	0.3	0.8	0.4	0.3	0.5	0.6	0.4	0.5
Non-Hodgkin lymphoma (C82–C85,C96)	9.2	10.9	12.4	10.9	8.5	8.8	8.1	8.5	6.9	8.5
Multiple myeloma (C90)	2.1	1.3	2.1	1.5	2.6	2.3	2.0	2.4	1.6	1.9
Leukemia (C91–C95)	5.2	5.1	4.3	4.9	6.7	3.9	5.0	5.0	4.7	5.0

KSCO1 = Legislators, Senior Officials, and Managers; KSCO2=Professionals; KSCO3=Technicians and Associate Professionals; KSCO4=Clerks; KSCO5=Service and Sale Workers; KSCO6=Agricultural, Forestry, and Fishery workers; KSCO7=Craft and Related Trades Workers, KSCO8=Plant, Machine Operators, and Assemblers; KSCO9 = Elementary Occupations.

**Table 3**  
Age-standardized cancer incidence rate by occupation (females, per 100,000)

Cancer site	Group 1			Group 2	Group 3	Group 4			Total	
	KSCO1	KSCO 2	KSCO 3	KSCO4	KSCO5	KSCO6	KSCO7	KSCO8		KSCO 9
All cancer(C00–C97)	472.6	556.8	412.7	501.0	367.5	194.8	334.3	397.4	312.4	355.4
Lip, oral cavity, and pharynx (C00–C14)	2.4	5.1	3.6	2.3	6.7	0.0	5.7	1.3	3.0	3.7
Esophagus (C15)	0.0	0.9	0.2	1.5	0.2	0.0	1.0	0.2	0.4	0.5
Stomach (C16)	55.0	70.6	74.5	47.6	47.0	26.1	55.8	56.3	52.7	54.6
Colon, rectosigmoid junction, rectum (C18–C20)	34.1	106.5	28.2	73.1	40.1	23.6	47.8	65.4	43.4	46.0
Liver and intrahepatic bile ducts (C22)	9.1	12.6	8.9	11.9	14.2	15.2	13.0	15.1	13.5	13.2
Gallbladder, other and unspecified parts of biliary tract (C23–C24)	6.5	2.8	4.2	4.8	7.4	4.2	8.6	5.8	6.9	7.0
Pancreas (C25)	1.3	5.9	1.5	2.6	6.0	0.0	3.5	3.4	5.0	4.5
Larynx (C32)	0.2	0.0	0.0	0.1	0.2	0.0	0.2	0.0	0.5	0.4
Trachea, bronchus, and lung (C33–C34)	17.3	19.6	30.5	26.0	13.7	13.7	14.1	17.1	17.0	16.6
Mesothelioma (C45)	0.0	0.2	0.1	0.0	0.0	0.0	0.2	0.1	0.4	0.3
Breast (C50)	113.0	163.8	93.7	108.2	62.6	40.8	52.3	62.3	43.7	58.0
Cervix uteri (C53)	33.7	10.6	45.2	30.0	41.1	13.8	33.1	39.3	33.8	34.9
Corpus uteri (C54)	24.9	8.5	6.8	8.9	8.7	4.3	6.1	14.3	6.5	7.5
Ovary (C56)	7.0	8.1	8.4	21.2	11.8	16.6	7.1	11.4	8.7	9.8
Kidney (C64)	17.1	2.1	6.2	7.7	2.7	0.0	4.1	2.5	3.6	4.2
Bladder (C67)	1.0	0.6	2.9	1.6	3.4	0.0	1.8	0.7	3.6	3.1
Brain and other parts of central nervous system (C70–C72)	2.7	2.2	2.8	6.7	4.5	0.0	2.0	3.2	2.3	2.8
Thyroid gland (C73)	115.1	109.1	72.4	98.1	64.5	14.9	48.2	55.4	38.1	57.0
Hodgkin lymphoma (C81)	0.2	0.2	0.1	0.2	0.5	0.0	0.2	1.0	0.2	0.3
Non-Hodgkin lymphoma (C82–C85,C96)	14.5	10.8	4.5	11.7	9.2	8.3	6.5	13.0	6.1	7.0
Multiple myeloma (C90)	1.1	0.0	1.6	1.1	1.4	0.0	1.1	1.8	2.7	2.3
Leukemia (C91–C95)	2.3	3.9	4.0	3.8	3.6	0.0	3.8	3.7	3.8	4.0

KSCO1 = Legislators, Senior Officials, and Managers; KSCO2=Professionals; KSCO3=Technicians and Associate Professionals; KSCO4=Clerks; KSCO5=Service and Sale Workers; KSCO6=Agricultural, Forestry, and Fishery workers; KSCO7=Craft and Related Trades Workers, KSCO8=Plant, Machine Operators, and Assemblers; KSCO9 = Elementary Occupations.

#### 4.1. All cancers

In the present study, the negative occupational trend was not found in both men and women. Even an inverted trend (highest incidence in higher SES occupation) was obvious in women. This finding seems to be most affected by the cancer sites related screening effect. Among men, rest of all cancers besides prostate and thyroid cancer show slightly negative trend; SRR 1.09 for clerk (95% CI 1.07–1.11), SRR 1.05 for service and sales (95% CI 1.03–1.08), and SRR 1.04 for blue-collar worker (95% CI 1.03–1.06) (data not shown). However, major cancer sites that account for almost half of all cancers in women were positive social gradient cancer (i.e., breast, thyroid, and colon cancer). In the previous studies, the inverse social class gradient in all cancer incidence was not as obvious as all cancer mortality, and several studies reported no gradient or positive gradient [7]. Indeed, in the study on occupational mortality inequalities using the study population from the same data source as the present study reported lowest all cancer mortality in manager (KSCO1) among both men and women, highest all cancer mortality in elementary occupation (KSCO9) in men and in plant and machine operators (KSCO8) in women [14]. This discrepancy between incidence and mortality suggests that higher SES occupations have higher incidence of good prognosis cancer sites, which usually related to screening effect due to more participation in screening, and also they have better survival of cancer.

#### 4.2. Lung cancer

Occupational inequalities in lung cancer exhibited opposing gradients in men versus women. The data from men were consistent with previous studies in Western settings, but the lower incidence of lung cancer among blue-collar female workers contrasts with previous data [7].

The largest contributor to lung cancer inequalities is smoking. Generally, the smoking rate is higher in the low socioeconomic population. However, the gap between social strata is different by gender and the times. According to an earlier Korean survey in 1992, smoking prevalence difference between women manual workers (7.3%) and nonmanual workers (6.4%) was much smaller than the difference in men (76.9% and 63.0%, respectively) [22]. Furthermore, in the study that used KSCO as occupational category in 1998, age-standardized smoking rates in women were higher among professionals (8.8%) compared to blue-collar workers (5.5%) and elementary occupations (5.0%), though the rate of total nonmanual workers was low due to office workers (1.2%) [23]. This suggests that occupational inequalities on smoking among women workers in the 1990s in Korea were not as evident as among men, or even the opposite direction might be possible. Examination of the diffusion of the mass-marketing of cigarettes in rapidly developing economies revealed that the epidemic spreads initially among men and among higher SES groups wherein individuals can afford manufactured cigarettes. As these groups begin to cease their smoking habits, the epidemic eventually spreads to lower SES groups. Our data from Korea might reflect the particular “stage of transition” in cigarette smoking to a lower prevalence in high SES males as well as a higher prevalence among professional women. Korean culture (in common with the rest of Asia) has traditionally disapproved of smoking among women, and smoking rates used to be low compared to Western countries where women smoke as commonly as men. However, dramatic changes occurred beginning in the 1990s (the period spanning our observation), after cigarette markets in Asia were forced open in 1988 because of the “section 301 actions” of the United States Trade Representative. In the face of increased competition from foreign (American) cigarettes, domestic manufacturers began to expand into new markets, including by appealing to working women and introducing “feminine” cigarette

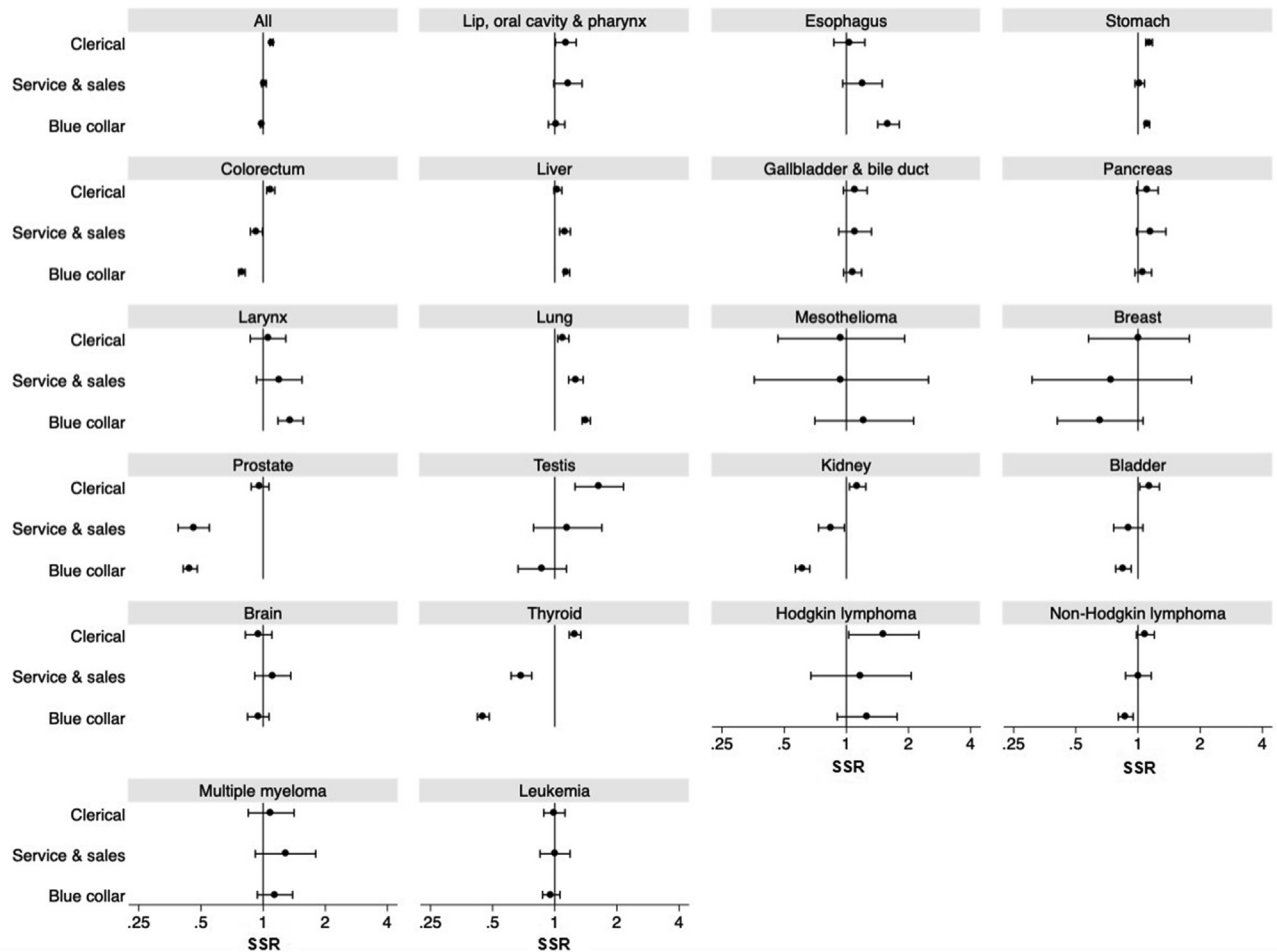


Fig. 1. Age-standardized rate ratios (SRRs) for occupational groups by cancer types with professionals and managers as reference group among men.

brands [24]. A “reverse” occupational gradient in smoking-related cancers of the lung, lip, oral cavity, and pharynx among Korean women might reflect this history.

The smoking rate in Korean men dropped from 68.9% to 50.1% between 1998 and 2009, and professionals reported the lowest smoking rate among occupational groups throughout the period [23]. During the same period, the smoking rate in Korean women remained at 5–6%, with rates among professionals falling while rates among blue-collar workers climbing [23]. As these trends continue, the occupational gradient among Korean women is likely to flip in the future. Indeed, in Western countries where the cigarette epidemic has “matured” (as the tobacco industry began marketing cigarettes to women in the West 40 years in advance of Asia), the SES gradients for lung cancer exhibit the same pattern for women and men.

A separate explanation for the association between occupational group and lung cancer could be occupational carcinogen exposure. Occupational lung cancer is estimated to account for approximately 7% of lung cancers in Korea [25]. The main carcinogens include crystalline silica, cadmium, chromium, nickel compound, and asbestos. The industries associated with these exposures predominantly involve men.

#### 4.3. Stomach cancer

The socioeconomic gradient in stomach cancer exhibited opposite patterns in men and women. Previous studies in Western

settings have shown increased incidences of stomach cancer among lower socioeconomic groups [7], as we also did among Korean men. Major risk factors for stomach cancer associated with SES include *Helicobacter pylori* infection, dietary habits (sodium intake), and cigarette smoking [5]. In a previous study of nationwide health examination recipients in Korea, the seropositive rate of *H. pylori* was slightly higher in the low-income group [26]. Higher education and high SES occupations are associated with lower sodium intake in Korea [27]. Gender differences in stomach cancer inequalities might be caused by different participation rates in screening. Although office workers showed a higher screening rate than manual workers in both men and women, overall women’s screening rate has been much higher than men in Korea [28]. Earlier diagnosis due to screening could have an influence on the age-standardized incidence ratio.

#### 4.4. Liver cancer

Consistent with previous studies, we found elevated incidences of liver cancer among men engaged in lower SES occupations. Lower education levels and service-related occupations are correlated with more harmful patterns of drinking among both men and women in Korea [29]. Additionally, differences in hepatitis B virus (HBV) vaccinations and in awareness of HBV infection status have been reported in the Korean population [30,31]. Blue-collar workers are also likely exposed to carcinogens such as vinyl chloride, arsenic, and trichloroethylene [32].



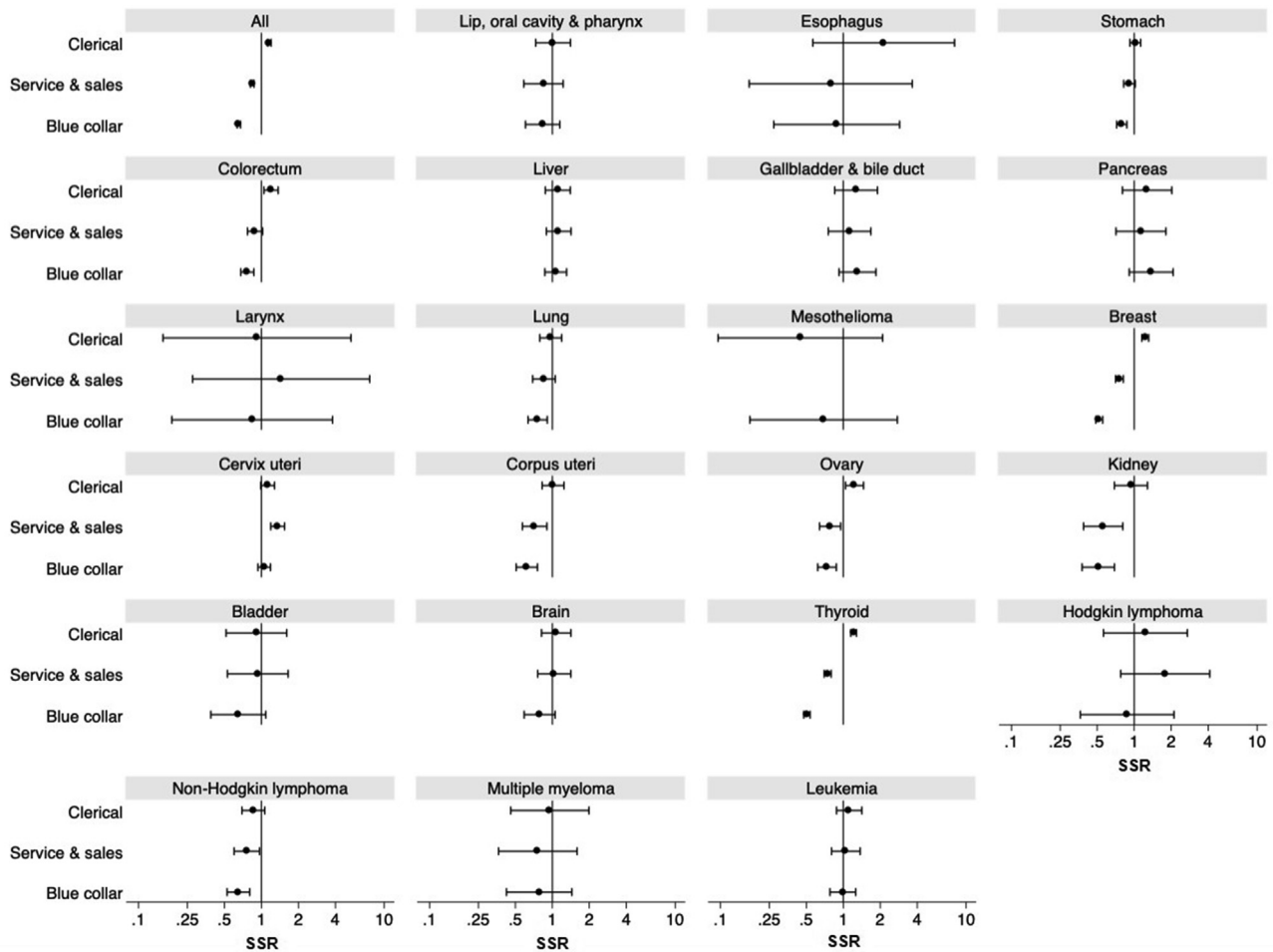


Fig. 2. Age-standardized rate ratios (SRRs) for occupational groups by cancer types with professionals and managers as reference group among women.

#### 4.5. Colorectal cancer

There has been a sharp rise in colorectal cancer in Korea since the 1990s; in fact, the age-standardized incidence of this malignancy has increased by 5.3% annually in both men and women between 1999 and 2008 [33]. The most likely cause of the rapid increase in colorectal cancer in developed East Asian countries (including Korea and Japan) is the adoption of a Western-style diet with higher consumption of red meat [16,34].

Compared to professional and managerial workers, blue-collar workers in our study showed a lower risk of colorectal cancer while clerks (Group 2) showed a higher risk. The same SES gradient was observed in men and women. Some previous studies found an increased incidence of colorectal cancer in high social strata, although others reported the absence of a gradient or even of an opposite pattern across social strata [7,16,35].

Different dietary patterns by SES could play a role in colorectal cancer differences. According to a previous study, higher SES individuals (surveyed in 1995) reported significantly higher percentages of calorie consumption from fat, while lower SES individuals consumed less animal foods (including meat, egg, and milk) as well as lower proportions of calories from fat [36]. Greater meat consumption among higher SES groups in the 1990s could explain our results; however, socioeconomic dietary patterns have been shifting so that, by 2007–2009, men and women with higher education consumed more vegetables and fruits than did those of

lower SES groups [37]. Thus, our observed SES gradient as related to the incidence of colorectal cancer may reverse in the future.

Access to screening test also could be a factor related to colorectal cancer differences. National cancer screening includes only fecal occult blood test (FOB) for those aged more than 50, so individuals less than the age of 50 or with negative results at FOB of NCSP should get colonoscopy privately. The lowest income population showed approximately 40% less experience rate of colonoscopy than the highest income population in Korea [38].

The highest incidence of colorectal cancer was found in clerks, which might be related to their reduced physical activity or sedentary work [39,40].

#### 4.6. Prostate cancer

A higher risk of prostate cancer was observed among men in higher SES occupations, which is consistent with previous studies [10,16,41,42]. The most likely cause of the differences in the incidence of prostate cancer is reportedly access to screening (prostate-specific antigen [PSA] testing). In Korea, prostate cancer screening is not included in the national cancer screening because evidence of the benefit of PSA screening is still limited [43]. However, PSA screening is usually conducted at outpatient clinics or private health examination centers via private payment.

Hence, despite having a lower incidence of prostate cancer, late-stage diagnosis of this disease is reported to be more prevalent

among lower SES occupation workers [10,42]. These findings suggest that the socioeconomic gradient in prostate cancer incidences found in our data is related to access to screening and potential overdiagnosis.

#### 4.7. Breast cancer

The incidence rate of female breast cancer has risen sharply in Korea and was 2.3-fold higher in 2014 than in 1999 [1]. This reflects the dramatic change in reproductive behavior among Korean women during the past half-century. The total fertility rate declined from 4.53 in 1970 to 1.08 in 2005 owing to fewer marriages and a higher mean maternal age [44]. This trend partially reflects cultural changes as well as the increased participation rate of women in the workforce (from 26.8% in 1960 to 47.2% in the early 1990s) that accompanied the rapid economic development of the country [45].

Generally, female breast cancer showed a greater incidence among higher SES groups, which is consistent with other studies including in Western settings. The risk of breast cancer is driven by reproductive behaviors, including a higher age at first childbirth, low parity, or use of hormone replacement therapy [9]. Professional women are more likely to have fewer children, start families at older ages, and prescribed hormone replacement therapy after menopause [46]. Additionally, the difference in access to screening could be a factor; while the national screening program covers a mammography every two years in women over the age of 40 years, the participation rate varies by household income and education (36.2% and 42.9% among the lowest and highest income groups, respectively, in 2005) [47]. According to a previous study, the lowest socioeconomic status group showed a 1.35-fold higher risk of breast cancer at an advance stage over the highest socioeconomic group [48].

In the present study, clerks showed the highest risk of breast cancer among the four occupational groups. Sedentary behavior (such as that engaged in by clerks) is reported to be associated with higher breast cancer incidence and mortality rates [39].

#### 4.8. Cervix uteri

Although the ASR of cervical cancer has continued to decrease rapidly (from 16.3 per 100,000 in 1999 to 9.0 per 100,000 in 2014), cervical cancer remained the sixth most common cancer among Korean women in 2014 [1]. One reason for the high incidence of cervical cancer is likely the low participation in Pap smear screening, as the removal of precursor lesions detected by Pap smears can circumvent the development of cervical cancer.

Studies consistently reveal higher incidences of cervical cancer among lower SES women [7,49]. In a previous study of the inequalities in female cancer-related mortality rates in Korea, death due to cervical cancer showed the most prominent gradient when stratified according to educational level [13]. In the present study, the highest risk of cervical cancer was found among service and sales workers. Notably, inequalities in screening utilization have been repeatedly documented, with Pap smear participation rates differing based on household income in Korea (43.2% among the lowest earners and 65.1% among the highest in 2005) [47].

#### 4.9. Corpus uteri and ovarian cancer

Incidences of cancers of the corpus uteri and ovary were also greater among women of higher SES, although not as prominently as was breast cancer. Previous studies in Western settings revealed a higher incidence of ovarian cancer in women of higher social classes. Generally, however, these cancers showed inconsistent patterns in terms of socioeconomic differences [7]. The main risk

factors for uterine cancer include obesity, reproductive and hormonal factors (i.e., nulliparity, early menarche, late menopause, and postmenopausal hormone therapy) [50,51]. In the case of obesity, women with higher education have a lower prevalence of obesity in Korea [52]. Therefore, reproductive and hormonal risk factors that are thought to be responsible for differences in breast cancer appear to have contributed more to the lower risk of disease among women of lower SES occupations. These reproductive factors might explain the relationship between SES and ovarian cancer as well, as they are also risk factors for the latter [53]. In addition, earlier diagnosis due to more frequent healthcare utilization of a higher SES population might effect age-standardized incidence across social strata. Pelvic sonography is not included in National Cancer Screening, but many private cancer screening programs recommend the examination of asymptomatic female individuals in Korea.

#### 4.10. Kidney cancer

Kidney cancer is not typically considered a disease with a social gradient [7]. However, we found a much lower incidence of kidney cancer among individuals with lower SES occupations than in professionals and managers among both men and women. Interestingly, a recent study in Japan also reported an excess risk of renal cell cancer among higher-SES men [54]. The researchers attributed this pattern to higher levels of job stress in managerial occupations, resulting in higher rates of smoking and hypertension.

It has been reported that incidental diagnoses of small kidney tumors in Korea have been increasing owing to the expanded use of abdominal imaging during routine screening [55]. Differential access to abdominal sonography (frequently performed at extra cost during periodic health check-ups in Korea) could be one explanation.

#### 4.11. Thyroid cancer

The incidence of thyroid cancer in Korea has risen sharply since the 2000s without a concomitant increase in associated mortality rates, leading to a high suspicion that the “epidemic” is attributable to screening and overdiagnosis. In fact, the incidence rate of thyroid cancer in 2011 was 15 times higher than that in 1993 [56]. The supply-induced epidemic of thyroid cancer has been a subject of debate [56,57], and the SES-based gradient in thyroid cancer incidences may also reflect differential rates of adoption of screening ultrasonography. Thyroid cancer screening is not covered by the national insurance program, and Korean cancer screening guidelines state that there is insufficient evidence to support the usefulness of thyroid cancer screening among asymptomatic individuals. However, many patients have continued to pay for such screening because majority of health examination centers offer a private cancer screening program as a “package” that included thyroid sonography for a modest extra charge (usually 30–50 USD) [56].

### 5. Strengths and limitations

The greatest strength of our study was the availability of a large, nationwide dataset. Subjects were enrolled in the employment insurance program operated by the Korean government between 1995 and 2000; insurance coverage expanded from 33.2% to 65.0% of all employed workers during that period, although the majority of participants were restricted to being full-time workers in the Korean private sector [58]. Owing to the large amount of data and extent to which they represent the Korean workers, we have described the overall picture of socioeconomic inequalities in

cancer incidences in Korea for the first time. Additionally, our follow-up of the longitudinal dataset enabled us to exclude individuals previously diagnosed with cancer from the outset; hence, reverse causation could be ruled out. Occupational classifications in our study were obtained from employment insurance data, which were provided by the companies that had hired the participants. Misclassification of occupational groups is therefore expected to be lower than if the information had been self-reported.

Some limitations of the study should also be noted. The KCCR was established in 1980, at which time it documented 80–90% of cancer cases from more than 180 hospitals training intern or resident throughout the country. Since 1999, the KCCR expanded to cover the entire population; hence, the completeness of data for 2009 was estimated to be 97.2% [33]. We used older KCCR data (1995–2007); therefore, the registry's coverage might have been lower than it would be in more recent years. Another limitation was that we had no information on the stage of cancer at the time of diagnosis. The incidence patterns for several types of cancer suggested a screening effect (and earlier diagnosis); however, we were unable to verify this. Moreover, we lacked information on behavioral factors such as smoking, alcohol consumption, physical activity, reproductive history, or occupational exposure.

## 6. Conclusion

Occupation-based inequalities in cancer incidences were observed in the male Korean working population, especially for lung and liver cancer. The Korean national cancer prevention strategy needs to focus more on individuals with lower SES occupations. Kidney, thyroid, and female breast cancer showed greater incidence rates in the higher occupational group, although the possible effects of screening and overdiagnosis should be evaluated further.

## Declaration of competing interest

All the authors do not have conflicts of interest to declare.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.shaw.2019.12.004>.

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