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Cancer Incidence Among Residents Near Coal-Fired Power Plants Based on the Korean National Health Insurance System Data

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ABSTRACT

Background: Cancer is a leading cause of death worldwide, posing a significant threat to human health and life expectancy. Numerous existing studies explored the correlation between coal-fired power plants and cancer development. Currently, Chungcheongnam-do Province hosts 29 coal-fired power plants, constituting half of the total 58 plants across South Korea.
Methods: This study assessed the cancer incidence by proximity to coal-fired power plants in Chungcheongnam-do Province, Korea. In this study, the exposed group comprised individuals residing within a 2-km radius of the coal-fired power plants, whereas the control group comprised individuals who had no prior residency within the 2-km radius of such plants or elsewhere in the province. Standardized incidence ratios were calculated using the cancer incidence cases retrieved from the National Health Insurance System data from 2007 to 2017.
Results: The study found that exposed men had a 1.11 (95% confidence interval [CI], 1.09–1.21) times higher risk of developing all cancer types and a 1.15 (95% CI, 1.09–1.22) times higher risk of developing cancers excluding thyroid cancer compared with control men. Exposed women had a 1.05 (95% CI, 1.00–1.14) times higher risk of developing all cancer types and a 1.06 (95% CI, 0.98–1.13) times higher risk of developing cancers excluding thyroid cancer than did control women. The colorectal, liver, prostate, and bladder cancer incidence rates were significantly higher in exposed men than that in all control groups. The incidence of esophageal, stomach, liver, and lung cancers were significantly higher in exposed women compared with all control groups.
Conclusion: The residents near coal-fired power plants had a higher risk of developing cancer than did those living in other areas. In the future, long-term follow-up investigations in residents living in the vicinity of power plants are warranted.

Keywords: Coal; Power Plant; Incidence; Neoplasms

INTRODUCTION

Since power plants have been situated in residential areas, stringent emission standards, real-time monitoring for emissions and environmental policies such as closing down old power

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Author Contributions
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plants have been enforced. However, the environmental and health effects of the emitted air pollutants have raised concerns, for which various related studies are being conducted.

A coal-fired power plant burns fossil fuels in a boiler to produce steam, which rotates a turbine to generate electricity.[1] Coal is a fossil fuel with abundant reserves; approximately 38% of the world's electricity is generated by coal-fired power plants.[2]

When four tons of coal are burned, approximately one ton of coal ash is produced.[3] Air pollutants emitted during the burning of fossil fuels and generation of electricity include sulfur dioxide (SO_2) and nitrogen oxides (NOx), which account for 63% of the total emissions. In addition, fine particulate matter ($PM_{2.5}$), coarse particulate matter (PM_{10}), carbon dioxide, mercury (Hg), acid gases, polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs) are mixed into emissions.[1]

In addition to the combustion process, the dispersion of coal dust during transportation, fine dust emissions caused by natural combustion during storage, and potential exposure to pollutants caused by coal ash after combustion have raised concerns.[4]

In the existing studies, a previous study conducted in Italy found an increased incidence of lung cancer among residents living near coal-fired power plants.[5] Another study estimated an increased risk of cancer among residents with high exposure to heavy metals, using soil samples from areas near coal-fired power plants.[6] A previous study on residents living near a coal-fired power plant in Taiwan reported higher urinary concentrations of heavy metals in those living in areas close to the plant.[7] Principal component analysis of soil samples obtained from an area near a coal-fired power plant in Inner Mongolia, China detected the presence of in the topsoil and subsoil.[8] The Hg concentrations increased by 14% in soil samples collected twice over 10 years from an area near a coal-fired power plant on the Spanish island of Mallorca.[9]

In studies on coal-fired power plants in Korea, residents within the influence area of coal-fired power plants were confirmed to be potentially exposed to environmental pollutants, such as heavy metals and VOCs, which are representative biological indicators.[10] Although not directly related to thermal power plants, the concentrations of PAHs and dioxins in the air near incinerators were high. Moreover, the concentrations of cadmium (Cd) and metabolites of PAHs in urine were also high.[11] Furthermore, there was a higher risk of developing all cancer types, such as esophageal, stomach, lung, gallbladder, and kidney cancers.[12]

Cancer-related mortality accounts for 27% of all deaths in South Korea, with a mortality rate of 160.1 per 100,000, making it one of the three primary causes of death.[13] Lifestyle modifications and environmental interventions remain the primary prevention of cancer.[14] Various studies are being conducted worldwide. However, studies that harness secondary datasets, such as health insurance records, to scrutinize cancer occurrence in Korea are limited.

Hence, this study aimed to evaluate whether individuals living near power plants could have a higher incidence of cancer than did those living in other areas using the Korean National Health Insurance System (KNHIS) data.

METHODS

Coal-fired power plants in South Korea have been operating since the 1930s and increased in power generation around 2000.[3] Since the 1980s, the share of coal-fired power plants in Chungcheongnam-do Province (Chungnam) has increased dramatically compared with that in other regions.[3] Of the 15 municipalities in Chungnam, four (Dangjin, Taean, Boryeong, and Seocheon) have coal-fired power plants (**Fig. 1**). Among them, coal-fired power plants such as Boryeong Units 1 and 2 and Seocheon Units 1 and 2 have been in operation since the 1980s have been shut down due to their old age, which is more than 30 years. Although Dangjin Unit 10, Taean Unit 10, Boryeong Unit 8, and the newly constructed New Seocheon Power Plant are currently in operation. Emissions from coal-fired power plants in Chungnam are among the 30 air pollutants in South Korea. In 2022, bituminous coal power generation in Chungnam accounts for 48% of the national total, while power generation capacity accounts for 45% of the country's total.[15]

Study area

Within a 2-km radius of each power plant, nearby towns were designated as exposed areas, while other areas within the same county and Chungcheongnam-do Province were designated as control areas.[16] Based on the KNHIS database (DB), individuals who resided in exposed areas from 2007 to 2017 were defined as the exposed group, whereas those who resided in control areas were defined as the control group.

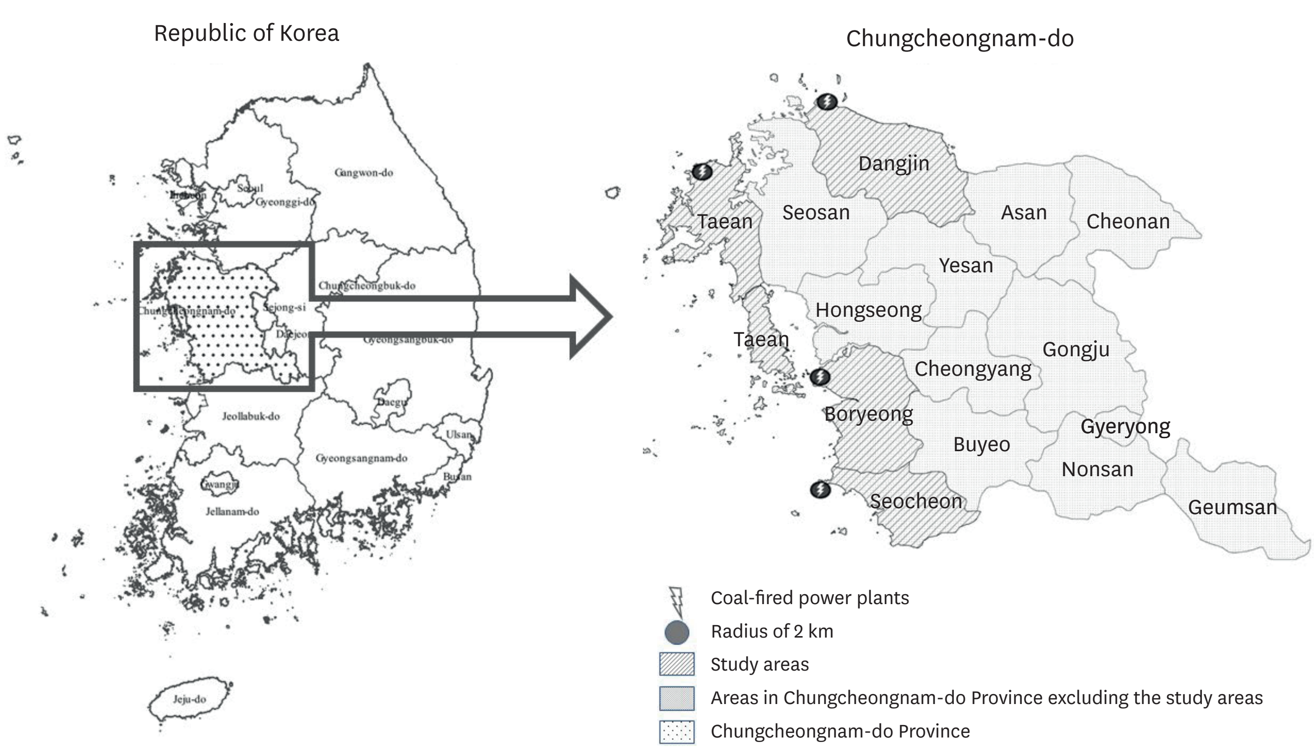

Fig. 1. Map of study areas and Chungcheongnam-do Province.

Collecting national data

The medical utilization data used in this study were collected from the KNHIS DB, which contains 100% of the medical utilization records of the entire population through the National Health Insurance Corporation.[17] The qualification and health insurance claims DB were used for each year. The qualification DB contains information on identity (ID), region, sex, and age, whereas the health insurance claims DB consists of ID and medical service use (date, type of treatment, and International Classification of Diseases, 10th revision [ICD-10] code of disease).[17] The two DBs were combined using the ID to calculate the number of patients with cancer by year, sex, and age group.[17]

Identifying cancer cases

The date of cancer incidence was defined as the date of the first KNHIS claim for an ICD-10 cancer diagnosis code (C00–C97) as the principal diagnosis in patients registered with cancer-related rare and incurable disease codes (V027, V193, and V194) from 2007 to 2017.[18] This study focused on 24 major types of cancers identified by the Korea National Cancer Center (KCCR). These included all cancer types (C00–C96); lip, oral, and pharyngeal (C00–C14); esophageal (C15); gastric (C16); colon (C18–C20); liver (C22); gallbladder (C23–C24); pancreatic (C25); laryngeal (C32); lung (C33–C34); prostate (C61); testicular (C62); kidney (C64); bladder (C67); brain (C70–C72); thyroid (C73); non-Hodgkin lymphoma (C82–C86, C96); multiple myeloma (C90); leukemia (C91–C95); lymphoma (C81–C96); and all cancer types excluding thyroid cancer. In Korea, analysis of all cancer types, excluding thyroid cancer, is essential due to the overreporting of thyroid cancer due to the detection bias of ultrasound examination.[19]

Statistical analysis

We estimated the standardized incidence ratios (SIRs) adjusted for age group of 10 years and sex for all cancer types and specific types of cancer from 2007 to 2017. We used resident population data from Korean Statistical Information Service, cancer registration data from the KNHIS and Chungcheongnam-do cancer registration data from the KCCR to calculate the standardized cancer incidence rates and 95% confidence intervals (CIs) for individuals residing within the 2-km radius of power plants compared with those living in areas beyond 2-km or in other regions of Chungcheongnam-do. We calculated the 95% CIs using the official formula from the International Agency for Research on Cancer (IARC)[20]:

$$SIR = \frac{Observed\ events}{Expected\ events}, \qquad Expected\ events = \sum_{i=1}^{A} \frac{a_i n_i}{100000}$$

$$95\%\ CI\ of\ SIR = \frac{\left[\sqrt{\text{Observed events}} \pm \left(Z_{\frac{\alpha}{2}} \times 0.5\right)\right]^2}{\text{Expected events}}$$

where a_i is the age-specific rate for standard population and n_i is the person-years of the specific age group in the target population.

$$ASR = \frac{\sum_{i=1}^{A} a_i w_i}{\sum_{i=1}^{A} w_i}$$

where a_i is the age-specific rate for target population, w_i is the standard population of a specific age group, and n_i is the person-years of a specific age group in the target population.

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A joinpoint regression analysis was performed using the Joinpoint Regression Program (https://surveillance.cancer.gov/joinpoint/) (National Cancer Institute 2023). We used the program to calculate the average annual percentage change (APC) and APCs. A *P* value of < 0.05 was considered statistically significant.

Ethics statement

The present study protocol was reviewed and approved by the Institutional Review Board (IRB) of Dankook University Hospital (approval No. DKUH-2017-03-007-021). With regard to the use of the KNHIS DB (NHIS-2020-1-086), the requirement for obtaining consent was waived by the IRB for the use of anonymized secondary data for public purposes.

RESULTS

Table 1 presents the distribution of the general characteristics between the exposed and control groups within the study area. A higher proportion of men was observed in all exposed groups. In Taean-gun and Seocheon-gun, the exposed group had a higher income level than did the control group. However, except for Seocheon-gun, the exposed group from other regions had a higher average age than did the control group.

The overall comparison between the exposed and control groups and Chungcheongnam-do residents stratified by sex across the four integrated areas is summarized in **Table 2**. Both male and female participants living within the 2-km radius had higher SIRs for all cancer types, except thyroid cancer, than did the controls and Chungcheongnam-do residents. Among men, exposed residents had 1.14 (95% CI, 1.08–1.46) times and 1.57 (95% CI, 1.18–1.59) times higher SIRs for developing colon cancer, 1.19 (95% CI, 1.16–1.66) times and 1.87 (95% CI, 1.41–2.02) times higher SIR for prostate cancer, and 1.28 (95% CI, 1.18–2.04) times and 2.78 (95% CI, 1.05–3.08) times higher SIR for developing bladder cancer, respectively. In women, the exposed group had 1.18 (95% CI, 1.04–1.51) times and 1.64 (95% CI, 1.21–1.74) times higher SIR for stomach cancer than the control and Chungcheongnam-do groups, respectively. **Fig. 2** shows the changes in age-standardized rate (ASR) for all cancer types

Table 1. Descriptive statistics of the study area in 2011

Characteristics	Overall		Dangjin		Taean		Boryeong		Seocheon	
	CFPP < 2-km	CFPP ≥ 2-km	CFPP < 2-km	CFPP ≥ 2-km	CFPP < 2-km	CFPP ≥ 2-km	CFPP < 2-km	CFPP ≥ 2-km	CFPP < 2-km	CFPP ≥ 2-km
Age, yr										
Mean ± SD	47.1 ± 22.2	42.4 ± 22.6	46.1 ± 22.0	39.8 ± 22.2	49.3 ± 22.9	44.7 ± 22.3	46.3 ± 21.8	41.9 ± 22.4	46.9 ± 22.2	47.3 ± 23.2
P value	< 0.001		< 0.001		< 0.001		< 0.001		0.190	
Sex										
Male	16,669 (51.8)	177,228 (50.7)	4,135 (51.7)	73,350 (52.0)	3,808 (50.4)	28,078 (50.1)	6,191 (52.9)	48,581 (50.3)	2,535 (51.4)	27,219 (49.0)
Female	15,532 (48.2)	172,147 (49.3)	3,865 (48.3)	67,761 (48.0)	3,753 (49.6)	28,015 (49.9)	5,513 (47.1)	48,082 (49.7)	2,401 (48.6)	28,289 (51.0)
P value	< 0.001		0.610		0.616		< 0.001		0.002	
Health insurance income index,[a] median										
Overall	39,994	39,480	41,227	42,300	45,222	40,409	35,700	36,220	42,493	36,833
P value	< 0.001		0.535		< 0.001		0.043		< 0.001	
Employee	52,006	37,187	56,719	57,800	57,771	53,697	45,357	45,257	52,995	43,621
Local-subscriber	50,992	37,077	36,425	38,612	41,915	35,149	33,840	35,312	37,229	37,447
P value	< 0.001		0.114		< 0.001		0.401		< 0.001	

Values are presented as number (%).
CFPP = coal-fired power plant, SD = standard deviation.
[a]National health insurance payment amount (KRW)/√number of households.

Table 2. SIRs for cancer and 95% CIs of the overall residents in the study area near the coal-fired power plants from 2007 to 2017

Cancer site	Male residents within 2-km (person-year = 156,091)							Female residents within 2-km (person-year = 145,068)						
	Observed	Vs. residents outside 2-km			Vs. Chungcheongnam-do Province			Observed	Vs. residents outside 2-km			Vs. Chungcheongnam-do Province		
		Expected	SIR	95% CI	Expected	SIR	95% CI		Expected	SIR	95% CI	Expected	SIR	95% CI
All sites (C00–C96)	1,276	1,145	1.11	(1.09–1.21)	906	1.41	(1.33–1.49)	898	854	1.05	(1.00–1.14)	719	1.25	(1.17–1.33)
All sites exclude thyroid	1,220	1,057	1.15	(1.09–1.22)	870	1.40	(1.33–1.48)	690	651	1.06	(0.98–1.13)	559	1.23	(1.14–1.33)
Lip, oral cavity, and pharynx (C00–C14)	25	28	0.89	(0.64–1.70)	17	1.47	(0.84–1.75)	12	12	1.00	(0.48–1.93)	6	2.00	(0.59–2.50)
Esophagus (C15)	40	33	1.21	(0.97–2.02)	19	2.11	(1.16–2.43)	5	4	1.25	(1.14–7.47)	1	5.00	(1.14–7.45)
Stomach (C16)	300	269	1.12	(0.79–1.51)	186	1.61	(1.38–1.76)	136	115	1.18	(1.04–1.51)	83	1.64	(1.21–1.74)
Colon and rectum (C18–C20)	207	182	1.14	(1.08–1.46)	132	1.57	(1.18–1.59)	114	120	0.95	(0.85–1.27)	86	1.33	(0.98–1.45)
Liver (C22)	171	140	1.22	(1.11–1.70)	86	1.99	(1.42–2.26)	61	50	1.22	(1.02–1.71)	28	2.18	(1.36–2.39)
Gallbladder (C23–C24)	44	42	1.05	(0.59–1.40)	23	1.91	(0.60–2.43)	38	30	1.27	(0.73–1.70)	20	1.90	(0.72–2.68)
Pancreas (C25)	52	50	1.04	(0.82–1.60)	26	2.00	(0.94–2.34)	37	31	1.19	(0.73–1.62)	20	1.85	(0.81–2.28)
Larynx (C32)	18	18	1.00	(0.42–1.62)	8	2.25	(0.49–2.91)	2	1	2.00	(0.00–6.47)	0	-	
Lung (C33–C34)	247	238	1.04	(0.85–1.51)	147	1.68	(1.29–1.70)	100	86	1.16	(1.02–1.60)	56	1.79	(1.17–1.83)
Breast (C50)	2	2	1.00	(0.00–5.03)	0	-		117	126	0.93	(0.84–1.23)	100	1.17	(0.95–1.38)
Cervix uteri (C53)	-	-	-		-	-		43	42	1.02	(0.80–1.55)	26	1.65	(1.03–2.00)
Corpus uteri (C54)	-	-	-		-	-		17	21	0.83	(0.42–1.40)	13	1.31	(0.43–1.45)
Ovary (C56)	-	-	-		-	-		20	23	0.87	(0.60–1.62)	13	1.54	(0.72–1.95)
Prostate (C61)	146	123	1.19	(1.16–1.66)	78	1.87	(1.41–2.02)	-	-	-		-	-	
Testis (C62)	1	2	0.50	(0.33–1.12)	0	-		-	-	-		-	-	
Kidney (C64)	39	31	1.26	(0.98–2.01)	19	2.05	(1.12–2.33)	12	12	1.00	(0.32–1.53)	8	1.50	(0.36–1.68)
Bladder (C67)	64	50	1.28	(1.18–2.04)	23	2.78	(1.05–3.08)	15	13	1.15	(0.54–1.94)	5	3.00	(0.96–3.48)
Brain and CNS (C70–C72)	32	21	1.52	(0.95–2.37)	8	4.00	(1.68–4.20)	15	20	0.75	(0.50–1.52)	6	2.50	(1.23–3.74)
Thyroid (C73)	56	88	0.64	(0.46–1.02)	36	1.56	(0.74–1.98)	208	203	1.02	(0.83–1.38)	160	1.30	(0.80–1.41)
Hodgkin lymphoma (C81)	1	3	0.33	(0.00–4.12)	0	-		1	0	-		0	-	
Non-Hodgkin's lymphoma (C82–C86, C96)	33	29	1.14	(0.84–1.36)	17	1.94	(1.13–2.64)	26	20	1.30	(0.81–1.76)	12	2.17	(1.09–2.81)
Multiple myeloma (C90)	9	10	0.90	(0.45–2.14)	6	1.50	(0.50–2.39)	7	6	1.17	(0.57–2.71)	5	1.40	(0.65–3.08)
Leukemia (C91–C95)	20	18	1.11	(0.53–1.69)	12	1.67	(0.58–1.96)	17	14	1.21	(0.89–2.50)	8	2.13	(1.13–3.19)

SIR = standardized incidence ratio, CI = confidence interval, CNS = central nervous system.

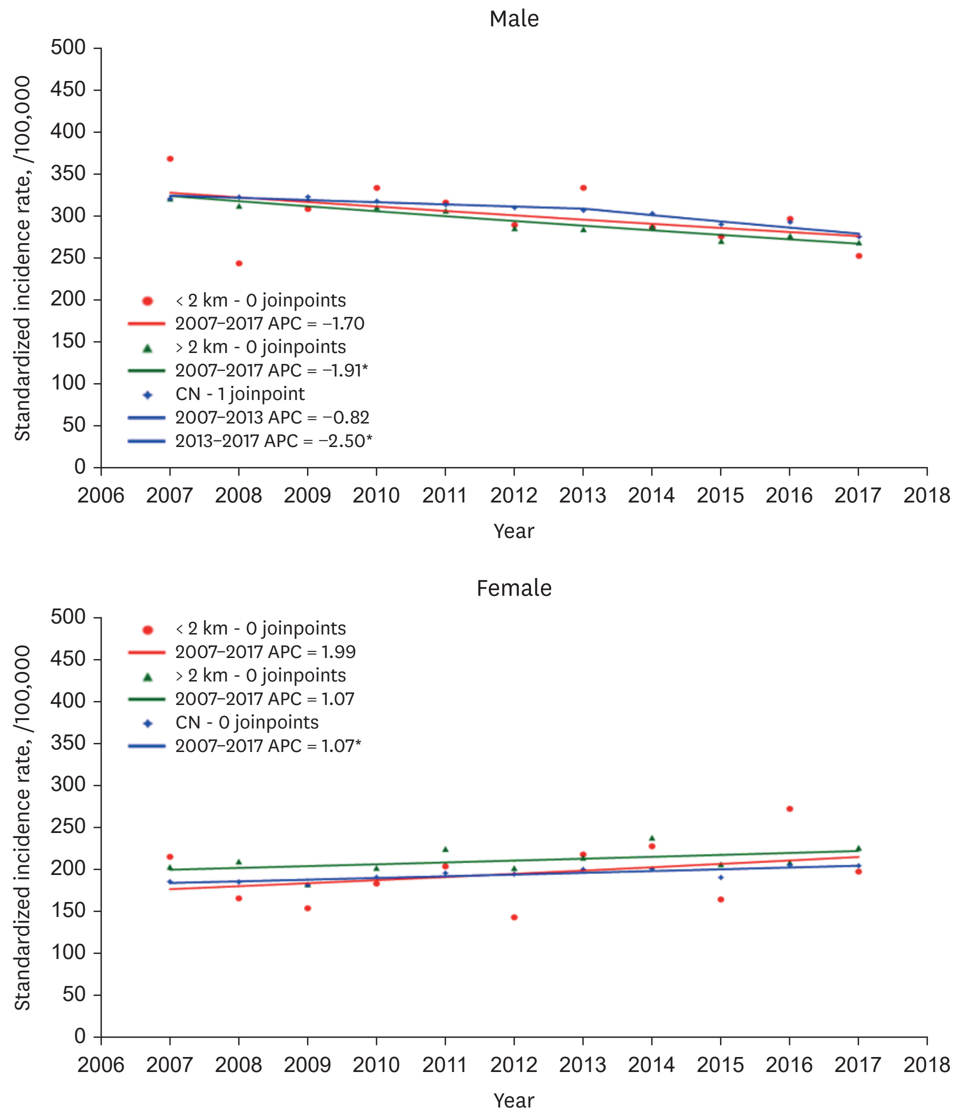

Fig. 2. The APC of the age-standardized incidence rate of all cancer types excluding thyroid cancer, in residents of the study area, CN by sex.
APC = annual percent change, CN = Chungcheongnam-do.

except for thyroid cancer stratified by sex. In men, a modest decrease in ASR was observed in the exposed group over the entire period and a significant decrease in both control groups; in women, the ASR noticeably increased in the exposed group for all cancer types except for female thyroid cancer, increased in both control groups, and significantly increased in Chungcheongnam-do residents.

Fig. 3 illustrates a visual representation of SIR values by region. No significant increase was observed in the number of cancer cases in Dangjin and Seocheon. In Boryeong, the incidence rates of prostate cancer in men and non-Hodgkin's lymphoma in women were significantly higher compared with those in the two control groups. In Taean, the incidence rates of stomach and liver cancer in men and liver and thyroid cancer in women were significantly higher compared with those in the two control groups.

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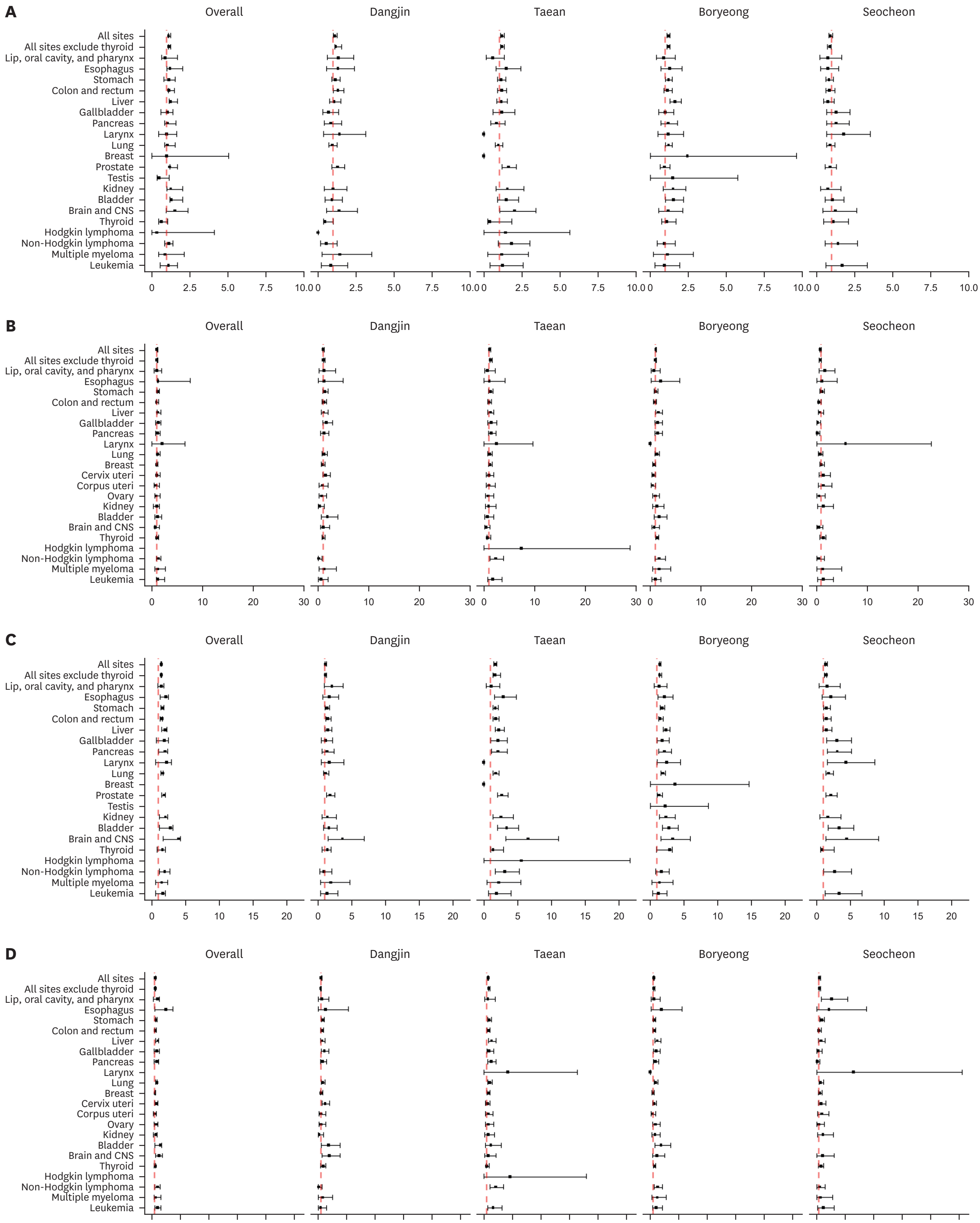

Fig. 3. Forest plot of the SIR for cancer and the 95% CIs of residents in the study area near the coal-fired power plants from 2007 to 2017 by area. (**A**) SIR (95% CI) for cancer among male residents living within the 2-km radius of the CFPP compared with those living outside the 2-km radius. (**B**) SIR (95% CI) for cancer among female residents living within the 2-km radius of the CFPP compared to those living outside the 2-km radius. (**C**) SIR (95% CI) for cancer among male residents living within the 2-km radius of the CFPP compared to those living in Chungcheongnam-do. (**D**) SIR (95% CI) for cancer among female residents living within the 2-km radius of the CFPP compared to those living in Chungcheongnam-do.
SIR = standardized incidence ratio, CI = confidence interval, CFPP = coal-fired power plant.

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DISCUSSION

In this study, the SIRs for all cancer types were higher in participants residing within the 2-km radius of the plant compared with those living outside the 2-km radius and in Chungcheongnam-do. Men had a significantly higher incidence of colorectal, liver, prostate, and bladder cancers than did the controls. Women had a significantly higher incidence of esophageal, stomach, liver, and lung cancers than did the controls. The annual ASR trends for all cancer types, except for thyroid cancer, showed a modest decrease in cancer incidence over time in men from the exposed group compared with those in the control group, and an increase in cancer rates in women.

In our study, the participants residing within the 2-km radius of the plant had higher SIRs for all cancer types than did those in the two control groups. Although the incidence of high-risk cancers differed by region, that of bladder cancer was significantly higher in men residing within the 2-km radius of coal-fired power plants compared with the two control groups. Bladder cancer incidence was also higher in women than in the two control groups. However, the difference was not significant. The incidence of lung cancer was significantly higher in women than that in both control groups. In previous studies, the IARC has classified arsenic (As) as a human carcinogen (group 1). As is a primary contributor to the onset of bladder cancer, whereas As and Cd are primary contributors to the onset of lung cancer.[21] Previous studies have reported an association between living near coal-fired power plants and cancer risk among residents. An Italian study analyzed the association between benzene, NOx, and SO_2 exposure levels and annual age-standardized incidence rates of lung and bladder cancers in residents living near coal-fired power plants. In women aged $\geq$ 75 years, the risk of lung cancer was higher in the high benzene exposure group than that in the low exposure group. No significant association was observed in men or women aged < 75 years.[5] This study categorized exposures based on coal-fired power plant exposure reports, which might not reflect the actual degree of exposure. The KNHIS data since 2002 were used in this study. The study was designed using cancer registry data aggregated by region from 2007 to account for a 5-year latent period and standardized to 10-year age groups. This study could not directly assess the degree of exposure to pollutants emitted by coal-fired power plants. Regarding privacy reasons, we used distance from coal-fired power plants as a proxy for exposure to pollutants in the KNHIS data, which were available based on administrative regions, as a risk factor for cancer incidence. The regional differences in the start-up times of coal-fired power plants and the fuels they use are likely to result in the differences in pollutant emissions.

In this study, the incidence of prostate cancer in men and non-Hodgkin's lymphoma in women near the power plant was significantly higher compared with those in the two control groups. Tang et al.[6] observed differences in heavy metal concentrations among 112 soil samples obtained from areas near coal-fired power plants according to the power plant and wind direction, with higher concentrations of heavy metals in the soil in the downwind area. Residents with a high level of exposure to As, Cd, chromium (Cr), and nickel (Ni) had an increased risk of developing cancer. Coal ash is mainly composed of silicon, aluminum, calcium, iron, As, Cd, Cr, and lead.[22-25] Trivalent and pentavalent As were detected in milled coal, while pentavalent As was detected in most fly ashes.[26] Inorganic As is the most toxic component of coal ash.[27,28] According to the United States Geological Survey, 89% of the As in fly ash samples collected from three coal plants was pentavalent As, while 11% was trivalent As.[25] Long-term exposure to As causes cancer, heart disease, and respiratory diseases.[29-42] Cd is an element found in the earth's crust, is commonly used in batteries and

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paints, and is also found in coal and coal ash. Exposure to Cd has been linked to lung, kidney, and prostate cancer; the IARC classifies Cd as a Group 1 human carcinogen; and benzene exposure is a probable cause of lymphoma.[21]

The risk of liver cancer in men and women residing within the 2-km radius of the power plant was higher than that in the two control groups, particularly in Boryeong. The risk of lung cancer in women residing within the 2-km radius of the integrated power plant was higher than that in the control group. Furthermore, the risk of stomach cancer was higher than that in the control group. Based on the composition and molecular ratios of PAHs in residential soil samples from areas around coal-fired power plants in India, Kumar et al. assumed that PAHs enter the body from soil contaminated by power plants, and the resulting adult incremental lifetime cancer risk was 3.1 × 10-7. A previous study investigated the association between exposure to PAHs and cancer across industries.[43] Boffetta et al.[44] reported that the primary target organ for PAHs is the lungs and that large exposures increase the risk of lung, skin, and bladder cancer. Chen et al.[7] studied the urinary exposure to heavy metals and PAHs in residents living near a coal-fired power plant in Taiwan, stratifying exposure based on the distance from the plant. Urinary concentrations of 1-OHP, vanadium, Ni, copper, As, strontium, Cd, and Hg were higher in the high-exposure group than that in the low exposure group.[7] Principal component analysis of soil samples near a coal-fired power plant detected Hg in the topsoil and subsoil.[8] Hg exists in the form of elemental, organic, and inorganic Hg, all of which are harmful to humans, and has been found in coal ash. Hg is difficult to eliminate from the body and can accumulate in the liver and kidneys, causing neurotoxicity.[45,46] Hg levels increased by 14% in the soil near a coal-fired power plant on the island of Mallorca, Spain, based on the analysis of samples obtained twice over 10 years.[9] According to IARC, agents with limited evidence in humans, inorganic Hg, and salted fish are associated with the development of stomach cancer.[21]

This study some several limitations. First, we only analyzed the data since 2007. Therefore, we were unable to determine the impact of the plant on cancer incidence for approximately 20 years after the plant was built in the 80s. Health Insurance Corporation data have been available since 2002; we utilized the most recent 11 years of data because of their stability and the latency period for cancer development. Therefore, some participants were excluded from the study; the latency period for cancer development was not sufficiently considered. Therefore, long-term follow-up studies are required. Second, this study did not assess the residential history of the exposed and control areas. If some participants had a history of living in both the exposed and control areas, errors in exposure categorization would have occurred. However, considering the residential history based on the cancer registration data aggregated by region and year is difficult. Hence, further studies that consider individual characteristics, such as length of residence, are needed. Third, when defining the date of cancer incidence, we defined the date of cancer incidence as the date of the first medical institution visit with cancer as the main diagnosis. The KNHIS data used in this study were medical claims data and were not collected for research purposes. Linking the KCCR cancer registration data with the KNHIS data could identify the exact date of cancer incidence. Access to the KCCR-KNHIS linked data was restricted for policy and security reasons. However, previous studies have shown that the concordance between the cancer incidence date registered in the KCCR and the operational definition of the cancer incidence date using the primary diagnosis is 80%. Moreover, the difference between the patient's cancer incidence date and the operational definition of the diagnosis date is 31 days or less in more than 80% of the patients.[18] Fourth, identifying the health effects of a single source of pollution from a coal-fired power plant by excluding exposure to other environmental pollution facilities in the exposure area is difficult. Therefore, the control group was defined as those living in the area more than 2 kilometers away from the power plant in the same municipality and in the entire Chungcheongnam-do Province, where the power plant is located, for comparison with various control groups.

Despite these limitations, this study evaluated the risk of cancer among residents in areas near coal-fired power plants using data from the National Health Insurance Personal Healthcare Utilization Survey. Future analyses should take into account the residence history and characteristics of individuals to identify the risk of cancer.

The incidence of all cancer types was higher in residents living near coal-fired power plants compared with those living in other areas. Future studies should conduct a long-term follow-up of residents in the areas around coal-fired power plants using national health insurance data. Moreover, exposure assessments and ongoing observations of power plant emissions are warranted to support the finding of a higher cancer incidence.

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