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Original article

Lung Cancer Risk in Female School Cooks: A Nationwide Retrospective Cohort Study in the Republic of Korea

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A B S T R A C T

Background: Exposure to cooking fumes exposure likely increases the lung cancer risk in school cooks, but research on the incidence of lung cancer in school cooks is lacking. Therefore, this study aimed to examine a nationwide cohort of school cooks for lung cancer by linking three Korean social insurance databases to determine whether working as a school cook increases lung cancer risk.

Methods: A nationwide retrospective cohort of school cooks and clerks with lung cancer was established by linking Employment Insurance, Industrial Accident Compensation Insurance, and National Health Insurance Service databases. Covariates were matched using 1:1 propensity score matching (PSM) for school cooks and clerks. Age-standardized incidence and hazard ratios (HRs) for lung cancer were calculated using the Cox proportional hazards model. Fine–Gray subdistribution HRs were used for sensitivity analysis. After further categorization into never- and ever-smoked subcohorts, the same analyses were performed.

Results: Post PSM, we identified 76 cases of lung cancer in school cooks during 259,819 person-years of follow-up. The age-standardized incidence was 199.8 (95% confidence interval [CI]: 120.7–278.9) and 166.8 (95% CI: 95.8–237.7) for school cooks and clerks, respectively. The subdistribution HR for school cooks post PSM was 1.72 (95% CI: 1.14–2.60). In the never-smoked subcohort, the subdistribution HR for school cooks post PSM was 4.23 (95% CI: 2.36–7.58).

Conclusion: School cooks were at an elevated risk of developing lung cancer, likely due to exposure to cooking fumes, highlighting the need for improved ventilation and preventive measures in school kitchens to reduce lung cancer risk.

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1. Introduction

Globally, inclusive of the Korea, lung cancer is the most prevalent and the leading cause of mortality [1,2]. Smoking is the most well-known risk factor for lung cancer [1]; however, only 8.1% of lung cancers in Korean female patients are attributed to smoking [3]. Several studies have recently highlighted the potential role of "cooking fumes," which are ultrafine particulate matter generated during the cooking process, as a significant risk factor for lung cancer [4,5]. However, the International Agency for Research on Cancer continues to classify cooking fumes as Group 2A potentially carcinogenic substances [6].

Cooking methods that generate cooking fumes, such as deep frying, frying, and stir frying, wherein the oil is heated to high temperatures, along with cooking time and frequency, cooking experience, solid fuels, heating, and different types of oils, are associated with lung cancer [7–18]. However, most existing research involves case–control studies conducted mainly in

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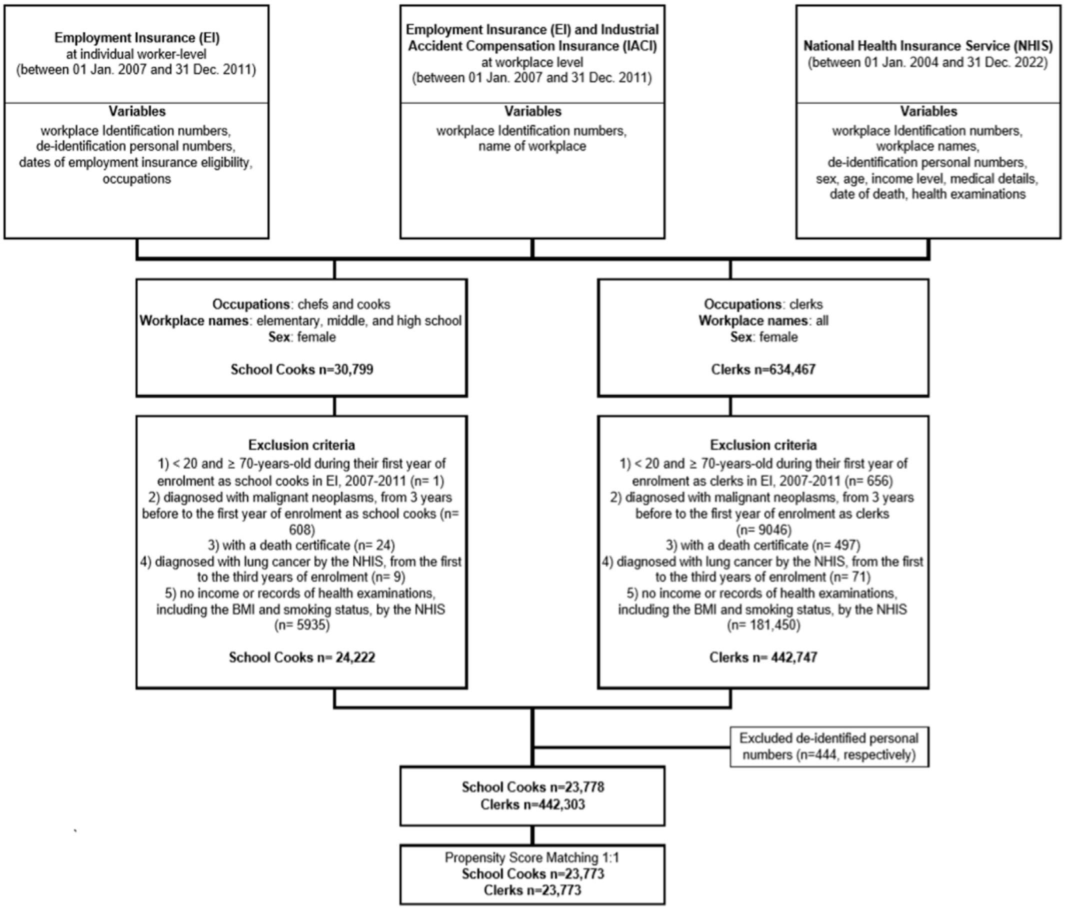

Fig. 1. Flow diagram.

households in China and Taiwan. Studies on lung cancer in cooks who cook large-scale fried dishes are rare and demonstrate conflicting results [19,20].

In the Korea, lung cancers in school cooks have recently become a social issue. In 2021, the Korean government officially designated lung cancer in school cooks as an occupational disease for the first time [21]. Korean school kitchens cook large amounts of fried meat and are poorly ventilated [22]. This kitchen environment is postulated to increase exposure to cooking fumes, likely compounding the risk of lung cancer in school cooks. However, to the best of our knowledge, no research has been conducted on the incidence of lung cancer in school cooks.

Therefore, this study aimed to establish and analyze a nationwide cohort of school cooks with lung cancer by linking Korean social insurance databases to determine whether working as a school cook increases the risk of lung cancer.

2. Materials and methods

2.1. Linkage of databases

To construct a nationwide cohort of school cooks with lung cancer, we linked Korea's social insurance databases, Employment Insurance (EI), Industrial Accident Compensation Insurance (IACI), and National Health Insurance Service (NHIS).

EI aims to promote reemployment and prevent unemployment. IACI aims to protect workers from industrial accidents. EI and IACI are mandatory for all businesses that employ workers, excluding businesses governed by other laws. The EI database was created by the Korea Employment Information Centre at the individual worker level and includes deidentified personal numbers and workplace identification numbers, dates of employment insurance eligibility, and occupations classified by the Korean Employment Classification of Occupations (KECO). The EI and IACI databases at the workplace level have been established by the Korea Workers' Compensation and Welfare Service and include identification numbers and workplace names.

The NHIS ensures that all citizens have access to medical care in the event of illness or injury and is compulsory for all employers, apart from those who employ day laborers with <1 month of employment. The NHIS database contains information on all medical records, excluding the nonbenefits to all citizens who have consulted at a medical institution. The collected data included the demographic, medical, and employment details of patients. Demographic details included deidentified personal numbers, sex, age, and income level of patients. Medical details encompass disease type and medical treatment, date of death, and health examinations, including smoking status and body mass index (BMI). Employment details included workplace identification numbers and names.

The primary purpose of these three databases is administrative, and only the NHIS database is refined for research. We linked all three databases for a period of 5 years (2007–2011), considering reliability, validity, and stability.

We found that the eligibility criteria for the three insurance schemes differed, making it likely that data from the same worker would not be linked across all three schemes. To improve the matching rate and ensure the correct linkage of the same worker across the three databases, we took two steps. The first step entailed utilizing the common workplace identification numbers of all three insurers as a linkage variable. The 5-year average matching rate was 86.5%. In the second step, we used the deidentified personal numbers of individual workers to match the workplaces with the mismatched workplace identification numbers from the first step, resulting in a 5-year average match rate of 97.4%. Database linkage was performed by the NHIS, which provided deidentified, untraceable data.

This study was approved by the institutional review board.

2.2. Lung cancer definition

Lung cancer was defined as the principal diagnosis according to the 6th revision of the Korean Standard Classification of Diseases (KCD-6), with lung cancer codes (C33 and C34) and differential copayment codes (V027, V193, and V194). The differential copayment codes relate to NHIS benefit coverage, which helps alleviate out-of-pocket expenses for patients with cancer. Codes V027, V193, and V194 indicate "registered cancer patients" who are covered by health insurance. Therefore, if these codes are found in the NHIS database alongside the lung cancer codes, it indicates that the patient has been diagnosed with lung cancer. The observation time was based on the date of the first diagnosis of lung cancer, the date of death, or the study end date (December 31, 2022), whichever occurred first. To apply the minimum latent period for lung cancer, this observation period was initiated 3 years after the first year of enrollment as a school cook from 2007 to 2011.

2.3. Study population

Using linked databases, we constructed a lung cancer cohort of school cooks (Fig. 1). Furthermore, the NHIS database was used to extract the latent period and follow-up data for lung cancer from 2004 to 2022. Among the female workers who signed up for EI, school cooks were classified as "chefs and cooks" by KECO from 2007 to 2011. Workplaces were categorized as elementary, middle, and high schools.

A total of 30,799 female workers were included in this study, and 310 male school cooks were excluded from the analysis due to their small sample size. Moreover, the exclusion criteria were as follows: 1) school cooks aged $<$20 years and $\geq$70 years during their first year of enrollment as school cooks from 2007 to 2011 ($n = 1$); 2) school cooks who were diagnosed with malignant neoplasms, from 3 years before to the first year of enrollment as school cooks ($n = 608$); 3) school cooks with a death certificate ($n = 24$); 4) those who were diagnosed with lung cancer by the NHIS, from the first to the third years of enrollment in this position ($n = 9$); and 5) school cooks with no income or records of health examinations, including the BMI and smoking status, by the NHIS ($n = 5935$). The final cohort of female school cooks was 24,222.

The comparative cohort of clerks was selected from the female workers who were enrolled in the EI from 2007 to 2011 and classified as "clerks" by the KECO. Without any restrictions on workplace names, the total number of clerks was 634,467. The final sample selection process for clerks was the same as that for school cooks. The exclusion criteria were as follows: 1) clerks aged $<$20 years and $\geq$70 years during their first year of enrollment in this position, from 2007 to 2011 ($n = 656$); 2) clerks who were diagnosed with malignant neoplasms from 3 years before to the first year of enrollment as clerks ($n = 9{,}046$); 3) clerks with a death certificate ($n = 497$); 4) clerks who were diagnosed with lung cancer by the NHIS, from the first to the third year of enrollment in this position ($n = 71$); and 5) clerks with no income or records of health examinations, including the BMI and smoking status, by the NHIS ($n = 181{,}450$). The final cohort of female clerks was 442,747.

Finally, the data of 23,778 school cooks and 442,303 clerks were extracted after excluding 444 duplicate deidentified personal numbers from among both the school cooks and clerk cohorts.

2.4. Covariates

The covariates used in the analysis included age, BMI, the Charlson Comorbidity Index (CCI), and income level of workers. Age was extracted as a continuous variable in the last year of enrollment, and BMI was extracted as a categorical variable, divided into $<$25 and $\geq$25 kg/m^2 (obesity). The CCI was calculated for 17 comorbidities using the 10th revision of the International Classification of Diseases (ICD-10) algorithm proposed by Quan et al, in 2005 [23], applying the original weights [24], and categorized as 0 or $\geq$1. Comorbidities were analyzed based on the main diagnosis, and the index date was defined as the start of the follow-up period for each study population. The Charlson comorbidity score was coded 1 year prior to the index date (in the year preceding follow-up), and this score was applied at the index date to calculate the comorbidity score. Income level, determined by the NHIS based on health insurance premiums, was categorized into quintiles 1 to 5 for lower income and 6 to 10 for upper income. Smoking status was categorized as never- or ever-smoked.

2.5. Statistical analysis

We performed 1:1 propensity score matching (PSM) to compare lung cancer incidence between female school cooks and clerks, adjusting for confounding and selection biases. Age, BMI, and CCI were chosen as covariates for PSM. Age and BMI are strongly correlated with lung cancer, and the CCI was included to correct for selection bias related to comorbidities prior to the start of lung cancer follow-up. Smoking status was not selected as a covariate in the PSM in order to categorize school cooks and clerks into nonsmoker and ever-smoker subcohorts and to conduct post-PSM analyses with clerks. Income level was not included as a covariate in the PSM as it is influenced by the nature of the different occupations [25]. The PROC PSMATCH procedure was performed using the SAS software program (version 9.4; SAS Institute Inc., Cary, NC, USA). Nearest-neighbor matching was used to ensure that the difference in the logit of the propensity score was not $>$0.2. The recommended maximum absolute value of the standardized mean difference was 0.10 [26].

All analyses of the 2 cohorts of school cooks and clerks were conducted before and after PSM. First, covariates were analyzed using an independent t test for continuous variables and a Chi-square test for categorical variables. Second, we calculated crude and age-standardized incidence (95% confidence interval [CI]) per 100,000 person-years, stratified by age every 5 years, using all female workers in the EI database from 2007 to 2011 as the standard population. Third, we calculated crude hazard ratios (HRs) for lung cancer using the Cox proportional hazards model. For sensitivity analysis, we analyzed mortality as a competing event and adjusted for age, BMI, smoking status, income level, and CCI to obtain Fine–Gray subdistribution HRs. Finally, for the subcohort analysis, school cooks and clerks were categorized by smoking status and matched 1:1 using PSM based on age, BMI, and CCI. Lung cancer HRs (including Fine–Gray sub-distribution HRs) were calculated separately for school cooks and clerks who had never smoked, as well as for those who had ever smoked.

All statistical analyses were performed using the SAS software program. A histogram of the logit of the propensity score and cumulative incidence function for lung cancer was created, using the R software (version 4.2.2; R Foundation for Statistical Computing).

3. Results

As a result of the 1:1 PSM of the final study population, 23,772 school cooks and clerks were matched. Post PSM, the maximum absolute value of the standardized mean differences of the covariates used in PSM was 0.00196, and a balanced change was observed in the logit of the propensity score (Fig. 2).

Post PSM, the difference in the mean age of school cooks and clerks was not statistically significant (44.35 and 44.35 years, respectively). Smoking status and income level, which were not included as PSM covariates, remained significantly higher in clerks (Table 1).

Post PSM, the lung cancer incidence in the cohort of school cooks was 76 cases over 259,819 person-years of follow-up (mean follow-up: 10.9 years), whereas that in the cohort of clerks was 55 cases over 307,545 person-years (mean follow-up: 12.9 years). The age-standardized incidence was 199.8 (95% CI: 120.7–278.9) and 166.8 (95% CI: 95.8–237.7) in the school cook and clerk cohorts, respectively. The subdistribution HR of lung cancer in the school cooks cohort was 1.72 (95% CI: 1.14–2.60) (Table 2). The cumulative incidence of lung cancer was higher in the school cook cohort than in the clerk cohort, both brfore and after PSM (Fig. 3).

According to the smoking subcohort analysis, in the never-smoked subcohort, as a result of the 1:1 PSM, 23,444 school cooks and clerks were matched, and lung cancer occurred in 74 and 24 school cooks and clerks, respectively (Table 3). The subdistribution HR of lung cancer was 4.23 (95% CI: 2.36–7.58) in the never-smoked subcohort. In the ever-smoked subcohort, as a result of the 1:1 PSM, 329 school cooks and clerks were matched, and lung cancer occurred in 2 and 1 of the school cooks and clerks, respectively (Table 4). The subdistribution HR of lung cancer was 6.80 (95% CI: 1.54–30.05) in the ever-smoked subcohort.

4. Discussion

By linking the EI, IACI, and NHIS databases, our comparative analysis of lung cancer incidence in cohorts of female school cooks and clerks revealed that the lung cancer risk was significantly higher in the school cooks cohort than in the clerk cohort. These results indicate that school cooks are at an elevated risk of exposure to cooking fumes in the environment in which they work.

Male bakers, pastry cooks, and cooks in the United Kingdom, Canada, and Sweden have an increased lung cancer risk [27–29]. Conversely, the results of the SYNERGY study, which analyzed pooled case–control studies of occupational lung cancer from 16 countries, revealed that apart from 1 study, the lung cancer risk for both male and female bakers did not increase after adjusting for smoking [20,30]. These conflicting results may be due to the effects of cooking fumes, known lung carcinogens, which vary by cooking method and time, and ventilation, rather than the lung cancer risk from cooking itself.

The cooking method most strongly associated with lung cancer is deep frying, followed by frying and stir frying [7,9]. The risk of lung cancer is increased by 1.64 fold in never-smoking females from China and by 1.97 fold in those from Hong Kong when cooking oil is heated to high temperatures [9,10]. Conversely, a study of Chinese women found that daily stir frying of nonmeat foods does not increase the risk of lung cancer [31].

Cooking time and experience are highly correlated with the lung cancer risk [7,8,12,13,16]. Particularly, an increase in the total cooking dish-years for the three cooking methods, i.e., deep frying, frying, and stir frying, has been shown to have a dose–response association with the lung cancer risk [7,9]. Chinese restaurant cooks had a 5-fold higher risk of lung cancer if they had worked for ≥5 years [19]. Our analysis did not include the total number of years employed by school cooks because of data limitations; nonetheless, most school cooks who applied for IACI for lung cancer had worked for several decades. As per Republic of Korea Workers' Compensation and Welfare Service's professional investigation case report on school cooks approved by the IACI for lung cancer, school cooks have worked for 12–22 years. Furthermore, school cooks in the Korea mainly perform deep frying and stir frying at high temperatures [32]. School cooks in the Korea prepare an average of 120–150 cooking dishes per day, twice as many as that of cooks in other occupations [33]. These cooking behaviors may contribute to higher levels of cooking fumes in the school kitchen environment. Long-term and continuous exposure to such environments with elevated cooking fumes could increase their risk of lung cancer.

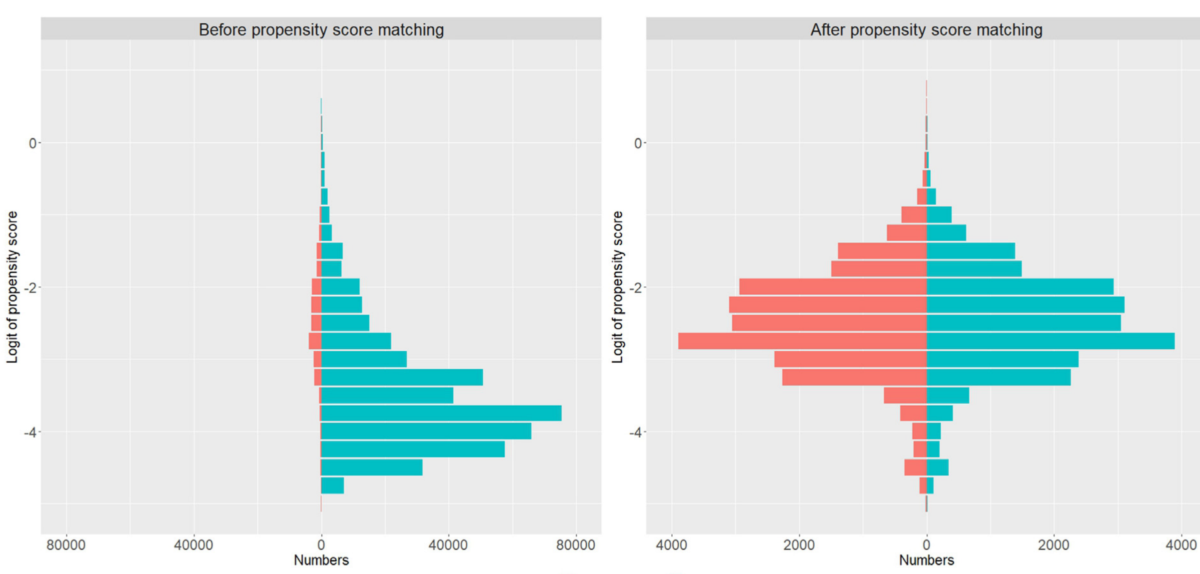

Fig. 2. Histogram of logit propensity score before and after propensity score matching.

Table 1
Covariates among female school cooks and clerks

		Before propensity score matching*					After propensity score matching*				
		School cooks		Clerks		*p*	School cooks		Clerks		*p*
		n	%	*n*	%		*n*	%	*n*	%	
Total (*n*)		23,778		442,303			23,772		23,772		
Age, year, mean (SD)		44.34	(6.11)	35.98	(7.42)	<0.0001	44.35	6.10	44.35	6.10	0.996
Age group	20–29	654	2.75	70,109	15.85	<0.0001	648	2.73	648	2.73	0.999
	30–39	3367	14.16	261,400	59.1		3367	14.16	3367	14.16	
	40–49	15,218	64	81,381	18.4		15,218	64.02	15,218	64.02	
	50–59	4412	18.55	25,117	5.68		4412	18.56	4412	18.56	
	60–69	124	0.52	4153	0.94		124	0.53	125	0.52	
	70–79	3	0.01	143	0.03		3	0.01	2	0.01	
BMI	<25	17,103	71.93	392,028	88.63	<0.0001	17,097	71.92	17,096	71.92	1.0000
	25≤	6675	28.07	50,275	11.37		6675	28.08	6676	28.08	
CCI	0	18,821	79.15	372,247	84.16	<0.0001	18,815	79.15	18,814	79.14	1.0000
	1≤	4957	20.85	70,056	15.84		4957	20.85	4958	20.86	
Smoking status	Never	23,449	98.62	422,934	95.62	<0.0001	23,443	98.62	23,181	97.51	<0.0001
	Ever	329	1.38	19,369	4.38		329	1.38	591	2.49	
Income level	Lower	23,555	99.06	261,176	59.05	<0.0001	23,549	99.06	13,295	55.93	<0.0001
	Upper	223	0.94	181,127	40.95		223	0.94	10,477	44.07	

BMI, body mass index; CCI, Charlson Comorbidity Index; SD, standard deviation.
* Propensity score matching using age, BMI, and CCI.

In addition, school kitchens in the Korea often have inadequate ventilation facilities [22]. Meta-analyses have demonstrated that exposure to cooking fumes without kitchen exhaust fans increases the lung cancer risk in never-smoking women [34,35]. The lung cancer risk of bakers in small bakeries is higher than that of bakers in large bakeries [29], suggesting that small bakeries may not be equipped with ventilation facilities. Ventilation and fume extractors can reduce lung cancer risks [5,11,36]. Switching to ventilated stoves in rural Chinese kitchens has been found to reduce lung cancer incidence [37]. A Taiwanese birth cohort study noted a decrease in lung cancer incidence in young women, which may be attributed to a gradual increase in kitchen exhaust fan use [38]. Poor ventilation has been shown to increase the risk of lung cancer in school cooks [39].

According to a meta-analysis, cooking fumes may be a risk factor for lung cancer in women, regardless of their smoking status [11]. Analyzing the combined effects of smoking and cooking fumes, both factors significantly contribute to lung cancer risk, with exposure to both smoking and cooking fumes being associated with a greater risk than exposure to cooking fumes alone [40]. Similarly, in this study, the risk of lung cancer among school cooks was approximately four times higher than that of clerks in the subcohort that had never smoked. In the subcohort that had ever smoked, the lung cancer risk among school cooks was approximately seven times higher than that of clerks. However, the number of smokers was small and requires further investigation.

To the best of our knowledge, this is the first study to analyze lung cancer risk in school cooks who cook large quantities of food in school kitchens. These findings may have implications for improving workplace environments and formulating policies to lower the incidence of lung cancer in school cooks. By linking databases from the EI, IACI, and NHIS, we were able to build a nationwide cohort of approximately all school cooks and clerks enrolled in the EI program from 2007 to 2011, making the results generalizable. Moreover, this linkage increased the reliability and validity of the core study data, as workers' occupational classifications, workplace names, and lung cancer diagnoses were available. To correct for confounding and selection biases, the characteristics of school cooks and clerks were matched and analyzed using PSM.

However, this study had some limitations. First, we were unable to select a comparative cohort working in the same industry and

Table 2
Incidence and hazard ratios of lung cancer among female school cooks and clerks

	Before propensity score matching*				After propensity score matching*			
	School cooks		Clerks		School cooks		Clerks	
Total (*n*)	23,778		442,303		23,772		23,772	
Lung cancer (*n*)	76		749		76		55	
Person-year	259,874		5,724,159		259,819		307,545	
Crude incidence rate (per 100,000)	319.6		169.3		319.7		231.4	
Age-standardized incidence rates (95% CI)†	199.8	(120.7–278.9)	291.1	(261.8–320.4)	199.8	(120.7–278.9)	166.8	(95.8–237.7)
HRs								
crude HR (95% CI)	2.53	(2.00–3.21)	1.00	(reference)	1.83	(1.28–2.61)	1.00	(reference)
Subdistribution HR (95% CI)‡	1.48	(1.15–1.89)	1.00	(reference)	1.72	(1.14–2.60)	1.00	(reference)
Age (continuous)	1.10	(1.09–1.11)			1.11	(1.08–1.14)		
BMI < 25 (reference: 25≤)	1.32	(1.08–1.61)			1.27	(0.86–1.89)		
Never smoked (reference ever smoked)	1.21	(0.79–1.85)			1.25	(0.30–5.17)		
Lower income (reference upper income)	0.83	(0.72–0.96)			1.12	(0.66–1.91)		
CCI = 1 or more (reference: 0)	1.39	(1.19–1.63)			1.71	(1.18–2.47)		

BMI, body mass index; CCI, Charlson Comorbidity Index; CI, confidence interval; HR, hazard ratio.
* Propensity score matching using age, BMI, and CCI.
† Standard population: 2007∼2011 total women working group in Employment Insurance database.
‡ Fine–Gray subdistribution HRs for analyzing death as competing events (sensitivity analysis) and adjusting for age, BMI, smoking status, income level, and CCI.

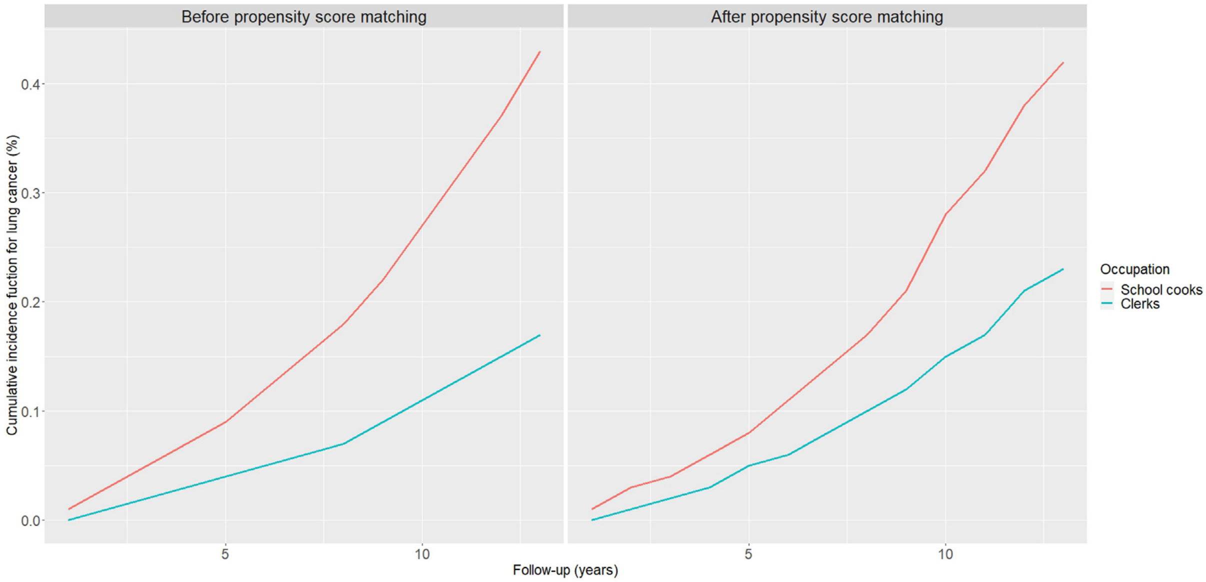

Fig. 3. Cumulative incidence function for lung cancer.

Table 3
Hazard ratios for lung cancer among female school cooks and clerks who had never smoked

	Before propensity score matching*			After propensity score matching*		
	School cooks		Clerks	School cooks		Clerks
Total (n)		23,449	422,934		23,444	23,444
Lung Cancer (n)		74	729		74	24
Hazard ratios						
crude HR (95% CI)	2.46	(1.93–3.13)	reference	4.21	(2.63–6.74)	reference
Subdistribution HR (95% CI)†	1.46	(1.13–1.87)	reference	4.23	(2.36–7.58)	reference
Age (continuous)	1.10	(1.09–1.11)		1.10	(1.07–1.14)	
BMI < 25 (reference: 25≤)	1.32	(1.07–1.61)		1.11	(0.71–1.73)	
Lower income (reference upper income)	0.83	(0.72–0.96)		0.96	(0.44–2.10)	
CCI = 1 or more (reference: 0)	1.41	(1.20–1.65)		1.57	(1.02–2.41)	

BMI, body mass index; CCI, Charlson Comorbidity Index; CI, confidence interval; HR, hazard ratio.
* Propensity score matching using age, BMI and CCI.
† Fine–Gray subdistribution HRs for analyzing death as competing events (sensitivity analysis) and adjusting age, BMI, income level, and CCI.

Table 4
Hazard ratios for lung cancer among female school cooks and clerks who had ever smoked

	Before propensity score matching *			After propensity score matching *		
	School cooks		Clerks	School cooks		Clerks
Total (n)		329	19,369		329	329
Lung Cancer (n)		2	20		2	1
Hazard ratios						
crude HR (95% CI)	8.16	(1.88–35.41)	reference	2.01	(0.1–22.12)	reference
Subdistribution HR (95% CI)†	3.42	(0.66–17.66)	reference	6.80	(1.54–30.05)	reference
Age (continuous)	1.11	(1.06–1.17)		0.96	(0.73–1.28)	
BMI < 25 (reference: 25≤)	1.53	(0.41–5.69)		0.97	(0.07–12.96)	
Lower income (reference upper income)	1.18	(0.47–2.94)		0.13	(0.03–0.64)	
CCI = 1 or more (reference: 0)	0.83	(0.26–2.63)		1.72	(1.02–2.41)	

BMI, body mass index; CCI, Charlson Comorbidity Index; CI, confidence interval; HR, hazard ratio.
* Propensity score matching using age, BMI and CCI.
† Fine–Gray subdistribution HRs for analyzing death as competing events (sensitivity analysis) and adjusting age, BMI, income level, and CCI.

school, which may have introduced potential biases or confounding factors. Initially, school clerks (or school teachers) working in the same workplace as the school cooks were selected as the comparative cohort. The age difference between the school cooks and school clerks (or school teachers) was large; however, PSM was not feasible because the number of school clerks (or school teachers) was smaller than that of the school cooks. Second, income was not included as a covariate for PSM in school cooks and clerks because it is directly influenced by occupation [25]. As a result, even after PSM, approximately 99% of school cooks had lower incomes than 56% of clerks. Socioeconomic status, including income, can influence the incidence and mortality of cancer [41,42], so the interpretation of our findings should be cautious. Further studies with alternative comparative cohorts are needed. Third, the three databases used in this study were primarily created for administrative purposes, which led to the lack of several important covariates. Employment information, such as the total number of years employed and occupational history, as well as demographic data on marital status and educational level, was not available in all databases. Additionally, the databases did not include key working conditions, such as working hours, frequency and timing of cooking, type of cooking oil and fuel, main ingredients, ventilation conditions, and lifestyle factors, such as dietary patterns, physical activity, exposure to second-hand smoke in the home, and ambient particulate matter 2.5. Therefore, prospective cohort studies that investigate a broader range of covariates that may influence lung cancer risk in school cooks are needed. Finally, caution is needed when interpreting the findings regarding lung cancer risk in the ever-smoked subcohort as the number of lung cancer cases in ever-smokers was relatively low.

This is the first nationwide cohort study to reveal that school cooks who cook large quantities of food are at an elevated risk of lung cancer due to exposure to cooking fumes in their working environments. These findings can help in improving workplace environments and formulating policies to lower lung cancer incidence among school cooks. Future prospective cohort studies should investigate the cooking environment, including working conditions and hours, types of oil and fuel, ventilation, and main ingredients, using linked databases.

CRediT authorship contribution statement

Jungwon Jang: Writing – original draft, Visualization, Software, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Eun Mi Kim:** Validation, Resources, Methodology, Investigation. **Jaiyong Kim:** Resources, Methodology, Investigation. **Jeehee Min:** Writing – review & editing, Software. **Inah Kim:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

Ethical statement

This study was approved by the institutional review board at Hanyang University, Seoul, Republic of Korea (HYUIRB-202311-016).

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Conflicts of interest

The authors declare no conflicts of interest.

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