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OCCUPATIONAL RISK OF LUNG CANCER AMONG LIFETIME NON-SMOKING WOMEN IN SHANGHAI, CHINA

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Abstract

Objectives—Occupational lung carcinogens have been primarily studied in men. The aim of this study was to investigate occupational lung cancer risk in a cohort of Chinese non-smoking women.

Methods—In 1996–2000, 71,067 non-smoking women that had held a job outside the home were interviewed for the prospective Shanghai Women's Health Study in China. Exposure to lung carcinogens was assessed by matching occupation and industry titles from lifetime occupational histories with lists of jobs identified by the International Agency for Research on Cancer to have potential exposure to: 1) known (A-list) or 2) suspected (B-list) carcinogens. In addition, similar occupational titles were grouped independent of the *a priori* defined lists. Relative risks (RR) were calculated using Cox proportional hazards regression.

Results—During follow-up through 2005, 219 incident lung cancer cases were diagnosed. Jobs on the A- and B-list were held by 0.8–6.7% and 2.7–9.4% of the cohort, respectively. Overall, ever holding any job on the A- or B-list was not associated with lung cancer incidence. Indications of excess risk were found for two subgroups: painters (A-list) and rubber workers (B-list) (RR: 2.0 and 1.7, respectively, $p \leq 0.1$). An exploratory analysis of 35 occupational categories independent of the lists showed significantly increased risks for leather products/shoes, wood/paper products and miscellaneous production/transportation. The former two of these categories were similar to subgroups of the B-list, but broader than the specific *a priori* defined jobs.

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MAIN MESSAGES

Although indications of excess risk were found for painters and rubber workers, overall exposure to known (A-list) or suspected (B-list) occupational lung carcinogens was not associated with lung cancer risk in this cohort of non-smoking women.

Independent of these *a priori* defined lists, significantly elevated cancer risk was found for two broad occupational groups that also included jobs with exposure to suspected occupational lung carcinogens (B-list).

This suggests that although similar exposures may play a role in this cohort of Chinese women, carcinogenic exposures may not be restricted to the specific jobs on the B-list.

POLICY IMPLICATIONS

It is too early to formulate policy implications based on this study alone.

Conclusions—Significantly elevated lung cancer risk was associated with employment in some broad occupational categories that also included jobs with potential exposure to suspected carcinogens (B-list). The results suggest that although similar exposures to those described on the B-list may play a role in this cohort of Chinese women, carcinogenic exposure may not be restricted only to the jobs on the B-list.

Keywords

lung cancer; occupational carcinogen; A-list; B-list; women

INTRODUCTION

Lung cancer is the leading cancer in incidence and mortality worldwide.[1] Although smoking is the most important risk factor, other contributors have been identified, including environmental tobacco smoke, residential radon, a family history of cancer and occupational exposures. The contribution of occupational exposures is large compared to the other non-smoking contributors, with an estimated attributable lung cancer proportion between 9–15%.[2] Of all cancers, lung cancer is one of the cancers most commonly associated with occupational exposure.[2]

Investigations of occupational populations have identified a number of recognized occupational lung carcinogens, such as asbestos, tar and soot, and several metals.[2] For other workplace agents or situations, the evidence has been less clear.[2,3] Occupations and industries known and suspected to be associated with cancer have been classified into two lists based on the International Agency for Research on Cancer's (IARC) evaluations of occupational exposures.[3,4] These lists have been used to estimate the prevalence of exposure to known and suspected occupational lung carcinogens and assess associations with lung cancer risk in various population-based case-control studies.[5–15]

Most studies on which knowledge of occupational carcinogens is based were performed largely or entirely in men.[16,17] Information on occupational lung cancer in female populations is less often reported. Despite a relatively low smoking prevalence,[18] lung cancer incidence among women in China is among the highest in the world.[1] In a cohort of almost 75,000 women in Shanghai, China, less than 3% smoked and over 99% was ever employed with infrequent job changes.[19] This cohort provides a unique opportunity to study occupational risk factors of lung cancer in non-smoking women. The aim of this study was to assess the potential for occupational exposure to known or suspected carcinogens as identified by IARC and investigate associations with lung cancer in non-smoking women. In addition, we explored risk of lung cancer by occupational group.

METHODS

Study design and population

The Shanghai Women's Health Study (SWHS) is a population-based prospective cohort study conducted in Shanghai, China.[19] All women aged 40–70 identified through resident offices in seven representative urban communities of Shanghai were eligible. Between 1996 and 2000, 74,942 women were recruited with a participation rate of over 92%. In-person interviews were conducted at baseline by trained interviewers using a structured questionnaire to elicit information on demographic background, socioeconomic status, family history of cancer, tobacco use, residential history including use of cooking oil and fuel, and a lifetime occupational history. Follow-up for mortality and cancer incidence was conducted using a combination of linkage to the population-based Shanghai Cancer Registry and by in-person re-contacting the women biennially. The study was approved by the Institutional Review Boards of the participating institutes in China and the United States.

For the present analysis, women who had a history of cancer at study entry (n= 1,576), ever smoked (n= 2,044 (23 lung cancer cases)), or never held a job outside the home (n= 255) were excluded. From the final study population of 71,067 women, 219 were diagnosed with malignant neoplasm of bronchus or lung (ICD-9 codes 162.0–162.9) during the follow-up through December 31st 2005.

Occupational exposure assessment

Lifetime occupational histories included the name of the work place, job title including main duties and products, and year started and year ended for each job held longer than one year. Each occupation and industry was coded (3 digits) according to the Chinese National Standard Occupational and Industry Codes Manual (1986).

To identify jobs with potential for exposure to known and suspected carcinogens, the industry and job title codes in the occupational histories of the SWHS were matched by an industrial hygienist to two mutually exclusive lists: the A-list included industries and occupations with potential exposure to known carcinogens, and the B-list included industries and occupations with potential exposure to suspected carcinogens.[3] These published lists of potentially exposed jobs have been developed based on evidence reviewed in the IARC Monographs irrespective of whether the etiologic agent was known. Because the industry and occupation descriptions on the lists did not correspond directly to the Chinese National Standard codes used in the SHWS, two criteria were used for matching with the lists. The first more stringent criterion required that both the industry and occupation code matched the occupation and industry described on the lists. For instance, a specific job on the B-list is described as various occupations in rubber manufacture in the rubber industry, resulting in a match for rubber processing machine operators in the rubber products manufacturing industry in the SWHS. A second less stringent criterion was used that included production workers with similar exposures in the same industry, such as workers involved in production and packaging process in the rubber industry, or the same occupation in other industries, such as rubber processing machine operators in the toy manufacture or the leather industry.

A separate analysis by occupation independent of the *a priori* defined lists was also conducted. For this analysis, an industrial hygienist (J. Coble) grouped all occupational codes (n=306) into 35 occupation categories with similar exposures based on the job code titles. These general occupational categories were broader than the specific jobs described on the lists.

Statistical analysis

All statistical analyses were performed in SAS Version 9.1 (SAS Institute, Cary, NC). The association between occupational exposure and risk of lung cancer was evaluated using Cox proportional hazards regression (PROC PHREG) with age as the time scale and stratification by birth cohort (5-year intervals). Relative risks (RR) and 95% confidence intervals (95% CI) were calculated for subjects who ever worked in a job on the A-list, on the B-list (never A-list), or on either list (A or B). Duration of employment (0, $<$ 15, and $\geq$ 15 years) and time since first employment (0, $<$26 and $\geq$ 26 years) were also investigated. Cut points were chosen resulting in roughly 50% of the exposed subjects in each exposed category. Specific jobs on the lists were investigated when there were at least 5 exposed cases. The referent category for analyses of both the A- and B-list was confined to subjects, including production workers, who never worked in a job on either list.

For the exploratory analysis of the occupational categories independent of the lists, a similar approach was taken. For these analyses, the referent category comprised of all subjects that were never employed in the investigated category. Duration (0, < 12, and ≥ 12 years) and time since first employment (0, <26 and ≥ 26 years) were further investigated for occupational categories with a suggestive association with lung cancer risk ($p \leq 0.1$).

Presented RR's were adjusted for passive smoking, education level and a family history of lung cancer. Information on passive smoking at home before age 20, at home after age 20 (husband smoking) and the number of years of passive smoking at work was available. Risk estimates were similar when adjusting for these variables separately compared to one combined variable indicating ever exposed to passive smoking and the latter was used in the final models. Type of cooking fuel (coal, gas or other), and ventilation status of the kitchen (good, fairly good, poor) for the three most recent addresses was available. These did not alter the risk estimates meaningfully and were therefore not included in the final models. Other potential confounders that were examined but not included in the final model are income, chronic lung diseases, and cooking oil.

RESULTS

Among the 71,067 subjects included in the analysis, 505,216 person-years of follow-up were accrued. A total of 219 incident lung cancer cases were diagnosed, with an average follow up of 4.1 years. The study characteristics are provided in the online supplementary table. Compared to the overall cohort, cases were older (median (range): 60 (40–70) vs. 50 (40–70) years), had less education (67% vs. 58% had middle school or less education), were less often exposed to passive smoke (at home or at work: 71% vs. 80%), had less often used coal as a cooking fuel (61% vs. 63%), and had a similar family history of lung cancer (4% vs. 5%). After adjustment for age, none of these potential risk factors was significantly associated with lung cancer. On average, women held 2.3 jobs and were employed for 26 years. Sixty percent of the women had worked in manufacturing jobs.

Table 1 shows the number of women who had ever held a job with potential exposure to known occupational lung carcinogens (i.e., the A-list). Overall, 0.8% of the women in this cohort, but none of the lung cancer cases, had held jobs that matched both the industry and occupation described on the A-list. When the matching criteria were extended to include jobs with potentially similar exposures (less specific criteria), the proportion increased to 6.7% for the cohort and 6.4% for cases. Regardless of the matching criteria, the most common job category for the cohort was metal worker, in which 0.3% of the women had worked using more specific matching and 2.7% using the less specific criteria. Among cases, painter was the most common job (2.7%, less specific criteria).

The proportion of women who had ever held a job with potential exposure to suspected occupational lung carcinogens (i.e. B-list) was 2.7% for the cohort and 2.3% for the lung cancer cases when matching with a high level of specificity (Table 2). When using the less specific criteria, this proportion increased to 9.4% for the cohort and 8.7% for cases. Rubber worker was the most common job category for both the cohort (1.1%) and cases (1.8%) when the more specific match to the B-list was used. When the less specific matching criteria were used, rubber worker remained the most common job among the cases (3.2%) but became the second most common among the cohort (1.7%), following transportation workers (1.8%).

Overall, lung cancer risk was not elevated among women who had held one or more jobs on either the A- or B-list, regardless of the specificity of matching criteria used (Table 3). No indications of a trend were found for duration of employment or time since first employment

(Table 3). Assessment of the specific jobs on the lists was restricted by small numbers. From the A-list, only painters had at least five exposed cases (RR (95% CI): 2.0 (0.9–4.5). The risk for painter increased with duration of employment and time since first employment, and reached statistical significance for the group with the longest time since first employment (≥26 years, RR (95% CI): 3.1 (1.4–7.0). From the B-list, rubber workers had at least five exposed cases (RR (95% CI): 1.7 (0.8–3.7)), without indications of a trend for duration or time since first employment (data not shown).

Table 4 shows lung cancer risk by occupational category independent of the A- and B-lists. Of the 35 occupational categories examined, significant associations were observed for three. Ever working in leather product/shoe manufacturing was associated with an elevated risk (RR (95% CI: 2.7 (1.1–6.6)). The risk increased with duration of employment and time since first employment, and was statistically significant for the group with longest duration (≥ 12 years, RR (95% CI): 4.5 (1.7–12.0), 4 exposed cases) and longest time since first employment (≥ 26 years, RR (95% CI): 2.9 (1.1–7.8), 4 exposed cases). Similarly, ever working in wood/paper product manufacturing (overall RR (95% CI): 2.3 (1.1–4.7)) showed the highest risks for longest duration of employment (≥ 12 years, RR (95% CI): 3.0 (1.2–7.4), 5 exposed cases) and longest time since first employment (≥ 26 years, RR (95% CI): 2.5 (1.2–5.4), 7 exposed cases). Working in miscellaneous production / transportation (overall RR (95% CI: 1.7 (1.1–2.6)) also showed a higher risk among women with the longest duration of employment (RR (95% CI: 1.9 (1.1–3.4), 15 exposed cases). However, for time since first employment, the highest risk was found for the group with shortest time since first exposure (RR (95% CI): 1.9 (1.1–3.4), 14 exposed cases). Borderline significant decreased risks were found for metal forge/press/machine tool installers and electronical/ electronics, without indications of a trend for time since first exposure or duration.

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DISCUSSION

In this study, lists of jobs with exposure to known (A-list) and suspected (B-list) carcinogens were used to assess the prevalence of occupational exposure to lung carcinogens in a cohort of non-smoking women in China. We estimated that between 0.8–6.7% and 2.7–9.4% of the cohort ever worked in a job with potential exposure to known or suspected lung carcinogens, respectively. Overall, working in a job with potential exposure to any carcinogens was not associated with lung cancer. However, of the specific jobs on the lists, indications of excess risk were found for painters and rubber workers. In addition, an independent exploratory analysis by broad occupational category showed significantly increased risks for women who had worked in leather products/shoes, wood/paper products and miscellaneous production/transportation.

A number of other case-control studies have used these lists for exposure assessment (Table 5). In men, all studies except one reported odds ratios (OR's) above 1.2 for the A-list. [5,7,8,10–13] OR's were generally lower for the B-list for which only three studies reported OR's above 1.2. In contrast, only half of the six studies in women reported elevated OR's for the A-list,[6,7,10] whereas all six studies reported elevated OR's for the B-list. [6,7,9,10,12,15] The dominance of excess risks for known carcinogens in men and suspected carcinogens in women suggests that current knowledge on occupational carcinogens is biased towards exposures found typically in male jobs.

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The findings of our A/B-list analyses were largely consistent with those from a large multicentre case-control study of European women, which also found indications of an increased risk for painters and rubber workers, but no overall risk for the A-list and a small to moderate risk for the B-list.[15] Several other studies in women also reported elevated risks for painters,[6,9] and rubber workers. [6,10,12] Suspected causative agents are not identified for painters,[3] but solvents, metals and thinners have been suggested.[15] For rubber workers, benzene and Methylene-bis-Ortho-ChloroAniline (MOCA) are identified as causative agents,[3] and asbestos, nitrosamines, carbon black and solvents have been suggested.[15] Other specific jobs on the lists for which increased risks have been repeatedly reported in women are dry-cleaning,[6,10,12] ceramic/glass/refractory,[6,9,12] and printing.[6,9] None of these jobs had enough exposed cases for a separate investigation in our study.

The previous studies all used specific matching criteria. The more recent studies[8–10,12,15] have used a published tool for matching the lists to the occupation and industry codes,[20] resulting in a more uniform exposure assessment in these studies. The International Standard Classification of Occupations (ISCO) and International Standard Industrial Classification of All Economic Activities (ISIC) codes presented in this tool are more specific (3–5 digits) than the Chinese National Standard Occupational and Industry Codes used in our study (3 digits). This lower level of detail decreases specificity of matching, and may partly explain the lack of overall associations for the A- or B-lists in our study.

When we explored risk by more general occupational groups independent of the A- and B-lists, we found three groups (leather products/shoes, wood/paper products and miscellaneous production/transportation) associated with lung cancer risk. The former two of these occupational categories are similar to jobs described on the B-list, although the general occupational categories are much broader. For both of these B-list subgroups, the descriptions were very specific, restricting the number of exposed subjects and hampering a separate risk analysis. The similarity of the leather products/shoes and wood/paper products categories to jobs described on the B-list suggests that the exposures responsible for the elevated risks in these categories may be similar to exposures that have previously been suggested to be associated with an increased risk of lung cancer. This increases the plausibility of the findings. Moreover, it suggests that carcinogenic exposure experienced by the women in this cohort is not restricted to the specific jobs described on the B-list, and other jobs in the broader occupational groups may have similar exposures. Suspected causative agents reported on the B-list are leather dust, chromium, and other chemicals for leather workers, while no suspected agents were reported for wood workers.[3] The reason for the decreased risk of lung cancer for metal forge/press/machine tool installers and electronics is not clear. Several metals are known or suspected to be carcinogens and an increased risk would be expected. Possible explanations are misclassification of exposures and chance variations.

This study has several strengths. The low prevalence of smoking (3%) provided the opportunity to study non-smoking women. In addition, detailed information on passive smoking was available. Because of the prospective design, the occupational histories were collected before lung cancer developed, reducing the chance of recall bias. Recall was improved by stable work histories and self-completed lifetime occupational histories, which were reviewed for completeness and accuracy by trained interviewers conducting in-person interviews. Furthermore, the high response rate minimises selection bias, suggesting that the results of this study can be generalized to women in urban Shanghai.

Studying occupational risks in population-based cohort studies, however, is challenging. Information on occupational exposures is often limited and many different occupational exposures may contribute to occupational lung cancer. Investigation by general occupational group is limited by the lack of specificity and the large number of groups, which may bring about multiple comparison issues. Therefore, the analyses by broad occupational group independent of the lists should be viewed as exploratory. The use of the *a priori* defined lists provides a way of combining occupational categories with similar carcinogenic exposures and constructing a non-exposed reference category. However, several limitations still exist. The high specificity of job categories on the lists in conjunction with the relatively small number of cases in our study resulted in numbers of exposed cases in most job categories that were too small for separate risk analysis. In addition, misclassification of exposure may occur when matching the industries and occupations described on the lists, which included specific information on processes and carcinogenic exposures, to the general Chinese National Standard codes for industry and occupation. For this reason, more specific matching criteria were used to maximize specificity, whereas the more lenient matching criteria were used to increase sensitivity. A large range in the number of subjects classified as exposed when using these two approaches, for example among metal workers and chemical workers, reflects uncertainty arising when jobs described on the lists are highly specific, while the occupation and industry codes are more general.

Another limitation is the lack of information about exposure level, exposure frequency and carcinogenic potency. A related issue is the applicability of the lists to our population. The lists are based on the published literature, which mostly consists of epidemiological studies conducted in North America and Europe. In addition, current knowledge on occupational carcinogens is mainly based on studies in men.[16,17] The lack of an overall increased risk for the A/B list suggests that exposure frequency and levels experienced by the women in this cohort may have been too low to result in an increased cancer risk. However, a review of Chinese factory working conditions reports on unmeasured and uncontrolled exposures, ineffective ventilation systems, inadequate personal protective equipment, a general lack of workers' knowledge of hazards, and an overwhelmingly female workforce. [21] Possibly, the lists were not applicable to our population because of differences in tasks, industrial techniques, products and exposure circumstances experienced by the study population compared to the populations on which the lists were based.

In conclusion, although indications of excess risk were found for painters and rubber workers, overall exposure to known or suspected occupational lung carcinogens was not associated with lung cancer risk in this cohort of non-smoking women. An exploratory analysis independent of the lists, showed increased risks for leather products/shoes, wood/paper products and miscellaneous production/transportation. The former two of these occupational groups are similar to those with exposure to suspected carcinogens, but are broader than the specific *a priori* defined jobs on the B-list. This suggests that although similar exposures may play a role in this cohort of Chinese women, carcinogenic exposures may not be restricted to the specific jobs on the B-list. The findings of this study warrant further investigation of occupational lung cancer associated with exposures predominantly experienced by women.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Number (%) of women ever employed in occupations and industries known to present an excess risk of lung cancer (A-list) using two different levels of specificity for matching the occupation and industry codes to the A-list.

Industry	Occupation	More specific criteria		Less specific criteria	
		Cohort (n=71,067)	Lung cancer (n=219)	Cohort (n=71,067)	Lung cancer (n=219)
Agriculture, forestry and fishing	Vineyard workers using arsenical insecticides	‡	‡	‡	‡
Mining and quarrying	Arsenic mining, iron-ore mining, asbestos mining, uranium mining, talc mining and milling	5 (0.01)	0	46 (0.1)	0
Chemical (basic industrial)	BCME and CCME production workers and users, pigment chromate production†	‡	‡	‡	‡
Pesticides and herbicides production	Arsenical insecticides production and packaging	‡	‡	35 (0.1)	1 (0.5)
Asbestos production	Insulated material production (pipes, sheeting, textile, clothes, masks, asbestos cement products)	52 (0.1)	0	100 (0.1)	0
Metals	Aluminium production, copper smelting, chromate production, etc.	233 (0.3)	0	1,885 (2.7)	1 (0.5)
Shipbuilding, motor vehicle and railroad equipment manufacture	Shipyard and dockyard, motor vehicle, and railroad manufacture workers	38 (0.1)	0	1050 (1.5)	2 (0.9)
Gas	Coke plant workers, gas workers	27 (0.04)	0	74 (0.1)	0
Construction	Insulators and pipe coverers, roofers, asphalt workers	‡	‡	1,178 (1.7)	4 (1.8)
Other	Painters (construction, automotive industry, and other users)	201 (0.3)	0	970 (1.4)	6 (2.7)
Any A-list		551 (0.8)	0	4,941 (6.7)	14 (6.4)

‡ No satisfactory definition of this group by the Chinese National Standard Occupational and Industry Codes

† BCME: bischloromethylether; CCME: chloromethylmethylether

Table 2

Number (%) of women ever employed in occupations and industries known to present an excess risk of lung cancer (B-list) using two different levels of specificity for matching the occupation and industry codes to the B-list.

Industry	Occupation	More specific criteria		Less specific criteria	
		Cohort (n=71067)	Lung cancer (n=219)	Cohort (n=71067)	Lung cancer (n=219)
Agriculture, forestry and fishing.	Insecticide application	‡	‡	‡	‡
Mining and quarrying	Zinc-lead mining, metal mining	3 (0.00)	0	20 (0.03)	0
Food industry	Butchers and meat workers	54 (0.1)	1 (0.5)	134 (0.2)	1 (0.5)
Wood and wood products	Carpenters, joiners	63 (0.1)	0	144 (0.2)	0
Leather	Tanners and processors	31 (0.04)	0	88 (0.1)	0
Printing	Rotogravure workers, binders, printing pressmen, machine-room workers, binders, and other jobs	362 (0.5)	0	671 (0.9)	1 (0.5)
Chemical	Production of: Acrylonitrile, vinylidene chloride, polychloroprene, dimethyl-sulfate, epichlorohydrin, benzoyl chloride	‡	‡	1,162 (1.6)	2 (0.9)
Rubber	Various occupations in rubber manufacture	788 (1.1)	4 (1.8)	1,216 (1.7)	7 (3.2)
Ceramic, glass and refractory brick	Ceramic and pottery workers, glass workers (art glass, container and pressed ware)	297 (0.4)	0	657 (0.9)	3 (1.4)
Metals	Lead smelting, iron and steel founding	72 (0.1)	0	546 (0.8)	1 (0.5)
Motor vehicle manufacture	Mechanics, welders etc	20 (0.03)	0	758 (1.1)	3 (1.4)
Transport	Railroad workers, filling station attendants, bus and truck drivers, operators of excavating machines.	154 (0.2)	0	1,284 (1.8)	2 (0.9)
Other	Laundry and dry cleaners	78 (0.1)	0	224 (0.3)	1 (0.5)
Any B-list		1902 (2.7)	5 (2.3)	6,673 (9.4)	19 (8.7)
Any B-list without exposure to A-list		1,806 (2.5)	5 (2.3)	5,049 (7.1)	14 (6.4)

‡ No satisfactory definition of this group by the Chinese National Standard Occupational and Industry Codes

Table 3

Associations between lung cancer incidence and employment in occupations involving exposure to known (A-list) or suspected (B-list) carcinogens.

	Less specific criteria			More specific criteria		
	cases	Person years	RR*	cases	Person years	RR*
Never A or B list†	191	434,674	1	214	488,662	1
Ever exposed						
A-list	14	34,826	0.9 (0.5–1.6)	0	3,883	-
B-list (not A)	14	35,716	0.9 (0.6–1.5)	5	12,671	0.8 (0.3–1.9)
A or B list	28	70,542	0.9 (0.6–1.4)	5	16,554	0.6 (0.3–1.6)
Duration						
<15 yrs A-list	7	19,088	0.9 (0.4–1.9)	0	2,321	-
≥ 15 yrs A-list	7	15,738	1.0 (0.5–2.1)	0	1,563	-
<15 yrs B-list	4	15,682	0.7 (0.3–1.6)	2	5,824	0.7 (0.2–2.9)
≥ 15 yrs B-list	10	20,034	1.1 (0.6–1.9)	3	6,847	0.8 (0.3–2.6)
<15 yrs A or B list	10	33,765	0.7 (0.4–1.4)	2	8,090	0.6 (0.1–2.3)
≥ 15 yrs A or B list	18	36,777	1.0 (0.6–1.7)	3	8,464	0.7 (0.2–2.2)
Time since first employment						
<26 yrs A-list	3	16,817	0.7 (0.2–2.1)	0	1,625	-
≥26 yrs A-list	11	17,955	1.1 (0.6–2.0)	0	2,258	-
<26 yrs B-list	3	18,993	0.8 (0.3–1.9)	1	6,284	0.6 (0.1–4.1)
≥26 yrs B-list	11	16,571	1.0 (0.6–1.8)	4	6,336	0.9 (0.3–2.3)
<26 yrs A or B list	6	36,235	0.6 (0.3–1.4)	1	7,940	0.5 (0.1–3.3)
≥26 yrs A or B list	22	34,094	1.0 (0.7–1.6)	4	8,563	0.7 (0.3–1.9)

*Relative risk adjusted for passive smoking, education level and family history of lung cancer

†Reference category for all risk ratios

Table 4

Number (%) of women in the cohort (n=71,067) and among lung cancer cases (n=219) ever employed in occupational categories and associations with lung cancer incidence.

	Cohort	Lung cancer cases	RR*
Service	14,307 (20.1)	52 (23.7)	1.3 (0.9–1.8)
Textile	9,525 (13.4)	35 (16.0)	0.9 (0.6–1.4)
Miscellaneous Production/transportation	6,211 (8.7)	26 (11.9)	**1.7 (1.1–2.6)**
Agriculture/Farmers	13,777 (19.4)	24 (11.0)	0.9 (0.6–1.4)
Financial/Legal	10,673 (15.0)	23 (10.5)	0.9 (0.6–1.4)
Business/Sales	9,374 (13.2)	21 (9.6)	1.1 (0.7–1.7)
Academics/Teachers	6,284 (8.8)	21 (9.6)	1.0 (0.6–1.6)
Examiners/Inspectors	6,938 (9.8)	16 (7.3)	0.8 (0.5–1.4)
Public Services	6,346 (8.9)	16 (7.3)	0.8 (0.5–1.4)
Government Officials	5,755 (8.1)	14 (6.4)	0.7 (0.4–1.3)
Medicine/Health Care	4,231 (6.0)	14 (6.4)	1.1 (0.6–1.9)
Administrative/Clerical	3,294 (4.6)	12 (5.5)	1.3 (0.7–2.4)
Metal Forge/Press/Machine Tool Installers	6,527 (9.2)	11 (5.0)	0.6 (0.3–1.1)
Engineers/Technical	3,486 (4.9)	11 (5.0)	1.1 (0.6–2.0)
Tailoring/Sewing	2,330 (3.3)	8 (3.7)	0.9 (0.5–1.9)
Cultural/Religious/Entertainment	2,055 (2.9)	8 (3.7)	1.3 (0.7–2.8)
Machinery/Precision Goods	1,935 (2.7)	8 (3.7)	1.6 (0. 8–3.2)
Wood / Paper Products	966 (1.4)	8 (3.7)	**2.3 (1.1–4.7)**
Welders/Metalwork	1,727 (2.4)	7 (3.2)	1.3 (0.6–2.8)
Equipment Operators	1,700 (2.4)	7 (3.2)	1.4 (0.7–3.0)
Food & Drink	1,048 (1.5)	6 (2.7)	1.5 (0.7–3.4)
Painters	970 (1.4)	6 (2.7)	2.0 (0.9–4.5)
Electrical/Electronics	4,033 (5.7)	5 (2.3)	0.4 (0.2–1.0)
Chemical	1,864 (2.6)	5 (2.3)	0.9 (0.4–2.1)
Leather Products/Shoes	579 (0.8)	5 (2.3)	**2.7 (1.1–6.6)**
Rubber/Plastics	1,647 (2.3)	4 (1.8)	
Construction	746 (1.1)	4 (1.8)	
Transportation	1,433 (2.0)	3 (1.4)	
Foundry/Smelting	1,306 (1.8)	2 (0.9)	
Miscellaneous Manufacturing	1,132 (1.6)	1 (0.5)	
Repair/Maintenance	124 (0.2)	1 (0.5)	
Mining/Stone	44 (0.1)	1 (0.5)	
Printing	564 (0.8)	0	
Glass/Ceramics/Tiles/Stone	443 (0.6)	0	
Power and utility	415 (0.6)	0	

*Relative risk adjusted for passive smoking, family history of cancer and education level.

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Table 5

Overview of publications (all case control studies) that have reported risk estimates for the association between exposure to known and suspected lung carcinogens (A- and B-list) and lung cancer.

Study description	Study population			Odds ratio (95% confidence interval)		Comments
	Gender*	Cases	Controls	A-list	B-list	
Europe, MC‡ 1998–2002 [15]	M	48	534	0.4 (0.1–2.1)	0.9 (0.4–2.0)	Never smokers, exp. tool†
	F	175	505	0.7 (0.3–2.0)	1.4 (0.7–2.8)	
Europe, MC‡ 1988–1994 [10]	M	141	531	1.5 (0.8–3.0)	1.1 (0.6–1.8)	Never smokers, overlap with [8,9,12], exp. tool†
	F	509	1,011	1.5 (0.5–4.5)	1.7 (1.1–2.6)	
Germany, MC‡ 1990–1996 [9]	F	234	535	0.8 (0.3–2.5)	1.5 (0.8–2.7)	Never smokers, overlap with [10], exp. tool†
Germany, MC‡ 1990–1996 [8]	M	58	803	2.4 (1.1–5.4)	1.4 (0.7–2.8)	Non smokers, overlap with [10], exp. tool†
Germany, MC‡ 1988–1993 [7]	M	839	839	1.6 (1.3–2.1)	1.3 (1.1–1.7)	
	F	165	165	2.8 (0.9–9.0)	1.8 (0.9–3.4)	
Germany, MC‡ 1988–1996 [6]	F	686	712	2.7 (1.1–6.9)	1.9 (1.2–2.9)	Pooled analysis of [9] (plus smokers) and [7]
Italy 1992–1994 [14]	B	178	257	1.0 (0.3–3.0)^{R}	0.9 (0.2–4.2)^{R}	Part of unspecified case-control study
				1.3 (0.6–2.2)^{I}	1.6 (0.8–3.1)^{I}	
Italy, MS 1990–1992 [12]	M	956	1253	1.8 (1.4–2.5)	1.0 (0.8–1.3)	Overlap with [10], exposure tool†
	F	176	300	0.6 (0.1–3.7)	1.6 (0.8–3.3)	
Italy 1979–1986 [5]	M	756	756	2.3 (1.7–3.0)	1.3 (1.0–1.7)	Industrial area, after death: next of kin
Italy 1976–1980 [13]	M	164	492	2.3 (0.9–5.9)		2 Industrial areas, after death: next of kin
				1.4 (0.6–3.4)		
Italy 1976–1979 [11]	M	53	106	1.7 (0.7–4.1)		Industrial area, after death: next of kin

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*Gender: M = male, F = female, B = both

‡Multi-centre study

†Published tool used for exposure assessment [20]

*R*Residential area,

*I*Industrial area