

# Occupational exposure to eight organic dusts and respiratory cancer among Finns

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**Background:** There is inconclusive evidence concerning cancer risks of organic dusts.

**Aim:** The carcinogenic exposures are mainly inhalatory and the authors therefore studied associations between occupational exposure to eight different organic dusts and respiratory cancers in Finland.

**Methods:** The authors followed up a cohort of all economically active Finns born between 1906 and 1945 for 30 million person-years during 1971–95. Incident cases of nasal, laryngeal, and lung cancer and mesotheliomas were identified through a record linkage with the Finnish Cancer Registry. Occupations from the population census in 1970 were converted to exposures to eight organic dusts with a job-exposure matrix (FINJEM). Cumulative exposure (CE) was calculated as a product of prevalence, level, and estimated duration of exposure. Standardised incidence ratios (SIR) and 95% confidence intervals (CI) adjusted for age, period, and social class were calculated for each organic dust using the economically active population as the reference.

**Results:** A total of 20 426 incident cases of respiratory cancer were observed. Slightly increased risk was observed among men exposed to wood dust for nasal cancer (SIR 1.42, 95% CI 0.79 to 2.44). For laryngeal cancer, men exposed to plant dust (mainly grain millers) had a raised SIR in the high exposure class (SIR 3.55, 95% CI 1.30 to 7.72). Men exposed to wood dust had a raised SIR for lung cancer, but only in the low exposure class (SIR 1.11, 95% CI 1.04 to 1.18). Women exposed to wood dust showed an increased SIR for mesotheliomas in the low exposure class (SIR 4.57, 95% CI 1.25 to 11.7) and some excess in the medium exposure category.

**Conclusions:** Exposure to organic dusts is unlikely to be a major risk factor of respiratory cancer. Even exposure to wood dust which is a major exposure in Finland seems to have minor effect for nasal cancer. The authors found suggestive evidence that exposure to grain dust may increase the risk of laryngeal cancer, and some support to the hypothesis that exposure to textile dust, and to plant and animal dust (agricultural dusts) may decrease the risk of lung cancer.

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Organic dusts are established causes of respiratory tract irritation and allergy<sup>1</sup> but their significance as occupational carcinogens is mostly unknown. Exposure to organic dusts occurs in many industries and occupations, and the number of people exposed is high. The International Agency for Research on Cancer (IARC) has published monographs on cancer risks in the textile, leather, and wood industries where exposure to organic dusts is frequent.<sup>2–4</sup> Textile manufacturing industry has been classified as possibly carcinogenic to humans (group 2B) by the IARC. There is limited evidence that the risk of cancer of the nasal cavity among weavers is increased. There is no evidence to suggest an association between work in the leather industry and respiratory cancer according to the IARC monograph. Wood dust has been classified as carcinogenic to humans (group 1) by the IARC, mainly based on evidence on nasal cancer among workers predominantly exposed to hardwood dusts. Excesses of lung cancer have been reported among bakers and tailors.<sup>5</sup> An increased risk of lung cancer and pleural mesothelioma has been found in some studies also among furniture workers<sup>6</sup> and in the pulp and paper industry.<sup>7</sup> An increased risk of lung cancer has been found among cardboard workers.<sup>8</sup> Finnish sawmill workers have been found to have an excess of pharyngeal cancer.<sup>9</sup> However, there are also studies suggesting no excess risk of respiratory cancer among woodworkers,<sup>10–11</sup> pulp mill workers,<sup>12</sup> or paper mill workers.<sup>13</sup>

Because of inconclusive evidence concerning cancer risks of organic dusts, the objective of the present study was to

assess associations between occupational exposure to eight different organic dusts and four types of respiratory cancer in Finland.

## METHODS

The study cohort comprised all economically active Finns born between 1906 and 1945 who participated in the national population census on 31 December 1970 (667 121 men, 513 110 women). The census files are maintained at Statistics Finland and updated for vital status to allow exact person-year calculation. Data on the occupation held for the longest period in 1970 were obtained from the Population Census records.<sup>14</sup> The occupational classification is based on the Nordic Classification of Occupations, which is compiled on the basis of the International Standard Classification of Occupations (ISCO) published in 1958 by the International Labour Organization (ILO).<sup>15</sup> The socioeconomic status (SES) for each subject was based on the subject's own, or in some cases the spouse's, occupation. In our analyses, the SESs were categorised as farmers, higher white-collar, clerical, skilled blue-collar, and unskilled workers. FINJEM also includes alcohol (g/week) and smoking data (daily smokers) by occupation. These data were obtained from annual surveys carried out on the health behaviour of the Finnish adult

**Abbreviations:** CE, cumulative exposure; FCR, Finnish Cancer Registry; ILO, International Labour Organization; ISCO, International Standard Classification of Occupations; PID, personal identifier; SES, socioeconomic status; SIR, standardised incidence ratio

population by the Finnish National Public Health Institute during 1978–91.<sup>16</sup> For rare occupations in which the number of respondents in the surveys was below 20, we estimated the values by using data of larger proxy occupations. The smoking index indicated the effect of a 10% increase in the daily smoking prevalence of an occupation and alcohol index the effect of one additional drink/day. The Finnish Cancer Registry (FCR) has collected data on all cancer cases diagnosed in Finland since 1953. All physicians, hospitals, and other institutions, and all pathological, cytological, and haematological laboratories in the country must notify the FCR of all cancer cases that come to their attention. In addition, Statistics Finland annually provides a computerised file on death certificates in which cancer is mentioned. The FCR coverage is virtually complete and the data accuracy high.<sup>17, 18</sup>

In this study the incident cases of respiratory cancers diagnosed during 1971–95 among people born 1906–45 were extracted from the FCR and linked with the Statistics Finland Population Census 1970 file. Since 1967, every person residing in Finland has been assigned a unique 11-digit personal identifier (PID), which facilitates reliable computerised record linkages. The researchers had only data in which no individuals could be recognised.

Occupational exposures of the cohort were assessed by using FINJEM,<sup>19, 20</sup> which covers major occupational exposures in Finland since 1945 by occupation and calendar time. Exposure is characterised by the proportion of exposed persons (P) and the average level of exposure (L) among the exposed persons in each occupation. The estimates are based on exposure measurements, hazard surveys, and the judgements by occupational hygienists. In the present study, the exposure estimates for 1960–84 were used. The number of workers potentially exposed to organic dusts in Finland is estimated to be about 200 000 according to FINJEM, which is 8% of the employed population. The main organic dusts are plant dust, animal dust, wood dust, and textile dust. The occupations with organic dust exposure in Finland according to FINJEM are presented in table 1.

The respiratory cancers studied were nasal cancer (ICD10 C30, C31), laryngeal cancer (C32), lung cancer (C34), and mesotheliomas (C45). The observed and expected numbers of respiratory cancer cases for every organic dust class were calculated for each five year calendar period, five year birth cohort, gender, and SES. The expected number in each stratum was calculated by multiplying the number of person-years with the cancer incidence rate of the entire economically active Finnish population in the respective stratum. The standardised incidence ratio (SIR) was defined as the ratio of observed to expected number of cases. The 95% confidence interval (CI) was calculated for the SIR with adjustments for confounding factors. Poisson regression analysis of the stratum specific observed numbers of cases and person-years at risk was used in internal comparison to further study dose-response patterns and the effects of confounding factors. We calculated agent specific cumulative exposure (CE) estimates to every five year birth cohort (1906–10, ..., 1941–45) and every five year calendar period of observation (1971–75, ..., 1991–95). Exposure for each birth cohort was assumed to start in the year when the average age of the birth cohort was 20 and to end in the mid-year of the observation period, or at 65 years of age, whichever came first. If the exposure took place before 1960, we used the FINJEM estimates for the period 1945–59; otherwise the estimates for the period 1960–84 were applied in the analyses. A lag period was incorporated into the CE by omitting exposure years before the mid-point of the observation period. A 20 year lag period was applied. For instance, when studying cancer risk in 1971–75, only exposures until 1953 were taken into account.

The exposure class limits for organic dusts in FINJEM were set a priori so that the “high” CE class was rather small, and included as far as possible long term workers with high exposure. The rest of the potentially exposed subjects were divided into “medium” and “low” CE classes.

## RESULTS

Men exposed to wood dust had an increased SIR for nasal cancer (table 2); the SIR for all exposed men was 1.42 (95% CI 0.79 to 2.44). The number of cases among exposed women was only two. The other organic dusts did not show significant differences from the entire economically active Finnish population for nasal cancer, although SIRs related to exposure to flour dust tended to be above 1.0.

For laryngeal cancer, men exposed to plant dust had a statistically elevated SIR in the highest exposure class (SIR 3.55, CI 1.30 to 7.72) (table 2). Women did not show elevated SIRs for plant dust and laryngeal cancer. The most exposed men were mainly grain millers. Flour dust suggested an exposure response trend among men. Textile dust also showed minor suggestions of a similar trend.

For lung cancer, men exposed to wood dust had a significantly elevated SIR for lung cancer, but only in the low exposure class (SIR 1.11, CI 1.04 to 1.18) (table 3). The excess cases were mainly squamous cell carcinomas (SIR 1.14, CI 1.06 to 1.22). No other organic dust showed increased SIRs for lung cancer, but numerous worker groups with dust exposure had lung cancer incidence significantly below the national average (table 3).

Women exposed to wood dust showed a significantly increased SIR for mesotheliomas in the low exposure class (SIR 4.57, CI 1.25–11.7) and also some excess in the middle exposure category (table 3). The total number of cancer cases was eight. The cases were saw mill workers, plywood and wooden board makers, bench carpenters, cabinetmakers and joiners, and woodworking machine operators.

We analysed further some of our suggestive findings by Poisson regression modelling. The significance of plant dust exposure as a risk factor for laryngeal cancer remained in the high exposure class in a Poisson regression analysis where smoking and alcohol exposure was added to the model (table 4).

Varying the lag time from 10 to 20 years or the middle/high cumulative exposure value from 30 mg/m<sup>3</sup>/year to 40 mg/m<sup>3</sup>/year did not change the values significantly. The risk was not increased in the lower exposure classes among either men or women. Farmers had a significantly reduced risk of laryngeal cancer.

We also performed a Poisson regression analysis for lung cancer and exposure to plant dust, asbestos, quartz dust, and smoking for methodology control reasons. Increased risks for lung cancer and asbestos and quartz dust exposure and smoking were found as expected but not for plant dust (table 5).

## DISCUSSION

There is comprehensive evidence on wood dust exposure and sinonasal cancer.<sup>21–26</sup> Exposure to wood dust has been reported to also increase the risk of laryngeal<sup>27, 28</sup> and lung cancer.<sup>29</sup> The risk of laryngeal cancer was not observed in some other studies.<sup>30, 31</sup> No risks of upper respiratory and lung cancer was found for endemic wood dusts among Finnish woodworkers in a case control study within a cohort.<sup>10</sup> A major part of the excesses of lung and pleural mesothelioma among pulp and paper industry workers can be explained by smoking and asbestos exposure, but the role of sulphur compounds, chloride compounds, and wood dust cannot be excluded.<sup>7</sup> We found a slight excess of nasal cancer among men exposed to wood dust. The wood dust exposure in

**Table 1** Occupations with exposure to eight organic dusts, proportion of exposed persons (P) in %, and average exposure level (L) in 1960–84 according to FINJEM

Code	Occupation	Exposure (unit mg/m <sup>3</sup> )															
		Wood dust		Pulp or paper dust		Flour dust		Plant dust		Textile dust		Leather dust		Animal dust		Synthetic polymer dust	
		P	L	P	L	P	L	P	L	P	L	P	L	P	L		
024	Veterinarians												100	0.05			
052	Secondary school rector, teachers, and instructors	1	0.25														
300	Farmers, silviculturists, horticulturists							89	0.51				74	0.02			
305	Livestock breeders							29	0.60				100	0.02			
306	Fur farmers												100	0.38			
310	Farm workers							80	0.66				62	0.03			
312	Fur farm workers												100	0.38			
319	Occupations in agriculture, horticulture, and animal husbandry, nec												63	0.05			
600	Fibre processors							44	3.13				11	1.00	22	0.20	
601	Spinning machine operators							45	1.57	100	1.00		5	1.00			
602	Wearing machine operators									61	0.71				26	0.40	
603	Textile machine setter operators							6	1.60	100	0.80						
604	Knitting machine operators									100	0.7						
605	Textile finishers, dyers									29	0.50				9	0.10	
606	Textile inspectors									100	0.50						
609	Occupations in textiles, nec									19	0.30				19	0.35	
610	Tailors, salon seamstresses									100	0.15						
611	Furriers												100	0.70			
612	Milliners and hatmakers									73	0.20						
613	Upholsterers	65	0.05							43	0.08						
614	Patternmakers and cutters (also leather garments and gloves)									76	0.70	4	0.20		22	0.40	
615	Industrial sewers etc (also leather garments and gloves)									77	0.60		4	0.60	19	0.40	
619	Cutting, sewing, and upholstering occupations, nec									58	0.70				29	0.50	
621	Leather cutters for footwear											74	0.70				
623	Lasters and sole fitters, etc											17	0.15				
625	Leather sewers, etc											18	0.50				
670	Timbermen	56	0.68														
671	Sawyers	100	0.75														
672	Plywood and fibreboard workers	66	1.02														
673	Construction carpenters	100	0.08														
674	Wooden boatbuilders, coach-body builders, etc	90	0.20														
675	Bench carpenters	100	1.14														
676	Cabinetmakers and joiners etc	100	1.00														
677	Woodworking machine operators, etc	100	2.50														
678	Wooden surface finishers	80	0.10														
679	Woodworking occupations, nec	100	0.10														
680	Painters, lacquerers, and floor layers														18	2.98	
703	Bookbinders			100	0.10												
720	Grain millers					45	17.25	67	3.22								
721	Bakers					87	3.20	9	1.00								
722	Chocolate and confectionery manufacturers							4	1.00								
723	Brewers, beverage makers, and kilnmen							3	5.00								
725	Butchers and sausage makers					2	10.00										
727	Processed food workers					16	5.00										
729	Occupations in the food industry, nec					12	10.00	33	1.00								
735	Paper and cardboard mill workers			47	0.80												
740	Tobacco industry workers							82	0.38								
751	Rubber products workers														10	1.00	
752	Plastic product workers														2	0.92	
753	Tanners, fellmongers, and pelt dressers											23	1.00				
757	Paper products workers			49	0.50												
760	Packers and labellers etc			5	0.50	5	1.19	1	3.57	5	0.60						
811	Cooks etc					4	0.25										
831	Charworkers	1	4.00	1	0.50	1	8.24										
850	Laundry workers									6	0.20						

**Table 2** Standardised incidence ratio (SIR) of nasal and laryngeal cancers in 1971–95 by gender and cumulative exposure (CE) to eight organic dusts among economically active Finns born 1906–45

Agent	CE class	Nasal cancer						Laryngeal cancer					
		Men			Women			Men			Women		
		O	SIR	95% CI	O	SIR	95% CI	O	SIR	95% CI	O	SIR	95% CI
Wood dust	None (0)	259	0.96	0.85–1.09	118	1.00	0.83–1.20	1965	1.02	0.97–1.06	128	0.99	0.83–1.18
	Low (<3 mg/m <sup>3</sup> -year)	15	1.57	0.88–2.58	1	1.74	0.04–9.69	76	1.06	0.83–1.32	1	1.22	0.03–6.80
	Medium (3–50 mg/m <sup>3</sup> -year)	17	1.29	0.75–2.07	1	0.80	0.02–4.43	77	0.71	0.56–0.88	3	2.09	0.43–6.11
	High (>50 mg/m <sup>3</sup> -year)	1	1.24	0.03–6.89	0	0.00	0.00–9.70	1	0.13	0.00–0.74	0	0.00	0.00–7.79
Pulp or paper dust	None (0)	290	1.00	0.89–1.12	118	1.00	0.83–1.20	2097	1.00	0.96–1.04	130	1.00	0.84–1.19
	Low (<10 mg/m <sup>3</sup> -year)	1	0.70	0.02–3.88	1	1.42	0.04–7.89	12	1.32	0.68–2.31	2	1.97	0.24–7.11
	Medium (10–15 mg/m <sup>3</sup> -year)	1	1.03	0.03–5.76	1	0.95	0.02–5.27	10	1.15	0.55–2.12	0	0.00	0.00–3.22
	High (>15 mg/m <sup>3</sup> -year)	0	0.00	0.00–131	0	0.00	0.00–66.4	0	0.00	0.00–11.4	0	0.00	0.00–134
Flour dust	None (0)	290	1.00	0.89–1.12	102	0.96	0.78–1.17	2102	1.00	0.96–1.04	120	1.05	0.87–1.26
	Low (<5 mg/m <sup>3</sup> -year)	0	0.00	0.00–5.65	15	1.22	0.69–2.02	3	0.68	0.14–1.99	10	0.62	0.30–1.13
	Medium (5–50 mg/m <sup>3</sup> -year)	0	0.00	0.00–6.62	3	3.96	0.82–11.6	4	0.96	0.26–2.46	0	0.00	0.00–5.63
	High (>50 mg/m <sup>3</sup> -year)	2	2.45	0.30–8.83	0	0.00	0.00–3.98	10	1.51	0.72–2.78	2	1.81	0.22–6.54
Plant dust	None (0)	233	1.02	0.89–1.16	80	0.99	0.79–1.23	1677	1.01	0.96–1.06	99	1.05	0.86–1.28
	Low (<10 mg/m <sup>3</sup> -year)	27	0.85	0.56–1.23	23	1.06	0.67–1.59	219	0.96	0.84–1.10	18	0.77	0.46–1.22
	Medium (10–40 mg/m <sup>3</sup> -year)	32	1.01	0.69–1.43	17	0.97	0.57–1.55	217	0.95	0.83–1.09	15	1.02	0.57–1.68
	High (>40 mg/m <sup>3</sup> -year)	0	0.00	0.00–18.7	0	0.00	0.00–49.9	6	3.55	1.30–7.72	0	0.00	0.00–96.8
Textile dust	None (0)	288	1.00	0.88–1.12	117	1.04	0.86–1.25	2099	1.00	0.96–1.04	122	0.99	0.82–1.18
	Low (<5 mg/m <sup>3</sup> -year)	2	1.40	0.17–5.07	0	0.00	0.00–1.28	8	0.74	0.32–1.46	4	1.15	0.31–2.94
	Medium (5–20 mg/m <sup>3</sup> -year)	1	1.19	0.03–6.63	2	0.49	0.06–1.77	7	1.09	0.44–2.24	3	0.65	0.13–1.90
	High (>20 mg/m <sup>3</sup> -year)	1	3.34	0.08–18.6	1	1.23	0.03–6.87	5	1.83	0.59–4.26	3	3.71	0.77–10.8
Leather dust	None (0)	291	1.00	0.89–1.12	120	1.00	0.83–1.20	2112	1.00	0.96–1.04	132	1.01	0.84–1.19
	Low (<5 mg/m <sup>3</sup> -year)	1	2.01	0.05–11.2	0	0.00	0.00–7.83	5	1.30	0.42–3.04	0	0.00	0.00–6.61
	Medium (5–20 mg/m <sup>3</sup> -year)	0	0.00	0.00–18.6	0	0.00	0.00–31.9	2	1.22	0.15–4.42	0	0.00	0.00–29.8
	High (>50 mg/m <sup>3</sup> -year)	0	0.00	0.00–1080	0	0.00	0.00–728	0	0.00	0.00–94.0	0	0.00	0.00–1460
Animal dust	None (0)	241	1.01	0.88–1.14	96	1.01	0.82–1.23	1760	1.01	0.97–1.06	112	1.00	0.82–1.20
	Low (<0.5 mg/m <sup>3</sup> -year)	36	0.92	0.64–1.27	8	0.81	0.35–1.59	300	0.95	0.85–1.07	8	1.04	0.45–2.06
	Medium (0.5–1.5 mg/m <sup>3</sup> -year)	14	1.07	0.58–1.79	16	1.10	0.63–1.79	53	0.83	0.62–1.08	12	1.03	0.53–1.80
	High (>1.5 mg/m <sup>3</sup> -year)	1	2.22	0.06–12.4	0	0.00	0.00–22.7	6	1.90	0.70–4.14	0	0.00	0.00–24.0
Synthetic polymer dust	None (0)	291	1.00	0.89–1.12	118	1.02	0.85–1.22	2105	1.00	0.96–1.04	129	1.02	0.85–1.21
	Low (<5 mg/m <sup>3</sup> -year)	1	0.55	0.01–3.08	2	0.45	0.05–1.61	14	1.03	0.56–1.72	3	0.61	0.13–1.79
	Medium (5–20 mg/m <sup>3</sup> -year)	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	High (>20 mg/m <sup>3</sup> -year)	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00

O, observed number of cases; CI, confidence interval; SIRs adjusted for age and social class, exposure lag period 20 years.

Finland is mainly to softwood dust (pine, spruce), which may explain the smaller risk as compared to many other studies.<sup>32</sup> A suggestion of an increased risk of lung cancer among men was found in the low exposure class comprising mainly carpenters. However, the excess was small and it may be explained by slightly higher prevalence of smoking among carpenters as compared to all economically active men.

An excess of lung cancer has been associated with paper dust exposure among maintenance workers in paper mills in Sweden.<sup>33</sup> There is potential coexposure—for example, to asbestos and welding fumes in the paper industry.<sup>34</sup> We did not find any excesses of respiratory cancers among those exposed to paper or pulp dust.

No associations between exposure to flour dust and laryngeal cancers<sup>31</sup> or lung cancer<sup>29</sup> have been found with the exception of a suggestive finding of lung cancer among bakers.<sup>5</sup> We found only suggestions of an increased risk of laryngeal cancer in the high cumulative exposure class, which mainly includes bakers. Smoking and alcohol consumption among male bakers is more common than among the economically active male Finnish population,<sup>16</sup> which may confound this result. We did not find excesses of lung cancer among workers exposed to flour dust. The main flours used in Finland are wheat, rye, and oats.

No excesses of respiratory cancers among those exposed to grain dust were found in Canada.<sup>29</sup> Farmers have multiple

exposures—for example, to plant dust and animal dust. Farmers have significantly less lung cancer than expected.<sup>35</sup> The reduced risk of lung cancer may be due to endotoxin exposure, which occurs in dairy farming.<sup>36–37</sup> We also found significantly reduced lung cancer SIRs among those exposed to plant dust and animal dust which are predominantly farmers. We found an excess of laryngeal cancer among men in the high cumulative exposure class of plant dust. The majority in the heavily exposed group were grain millers whereas farmers were the majority in lower exposure categories. The significance of high exposure to plant dust exposure as a separate risk factor for laryngeal cancer remained in Poisson regression analysis model where known risk factors of laryngeal cancer smoking and alcohol were added. The main field crops in Finland are wheat, barley, rye, oats, turnip rape, sugar beet, and timothy, and grains are milled wheat, barley, rye, and oats.

Exposure to textile dust may increase the risk of sinonasal cancer according to some studies<sup>38–40</sup> but not according to others.<sup>21</sup> The mortality from lung cancer has been found to be lower than expected among cotton industry workers and it has been assumed that exposure to cotton dust may reduce the risk of lung cancer.<sup>41</sup> No significant excess of lung cancer has been found among glass filament textile workers.<sup>42</sup> We found only suggestions of an increased risk of laryngeal cancer among men and women in the highest exposure class.

**Table 3** Standardised incidence ratio (SIR) of lung cancer and mesotheliomas in 1971–95 by gender and cumulative exposure (CE) to eight organic dusts among economically active Finns born 1906–45

Agent	CE class	Lung cancer						Mesotheliomas					
		Men			Women			Men			Women		
		O	SIR	95% CI	O	SIR	95% CI	O	SIR	95% CI	O	SIR	95% CI
Wood dust	None (0)	27309	1.00	0.98–1.01	3446	1.00	0.97–1.03	408	1.01	0.91–1.11	135	0.97	0.81–1.14
	Low (<3 mg/m <sup>3</sup> -year)	936	1.11	1.04–1.18	21	0.92	0.57–1.41	12	0.83	0.43–1.46	4	4.57	1.25–11.7
	Medium (3–50 mg/m <sup>3</sup> -year)	1784	1.02	0.97–1.06	48	1.03	0.76–1.37	28	0.98	0.65–1.41	4	2.10	0.57–5.37
Pulp or paper dust	High (>50 mg/m <sup>3</sup> -year)	108	0.85	0.70–1.02	12	0.95	0.49–1.66	2	1.06	0.13–3.84	0	0.00	0.00–7.67
	None (0)	29933	1.00	0.99–1.01	3477	1.00	0.97–1.04	449	1.01	0.92–1.11	139	0.99	0.83–1.17
	Low (<10 mg/m <sup>3</sup> -year)	102	0.82	0.67–1.00	25	0.97	0.62–1.43	0	0.00	0.00–1.42	3	2.97	0.61–8.67
Flour dust	Medium (10–15 mg/m <sup>3</sup> -year)	100	0.82	0.66–0.99	23	0.71	0.45–1.07	1	0.43	0.01–2.38	1	0.80	0.02–4.44
	High (>15 mg/m <sup>3</sup> -year)	2	1.22	0.15–4.42	0	1.08	0.13–3.89	0	0.00	0.00–31.8	0	0.00	0.00–65.2
	None (0)	29944	1.00	0.99–1.01	3116	1.00	0.97–1.04	448	1.00	0.91–1.10	132	1.03	0.87–1.23
Plant dust	Low (<5 mg/m <sup>3</sup> -year)	54	0.86	0.65–1.13	350	0.97	0.87–1.07	0	0.00	0.00–3.13	10	0.78	0.37–1.43
	Medium (5–50 mg/m <sup>3</sup> -year)	50	0.89	0.66–1.18	17	0.68	0.40–1.10	1	0.83	0.02–4.60	0	0.00	0.00–3.55
	High (>50 mg/m <sup>3</sup> -year)	89	0.95	0.77–1.18	44	1.20	0.87–1.61	1	0.63	0.02–3.50	1	0.66	0.02–3.66
Textile dust	None (0)	23211	1.03	1.02–1.05	2684	1.00	0.97–1.04	409	1.01	0.91–1.11	106	1.00	0.82–1.21
	Low (<10 mg/m <sup>3</sup> -year)	2555	0.86	0.82–0.89	495	0.99	0.90–1.08	20	0.93	0.57–1.43	20	0.90	0.55–1.39
	Medium (10–40 mg/m <sup>3</sup> -year)	4340	0.93	0.90–0.96	347	0.98	0.88–1.09	21	0.98	0.60–1.49	17	1.16	0.68–1.86
Leather dust	High (>40 mg/m <sup>3</sup> -year)	31	1.06	0.72–1.51	1	0.55	0.01–3.05	0	0.00	0.00–8.50	0	0.00	0.00–50.1
	None (0)	29867	1.00	0.99–1.01	3288	1.01	0.98–1.05	449	1.01	0.92–1.11	131	0.99	0.83–1.18
	Low (<5 mg/m <sup>3</sup> -year)	162	1.08	0.92–1.26	95	0.99	0.80–1.21	0	0.00	0.00–1.43	4	1.15	0.31–2.94
Animal dust	Medium (5–20 mg/m <sup>3</sup> -year)	82	0.87	0.69–1.08	125	0.79	0.66–0.95	1	0.61	0.02–3.42	4	0.62	0.17–1.59
	High (>20 mg/m <sup>3</sup> -year)	26	0.66	0.43–0.97	19	0.60	0.36–0.94	0	0.00	0.00–5.24	4	3.18	0.87–8.15
	None (0)	30069	1.00	0.99–1.01	3511	1.00	0.97–1.04	450	1.00	0.91–1.10	143	1.01	0.85–1.19
Synthetic polymer dust	Low (<5 mg/m <sup>3</sup> -year)	47	0.85	0.62–1.13	12	0.66	0.34–1.15	0	0.00	0.00–4.04	0	0.00	0.00–51.4
	Medium (5–20 mg/m <sup>3</sup> -year)	20	0.88	0.54–1.36	4	0.90	0.24–2.30	0	0.00	0.00–8.58	0	0.00	0.00–19.4
	High (>20 mg/m <sup>3</sup> -year)	1	1.00	0.03–5.55	0	0.00	0.00–28.1	0	0.00	0.00–26.3	0	0.00	0.00–728
Synthetic polymer dust	None (0)	24237	1.03	1.01–1.04	3105	1.01	0.97–1.05	420	1.00	0.91–1.10	122	1.01	0.84–1.20
	Low (<0.5 mg/m <sup>3</sup> -year)	4519	0.89	0.87–0.92	136	0.95	0.79–1.12	22	0.98	0.61–1.49	6	0.63	0.23–1.37
	Medium (0.5–1.5 mg/m <sup>3</sup> -year)	1321	0.92	0.87–0.97	284	0.93	0.83–1.05	8	0.99	0.43–1.96	15	1.21	0.68–2.00
Synthetic polymer dust	High (>1.5 mg/m <sup>3</sup> -year)	60	1.22	0.93–1.57	2	0.46	0.06–1.65	0	0.00	0.00–10.2	0	0.00	0.00–18.5
	None (0)	29877	1.00	0.99–1.01	3392	1.01	0.98–1.04	448	1.00	0.91–1.10	138	1.01	0.85–1.20
	Low (<5 mg/m <sup>3</sup> -year)	204	0.94	0.82–1.08	135	0.81	0.68–0.96	2	0.54	0.07–1.96	5	0.75	0.24–1.75
Synthetic polymer dust	Medium (5–20 mg/m <sup>3</sup> -year)	46	0.68	0.49–0.90	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
	High (>20 mg/m <sup>3</sup> -year)	10	1.23	0.59–2.26	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00

O, observed number of cases; CI, confidence interval; SIRs adjusted for age and social class, exposure lag period 20 years.



**Table 4** Relative risk (RR) and confidence interval (CI) of laryngeal cancer by cumulative exposure (CE) to plant dust, smoking and alcohol consumption among Finns in 1971–95 adjusted by each other, age, social class and period, lag time 10 years

Agent/confounder	CE class	Men		Women	
		RR	95% CI	RR	95% CI
Plant dust	High (>40 mg/m <sup>3</sup> -year)	2.89	1.50–5.57	0	0
	Medium (10–40 mg/m <sup>3</sup> -year)	0.91	0.72–1.14	0.86	0.23–3.16
	Low (<10 mg/m <sup>3</sup> -year)	1.03	0.82–1.30	0.65	0.36–1.21
	None (reference)	1.00	(reference)	1.00	(reference)
Smoking index	Effect of 10% increase in daily smoking prevalence of an occupation	1.12	1.04–1.21	1.45	1.03–2.05
Alcohol index	Effect of one additional drink/day	1.31	1.06–1.61	1.65	0.25–10.8

The result may be confounded by smoking and alcohol use or it may be a chance finding. We found a significantly decreased risk of lung cancer in the high exposure category, which supports the hypothesis that endotoxins in textile dust may prevent textile workers from contracting lung cancer.<sup>41</sup>

Exposure to leather dust may increase the risk of cancer of the nose and paranasal sinuses.<sup>43–44</sup> Leather dust particles contain numerous chemicals acquired during the process of leather tanning and finishing (chromium salts, vegetable dye extracts, mineral oils), which may contribute to the carcinogenic effect. An association between leather dust from vegetable tanning and lung cancer has been reported in Swedish leather tanneries.<sup>45</sup> We did not find any excesses of respiratory cancer among those exposed to leather dust.

Animal dust is not usually considered as a cause of respiratory cancer. However there are some suggestions that animal origin microbe exposures may increase the risk of lung cancer among farmers<sup>46</sup> and butchers.<sup>47</sup> Previous studies have reported that endotoxin and other microbial products are inherent elements of farm dusts, particularly in cowsheds, where faeces of animals contaminate organic dusts on which bacteria and fungi adhere and grow.<sup>48–49</sup> The job title “farmer” is a crude proxy for exposure to farm dust containing endotoxin-like substances. A reduced risk of lung cancer has been found among dairy farmers but not among crop/orchard farmers.<sup>50–51</sup> Fur farmers are exposed to higher levels of animal dust but lower levels of endotoxins compared to dairy farmers.<sup>49–52</sup> We did not find any excess of respiratory cancer among workers

exposed to animal dust. Farmers, many of whom are exposed to animal dust, had a significantly low incidence of lung cancer. The heterogeneity of the jobs with animal dust exposure probably explains why lung cancer SIR does not decrease with increasing level of “animal dust”.

Painters (and spray painters in particular) may be exposed to synthetic polymers in paints (polyurethane, epoxy- and polyacrylic compounds, etc). These synthetic polymers are not suspected to cause cancers of the respiratory tract according to an IARC monograph.<sup>53</sup> We did not find any excesses of respiratory cancer among those exposed to synthetic polymer dust.

To date there is no paradigm providing a base from which the protective effects afforded by an exposure can be confirmed. In a case control study nested in a cohort of Italian farmers, there was evidence for an exposure dependent reduction of lung cancer risk in farmers who ceased working on dairy farms less than 15 years previously.<sup>36</sup> Thus protection afforded by exposure to endotoxin-containing organic dust diminishes over time after removal from that exposure.<sup>36</sup> We analysed our animal dust exposure and lung cancer data without lagging exposure and setting the follow up time to 15 years. This did not change the results.

The use of FINJEM in epidemiology has been evaluated in several studies and it has been found accurate enough to reveal established occupational cancer risks.<sup>20–54</sup> We used cross sectional 1970 census data. FINJEM converts occupational to exposure data. The occupation at one point in time

**Table 5** Relative risk (RR) and confidence interval (CI) of lung cancer by cumulative exposure (CE) to plant dust, asbestos, quartz dust, and smoking among Finns in 1971–95 adjusted by each other, age, social class, and period, lag time 10 years

Agent/confounder	CE class	Men		Women	
		RR	95% CI	RR	95% CI
Plant dust	High (>40 mg/m <sup>3</sup> -year)	1.06	0.80–1.40	0.84	0.40–1.77
	Medium (10–40 mg/m <sup>3</sup> -year)	0.78	0.73–0.83	0.95	0.72–1.26
	Low (<10 mg/m <sup>3</sup> -year)	0.94	0.88–1.01	1.02	0.91–1.16
	None (reference)	1.00	(reference)	1.00	(reference)
Asbestos	High (>10 f/cm <sup>3</sup> -year)	1.24	1.15–1.34	1.10	0.69–1.75
	Medium (2–10 f/cm <sup>3</sup> -year)	1.22	1.15–1.29	0.91	0.54–1.54
	Low (<2 f/cm <sup>3</sup> -year)	1.06	1.00–1.12	0.75	0.46–1.22
	None (reference)	1.00	(reference)	1.00	(reference)
Quartz dust	High (>10 mg/m <sup>3</sup> -year)	1.24	1.09–1.41	1.18	0.78–1.79
	Medium (1–10 mg/m <sup>3</sup> -year)	0.98	0.92–1.05	1.23	0.85–1.78
	Low (<1 mg/m <sup>3</sup> -year)	1.04	0.98–1.09	0.96	0.68–1.34
	None (reference)	1.00	(reference)	1.00	(reference)
Smoking index	Effect of 10% increase in daily smoking prevalence of an occupation	1.18	1.16–1.21	1.39	1.31–1.47

may not correspond to the lifelong occupational history of a person, although the occupational stability in the occupations with organic dust exposure is high.<sup>55</sup> The use of cross sectional exposure estimates adds some misclassification and therefore dilutes the RR estimates towards unity but because of the large size of our study even these diluted risk estimates are likely to remain significant and show possible patterns of risk increase with increasing exposure.<sup>20–56</sup> Multiple comparisons were made in this study, and therefore some of the findings are probably due to chance.

Occupational exposure to organic dust is unlikely to be a major risk factor of respiratory cancer in Finland. Exposure to wood dust has a minor effect on the risk of nasal cancer in Finland, possibly because this exposure is mainly to softwood dusts. We found that exposure to plant dust may increase the risk of laryngeal cancer. We found support to the finding that exposure to plant dust and animal dust (mainly among farmers) and textile dust decreases the risk of lung cancer. There were no increased risks of respiratory tract cancers among workers exposed to pulp/paper, leather, or synthetic polymer dust.

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