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Cancer of the mouth and pharynx, occupation and exposure to chemical agents in Finland [in 1971–95]

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The objective of this article was to find associations between cancer of the mouth and pharynx, occupation and chemical exposure. A cohort of Finns born between 1906 and 1945 was followed-up for 46.8 (21.5 in males and 25.3 in females) million person-years during 1971–95. Incident cases of cancer of the mouth and pharynx (n = 2,708) were identified in a record linkage with the Finnish Cancer Registry. The Census occupations in 1970 were converted to chemical exposures with a job-exposure matrix (FINJEM). Cumulative exposure (CE) was calculated as the product of prevalence, level and duration of the exposure. Standardized incidence ratio (SIR) was calculated for each of the 393 occupations, and for CE categories of the 43 chemical agents, using total Finnish population as reference. Relative risks (RR) comparing various CE-categories with unexposed ones were defined for selected agents by Poisson regression analysis. Elevated SIRs were observed among lawyers, authors, journalists, performing artists, musicians, electronics and telefitters, painters (building), building hands, dockers, unskilled labourers and hotel porters in males and private secretaries, dressmakers, shoemakers and cobblers, waiters, pursers and stewardesses in females. The multivariate analyses showed high RRs for high exposure to aliphatic and alicyclic hydrocarbons, pesticides and alcohol. In conclusion, occupations with high SIRs were mostly the ones with high consumption of alcohol. Exposure to solvents and possibly to pesticides, engine exhaust, textile dust and leather dust may increase the risk of cancer of mouth and pharynx.

Key words: neoplasms of mouth and pharynx; oral cancer; occupations; occupational exposure; chemicals

Results on whether occupational exposures could cause cancer of the mouth and pharynx are conflicting. Some studies have reported excess risks of cancers of the tongue, oral cavity and pharynx for electrical workers, waiters, cooks, butchers, printers, artists, pulp industry or wood workers, tailors and sewers, beverage manufacturers, packers, loaders, dockers and warehouse workers, seamen, plumbers and pipe fitters, journalists, motor vehicle drivers, dentists, hairdressers, shoemakers, launderers and drycleaners, bricklayers, painters and wall paper hangers, building hands, lawyers, PR officers and sales professionals.[1–9]

In a large Finnish study[6] there was no variation in the risk by social class among cancer of the tongue. The incidence of cancer of the oral cavity in women increased with increasing social status. The risk of cancer of the pharynx (excluding nasopharynx) was significantly elevated among women in the lowest social class. In men the risk of cancers of oral cavity and pharynx were elevated in the lowest and highest social classes. Lower social class has been related to an increased risk of cancer of the mouth and pharynx in some studies,[10,11] but not in all.[7]

This study evaluated the incidence of cancer of the mouth and pharynx in relation to 393 occupational titles and 43 chemical agents. The target organs are the tongue (C01-02 in ICD-10), in oral cavity (C03-06) and the pharynx (C09-14, excluding nasopharynx C11).

Material and methods

The study cohort comprised all Finns born between 1906 and 1945 who participated in the national population census on December 31, 1970. Average number of persons under follow up was 725,868 in males and 825,528 in females. 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 census records. The socioeconomic status for each subject was determined based on the subject's own or spouse's occupation (for details, see[12]). In our analyses, the cohort was categorized into the following: higher white collar, clerical, skilled blue collar, unskilled workers and farmers.

Finnish Cancer Registry (FCR) has collected data on all cancer cases diagnosed in Finland since 1953. All physicians, hospitals and other institutions treating cancer patients, and all pathological, cytological and haematological laboratories in the country are obliged to notify the FCR of all cancer cases that come to their attention. In addition, Statistics Finland annually sends a computerized file on death certificates in which a cancer is mentioned. The coverage of the FCR is virtually complete and the data accuracy is high.[13] For the present study, the incident cases of cancer of the mouth and pharynx (excluding nasopharynx) diagnosed during 1971–95 among persons born between 1906 and 1945 (n = 2,708, from which 939 are in tongue, 959 in oral cavity and 810 in pharynx, excluding nasopharynx, 1,556 in male and 1,152 in female) were extracted from the FCR and sent to Statistics Finland for linkage with the Census 1970 file. Since 1967, everyone residing in Finland has been assigned a unique 11-digit personal identifier (PID), which is used in all main registers. PIDs have greatly facilitated reliable record linkage operations.

The occupational exposure estimates for the study cohort were derived from a national job-exposure matrix (FINJEM).[14] FINJEM covers major occupational exposures in Finland since 1945 by occupation and calendar time. Exposure is characterized by the proportion of exposed persons (P) and the average level of exposure (L) among the exposed persons in each occupation. The exposure estimates are based on available exposure measurements, hazard surveys and judgement of Finnish occupational hygienists. FINJEM provides exposure estimates for 393 occupations[12] and 43 chemical agents. 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 behavior of the Finnish adult population by the Finnish National Public Health Institute during 1978–91.[15] In multivariate analyses, the smoking relative risks (RR) describes the effect of a 10% increase in the

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Abbreviations: CE, cumulative exposure; CI confidence interval; FCR Finnish Cancer Registry; FINJEM, Finnish national job-exposure matrix; IARC, International Agency for Research on Cancer; ICD, International Classification of Diseases; L, average exposure level among the exposed persons; P, percentage of exposed persons; PID, personal identifier; RR, relative risk; SIR, standardized incidence ratio.

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daily smoking prevalence of an occupation and the RR of alcohol describes the effect of 1 additional drink/day. One drink is estimated to contain 12 g of alcohol.

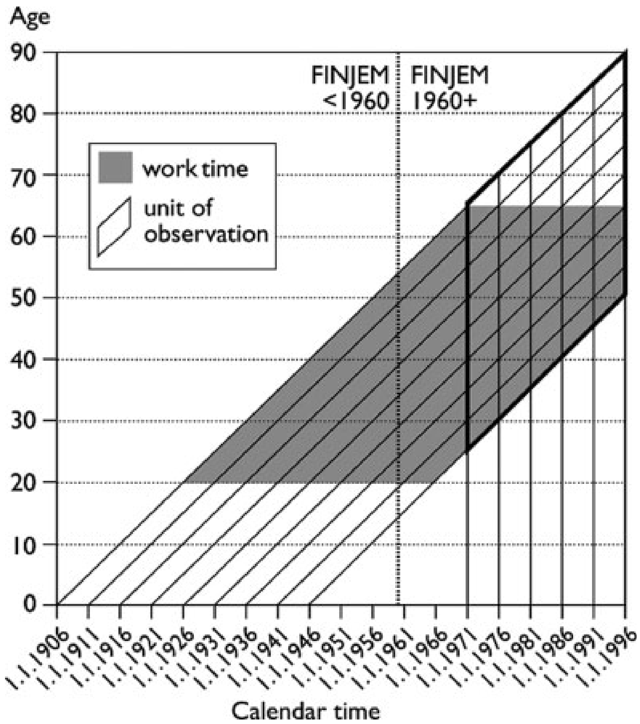

FIGURE 1 – Units of observation, defined by birth year of the persons in the cohort (1906–10, . . . , 1941–45) and calendar period of follow-up (1971–75, . . . , 1991–95), estimated work (exposure) time, and FINJEM periods used for exposure estimation.

We calculated agent specific cumulative exposure (CE) estimates for every 5-year birth cohort (1906–10, . . . , 1941–45) and every 5-year calendar period of observation (1971–75, . . . , 1991–95) (Fig. 1). The annual average exposure was the product of the proportion of exposed persons (P) and the mean level of exposure (L) in that occupation. Some agents, such as organic solvents, pesticides and metals, were also assessed at the level of the group of agents. In those cases, the CE of the group was expressed as score-years calculated from P and L of specific agents belonging to the group. 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 used. The 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 year of the mid-point of the observation period, or at 65 years of age, whichever came first. Because of the high occupational stability of Finns,[16] it is justified to assume that a substantial part of workers remained in the Census 1970 job during the entire working career. The effect of overestimation of the duration of exposure among workers who have changed their occupation has been studied and found to be insignificant.[17] A lag period was incorporated into the CE by omitting exposure during the period prior to the mid-point of the observation period. For example, when studying cancer risk in 1971–75, only exposures until 1963 were taken into account if the lag was 10 years. The estimated CE was then divided *a priori* into 4 categories in the analyses: none, lowest, middle and highest. The "high" CE category was set to include long-term workers with high exposure and was for most exposures rather small. The rest of the potentially exposed subjects were divided into "middle" and "lowest" CE classes.

Statistical analyses

The observed and expected numbers of cases for every occupation were calculated for each gender, 5-year birth cohort and 5-year calendar period (Fig. 1). Standardized incidence ratio (SIR) was defined as the ratio of observed to expected numbers of cases. The expected number of cases was achieved by multiplying the

TABLE I – STANDARDIZED INCIDENCE RATIOS (SIR) OF CANCER OF MOUTH AND PHARYNX (EXCL. NASOPHARYNX) IN ALL OCCUPATIONAL BRANCHES AND SELECTED SPECIFIC OCCUPATIONS WITH SIGNIFICANT SIRS, MALES

Occupation	Obs. cases	Exp. cases	SIR	95% CI
All economically active persons	1,294	1396.1	0.93	0.88–0.98
Technical, humanistic, etc. work	156	148.7	1.05	0.89–1.22
Civil eng. technicians, building	1	7.6	0.13	0.00–0.74
Lawyers	4	0.7	5.70	1.55–14.59
Authors	2	0.2	9.32	1.13–33.65
Journalists	10	3.1	3.28	1.57–6.03
Performing artists	4	0.7	5.60	1.53–14.35
Musicians	7	2.3	3.03	1.15–5.90
Administrative and clerical work	86	85.2	1.01	0.81–1.25
Sales professions	82	72.3	1.13	0.90–1.41
Farming, forestry and fishing	254	371.9	0.68	0.60–0.77
Farmers, silviculturists	189	282.5	0.67	0.58–0.77
Forestry managers	3	11.1	0.27	0.06–0.79
Mining and quarrying	3	7.5	0.40	0.08–1.16
Transport and communications	135	137.6	0.98	0.82–1.15
Railway staff	4	11.5	0.35	0.09–0.89
Industrial and construction work	509	508.3	1.00	0.92–1.09
Smelting, metal and foundry work	4	13.7	0.29	0.08–0.75
Woodwork	75	94.6	0.79	0.62–0.99
Electronics and telefitters	6	2.1	2.92	1.07–6.35
Painters, building	21	12.9	1.63	1.01–2.49
Building hands	48	30.4	1.58	1.16–2.09
Machinists	28	42.6	0.66	0.44–0.95
Dockers	15	6.6	2.28	1.28–3.76
Labourers not classified elsewhere	24	14.9	1.61	1.03–2.39
Services	56	53.8	1.04	0.79–1.35
Policemen	3	9.4	0.32	0.07–0.93
Hotel porters	7	2.0	3.51	1.41–7.23
Work not classified elsewhere	13	10.8	1.20	0.64–2.06
Economically inactive	262	159.9	1.64	1.45–1.84

TABLE II – STANDARDIZED INCIDENCE RATIOS (SIR) OF CANCER OF MOUTH AND PHARYNX (EXCL. NASOPHARYNX) IN ALL OCCUPATIONAL BRANCHES AND SELECTED SPECIFIC OCCUPATIONS WITH SIGNIFICANT SIRS, FEMALES

Occupation	Obs. cases	Exp. cases	SIR	95% CI
All economically active persons	635	635.8	1.00	0.92–1.08
Technical, humanistic, etc. work	77	81.2	0.95	0.75–1.18
Administrative and clerical work	88	79.9	1.10	0.88–1.36
Private secretaries	9	4.1	2.20	1.00–4.17
Sales professions	48	60.9	0.79	0.58–1.04
Farming, forestry and fishing	133	149.4	0.89	0.75–1.05
Farming, animal husbandry	85	106.8	0.80	0.64–0.98
Mining and quarrying	–	0.2	–	0.00–18.50
Transport and communications	18	20.8	0.87	0.51–1.37
Industrial and construction work	102	109.9	0.93	0.76–1.12
Dressmakers	12	5.0	2.42	1.25–4.23
Shoemakers and cobblers	2	0.1	17.42	2.11–62.94
Services	167	132.1	1.26	1.08–1.46
Waiters	23	12.8	1.80	1.14–2.70
Pursers, stewardesses	2	0.2	9.56	1.16–34.52
Launderers	–	4.4	–	0.00–0.85
Work not classified elsewhere	2	1.3	1.54	0.19–5.57
Economically inactive	517	516.2	1.00	0.92–1.09

stratum-specific number of person-years by sex, period and age-specific incidence rate of the reference population. In calculations of social class-specific SIRs and crude occupation-specific SIRs, the expected numbers were based on the incidence of the total Finnish population of the same sex. For occupational categories social class adjusted SIRs were also calculated. In that case the expected number of cases for each stratum defined by sex, calendar period and age for each occupation was calculated according to the formula $Exp = \sum_{j=1}^{4} P_j I_j$, where P_j is the number of person-years in that occupation belonging to social class j, and I_j is the cancer incidence in social class j. The total SIRs over ages, periods, *etc.* were calculated as ratios of the sums of the observed numbers of cases to the sums of expected numbers of cases in the respective strata. The 95% confidence intervals (95% CI) for each SIR were defined under the assumption that the observed number of cases followed a Poisson distribution.

Using Poisson regression analysis, RR was calculated to compare exposed categories with unexposed ones. Trend was tested by using unclassified CE estimates in Poisson regression, *i.e.* assuming log linear relationship between CE estimate and cancer occurrence.

The analyses were carried out by 3 steps: (*i*) SIR was defined for each of the 393 occupations, with and without adjustment for social class. (*ii*) Occupational titles were linked to the FINJEM to quantify SIRs related to CE to various chemical agents ($n = 43$). (*iii*) Agents that were connected to occupations with high SIRs in step (*i*) or agents that showed high SIRs in step (*ii*), were selected for internal comparison using Poisson regression analysis. The model included age, calendar period and social class, and possible interaction terms.

Results

Occupations

In males significantly elevated SIRs for cancer of mouth and pharynx (excl. nasopharynx) were found among lawyers, journalists, artists, electronics and telefitters, painters (building), building hands, dockers, unskilled labourers and hotel porters (Table I). Civil engineering technicians (building), farmers and silviculturists, forestry managers, railway staff, smelting, metal and foundry workers, wood workers, machinists and policemen had significantly low SIRs (Table I). Economically inactive males had significantly elevated SIR for cancer of mouth and pharynx (excl. nasopharynx) (Table I). Adjustment for social class did not affect SIR much (SIR was 1.64 without adjustment and 1.61 when adjusted for social class).

In females significantly elevated SIRs were found among private secretaries, dressmakers, shoemakers and cobblers, waiters, pursers and stewardesses (Table II). Among farming and animal husbandry and launderers the risk was significantly low (Table II).

Chemical agents

Elevated SIRs with lag period of 10 years and adjustment for social class for men and women together were found in the highest CE category of aliphatic and alicyclic hydrocarbons, aromatic hydrocarbons and pesticides (Table III). Petroleum-based products and engine exhaust showed dose-response trends. Metals and fungicides had significantly elevated SIRs in the lowest CE category. Asbestos had similarly elevated SIRs in all CE categories (Table III).

In the Poisson regression multivariate analyses for men and women together, the final model included aliphatic and alicyclic hydrocarbons, pesticides and engine exhaust (Table IV). Smoking, alcohol and gender were also included in the model. Significant risk was observed for aliphatic and alicyclic hydrocarbon solvents and pesticides (Table IV). For different kinds of pesticides—herbicides, fungicides and insecticides—no significant risks were observed separately. They could not be separately in the same multivariate analyses, because of their high parameter correlation. From the cofactors RR of alcohol (effect of 1 additional drink per day) was 1.95 (95% CI 1.52–2.51). Increasing smoking did not have independent role.

Chemical agents related to occupations with high SIRs in step (*i*) were selected for calculation of RR by using Poisson regression analysis separately for men and women. Selected agents were chlorinated hydrocarbon solvents, other organic solvents (included mainly alcohols, ketones, esters, glycol ethers), textile dust, leather dust, asbestos, iron, lead and chromium. In the Poisson regression multivariate analyses no statistically significant risks were observed in males or in females.

Discussion

Covering 393 occupations and 43 chemical agents, our study is one of the most comprehensive studies on occupational aetiology of cancer of the mouth and pharynx. Male journalists, dockers, artists, lawyers, building hands and female waiters and shoemakers/cobblers had a high occupational risk of cancer of the mouth and pharynx, which is consistent with another study.[4] This Nordic study[4] had some overlapping with our study, because Finnish cancer cases from 1971 to 1990 (*i.e.*, majority of the cases of the present study) also constitute about one-fifth of the cases of

TABLE III – STANDARDISED INCIDENCE RATIO (SIR) FOR CANCER OF MOUTH AND PHARYNX (EXCL NASOPHARYNX) BY CUMULATIVE EXPOSURE (CE) TO 43 AGENTS, MEN AND WOMEN

Agent	Lowest		Middle		Highest		Cut points		Unit
	N	SIR (95% CI[1])	*N*	SIR (95% CI)	*N*	SIR (95% CI)	Lower	Higher	
All chemical agents	793	0.95 (0.89–1.02)	254	1.19 (1.05–1.34)	147	1.13 (0.96–1.33)			
Formaldehyde	59	0.79 (0.60–1.03)	8	1.01 (0.43 –1.98)	6	0.73 (0.27–1.59)	1	5	ppm-years
Organic solvents	149	1.02 (0.86–1.20)	8	0.69 0.30–1.36)	31	1.31 (0.89–1.86)	20	200	Score-years
Aliphatic and alicyclic hydrocarbons	29	0.97 (0.65–1.39)	14	0.90 (0.49–1.51)	22	1.97 (1.23–2.98)	50	500	ppm-years
Aromatic hydrocarbons	106	0.97 (0.79–1.17)	18	1.10 (0.65–1.74)	27	1.50 (0.99–2.19)	20	200	ppm-years
Chlorinated hydrocarbon	34	1.16 (0.80–1.62)	37	1.42 (1.00–1.96)	2	0.20 (0.02–0.73)	5	50	ppm-years
Other organic solvents[2]	18	0.71 (0.42–1.12)	34	1.30 (0.90–1.81)	6	1.06 (0.39–2.32)	50	500	ppm-years
Organic dust	180	0.84 (0.72–0.97)	385	0.93 (0.84–1.02)	55	0.87 (0.66–1.13)	10	100	score–-ears
Wood dust	17	1.10 (0.64–1.76)	69	0.94 (0.73–1.19)	13	1.55 (0.83–2.66)	5	50	mg/m^3-years
Hardwood dust	34	1.02 (0.71–1.43)	34	0.85 (0.59–1.19)	17	1.32 (0.77–2.11)	2	20	mg/m^3-years
Softwood dust	33	0.97 (0.67–1.37)	50	1.03 (0.77–1.36)	16	1.06 (0.60–1.72)	2	20	mg/m^3-years
Pulp or paper dust	6	0.77 (0.28–1.68)	9	0.66 (0.30–1.25)	0	0.00 (0.00–4.38)	10	20	mg/m^3-years
Flour dust	59	0.69 (0.52–0.88)	7	0.76 (0.31–1.57)	5	0.43 (0.14–1.01)	5	50	mg/m^3-years
Plant dust	118	0.78 (0.65–0.93)	308	0.95 (0.85–1.06)	2	1.04 (0.13–3.76)	10	50	mg/m^3–years
Textile dust	12	0.54 (0.28–0.95)	31	0.83 (0.57–1.18)	12	0.92 (0.47–1.60)	5	20	mg/m^3-years
Leather dust	5	0.87 (0.28–2.02)	3	1.75 (0.36–5.13)	0	0.00 (0.00–15.56)	5	20	mg/m^3-years
Animal dust	92	1.11 (0.90–1.36)	233	0.90 (0.79–1.03)	2	0.72 (0.09–2.61)	0.5	2	mg/m^3-years
Synthetic polymer dust	37	0.83 (0.59–1.15)	2	0.44 (0.05–1.60)	1	0.73 (0.02–4.05)	5	20	mg/m^3-years
Petroleum–based products	123	1.06 (0.88–1.26)	12	1.25 (0.64–2.18)	23	1.60 (1.02–2.41)	100	500	Score-years
Gasoline	74	1.22 (0.96–1.53)	18	1.13 (0.67–1.78)	6	1.51 (0.55–3.28)	1	5	ppm-years
Oil mist	27	0.81 (0.53–1.17)	12	0.96 (0.50–1.68)	27	1.48 (0.98–2.16)	2	20	mg/m^3-years
Bitumen fumes	2	2.26 (0.27–8.15)	2	0.41 (0.05–1.47)	0	0.00 (0.00–3.12)	2	10	mg/m^3-years
Inorganic mineral dust	280	1.05 (0.93–1.18)	55	1.17 (0.88–1.52)	41	1.13 (0.81–1.53)	100	500	Score-years
Asbestos	105	1.32 (1.08–1.60)	48	1.24 (0.92–1.65)	88	1.26 (1.01–1.55)	2	10	f/cm^3-years
Manmade mineral fibers (MMMF)	64	1.05 (0.81–1.34)	33	1.15 (0.79–1.61)	31	1.35 (0.92–1.92)	2	5	f/cm^3-years
Quartz dust (crystalline silica)	78	0.94 (0.74–1.17)	81	1.23 (0.97–1.52)	6	1.17 (0.43–2.54)	1	10	mg/m^3-years
Other mineral dusts	96	0.84 (0.68–1.03)	53	1.30 (0.97–1.70)	21	0.90 (0.56–1.37)	50	100	mg/m^3-years
Metals	231	1.16 (1.01–1.32)	83	1.20 (0.96–1.49)	7	0.77 (0.31–1.58)	100	500	Score-years
Iron	104	1.23 (1.00–1.49)	3	0.38 (0.08–1.11)	5	2.33 (0.76–5.44)	10	50	mg/m^3-years
Lead	164	1.32 (1.12–1.53)	39	1.04 (0.74–1.42)	0	0.00 (0.00–8.95)	10	50	μmol/l-years
Chromium	158	1.05 (0.89–1.23)	32	1.22 (0.84–1.73)	6	1.45 (0.53–3.15)	50	500	$\mu g/m^3$-years
Nickel	87	1.22 (0.98–1.51)	35	1.11 (0.77–1.54)	9	1.09 (0.50–2.08)	20	100	$\mu g/m^3$-years
Cadmium	90	1.45 (1.17–1.78)	18	1.09 (0.65–1.72)	0	0.00 (0.00–2.35)	2	20	$\mu g/m^3$-years
Arsenic	57	1.10 (0.83–1.42)	25	0.77 (0.50–1.13)	0	0.00 (0.00–4.91)	2	20	$\mu g/m^3$-years
Carbon monoxide	185	1.26 (1.08–1.45)	59	1.02 (0.78–1.32)	1	0.68 (0.02–3.76)	200	500	ppm-years
Engine exhaust	102	1.12 (0.92–1.36)	87	1.34 (1.08–1.66)	25	1.68 (1.09–2.48)	100	500	Score-years
Diesel engine exhaust	102	1.26 (1.03–1.53)	42	1.15 (0.83–1.55)	20	1.62 (0.99–2.50)	2	10	mg/m^3-years
Gasoline engine exhaust	130	1.28 (1.07–1.52)	51	1.37 (1.02–1.80)	8	1.43 (0.62–2.82)	100	500	mg/m^3-years
Polycyclic aromatic hydrocarbons	70	1.22 (0.95–1.54)	9	1.44 (0.66–2.73)	3	0.40 (0.08–1.16)	10	50	$\mu g/m^3$-years
Benzo(a)pyrene	73	1.22 (0.96–1.53)	9	0.91 (0.41–1.72)	1	0.41 (0.01–2.28)	1	5	$\mu g/m^3$-years
Pesticides	206	1.12 (0.98–1.29)	82	1.02 (0.81–1.27)	10	1.77 (0.85–3.26)	100	500	Score-years
Herbicides	58	1.12 (0.85–1.45)	216	1.14 (0.99–1.30)			0.005	0.02	mg/m^3-years
Fungicides	38	1.48 (1.05–2.04)	242	1.07 (0.94–1.22)	18	0.98 (0.58–1.55)	0.02	0.2	mg/m^3-years
Insecticides	235	1.10 (0.96–1.25)	0	0.00 (0.00–58.11)	16	1.10 (0.63–1.79)	0.002	0.1	mg/m^3-years

[1]Adjusted for age, calendar period and socioeconomic status. Lag period 10 years. Reference: total Finnish population. CI, confidence interval.–[2]"Other organic solvents" included mainly alcohols, ketones, esters and glycol ethers.

that study. Farmers had low occupational risk of cancer of the mouth and pharynx, which is consistent with another study.[18] Wood workers had significantly low risk for cancer of mouth and pharynx, which was not consistent with earlier study.[5] Comparison of our results on occupational exposure to the chemical agents with the previous literature is difficult because very few previous studies have addressed this issue.

We utilized a large cohort, exact person-years calculation and incidence rates instead of mortality rates. We assessed the risk of cancer of the mouth and pharynx both by occupation and by exposure. These are the strengths of our study. A limitation of our study is that this type of JEM-analysis, based on group-specific averages, cannot reach the same level of accuracy in the exposure assessment as studies based on direct data of individual subjects. However, JEM-based group-level analysis is the only reasonable choice to address occupational exposures in large retrospective studies when individual exposure data cannot be traced. In the present study, the slightly compromised accuracy was compensated by the high number of person-years at follow-up (21.5 million in males and 25.3 in females). Methodological calculations have convinced us that the FINJEM-based analysis is valid for replicating confirmed associations between occupational exposures and cancer risks.[17] Therefore we believe that it can be used to reveal new associations as well. The FINJEM method to quantify levels and probabilities of exposure to chemical agents for particular time windows has already been applied in several countries. Although FINJEM contains group level information on smoking and alcohol drinking, there may still be some residual confounding from these factors.

In this study there were no individual measures of alcohol intake, but FINJEM contains occupation-specific averaged estimates on some lifestyle factors such as smoking (proportion of daily smokers) and alcohol consumption (average in g/week).[17] These data originate from the annual surveys on health behavior of the Finnish adult population by the Finnish National Public Health Institute during 1978–1991. The smoking data are too

TABLE IV – MULTIVARIATE RELATIVE RISK (RR) OF CANCER OF MOUTH AND PHARYNX (EXCL NASOPHARYNX) BY CUMULATIVE EXPOSURE TO THE SELECTED AGENTS, MEN AND WOMEN

Exposure	Observed cases	RR[1]	95% CI[2]
Aliphatic and alicyclic hydrocarbon solvents			
High	22	1.69	1.06–2.71
Middle	14	0.92	0.59–1.46
Low	29	0.88	0.68–1.13
Pesticides			
High	10	1.92	1.00–3.68
Middle	82	1.06	0.80–1.40
Low	206	1.07	0.86–1.35
Engine exhaust			
High	25	1.37	0.90–2.09
Middle	87	1.11	0.89–1.39
Low	102	0.96	0.77–1.18

[1]Poisson regression model included age, calendar period and socioeconomic status and all 3 occupational exposures. Lag period 10 years. Reference: no occupational exposure to the agent.–[2]CI, confidence interval.

recent in terms of causation of cancers diagnosed during 1971–1995 and if the resent occupation-specific smoking habits do not correlate with those in the earlier decades, adjusting for smoking may bias the result. But because the time trends in smoking among the men in Finland has shown a rather parallel decrease in most population subgroups, it is justified to use FINJEM's smoking estimate as a cofactor in models of smoking-related cancers for men. Smoking among females and high alcohol consumption in both genders have varied more irregularly over time, and therefore the data available may not always guarantee proper adjustment.

The job titles were derived from the 1970 Census, and we assumed that person remained in the same job during the entire working career. Occupational stability in Finland has been generally high and job changes usually occur within the same broader occupational group having similar exposures.[16] Several analyses have been undertaken using different exposure metrics to show that variables describing occupational stability did not affect the results essentially.[17] The acceptability of our assumption is also supported by a Finnish study on cause-specific mortality,[19] which clearly demonstrated that the RRs did not much depend on whether job data were derived from 1 cross-sectional census or from occupational history based on several cross-sectional censuses.

This study produced over 700 occupation and sex specific SIRs. Theoretically, there should be about 2.5% of the occupation-specific SIRs significantly both below and above 1.0 on the 95% significance level. In practice, because most of the expected numbers are small and the number of observed cases is a discrete variable, the expected number of significant SIRs is smaller, especially in the case of SIRs below 1.0. If the expected number of cases is less than 3.69, which is true for cancer of mouth and pharynx in many occupations, the SIR can never be significantly below 1.0. We have followed the principle that the justification whether or not an observed association is likely to be true should not be based on statistical significance only. Other knowledge about the meaningfulness of the association such as similar earlier observations and theories of possible causal mechanisms should be taken into account.

FINJEM does not include data on some suspected or known risk factors of cancer of the mouth and pharynx, such as poor oral hygiene. However, the possible effect of these factors to our risk estimates was limited in this large cohort study. If the factors were social class related, adjustment of social class would have minimized their effect. Because social class variation was small, social class adjusted SIR's by occupation were almost the same as SIR's not adjusted for social class.

Economically inactive men had significantly elevated risk for cancer of mouth and pharynx. The same was not seen in females. In the 1970 Population Census the proportion of economically inactive 35–64 year-old men was 8% and big proportion of those were unable to work because of their health status or alcohol abuse. In females the proportion of economically inactive 35–64 year-old was 38% and included mostly housewives and farmers spouses. High and statistically significant site-specific SIRs among economically inactive men were obtained for numerous cancers associated with smoking or drinking.[6]

It is well-known that alcohol and smoking are the biggest risk factors for the cancer of mouth and pharynx and they interact in a multiplicative way on cancer risk.[20–25] Alcohol abuse in several occupational categories can be roughly estimated from the alcohol-related utilization of health care resources by these categories in 1972.[26] The highest indices for alcohol-related utilization of health care resources among men were obtained for labourers, painters, seamen, construction workers, forestry workers, artists and journalists. The indices were low for farmers, managers and drivers. Among women the alcohol-related utilization of health care resources was smaller than among men, but the order of the occupations was similar.[26] Most of the occupations that had higher risk for the cancer of mouth and pharynx in our study are the ones in which people are known to use alcohol and/or tobacco more than average; authors, journalists, performing artists, musicians, building hands, dockers, unskilled labourers in males and waiters, private secretaries in females.[26–29]

Alcohol was one of the cofactors in the Poisson multivariate analysis in our study. The RR for alcohol (effect of 1 additional drink/day) was 1.95. This is consistent with another study, which also states that the relationship between alcohol intake and the cancer of mouth and pharynx is linear.[30] Smoking was another cofactor in the Poisson multivariate analysis, but increasing smoking did not have independent risk-increasing effect. Heavy drinking has been very much combined with smoking, *i.e.*, correlation of these factors is high and in the multivariate model happens to set weight to alcohol.

Farmers had low risk for cancer of mouth and pharynx, which is consistent with earlier studies.[4,6] Farmers are known to drink and smoke less than average in Finland.[26,28,29,31] Other occupations that had significantly low SIRs for cancer of mouth and pharynx in our study were railway staff, machinists, civil engineering technicians (building), smelting, metal and foundry workers, wood workers and policemen in males and launderers in females. Some of these are occupations with low alcohol use, like railway staff, machinists and policemen.[26]

Wood workers had significantly low risk for cancer of mouth and pharynx, which was unexpected finding since pulp industry or wood workers had high risk for oral cancer in another study.[5] According to IARC there is no evidence of wood dust causing cancer of mouth and pharynx.[32]

Female shoemakers and cobblers had significantly high SIR for cancer of mouth and pharynx in our study. In addition, there were 2 cases (1.1 expected) in males. This can be a chance finding, but according to IARC there is positive associations between boot and shoe industry and oral and pharyngeal cancer.[33]

Female dressmakers had statistically significant high risk for cancer of mouth and pharynx. According to IARC, working in textile manufacturing industry entails exposures that are possibly carcinogenic to humans.[34] In our study there was statistically significant exposure-response trend between textile dust and oral cancer, *i.e.*, some other factors in textile work may cause the excess.

Male electronics and telefitters had 3-fold incidence of cancer of mouth and pharynx. Lead was used in solder for electronics until year 2006, when it had to be eliminated from electronic systems. IARC evaluated inorganic lead compounds as probably carcinogenic to humans.[35]

Male painters (building) had significantly elevated SIR for cancer of mouth and pharynx in our study. IARC has evaluated that occupational exposure as a painter is carcinogenic.[36] Also one study from Sweden found that risk for cancer of oral cavity was elevated among woman lacquerers and glaziers.[37] Painters may be exposed, *e.g.*, to solvents (petroleum solvents, toluene, xylene, ketones, alcohols, esters, glycol ethers, benzene), chlorinated hydrocarbons, titanium dioxide, chromium, iron compounds, lead, asbestos and silica. In our study high exposure to solvents associated with elevated RR's for cancer of mouth and pharynx in males.

Although the SIR for farmers was low, pesticides showed high RR for cancer of mouth and pharynx. The exposure to pesticides among Finnish farmers is usually low and highest exposures to chemically heterogeneous pesticides occur in other occupations than farmers. One study from Germany showed a positive relation between exposure to phenoxy herbicides and contaminants (dioxins and furans) and cancer of the buccal cavity and pharynx.[38]

We saw strong dose-response trend in engine exhaust on unadjusted SIRs (Table III), but association became weaker in multivariate analyses (Table IV). A significantly increased risk of oral and pharyngeal cancer was present in women exposed to diesel engine emissions in Sweden.[39]

More than 8 years of exposure to welding fumes was associated with an increased risk of pharyngeal cancer in Sweden.[40] In our study welders' SIR was 2.02 (95% CI 0.81–4.16). On contrary the SIR for smelting, metal and foundry work was only 0.29 (Table I).

Asbestos had high SIRs in all CE-categories, but in the multivariate analyses no statistically significant risks were observed in males or in females. According to IARC asbestos is carcinogenic to humans and exposure to asbestos increases the risk of lung cancer, mesothelioma, gastrointestinal cancers and laryngeal cancer.[41] It is possible that asbestos increases also the risk for cancer of mouth and pharynx, but it is also possible that the SIRs were high for asbestos because of other occupational exposures or it might be a chance finding.

In conclusion, the strongest risk factors for cancer of mouth and pharynx, *i.e.*, alcohol and smoking, seem to explain much of the occupational variation of cancer of mouth and pharynx. Exposure to solvents and possibly to pesticides, engine exhaust, textile dust and leather dust may increase the risk of cancer of mouth and pharynx.

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