

A cohort study on mortality among long-time employed Swedish chimney sweeps

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HOGSTEDT C, ANDERSSON K, FRENNING B, GUSTAVSSON A. A cohort study on mortality among long-time employed Swedish chimney sweeps. *Scand j work environ health* 8 (1982): suppl 1, 72-78. A cohort study on mortality among all members of the Swedish Chimney Sweeps Union who were active in 1950 or later and have been members for at least 10 a has been performed; 2,071 chimney sweeps fulfilled the criteria and the loss in the follow-up was less than 1 %. The observed numbers of death before the age of 80 were compared with sex-, calendar year-, and age class-specific expectancy values from the national statistics of 1951-1979. Two hundred and thirty deaths were observed versus 197.6 expected. This result was due to a significant excess of deaths from tumors, particularly lung and esophageal cancer, and from nonmalignant chronic respiratory diseases. The multifold increased risk from these diseases could hardly be explained by extreme smoking or alcohol habits but rather by exposure to polycyclic aromatic hydrocarbons, nitrogen compounds, arsenic, and asbestos in combination with exposure to sulfur dioxide. The excess mortality had occurred in spite of favorable selection factors as demonstrated in different subcohorts. Preventive actions to diminish inhalation of soot and combustion gases should be taken.

Key terms: circulatory diseases, coal, esophageal cancer, lung cancer, nitrosamines, occupational medicine, oil, respiratory diseases, smoking, sulfur dioxide.

In 1775 Sir Percival Pott published his classic report on an increased frequency of scrotal cancer among chimney sweeps in London. This observation was confirmed repeatedly, and also other workers exposed to combustion products of coal and tar have had an increased risk of developing malignant tumors (6, 14). However, epidemiologic studies of chimney sweeps are rare. Kupetz (10) reported a doubled risk for pulmonary carcinoma among chimney sweeps in Berlin, and Hansen (9) found an increased risk of lung cancer among Danish chimney sweeps.

Fuels have changed during the 20th century, from predominantly coal, coke and wood to oil, and thereby the exposures for

chimney sweeps have also changed. To study the occupational hazards of Swedish chimney sweeps from more recent decades, we have performed a cohort study on all members of the Swedish Chimney Sweeps Union who were active in 1950 or later and who had been members for at least 10 a.

Subjects and methods

The source material for this cohort study was records of the Swedish Chimney Sweeps Union. The records gave names, date and place of birth, place of work, years of membership in the Union, and, often, the reason for leaving the Union. A total of 2,071 chimney sweeps had been members of the Union for at least 10 a and were members in 1950 or later. The period of observation was 1951-1979. The vital status of alive cohort members was

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checked through National Health Insurance records, which register all living persons in Sweden by a ten-digit identification number based on time of birth. Deceased men were traced through the death and burial registers of the parishes. Seven men had emigrated from Sweden and were excluded from the study. Knowledge about life events could not be obtained for another 16 men, and they were not included in the calculations, which therefore included 2,048 men. The total loss in follow-up was less than 1 %.

Death certificates for the deceased men were checked with the Swedish National Central Bureau of Statistics, and the officially determined underlying cause of death was used and classified according to the 1965 revision of the International Classification of Diseases.

The observed numbers of death were compared with the expected numbers of death, calculated by multiplying the person-years of observation within 5-a age categories during respective calendar years of the study period by cause- and sex-specific national death rates and by summarizing the fractional contributions. The follow-up was ended at age 79. The data program developed by Anjou et al (1) at Linköping University was used.

The ratio between observed and expected numbers has the character of the standardized mortality ratio. One-tailed p-values have been calculated with the chi-square when the expected value was ≥ 5 but otherwise with a test based on the Poisson distribution (5).

Data on smoking habits were obtained from a health inquiry made in 1972–1973 for 1,040 active chimney sweeps from the whole country (17); the information was compared with the smoking habits reported from a large sample of Swedish men in 1963 (4).

The application forms for new members of the Union gave particulars on any chimney sweep work before they joined the union, and the first year of work was registered as the first year of exposure. The last local section of the Union started as late as 1950, and using only the years of Union membership would have caused a serious underestimation of the number of exposed years for many older individuals.

Exposure

In Sweden wood and coal were the fuels most commonly used until 1947, when oil became more common — and has dominated as industrial and home fuel ever since. Exposure reports from chimney sweeping are rare. However, a recent Swedish report (18) states that chimney sweeps are exposed to carbon monoxide, sulfur dioxide, vanadium, polycyclic aromatic hydrocarbons (PAH), asbestos, and numerous trace elements, and to organic solvents in cleaning operations. Combustion of wood gives rise to higher benzo(a)pyrene concentrations than the burning of coal and oil, while the combustion of coal and oil produces more sulfur dioxide and nitrogen compounds (7, 13, 15, 21).

Results

Compared with the national average, the mortality of the exposed cohort was found to be significantly increased — 230 observed versus 197.6 expected before the age of 80 — due to a greater number of deaths from tumors, particularly lung and esophageal cancer, and from nonmalignant diseases of the respiratory system (tables 1 & 2). The excess mortality was predominantly observed during the 1970s.

The excess mortality from nonmalignant respiratory diseases derived mainly from chronic bronchitis, emphysema, and asthma — not from bronchopneumonia.

Four cases of liver cirrhosis were found as the underlying cause of death compared to 4.8 expected. Two pleural malignancies were found in men with 39 and 55 a of exposure, respectively. One case of malignant melanoma was found, a level close to the expected value, but no other skin tumors had caused death.

When those with less than 30 a of exposure were compared with those with longer exposure, it was found that the increased overall mortality was higher among those with shorter exposure time. However, esophageal cancer and chronic respiratory diseases were more frequent among the long-time exposed individuals (table 3). The requirement of 30 a of induction-latency time increased the risk estimates in comparison with shorter induction-latency times.

Table 1. Observed and expected numbers of death before the age of 80 among Swedish chimney sweeps with at least 10 a of exposure; 10 a of induction-latency time was required; 33,500 person-years were observed in 1951–1979.

Cause of death ^a	Observed	Expected
All causes (1–999)	230 *	197.6
Tumors, all sites (140–209)	60 *	43.2
Hypopharynx (148)	2	0.3
Esophagus (150)	6	0.9
Gastric (151)	7	6.0
Colo-rectal (153–154)	4	5.2
Liver (155)	3	0.8
Pancreas (157)	1	3.2
Lung (162)	16 *	6.9
Melanoma (172)	1	0.8
Prostate (185)	4	3.7
Leukemia (204–207)	4	2.0
Other	12	10.1
Circulatory system (390–458)	80	77.7
Respiratory system (460–519)	15 *	7.6
Digestive system (520–577)	10	10.4
Liver cirrhosis (571)	4	4.8
Urogenital system (580–607)	3	4.1
Violent deaths and intoxications (800–999)	34	32.7
Other	28	21.9

^a International Classification of Diseases number in parentheses.

* $p < 0.05$.

Table 2. Observed and expected numbers of death in different decades before the age of 80, at least 10 a of exposure and induction-latency time.

Cause of death ^a	1951–1959		1960–1969		1970–1979		1951–1979	
	Ob-served	Ex-pected	Ob-served	Ex-pected	Ob-served	Ex-pected	Ob-served	Ex-pected
Total	31	30.8	65	64.6	134 *	102.2	230 *	197.6
All tumors (140–209)	7	6.5	17	13.8	36 *	22.9	60 *	43.2
Esophagus (150)	2	0.1	2	0.3	2	0.6	6 *	0.9
Lung (162)	1	0.7	3	1.9	12 *	4.2	16 *	6.9
Respiratory system (460–519)	2	1.1	5	2.7	8 *	3.8	15 *	7.6
Violence (800–999)	2	5.0	10	10.8	22	16.9	34	32.7

^a International Classification of Diseases number in parentheses.

* $p < 0.05$

Table 3. Observed (in 1951–1979) and expected numbers of death before the age of 80 among chimney sweeps, 30 a of induction-latency time required.

Cause of death	Time of exposure					
	10–29 a		≥ 30 a		≥ 10 a	
	Observed	Expected	Observed	Expected	Observed	Expected
Total	61 *	31.7	126 *	107.1	187 *	138.8
All tumors	20 *	7.6	34 *	25.3	54 *	32.9
Esophagus	1	0.2	5 *	0.6	6 *	0.8
Lung	8 *	1.5	7	4.1	15 *	5.6
Circulatory system	19	14.2	51	50.9	70	65.2
Respiratory system	3	1.1	11 *	4.9	14 *	6.0
Violence	7	4.2	9	6.7	16	10.9

* $p < 0.05$

The excess mortality was more predominant among those who left the profession before 1965 than among those who were still working that year or later (table 4). Even circulatory diseases were overrepresented in this "leaving" subcohort.

Concerning the pattern of smoking, a higher percentage of chimney sweeps were current and exsmokers than were other Swedish men. In the older age classes the frequency of current smokers was slightly less than in the general popu-

lation, but the frequency of exsmokers was higher (table 5). Smoking chimney sweeps did not seem to smoke more cigarettes per day than the average custom among Swedish men (table 6).

Discussion

The overall mortality was increased in this cohort of long-time employed chimney sweeps in comparison to the national aver-

Table 4. Observed and expected numbers of deaths before the age of 80 among those who left the profession before 1965 and among those active in the profession in 1965 or later, 30 a induction-latency time required. — Period of study 1970–1979.

Cause of death	Left before 1965		Active 1965 or later	
	Observed	Expected	Observed	Expected
Total	61 *	33.7	50 *	39.1
All tumors	17 *	8.2	16 *	9.6
Esophagus	5 *	0.2	1	0.2
Lung	5 *	1.6	7 *	1.9
Respiratory system	7 *	1.4	1	1.6
Circulatory system	24 *	17.1	18	20.3
Violence	5	3.1	6	3.1

* $p < 0.05$

Table 5. Frequency (%) of chimney sweeps, 1972 (N = 1,040), and Swedish men, 1963 (N = 21,126), in different smoking and age classes.

Age classes (a)	Current smokers		Exsmokers	
	Chimney sweeps	Swedish men	Chimney sweeps	Swedish men
≤39	67	61	15	10
40–49	70	61	15	11
50–59	57	62	21	9
60–69	56	56	26	9

Table 6. Comparison of smoking habits among smoking chimney sweeps, 1972–1973, and a sample of Swedish men 1963.

Age classes (a)	Smoking chimney sweeps				Smoking Swedish men			
	N	Cigarettes per day			N	Cigarettes per day		
		1–10 (%)	11–20 (%)	> 20 (%)		1–7 (%)	8–15 (%)	≥ 16 (%)
≤39	565	43	52	4	1,221	31	40	29
40–49	86	45	50	5	621	30	32	38
50–59	27	41	44	15	1,418	38	36	26
60–69	15	60	40	—	818	48	34	18

age in Sweden. The excess was mainly due to increased numbers of lung and esophageal cancer in addition to an excess of nonmalignant respiratory diseases. The discussion will be focused on the possible etiologies of the diseases in excess and on some illustrations of the selection processes involved in follow-up studies of industrial populations.

Lung cancer, chronic respiratory diseases, and circulatory diseases are associated with tobacco smoking (as is esophageal cancer). The work environment exposures of chimney sweeps have obvious similarities to the content of tobacco smoke and particulates, ie, an excess of "smoke diseases" could be expected and has been observed. The question of smoking habits among chimney sweeps compared with those of the general population naturally arises. Although no completely comparable information is available, it seems likely that the proportion of never smokers is less among chimney sweeps than among other Swedish men, but the average number of smoked cigarettes per day did not seem to be higher. Calculations presented by Axelson (3) indicate that a difference of 10 % in the proportion of never smokers between two populations increases lung cancer risk 22–25 %. The possible differences in smoking habits between chimney sweeps and the general population could hardly account for the obtained results, which indicate a risk increase of more than 100 %.

Six cases of esophageal cancer were observed, but only 0.9 was expected. Several studies report a synergism for a combined use of tobacco and alcohol, resulting in an excess of cancer of the esophagus in comparison with those resulting from the use of either substance alone (19). No data concerning the drinking habits of the chimney sweeps were available. However, four cases of liver cirrhosis were observed as the underlying cause of death, a number slightly less than the expected, ie, alcoholism did not seem to be in excess among the chimney sweeps.

It should also be remembered that the studied chimney sweeps had a very long employment time, and the esophageal cancer cases differed from most other causes of death by being more predominant among those employed the longest time.

Although not directly exposed to smoke of any kind, the esophagus is exposed to condensed smoke and soot that is coughed up from the lungs and swallowed. Nitrosamines are present in cigarette smoke and probably also in gaseous emissions from coal and coke combustion (7, 19, 21). Nitrosamines are decomposed more rapidly as the pH decreases (12), and this occurrence might explain why the number of esophageal cancers was increased but the number of gastric cancers was close to that expected. Interestingly, feeding nitroso-heptamethylene imine to rats gave rise to a high incidence of tumors of the esophagus, as well as squamous carcinoma of the lung (11), ie, the same pattern that was observed among the chimney sweeps in this cohort.

Lung cancer, as well as mesotheliomas and esophageal and other cancers, have been reported in excess for several asbestos cohorts (16). Two cases of pleural mesotheliomas had occurred, and this finding, as well as recent hygienic measurements (2), confirm that chimney sweeps have been and still are exposed to asbestos. Asbestos could be a contributory factor for the development of lung cancer, and possibly also for esophageal cancer, although the rate ratio for gastrointestinal cancer was close to one in this cohort.

Coal, coke, and wood burning brings about considerable amounts of proved and suspected carcinogens. The great majority of deceased chimney sweeps had been exposed to those initiators of carcinogenic processes during the first half of this century and later on to large amounts of sulfur dioxide from oil combustion, which has been shown to be a promotor of carcinogenesis (20).

In summary, the exposure of chimney sweeps could very well explain the mortality pattern observed in this cohort study, but cigarette smoking should be considered a contributing factor.

Selection for work and survival in work

Most occupational cohorts should be expected to have (and most do have) a better life expectancy than nonemployed persons, who include those in institutions, those with unstable employment and those already ill at the time job-seeking begins.

This selection was observed already in 1885, and at least three properties of occupational cohorts have been suggested to promote the "healthy worker effect": selection of work, selection in work, and length of follow-up (8). Although a significant excess mortality was observed among the chimney sweeps, this excess might still be underestimated if the national statistics are used for comparison.

The chimney sweep profession is physically demanding, and there is a definite selection among youngsters that choose to become and are accepted as chimney sweeps. In younger age classes the standardized mortality ratio was below 100, as could be expected.

A survival population effect might be more difficult to measure than the primary selection effect. The latter relates to the fitness of a group of men when they enter the industry, whereas the survival population effect is continuously altered by movements in and out of the occupation.

Although most people change jobs for reasons unrelated to health, some change because they are not fit enough to continue in their present occupation. This situation is clearly demonstrated with the present cohort, as the increased mortality was more prominent among those employed less than 30 a than among those who "survived" more than 30 a in the trade. The substantial excess mortality among those employed 10–29 a in comparison to the national average is alarming in view of the primary, favorable selection.

Any risk associated with occupational exposure should be expected to increase with reasonably increased requirements for induction-latency time, which automatically results in a longer follow-up time. This phenomenon is demonstrated by the increased risk ratios after requirement of at least 30 a of induction-latency time. The fact that the whole excess mortality is only observed during the 1970s underlines the importance of long follow-up time to demonstrate the full magnitude of exposure effects.

The cohort will be extended by those who left the Union before 1950, as well as by those with less than 10 a of membership.

Conclusions

Long-time exposed chimney sweeps had an increased overall mortality risk compared to the national average in spite of favorable selection factors. The excess mortality was significant for lung and esophageal cancers, as well as for chronic respiratory diseases. The multifold increased risks from these diseases could hardly be explained by extreme smoking or alcohol habits but rather by exposure to polycyclic aromatic hydrocarbons, nitrogen compounds, arsenic, and asbestos in combination with promotion from exposure to sulfur dioxide.

The results are in accordance with toxicological and other epidemiologic data. Preventive actions to diminish the inhalation of soot and combustion gases should be taken.

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