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Cancer incidence among marine engineers, a population-based study (Iceland)

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Abstract

Objectives: Marine engineers are in their occupation exposed to different chemicals, organic solvents, exhaust gases, oils, and petroleum products, and were formerly exposed to asbestos. The aim was to study the cancer pattern, with particular attention to lung and bladder cancer, in an Icelandic cohort of marine engineers, indirectly controlling for their smoking habits.
Methods: A cohort of 6603 male marine engineers was followed up from 1955 to 1998, a total of 167,715 person-years. The cohort was record linked by the engineers' personal identification numbers to population-based registers containing the vital and emigration status and cancer diagnosis. Standardized incidence ratios (SIRs) were calculated for all cancers and different cancer sites in relation to different lag time and year of graduation. Information on smoking habits was obtained by administering a questionnaire to a sample of the cohort (n = 1501).
Results: In the total cohort 810 cancers were observed, whereas 794 were expected (SIR 1.0, 95% CI 1.0–1.1), and significantly increased risk of stomach cancer (SIR 1.3, 95% CI 1.0–1.5) and lung cancer (SIR 1.2, 95% CI 1.0–1.5) was found. Increased risk of all cancers (SIR 1.2, 95% CI 1.1–1.3), stomach cancer (SIR 1.5, 95% CI 1.1–1.9), lung cancer (SIR 1.4, 95% CI 1.2–1.8), pleural mesothelioma (SIR 4.8, 95% CI 1.3–12.3), and urinary bladder cancer (SIR 1.3, 95% CI 1.0–1.8) were observed when a 40-year lag time was applied. The engineers' smoking habits were similar to those in a sample of the general population. The predictive value for lung cancer was 1.03.
Conclusions: The increased risk for mesothelioma is possibly attributable to the previous asbestos exposure. The excess of lung cancer could also be related to asbestos exposure. The high incidence of stomach cancer, lung cancer, and bladder cancer may be related to exposure to chemical risk factors, such as oils and petroleum products, as confounding due to smoking seems to be ruled out. In the light of the limited exposure information in the present study the importance of the different occupational exposures needs to be evaluated in further studies.

Introduction

In cohort studies among seamen an increase of lung cancer and mesothelioma has been observed [1–4]. These increased risks were of particular concern among marine engineers [1–3, 5]. The findings have been attributed to asbestos exposure [1–3, 5], which is supported by indication of asbestos-related non-malignant pleural changes found in engine-room crew [6–8]. Work practice studies have indicated that repair work of former machinists involved high exposure to airborne asbestos fibers [9]. Other studies have pointed out that exposure to mineral oils, organic solvents, and exhaust gases containing various amounts of polycyclic aromatic hydrocarbons (PAH) may have an etiological role for both lung cancer and bladder cancer among engine crews [10, 11]. In an investigation on the exposure of engine-room personnel to PAH, with 1-hydroxypyrene in urine as a biomarker, it was suggested that dermal uptake of PAH was the most significant [10]. In case–control studies and register-based studies an increased risk of bladder cancer has been found among machinists exposed to different types of oils [12–15].

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Lung cancer and bladder cancer are lifestyle-related cancers, in which smoking habits are the most important possible confounder; this has been discussed in former studies on engine crews [1, 3, 5], but not always well controlled for.

The aim of this investigation was to study the cancer pattern in an Icelandic cohort of marine engineers with an indirect control of their smoking habits.

Material and methods

Information on Icelandic marine engineers was obtained from the publication Register of Machinists and Mechanical Engineers (*Vélstjóra og vélfræðingatal*) [16]. The register included all persons who had graduated from the Marine Engineering College of Iceland or completed courses given by the Fishing Association of Iceland until 1997. All men born 1900 and later, who were alive in 1955 (the first year of the Cancer Registry) were entered into the study cohort. There were less than 10 women in the register, and as this number was considered too small for epidemiological study they were omitted.

The Marine Engineering College of Iceland requires four years of vocational training as a metal worker before admission. Admission to the courses offered by the Fishing Association required two years of practical experience in a mechanical industry. During these periods the men were presumably exposed to varying amounts and types of asbestos, various mineral oils and petroleum products, organic solvents, and exhaust gases. The exposure would have continued in their later careers as marine engineers. Marine engineers run engines of different sizes and kinds, and maintain engines and other mechanical equipment on board the vessels. Their job tasks include minor repairs in the engine room. Engine rooms of vessels are usually relatively confined spaces, as are most other compartments on board. The exposure to these different occupational factors included marked individual variations as to type and magnitude; however, information on exposure for each person was not available in the present study. The majority of the men worked on board transport and fishing vessels for a number of years immediately after graduation, but most of them eventually became employed on shore as stationary engineers, fitters, and machinists or in completely different occupations.

After graduation the majority of the marine engineers have been employed on vessels of the comparatively large Icelandic fishing fleet and on freight vessels, passenger vessels, or other vessels. The total number of registered decked vessels in Iceland has increased from 870 in the year 1966 to 1014 in the year 2000 (http://www.sigling.is/enska/ships.html). According to the register of ships in the year 1966 approximately 91% of the decked vessels were fishing vessels, while in the year 2000, 83% were fishing vessels. Approximately 66% of the decked fishing vessels were less that 100 gross tonnage, but the largest were more than 1500 gross tonnage. Beside these vessels there were 455 open motorized boats in 1977 and 1134 in 2000.

Since 1951, all residents of Iceland have had a unique personal identification number, which is used in the population registries. The identification number of each subject was used in record linkage to the National Registry and the Registry of Deaths. In this way vital and emigration status was ascertained for all subjects.

Follow-up for cancer was done through record linkage with the Icelandic Cancer Registry, which is a nationwide registry of cancer cases, with over 95% histological verification [17]. The follow-up for cancer began in the year of graduation according to the Registry of Machinists and Mechanical Engineers or 1955, the first year of the Cancer Registry, whichever came later. The follow-up ended at death, emigration, or at year-end 1998 (the last year of the follow-up period), whichever occurred first [18]. The number of expected cancers was calculated on the basis of person-years for each 5-year age category and the cancer incidence rates for the male population in Iceland obtained from the Icelandic Cancer Registry. The ratio between the observed and expected numbers of all cancers and cancer of selected sites and the standardized incidence ratio (SIR) was calculated with the 95% confidence interval (95% CI), assuming a Poisson distribution and making use of Byar's approximation [18]. Separate analyses were performed according to graduation period and with 20- and 40-year lag times. We considered that the earlier the graduation had occurred the larger the possibility of asbestos exposure. The exposure to oils and oil products was considered to have been more constant though the study period. The lag time corresponds to the number of years allowed to elapse before the counting of person-years started.

A survey on smoking habits, duration of work as machinists, and dermal contacts with mineral oil or oil products among active and retired members of the Association of Marine Engineers ($n = 2204$), was performed in 1998 using a postal questionnaire. The participation rate was 73.5%. The participants' smoking habits were compared to the smoking habits of the general population, information on which was gathered using the same questionnaire as used in 1998 by the Committee for Tobacco Use Prevention [19]. The method introduced by Axelson and Steenland was used to assess the effect of tobacco smoking [20] in the evaluation of the possible confounding due to smoking. In this way the predictive value of lung cancer was calculated on the basis of risk of lung cancer, which was assumed to be one for non-smokers, five for ex-smokers, and ten for smokers.

The National Bioethics Committee and the Data Protection Commission approved the study.

Results

A total of 6603 men were followed up in the cohort (Table 1). The total number of person-years was 167,715. Applying 20-year or 40-year lag time since graduation into account left 67% and 36% of the cohort for analysis, respectively. Altogether 1501 men in the questionnaire survey on smoking habits were members of the cohort, and there was information available on duration of work as machinists for 22.5% of the cohort. More than 80% of those who graduated in 1980 or before reported to have worked 20 or more years as machinists. Fifty-seven percent reported dermal contact with oils or petroleum products every day, and 92% reported dermal contact at least once a week. The use of gloves was rarely reported.

Table 2 shows the observed and expected number of cancer cases, the SIRs and the 95% CIs for all cancers and cancer of selected sites. During the follow-up period 810 cancers were diagnosed in the whole cohort *versus* 794 expected. The SIRs for stomach cancer and lung cancer were significantly increased and there was a deficit of brain cancer. All pleural cancers were mesotheliomas; four were observed *versus* 1.4 expected. There was no case of peritoneal mesothelioma.

Cancer rates applying 20- and 40-year lag times are also shown in Table 2. With a 20-year lag time there was a significantly high incidence of all cancers (SIR = 1.1). In this analysis the SIRs for stomach cancer and lung cancer were increased. With a 40-year lag time the SIR for pleural cancer was significantly increased, in addition to the excess for all cancers, stomach cancer, lung cancer, and cancer of other urinary organs. The SIRs for cancer of the thyroid gland and leukemia were 1.6 and 1.5 respectively; however, they had wide confidence intervals.

Among marine engineers who graduated in 1940 or earlier, when a 20-year lag time was applied (Table 3) there was a significantly high incidence of stomach cancer and lung cancer and a significantly low incidence of brain cancer. Among those who graduated from 1941 to 1960, when a 20-year lag time was applied (Table 3) a significantly high incidence of bladder cancer (41 cases and 26.47 expected) was found. There was a non-significantly high incidence for stomach (1.3), colon (1.2), liver (1.3), and larynx cancer (1.4). There were three pleural mesothelioma cases *versus* 0.68 expected. Among those who graduated 1961 and later, when a 20-year lag time was applied (Table 3), there was a non-significant low incidence for all cancers. For most cancer sites there were few cases and thus wide confidence intervals. However, a non-significant high incidence for lung cancer was found (SIR = 1.4, eight cases observed).

Table 4 shows the smoking habits of the participants of the survey among the marine engineers and the sample of the Icelandic male population. The smoking habits in both groups were similar according to age. The predictive value for lung cancer was 1.03 among the cohort members according to the method of Axelson and Steenland.

Discussion

This study showed an increased risk of stomach cancer, lung cancer, pleural cancers, and cancer of the urinary bladder. Smoking habits did not seem to confound the results.

Table 1. Numbers of marine engineers under follow-up, number of person-years at risk 1955–1998, number of participants in the questionnaire survey, percentages working less or more than 20 years as machinists, and percentage of dermal contact with oil and petroleum products

Categories	No.	Person-years	Participants in survey	Worked as machinist		Dermal contact with oils			
				Less than 20 years	More than 20 years	Every day	Every week	Less than every week	Used gloves
Total	6603	167,715.0	1488	46.4	53.6	56.6	35.7	4.2	3.4
With 20 years lag time	4444	86,712.0	620	12.6	87.4	60.1	31.6	5.0	3.7
With 40 years lag time	2348	24,935.0	206	5.8	94.2	59.0	29.7	8.2	3.1
Graduated 1940 or before	1067	31,325.5	22	9.1	90.9	59.1	36.4	4.5	0
Graduated 1941–1960	1833	71,051.5	230	7.8	92.2	58.3	30.6	7.9	3.2
Graduated 1961–1980	1807	46,496.0	536	20.3	79.7	60.2	33.1	3.0	3.8
Graduated 1981–1997	1846	18,797.5	700	80.4	19.6	53.2	40.0	4.0	3.4

Table 2. Observed (Obs) and expected (Exp) number of cancers, standardized incidence ratio (SIR), and 95% confidence interval (CI) among marine engineers, follow-up during 1955–1998, according to different lag time

Cancer sites (ICD-7)	No lag time				20-year lag time				40-year lag time			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
All cancers (140–205)	810	793.59	1.0	1.0–1.1	**793**	**738.24**	**1.1**	**1.0–1.2**	**556**	**478.68**	**1.2**	**1.1–1.3**
Oral cavity (143–144)	4	2.99	1.3	0.4–3.4	4	2.86	1.4	0.4–3.6	3	1.88	1.6	0.3–4.7
Esophagus (150)	15	15.47	1.0	0.5–1.6	13	15.00	0.9	0.5–1.5	10	10.59	0.9	0.5–1.7
Stomach (151)	**110**	**87.95**	**1.3**	**1.0–1.5**	**107**	**82.77**	**1.3**	**1.1–1.6**	**67**	**45.18**	**1.5**	**1.1–1.9**
Colon (153)	59	57.34	1.0	0.8–1.3	58	55.12	1.1	0.8–1.4	41	37.81	1.1	0.8–1.5
Rectum (154)	24	21.50	1.1	0.7–1.7	23	20.23	1.1	0.7–1.7	16	12.67	1.3	0.7–2.1
Liver (155)	13	12.89	1.0	0.5–1.7	13	12.26	1.1	0.6–1.8	9	8.30	1.1	0.5–2.1
Pancreas (157)	17	24.72	0.7	0.4–1.1	17	23.52	0.7	0.4–1.2	13	14.92	0.9	0.5–1.5
Larynx (161)	10	9.66	1.0	0.5–1.9	10	9.21	1.1	0.5–2.0	6	4.49	1.3	0.5–2.9
Lung (162)	**124**	**100.98**	**1.2**	**1.0–1.5**	**122**	**96.62**	**1.3**	**1.1–1.5**	**85**	**58.86**	**1.4**	**1.2–1.8**
Pleural (162.2)	4	1.41	2.8	0.8–7.3	4	1.33	3.0	0.8–7.7	**4**	**0.83**	**4.8**	**1.3–12.3**
Prostate (177)	162	165.55	1.0	0.8–1.1	161	164.14	1.0	0.8–1.1	132	133.83	1.0	0.8–1.2
Testis (178)	9	8.92	1.0	0.5–1.9	4	2.19	1.8	0.5–4.7	1	0.17	5.9	0.1–32.7
Kidney (180)	38	42.38	0.9	0.6–1.2	36	39.56	0.9	0.6–1.3	28	22.94	1.2	0.8–1.8
Other urinary organs (181)	61	54.81	1.1	0.9–1.4	59	52.32	1.1	0.9–1.5	**45**	**33.82**	**1.3**	**1.0–1.8**
Melanoma of skin (190)	8	9.71	0.8	0.4–1.6	7	7.77	0.9	0.4–1.9	4	4.39	0.9	0.2–2.3
Other skin (191)	17	20.41	0.8	0.5–1.3	16	19.28	0.8	0.5–1.3	13	14.66	0.9	0.5–1.5
Brain (193)	**11**	**24.67**	**0.4**	**0.2–0.8**	**7**	**19.33**	**0.4**	**0.1–0.7**	5	8.29	0.6	0.2–1.4
Thyroid gland (194)	20	15.87	1.3	0.8–1.9	19	13.72	1.3	0.8–2.1	11	6.82	1.6	0.8–2.9
Soft tissue sarcoma (197)	6	5.62	1.1	0.4–2.3	3	4.10	0.7	0.1–2.1	1	2.05	0.5	0.0–2.7
Unspecified sites (199)	16	16.62	1.0	0.5–1.6	15	15.94	0.9	0.5–1.6	11	11.10	1.0	0.5–1.8
Hodgkin's disease (201)	4	5.58	0.7	0.2–1.8	3	3.13	1.0	0.2–2.8	1	0.96	1.0	0.0–5.8
Non-Hodgkin's lymphoma (200, 202)	18	19.97	0.9	0.5–1.4	17	17.37	1.0	0.6–1.6	10	9.54	1.0	0.5–1.9
Multiple myeloma (203)	9	9.99	0.9	0.4–1.7	9	9.55	0.9	0.4–1.8	7	6.28	1.1	0.4–2.3
Leukemia (204)	20	17.84	1.1	0.7–1.7	18	14.88	1.2	0.7–1.9	14	9.18	1.5	0.8–2.6

Figures in bold are statistically significant.

To our knowledge the present cohort study of marine engineers is the largest cohort study published so far. The strength of the study is the use of the comprehensive population registries in Iceland, particularly the Icelandic Cancer Registry. The universal use of personal identification numbers made record linkage possible, which ascertained vital and emigration status for all cohort members and secured complete identification of cancers in the nationwide Cancer Registry. The cancer incidence rates for the male population were also obtained from the Cancer Registry, thus the source of information on cancers is the same for the cohort and the comparison material. More than 95% of the cancers reported to the Cancer Registry have histologically confirmed diagnoses [17].

Previous studies on engine officers and engine crew have found an excess of lung cancer [1–3, 5] and mesothelioma [1, 3] and these cancers were found in excess in the present study. Several previous observations on seamen, and particularly engine crews, have found non-malignant pleural changes attributable to asbestos exposure [6–8]. Previous asbestos exposure seems to have contributed to this mesothelioma risk; the cases were diagnosed in 1989–1997. Asbestos was banned in Iceland in 1983, and it is well known that the latency period of mesothelioma, after the initial exposure, may be long. Mesothelioma cases were recently observed in persons from the asbestos-user industry, such as machinists [21, 22]. In the present study, it was not possible to differentiate between the contribution of asbestos exposure and exposure to oils and petroleum products on lung cancer risk. Studies on engine crews have shown that dermal contact with oils leads to uptake of PAH [10] and exposure to mineral oil mist may lead to respiratory symptoms [11]. It has recently been reported that PAH exposure is a risk factor for lung cancer after adjustment for smoking and asbestos exposure [23]. Lung cancer is related to smoking habits, and information on smoking was obtained with a questionnaire survey in the present study. The risk of lung cancer, found to be 1.2, is not solely explained by confounding due to differences in smoking habits between the cohort and the general male population, as the predictive value for lung cancer was 1.03. Furthermore, a previous study in Iceland showed that a sample of marine engineers had a similar smoking

Table 3. Observed (Obs) and expected (Exp) number of cancers, standardized incidence ratio (SIR), and 95% confidence interval (CI) among marine engineers follow-up during 1955–1998, with 20-year lag time according to graduation year divided in three periods: 1940 and earlier, from 1941 to 1960, 1961 and later

Cancer sites (ICD-7)	Graduated 1940 and earlier				Graduated from 1941 to 1960				Graduated 1961 and later			
	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI	Obs	Exp	SIR	95% CI
All cancers (140–205)	364	347.23	1.0	0.9–1.2	370	347.44	1.1	1.0–1.2	39	43.58	0.9	0.6–1.2
Oral cavity (143–144)	1	1.64	0.6	0.0–3.4	3	0.81	3.7	0.7–10.8	0	0.41	0.0	– to 8.9
Esophagus (150)	5	7.71	0.6	0.2–1.5	7	6.75	1.0	0.4–2.1	1	0.53	1.9	0.0–10.5
Stomach (151)	**66**	**49.80**	**1.3**	**1.0–1.7**	39	29.92	1.3	0.9–1.8	3	3.05	1.0	0.2–2.9
Colon (153)	22	26.25	0.8	0.5–1.3	32	25.71	1.2	0.9–1.8	4	3.16	1.3	0.3–3.2
Rectum (154)	11	9.66	1.1	0.6–2.0	10	9.68	1.0	0.5–1.9	2	0.89	2.2	0.3–8.1
Liver (155)	6	6.18	1.0	0.4–2.1	7	5.52	1.3	0.5–2.6	0	0.57	0.0	– to 6.4
Pancreas (157)	8	12.41	0.6	0.3–1.3	6	9.87	0.6	0.2–1.3	3	1.24	2.4	0.5–7.1
Larynx (161)	3	3.99	0.8	0.2–2.2	6	4.44	1.4	0.5–2.9	1	0.78	1.3	0.0–7.1
Lung (162)	**61**	**39.51**	**1.5**	**1.2–2.0**	54	51.36	1.1	0.8–1.4	8	5.75	1.4	0.6–2.7
Pleural (162.2)	1	0.44	2.3	0.0–12.6	3	0.68	4.4	0.9–12.9	0	0.21	0.0	– to 17.5
Prostate (177)	74	78.58	0.9	0.7–1.2	81	79.33	1.0	0.8–1.3	6	6.23	1.0	0.3–2.1
Testis (178)	2	0.46	4.3	0.5–15.7	1	0.71	1.4	0.0–7.8	1	1.02	1.0	0.0–5.5
Kidney (180)	20	18.16	1.1	0.7–1.7	15	18.24	0.8	0.5–1.4	1	3.16	0.3	0.0–1.8
Other urinary organs (181)	17	22.74	0.7	0.4–1.2	**41**	**26.47**	**1.5**	**1.1–2.1**	1	3.11	0.3	0.0–1.8
Melanoma of skin (190)	3	2.02	1.5	0.3–4.3	3	4.31	0.7	0.1–2.0	1	1.45	0.7	0.0–3.8
Other skin (191)	7	9.83	0.7	0.3–1.5	9	8.66	1.0	0.5–2.0	0	0.79	0.0	– to 4.6
Brain (193)	**1**	**7.18**	**0.1**	**0.0–0.8**	5	9.87	0.5	0.2–1.2	1	2.29	0.4	0.0–2.4
Thyroid gland (194)	10	5.58	1.8	0.9–3.3	8	6.83	1.2	0.5–2.3	1	1.31	0.8	0.0–4.2
Soft tissue sarcoma (197)	1	1.96	0.5	0.0–2.8	2	1.78	1.1	0.1–4.0	0	0.39	0.0	– to 9.5
Unspecified sites (199)	5	7.47	0.7	0.2–1.6	10	7.60	1.3	0.6–2.4	0	0.87	0.0	– to 4.2
Hodgkin's disease (201)	3	1.24	2.4	0.5–7.1	0	1.60	0.0	– to 2.3	0	0.29	0.0	– to 12.6
Non-Hodgkin's lymphoma (200, 202)	7	5.94	1.2	0.5–2.4	7	9.24	0.8	0.3–1.6	2	2.20	0.9	0.1–3.3
Multiple myeloma (203)	5	4.30	1.2	0.4–2.7	4	4.72	0.8	0.2–2.2	0	0.53	0.0	– to 6.9
Leukemia (204)	10	7.09	1.4	0.7–2.6	7	6.77	1.0	0.4–2.1	1	1.02	1.0	0.0–5.5

Figures in bold are statistically significant.

pattern as the male population according to a survey performed during the period 1967–1981 [5]. Increased risk of lung cancer is still to be seen in the group most recently graduated, and although the confidence interval did include unity this does not allow us to conclude that lung cancer risk is not a concern among this group who have not reached the age for the peak of lung cancer incidence in the general male population [17].

The excess risk of stomach cancer was not exactly hypothesized *a priori* among marine engineers; however, the aim was also to describe the cancer pattern in general. A high incidence of stomach cancer has been found in previous studies of Icelandic seamen [4] and marine engineers [5]. We do not have information on dietary factors or consumption of N-nitroso compounds or the incidence of infections of *Helicobacter pylori* among the cohort members. Stomach cancer is inversely related to level of social classes; however, the marine engineers belong to middle to high level social classes. A Finnish study has found a high incidence of stomach cancer among engine crew but not among engine officers [1], and Swedish engine officers had a low incidence of

Table 4. Smoking habits of a random sample of the Icelandic male population (n = 1210) and among a sample of marine engineers (n = 1501). age range 20–89 years

	Population sample (n = 1210)		Marine engineers (n = 1501)	
	No.	Percent	No.	Percent
Never smoked	427	35.3	460	30.6
Stopped smoking more than 1 year ago	365	30.2	530	35.3
Stopped smoking less than 1 year ago	57	4.7	76	5.1
Smoker, not daily	57	4.7	95	6.3
Smoker, daily	304	25.1	340	22.7

stomach cancer [3]. In a Swedish register-based study an increased incidence of stomach cancer was found among machine and engine maintenance and machine installers [24]. Both the Finnish and the Swedish studies on seamen discuss alcohol-related cancers, mouth, pharynx, esophagus, liver, and larynx, among seamen in general [1, 3] and find a high incidence of these cancers. However, the incidences of alcohol-related cancers were not high among the Finnish engine officers [1] and this was also the case among the Swedish engine officers, with the exception of liver cancer [3]. In the present study, the incidences of cancers of the oral cavity, esophagus, liver, and larynx were in no instance significantly high, and there was no case of pharynx cancer, thus no indications of a high incidence of alcohol-related cancers.

The high incidence of urinary bladder cancer was found in the total cohort with a 40-year lag time and among those who graduated between 1941 and 1960, when a 20-year lag time was applied. It is unlikely that excessive smoking among the cohort members confounds these findings, as their smoking habits were similar to those of the general male population. This finding agrees with studies indicating an increased risk of bladder cancer among machinists exposed to oils and petroleum products [12–15]. Furthermore, an excess mortality from bladder cancer has been found among the engine-room crew of ships [25]. Other known risk factors for urinary bladder cancer, such as chemicals and dietary factors [26], could contribute to the excess found in the present study, but were not controlled for.

The low incidence of brain cancer in the total cohort is similar to the results of a study of Swedish engine officers [3], but in contrast to a Finnish study [1], where there was a non-significant high incidence of brain cancer.

In conclusion, the increased risk for mesothelioma points to previous asbestos exposure. The excess found for lung cancer could also be related to asbestos exposure. The high incidence of stomach cancer, lung cancer, and bladder cancer may be related to exposure to chemical risk factors, such as oils and petroleum products, as confounding due to smoking seems to be ruled out. In the light of the limited exposure information in the present study, the importance of the different occupational exposures needs to be evaluated in further studies.

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