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Cancer incidence and all-cause mortality among civilian men and women employed by the Royal Norwegian Navy between 1950 and 2005

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ABSTRACT

Objective: We aimed to investigate cancer incidence and all-cause mortality in a cohort of 8358 civilians (5134 men and 3224 women) employed by the Royal Norwegian Navy at any time between 1950 and 2005.
Methods: The cohort was followed for cancer incidence and all-cause mortality from 1960 through 2015. Standardised incidence ratios (SIR) and mortality ratios (SMR) were calculated from national rates. Separate SIRs were calculated for a subgroup of male workshop workers and another of female cleaners.
Results: Overall cancer incidence among men was similar to the reference rate; male breast cancer was more frequent (SIR = 3.23). Male workshop workers showed a SIR of 1.77 for stomach cancer, while their incidence of lympho-haematopoietic cancers was half that of the reference rates. Women had increased risks of overall cancer (SIR = 1.11), lung cancer (SIR = 1.35), and ovarian cancer (SIR = 1.39). Female cleaners showed a SIR of 2.33 for bladder cancer and a lowered incidence of brain cancer (SIR = 0.18). In the overall cohort, all-cause mortality was lower than expected for men (SMR = 0.92) and closer to the reference rate for women (SMR = 0.95).
Conclusion: In men, we observed a lowered all-cause mortality and an excess of stomach cancer in workshop workers. In women, increased risks of overall cancer, lung cancer and ovarian cancer was seen. An increased risk of bladder cancer and a lowered incidence of brain cancer was observed among female cleaners.

1. Introduction

The Norwegian media has occasionally reported on concerns regarding possible exposure to carcinogens in Royal Norwegian Navy personnel, such as asbestos exposure to vessel crews and a perceived excess of cancer among civilians employed at coastal forts in Northern Norway. All land-based naval installations employ civilian personnel. Typical civilian jobs are related to guard services, warehouse facilities, transport, provisioning, clerical work, catering, cleaning, and skilled work in engineering workshops, and the latter two can sometimes involve exposure to hazardous chemicals. For example, workshop workers might be exposed to cancer-causing agents such as metalworking fluids, which have been linked to male germ cell tumours [1] and bladder cancer [2]; wood dust, which has been linked to nasal cancers [3,4]; and welding fumes, which are associated with an increased risk of kidney cancer [5]. Moreover, until the compound was banned and removed from most workplaces in the mid-1980s, workshop workers were exposed to asbestos, which is associated with mesothelioma, lung cancer, laryngeal cancer, and probably cancers of the gastro-intestinal tract [4,6]. One study of civilian workers at a US Coast Guard shipyard reported a small, but significant excess mortality from all-causes, lung cancer, and mesothelioma – most of which could plausibly be attributed to asbestos exposure [7]. Non-military studies have shown a positive association between professional cleaning work (i.e., internal cleaning of buildings) and bladder and lung cancers in women [8–12] and a heightened risk of pancreatic cancer in men exposed to detergents, floor cleaning agents, or floor polish [13].

In order to address concerns regarding exposure to carcinogens, the Royal Norwegian Navy established two cohorts – one consisting of military personnel and one consisting of civilian personnel – employed at any time between 1950 and 2005. The military cohort has been the object of various studies, which showed low all-cause mortality, normal cancer mortality, and elevated cancer incidence. A normal lung cancer incidence indicated smoking rates on a par with that in the general

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population [14]. The excess incidence of mesothelioma observed among engine room crews in this cohort was taken as an indicator of asbestos exposure [15]. However, analysis of the civilian cohort has so far been limited to a preliminary cancer incidence study, which was intended for internal use in the Navy. This study showed elevated incidence of lung and bladder cancer in men and of lung cancer and malignant melanoma in women. Therefore, the aim of our study was to investigate cancer incidence and all-cause mortality among civilian men and women employed by the Royal Norwegian Navy.

2. Methods

2.1. Study population

The original cohort consisted of 8378 civilian men and women employed by the Royal Norwegian Navy at any time between 1950 and the end of 2005. The electronic military personnel database was used to identify personnel employed from 1989 onward, and paper service history files collected at the Navy's land-based workplaces and the National Archives of Norway were used to identify those employed before 1989 [16]. After removing 20 individuals whose start-of-service date was missing or incorrect, a total of 8358 persons – 5134 men and 3224 women – were eligible for the present analysis.

In 1964, the Norwegian government started assigning 11-digit personal identification numbers (PIN); however these numbers were only assigned to Norwegian citizens who were alive in 1960 or were born thereafter. As all members of our cohort were assigned a PIN, we concluded that records for personnel who died before 1960 were unavailable for analysis, i.e., that the cohort was not complete before 1960. Therefore, we chose to start the follow-up for cancer incidence and mortality from 1960.

Within the main cohort, two occupational subgroups were defined, using job titles and work place categories as a proxy for exposure to suspected carcinogenic agents. The subgroup "skilled workers at the engineering workshop" (i.e., workshop workers) consisted of 1253 men with job titles that included the terms "skilled worker", "mechanic", "constructor", "craftsman" or "engineer" combined with workplace category that included the term "workshop". The subgroup "cleaners", which consisted of 769 women who performed internal cleaning of buildings, was identified from job titles containing the words "cleaning" or "cleaner".

2.2. Follow-up of cancer incidence and all-cause mortality

Cancer diagnoses and dates of diagnosis were obtained by linkage to the Cancer Registry of Norway. This registry is regarded as complete back to 1953 due to compulsory reporting. Cancer was classified according to International Classification of Diseases, 7th revision (ICD-7) codes, as registered by the Cancer Registry of Norway, and one person may have more than one cancer diagnosis. Information on death and emigration was obtained by linkage to the National Registry, which is continuously updated for the whole Norwegian population. All linkage was done using the 11-digit PIN.

All cohort members were followed for cancer incidence and death from first day of recorded service in the Royal Norwegian Navy after 1 January 1960, until emigration, death, or the end of the study period (31 December 2015). The two subgroups of male workshop workers and female cleaners were followed in a similar manner, starting from the first day of employment after 1 January 1960 in their respective occupational categories. To gauge the extent of any loss of personnel files for employees who died during the study period, we also present standardised mortality ratios (SMRs) for total mortality for all male and female cohort members during each decade between 1960 and 1999 and during 2000–2015.

Table 1
Distribution of civilian personnel of the Norwegian Royal Navy with recorded service between 1950 and 2005 across selected variables by sex and occupational subgroup. IQR, interquartile range, SD, standard deviation. N = 8358 (total cohort).

Cohort	Men		Women	
	All	Workshop workers	All	Cleaners
Cohort members	5134	1253	3224	769
Died during follow-up	2248	346	841	207
Emigrated during follow-up	56	9	56	11
Year of birth				
< 1900	118	5	25	13
1900–1909	328	24	81	22
1910–1919	581	65	183	63
1920–1929	725	99	324	66
1930–1939	861	263	613	113
1940–1949	931	289	816	146
1950–1959	630	187	479	121
1960–1969	561	171	435	124
1970+	396	150	268	101
Range	1878–1986	1894–1985	1886–1988	1886–1983
Median (IQR)	1939 (32)	1945 (26)	1944 (24)	1947 (30)
Median age at first employment between 1950 and 2005 (IQR)	31.2 (20.9)	27.9 (15.4)	28.3 (19.2)	36.4 (20.9)
Mean years of employment between 1950 and 2005 (SD)	12.6 (11.9)	13.7 (11.4)	7.9 (9.5)	5.5 (6.9)
Age at end of follow-up				
Range	21–99	24–99	20–101	22–99
Median (IQR)	69.1 (20.4)	66.5 (21.2)	68.6 (21.5)	66.5 (25.3)

2.3. Statistical analysis

Standardised incidence ratios (SIRs) and mortality ratios (SMRs) were calculated as ratios of observed and expected numbers and presented with exact Poisson 95% confidence intervals (95% CI) using Stata version 14 (StataCorp LP, College Station, TX, USA). Because cancer incidence and mortality rates vary by age, by sex and over time, the expected annual number of cases among the cohort members was derived by multiplying the 5-year age-specific person-years for cohort members by the corresponding Norwegian national pooled incidence rates for each sex separately. A 2-sided p-value smaller than 0.05 indicated statistical significance.

3. Results

The accumulated person-years for the full cohort over the study period was 163 866 for men and 110 297 for women. Average follow-up time was 31.9 years for men and 34.2 years for women. The observed number of cancers was 1418 in men and 786 in women, while the number of all-cause deaths in the cohort over the study period was 2248 among men and 841 among women (Table 1).

3.1. Cancer incidence

Cancer incidence at all sites among men was close to the expected value (SIR = 1.02). However, the six cases of breast cancer observed implied a statistically significant excess (SIR = 3.23, 95% CI 1.19–7.03). The incidence of lympho-haematopoietic cancers was 20% below national rates (95% CI 0.64–0.99). Among women, the elevation of cancer incidence at all sites was statistically significant (SIR = 1.11, 95% CI 1.03–1.19), as was the excess of ovarian cancer (SIR = 1.39) and lung cancer (SIR = 1.35) (Table 2).