

## CANCER INCIDENCE AMONG MALE SALARIED EMPLOYEES AT A SMELTERY IN NORTHERN SWEDEN

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**This study focuses on mortality and cancer incidence among the male salaried employees at a copper smeltery in northern Sweden, where previously an increased lung cancer risk had been demonstrated among blue-collar workers, with all likelihood due to arsenic exposure. During the period 1928–1979 there has been 1 255 male salaried employees and 6 334 male blue-collar workers. Three cohorts were formed; those who had worked only as salaried employees, those who had worked only as blue-collar workers and those who had worked in both job categories. The mortality among the entire group of salaried employees was comparatively lower than that of Sweden as a whole. The incidence of lung cancer was highest among those who had worked in both job categories, most of them former blue-collar workers. The trends in lung cancer incidence among the blue-collar workers alone and among those who had had both types of jobs showed the same pattern, with a peak in the 1970s. The decrease in this trend started earlier among the salaried employees. When job category and employment cohort were analyzed together the highest risk was confirmed for those having been employed in both job categories.**

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Rönnskärsverken, a copper smeltery in Northern Sweden, was established in 1928. The smeltery processed ore from a nearby mine, which is rich not only in copper but also in silver and gold. Unfortunately, it has also a high arsenic level. For this reason it was necessary to develop processes which could transform the arsenic into saleable products.

Health problems among the workers can be identified as far back as in the 1930s. The main problems were gas and etching injuries (1). The respiratory problems among the workers were studied during the 1940s and 1950s, and the Rönnskär disease, bronchitis caused by chemicals, was first described (2, 3). A case-referent study (4) was performed based on male deaths aged 30–74 in the parish surrounding the plant. The smelter workers suffered a 5-fold relative risk of dying of lung cancer.

In the 1970s, a cohort study of 3 915 blue-collar workers first employed at the smeltery between 1928 and 1966 was performed. An excess mortality of 11% compared to Swedish males was revealed. Deaths from cancer, and especially from lung cancer, were found to greatly exceed the figures for the country as a whole and for the county of Västerbotten, where the smeltery is located. During the study period (up till 1977), lung cancer mortality steadily increased (5, 6). A follow-up of the cohort has then shown a steady decline both in the incidence of lung cancer and the mortality. The excessive number of cases of lung cancer was found mainly among workers who had first been employed during the 1930s and 1940s. (7, 8).

Other studies have dealt with the lung cancer mortality in the surrounding populations. Lung cancer mortality was shown to be significantly higher in the vicinity of the plant compared to a reference area but no increased lung cancer risk was found after exclusion of the persons who had also been employed at the smeltery (9). In a later case-referent study (10) it was shown, however, that the increased risk of developing lung cancer persisted after accounting for smoking and work history. The odds ratio for lung cancer

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was 2.3 for the male non-smokers in the exposed area relative to the male non-smokers in the reference area.

The salaried employees at the smeltery have not been studied previously. It seems likely that they are more exposed than those living in the vicinity of the plant but less exposed than those employed as blue-collar workers. Hence their mortality and morbidity patterns are of considerable interest. They not only represent a group with a different level of occupational exposure but also of a different social status which might confound or modify the effects of exposure.

Social inequalities in mortality over the entire age span also prevail in Sweden. Such differences have been reported, for instance, in ischaemic heart disease, cancer, respiratory diseases and accidents (11). A study of the cancer incidence among blue-collar workers, salaried employees and farmers, based on a record linkage between the Swedish Cancer Register and population census data, showed higher lung cancer and stomach cancer incidences among manual workers than among salaried employees, while rectal cancer and female breast cancer were more common among the salaried employees. Lower incidence of all cancer were found among farmers, who, however, ran an excessive risk of developing stomach cancer and skin cancer (12). It was also shown that the survival rate after a cancer diagnosis was highest among salaried employees. Types of cancer more often leading to death (e.g. lung cancer) are commoner among blue-collar workers (13).

The aim of the present paper is to assess the morality and the incidence of cancer, especially lung cancer, among the male salaried employees at Rönnskärsverken. The salaried employees will be compared with the earlier studied cohort of male blue-collar workers at the smeltery (5–8).

### Material and Methods

There are two main categories of employees at Rönnskärsverken; salaried employees (with salaries paid on a monthly basis) and employees who receive wages regulated by an agreement based on working hours (blue-collar workers). The 3 915 male blue-collar workers first employed in 1928–1966 have been studied earlier (4, 6). In a later report this cohort was extended by those first employed in 1967–1979 (7). Information on all male salaried employees who had been employed for 3 months or more during the period 1928–1979 was collected from the manual employment registrar at the smeltery. Some of them had, however, worked both as blue-collar workers and salaried employees and these employees were also analyzed separately.

The employment registrar at Rönnskär also contains information on work place history. On the basis of this information the principal tasks of the salaried employees

at the smeltery were divided into four sub-categories: white-collar work, laboratory work, production engineers, etc., and foremen. The two latter groups had daily contact with production and could thus be regarded as occupationally exposed. It has been the company policy at Rönnskärsverken to provide alternative work for those who, for health reasons, are unable to continue with their jobs. However, no information was available about each individual as regards such changes. In order to analyse this effect, the workers in both categories were separated into three groups; those who had worked as salaried employees before becoming manual workers, those who, after a time as blue-collar workers, were promoted to become foremen and those who started as blue-collar workers and later became salaried employees other than foremen.

The register was supplemented with the addition of civic numbers using the Swedish Population Register, SPAR. When the employee could not be traced in the population register, the parish authorities provided the information. A record linkage with the cause-of-death register held by Statistics Sweden yielded information regarding deaths and causes of death for persons who died during the period 1952–1987. The manual records kept by the parish authorities were used to supplement the register with causes of death for persons who died before 1952. Record linkage with the national cancer register at the National Board of Health and Welfare yielded information on the incidence of cancer from 1958, when the Swedish Cancer Registry was established, up till January 1, 1988.

Mortality from 1952–1987 and cancer incidence from 1958–1987 in the cohort were analysed, using sex-, age- and calendar year specific national data as reference. Comparisons were also made with the earlier studied cohort of blue-collar workers at the smeltery. The effect of job category and employment cohort (those first employed 1928–1939, 1940–1949 and 1950–1979) were jointly evaluated in a multivariate analysis using the Cox's proportional hazards model (14, 15). In this analysis lung cancer occurrence, i.e. deaths and/or incident cases, was studied.

### Results

In the 1940s, there was a peak in the recruitment of salaried employees at the smeltery when almost one-third of the 1 255 men were first employed (Table 1). They had a mean age of 27.5 years when first employed and represented 32 699 person-years in the study of mortality during the follow-up period 1952–1987. During this period, 258 deaths occurred. The mortality was lower than expected in comparison to the whole country. This was more marked in the younger age groups (Table 2). Although the study period for this analysis did not start until in 1952, 24 years after the establishment of the smeltery, only 6 deaths had occurred earlier. During the study period, 71 of the 258 deaths were due to cancer corresponding to a standardized

**Table 1**

*Number of male salaried employees during various decades*

Employment period	n	%
1928-1939	163	13.0
1940s	369	29.4
1950s	256	20.4
1960s	204	16.2
1970s	263	21.0
Total	1 255	100

**Table 2**

*Mortality 1952-1987 among salaried employees in different age groups in the Rönnskär cohort. Standardized mortality ratios (SMR = 100 for Swedish males)*

Age (years)	Person-years	No. of deaths		
		Obs.	Exp.	SMR
15-19	140	0		
20-24	942	2		
25-29	2 468	2		
30-34	3 624	2	28.8	48.6
35-39	4 289	4		
40-44	4 482	4		
45-49	4 395	14		
50-54	4 084	25		
55-59	3 304	33	120.0	86.7
60-64	2 273	32		
65-69	1 416	54		
70-74	759	39		
75-79	350	27	132.5	105.7
80-84	120	14		
85-	53	6		
Total	32 699	258	281	91.8

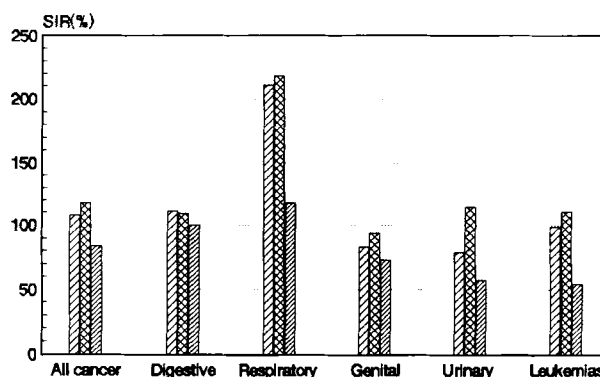
mortality ratio (SMR) of 112. The SMR values relative to the Swedish population increased with age.

The incidence of cancer was studied for a period of 30 years (1958-1987) and during this period 117 cases of cancer (affecting 108 persons) were reported. The standardized incidence ratio (SIR) was 108.1 (Table 3) relative to Swedish figures. The excess incidence of cancer was mostly accounted for by the 31 respiratory cancer cases which should be compared with the 15 cases expected. Among the 1 255 male salaried employees, however, 403 had also been blue-collar workers before 1980. Most of these men (311) had been blue-collar workers before they moved over to salaried employment. The standardized incidence ratios were compared with the ratios for those who at some time were employed as blue-collar workers (Fig. 1). The SIR of respiratory cancer was almost as high

**Table 3**

*Cancer incidence 1958-1986 among salaried employees at the Rönnskärsverken (SIR = 100 for Swedish males)*

Site	Obs.	Exp.	SIR
All cancer	117	108.2	108.1
Digestive tract	33	29.7	111.1
Respiratory tract	31	14.7	210.9
Genital organs	16	19.2	83.3
Urinary tract	10	12.7	78.7
Blood, bone marrow and lymphatic system	10	10.1	99.0



*Fig. 1. Standardized incidence ratios among males at the Rönnskär smeltery in relation to Swedish males for some cancer sites in different job categories (SIR = 100 for Swedish males). ▨: salaried employees only; ▩: blue-collar workers; ▧: all salaried employees.*

for the whole group of salaried employees as for blue-collar workers. However, the SIR for respiratory cancer for those being salaried employees only was much lower. Of the 31 cases of respiratory cancer found in the cancer register, 28 represented lung cancer. Seventeen of these persons had worked in both job categories. Fourteen of them were first employed as blue-collar workers (for an average of 15.5 years) before they became salaried employees. The remaining three were first employed as salaried employees (3, 16 and 25 months respectively) before being employed as blue-collar workers.

The two cohorts of salaried employees and blue-collar workers had about the same incidence of lung cancer during the study period 1958-1987—2 per 1 000 and year after age-adjustment (age-groups 45 years and above). When all three job categories were studied it was found that the incidence of lung cancer was highest among those who had worked in both job categories and lowest among those who had been salaried employees only (Fig. 2). Thus, in relation to those who had worked as salaried employees only, the standardized rate ratio was 182 for those who had worked as manual workers only, and 368 for those who had worked in both job categories.

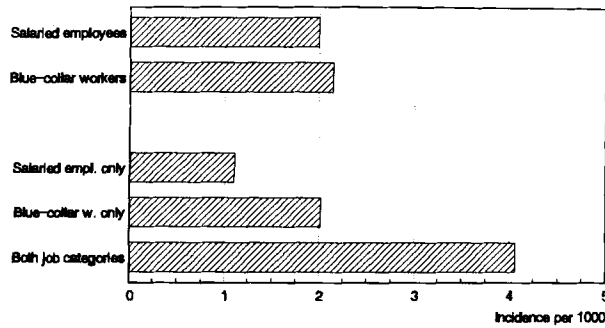


Fig. 2. Age-standardized incidence of lung cancer in males among the different study groups, in the age group 45 years and above (reference population: Swedish males 1951–1955).

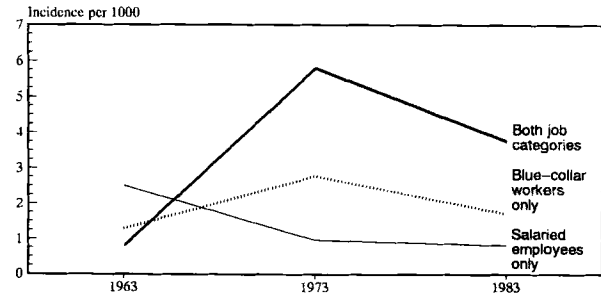


Fig. 3. Trends in the age-standardized incidence of lung cancer in males among the three job categories. Ages 45 years and above (reference population: Swedish males, 1951–1955).

The trends in the incidence of lung cancer were studied using three calendar periods: 1958–1967, 1968–1977 and 1978–1987. The trend patterns were similar for the blue-collar workers and for those who had worked in both job categories although the latter group had a higher incidence level and showed a more marked peak in the 1970s. For the salaried employees, however, the trend was quite different with a much earlier decrease (Fig. 3).

Table 4 shows that the group who started as salaried employees and then became manual workers did so after a

relatively short period (on an average after 3.5 years). Those who became foremen, on the other hand, had quite a long experience as manual workers (on an average 12.4 year) as did the third group with various types of jobs (7.5 years). Table 4 shows that most of the lung cancers among former blue-collar workers occurred among the foremen.

Job category and employment cohort were analyzed together using the Cox's proportional hazards model taking into account also age at hire. The highest risk was confirmed for those being employed in both categories (Table 5). Age

Table 4

Persons with both types of work and duration of their employment before they changed job category, by different subgroups

Occupational mobility	All employees		Lung cancer	
	n	Mean time before change (years)	n	Mean time before change (years)
From salaried employee to manual worker	92	3.5	3	1.2
From manual worker to foreman	200	12.4	11	15.9
From manual worker to other category of salaried employee	111	7.5	3	13.2

Table 5

Odds ratios for the occurrence of lung cancer using Cox's proportional hazards model with the variables job category, employment cohort and age when first employed

Variable	Category	Odds ratio	95% CI
Job category	Salaried employees only	1.0	—
	Blue-collar workers only	1.90	1.02; 3.52
	Both categories	3.13	1.46; 6.69
Employment cohort	1950–1979	1.0	—
	1940–1949	1.56	0.90; 2.71
	1928–1939	1.73	1.00; 2.99
Age when first employed	Continuous	0.97	0.95; 0.99

at hire had a significant influence in the model, the risk of lung cancer decreasing with increasing age at employment.

### Discussion

The Rönnskär smeltery is probably the industrial plant in Sweden which has been subjected to the greatest number of occupational and environmental studies. However, neither the mortality, nor the incidence of cancer among the salaried employees at the Rönnskär smeltery has been studied before.

The standardized mortality ratio for the male salaried employees was 92 relative to Swedish males in general, which may be compared to 117 for the blue-collar workers during the same study period, 1952–1987 (8). The overall cancer mortality of 112 can be compared with an overall cancer incidence of 108. Among the 1 255 male salaried employees, 28 cases of lung cancer were found during the study period 1958–1987. Seventeen of those had also been working as blue-collar workers.

Pershagen (10) reported an odds ratio of 2.3 for lung cancer among those living in the vicinity of the smeltery, but not working there, when smoking was not taken into account. In that study those who at some time had worked in the smeltery, without specifying their type of employment, ran a 3.9 times higher risk of developing lung cancer. The present study describes a corresponding pattern among various categories of smelter employees, categories which are different as to exposure and social conditions.

Sparse data make trends in the incidence of lung cancer more uncertain when different job categories were analyzed. However, it seems obvious that the trend among those who had been salaried employees only had a slope unlike that of the other job categories. Socially they represented a well-defined and recognized position in the smeltery and the community. Thus, salaried employees enjoyed specific advantages, including residence in a separate area in the municipality, free rides on a special bus every morning and afternoon and free pre-school activities for children during the 1950s. They were probably more likely to be reached by health education and to act accordingly—for instance as regards smoking. In Sweden the better-educated were the first to stop smoking and medical knowledge has thus contributed to a new class pattern of smoking, very different from that of only two decades ago (16).

Former blue-collar workers may have become salaried employees for different reasons. On the one hand, there is the 'A-worker', who has been promoted from a blue-collar worker to a foreman. On the other hand, there are those who could not continue their heavy manual work and had to choose between long-term sick-leave or another kind of job, perhaps as a salaried employee in the company. In the salaried employee group, therefore, the class line mainly

distinguishes those who have once been blue-collar workers from those who have never been thus employed.

Although the numbers become small when the former blue-collar workers are divided into subgroups, Table 4 indicates that the excessive incidence of lung cancer among the former blue-collar workers was seen mainly related to those who became foremen. Were they as foremen more involved in the process when problems arose? Did they have higher peak exposures than the ordinary blue-collar worker? The 11 cases of lung cancer had been blue-collar workers for an average period of 16 years before becoming foremen. Were those who made a career and became foremen less careful and readier to take exposure risks than the others? To further study such questions the experience and the attitudes of employees in the various categories have been evaluated in a questionnaire study supplemented by in-depth interviews (17, 18).

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