

## CANCER MORTALITY AMONG FERROCHROMIUM WORKERS

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### ABSTRACT

An investigation of the causes of death was made among 380 workers in a ferrochromium industry in Sweden where the main exposure agents are metallic and trivalent chromium. The cohort was defined as all male workers who had been employed for at least one year during the period 1930 to 1975, and information on death certificates was collected from the National Central Bureau of Statistics. Expected death values were calculated from the rates for the county in which the factory was situated. Individual workers were classified according to their occupation within the industry.

The total number of deaths from tumours was less than expected (69 versus 76.7). Five cases of respiratory cancer were found against the expected 7.2. The maintenance workers showed an increased death rate from tumours, and also an increased number of respiratory tumours. No increase was found for respiratory tumours among the heavily exposed workers at the arc furnaces. The number of persons who died from respiratory tumours during the years 1931–1950 was proportionally higher than those who died during the years 1951–1975.

While a relationship between exposure to chromates ( $\text{Cr}^{6+}$ ) and the development of cancer has been demonstrated in several studies on workers in chromate industries<sup>1,2</sup>, no investigations have been performed showing any conclusive evidence concerning risks from malignant tumours after exposure to metallic and trivalent chromium ( $\text{Cr}^0$  or  $\text{Cr}^{3+}$ ). Mancuso<sup>3</sup> suggested that  $\text{Cr}^{3+}$  could be responsible for the development of lung cancer, but this conclusion was drawn from studies in which the major exposure agent was  $\text{Cr}^{6+}$ .

In a ferrochromium industry during the process of electrolytic reduction, chromite-ore, quartz, lime and coke are mixed in arc furnaces. The chief exposure agents are metallic Cr and  $\text{Cr}^{3+}$ . However,  $\text{Cr}^{6+}$  has also been detected close to the furnaces.

In order to investigate whether exposure to these substances may be associated with an increased risk from tumours – notably lung cancer – a cohort study was made among workers in a ferrochromium plant (Ferrolegeringar Trollhätteverken AB, Trollhättan, Sweden). Other products such as ferrovandium and ferromolybdenium, are produced in a separate department in this ferrochromium industry.

## SUBJECTS AND METHODS

The subjects in the study were male workers employed for at least one year during the period January 1, 1930 to December 31, 1975. All but one subject in this original cohort were traced and information was collected on whether the subjects were still alive or, if not, what was the cause of death.

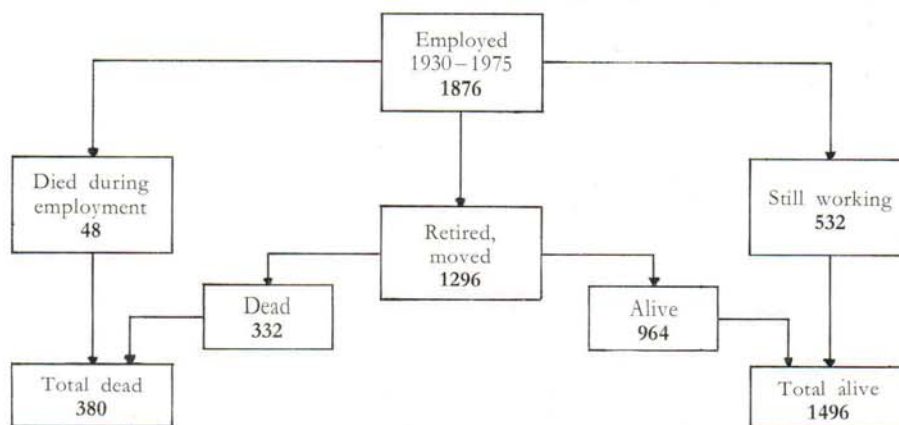
TABLE 1  
Workplaces and estimated exposure levels in mg/m<sup>3</sup>.

Workplaces	Cr <sup>0</sup> + Cr <sup>3+</sup>	Cr <sup>6+</sup>
Arc furnaces	2.5	0.25
Transport, metal grinding, sampling	0.5-2.5	0.01-0.05
Maintenance	2.5	0.05
Office, storage area	0	0

The individual subjects in the cohort were classified according to the workplace within the industry and a rough estimate was developed (Table 1). Because of a lack of data on early exposure this estimate is based on recent measurements and discussions with retired workers and foremen who worked in the 1930s. It must be considered, therefore, that the estimates are rough and might differ from today's exposure. It is seen in the table that persons working at the arc furnaces had the highest exposure of all categories studied. The concentration of Cr<sup>6+</sup> was estimated to be about 10% of Cr<sup>3+</sup>. Because the arc furnaces were more open at the time the factory was started (1913), it is very possible that the concentrations were considerably higher at that time.

The information about the cause of death was obtained for each subject from the National Central Bureau of Statistics (Statistiska Centralbyrån), and the

TABLE 2  
Ferrochromium worker cohort. Personnell who worked for at least one year between January 1, 1930, and December 12, 1975, and who were alive on January 1, 1951.



underlying causes of death were coded according to the "International Statistical Classification of Diseases Injuries and Causes of Death, 8th Revision". As the Bureau altered its classification of causes of death on January 1, 1951 it was necessary to limit the sample to those who were still alive on this date. Expected numbers of deaths were calculated from the rates for the county in which the factory was situated<sup>4</sup>.

Table 2 reports details of the cohort used for the mortality study. It is seen in the table that the analysis was based on the death certificates of 380 persons.

### RESULTS

Table 3 demonstrates the observed and expected number of deaths in the population under study for different diagnoses. A total of 69 cases of cancer was found, compared to the 76.8 expected. An unusually high rate of accidental deaths was observed which was due to 14 cases of suicide and 12 cases of drowning.

TABLE 3  
Observed and expected death rates for various diagnoses for all employees.

	Observed	Expected	SMR Obs/Exp
Total deaths	380	382.3	99
Tumours	69	76.8	90
Circulatory diseases	182	174.4	104
Respiratory diseases	16	21.1	76
Digestive diseases	24	17.0	141
Urogenital diseases	11	11.7	94
Accidents, suicides, poisoning	48	35.9	134
Other causes	30	45.4	66

TABLE 4  
Observed and expected deaths from tumours for different sites and for different periods of employment.

Tumours as a cause of death	Length of employment (years)							
	1-4		5-14		15+		Total	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
All sites	16	15.3	21	19.6	32	41.8	69	76.7
Stomach	5	2.3	6	3.3	3	8.0	14	13.6
Small intestine + colon	1	1.2	1	1.6	2	3.6	4	6.4
Rectum	1	0.7	1	1.0	0	2.3	2	4.0
Trachea, bronchus, lung, pleura	1	1.6	1	2.1	3	3.5	5	7.2
Prostate	3	1.3	2	2.3	7	6.3	12	9.9
Leukemia	0	0.7	0	0.8	3	1.7	3	3.2
Other sites	5	7.5	10	8.5	14	16.4	29	32.4

Table 4 reports the number of deaths from tumours in different sites and for different periods of employment. It is seen that the total number of deaths from tumours is less than expected. The number of respiratory tumours is also less than expected. However, in the group "other sites" there is one case of lung cancer which was not classified ICD 162, but rather 231 (unspecified respiratory tumour). In this group there is also one case of mesothelioma.

TABLE 5  
Observed and expected deaths from tumours for different workplaces and different periods of employment.

Workplace	Length of employment (years)							
	1-4		5-14		15+		Total	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
Arc furnaces	3	4.6	7	7.0	13	16.5	23	28.1
Transport, metal grinding, sampling	7	7.0	5	7.7	7	11.1	19	25.8
Maintenance	4	1.9	7	2.7	7	9.0	18	13.6
Office, storage area, other nonchromium exposed workplaces	2	1.7	2	2.2	5	5.3	9	9.2

The number of deaths from tumours for different workplaces and for different periods of employment is illustrated in Table 5. It is seen that the observed death rate in tumours was less than the expected rate for all workplaces and for all employment periods, except in the case of maintenance workers. In this group the increase above expected rates was above the expected value for the groups employed from 1 to 4 years and from 5 to 14 years.

Table 6 reports the number of respiratory tumours at different sites and for different periods of employment. There were three cases in the maintenance

TABLE 6  
Observed and expected deaths from respiratory tumours for different workplaces and different periods of employment.

Workplace	Length of employment (years)							
	1-4		5-14		15+		Total	
	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.
Arc furnaces	0	0.4	1	0.7	0	1.3	1	2.4
Transport, metal grinding, sampling	0	0.8	0	0.9	0	0.9	0	2.6
Maintenance	1	0.2	0	0.3	2	0.8	3	1.3
Office, storage area, other nonchromium exposed workplaces	0	0.2	0	0.3	1	0.6	1	1.1



group compared to 1.3 expected. The earlier mentioned cases of unspecified lung tumour and mesothelioma should, however, be added to this group.

An additional analysis of the death rates in all subjects including those who died before 1951 was performed according to the diagnoses from the parish death register.

TABLE 7  
Deaths from respiratory tumours and all tumours during two time periods (diagnoses from parish death certificates).

Year of death	Number of deaths	Tumours				Respiratory tumours of all tumours %
		Respiratory %	All %	Respiratory %	All %	
1931-1950	56	6	11	14	25	43
1951-1975	380	9	2	66	17	14

Table 7 reports the number of deaths from respiratory tumours only and from all tumours during two different periods of time. The number of persons who died from respiratory tumours during the years 1931 to 1950 was proportionally higher than those who died during the years 1951 to 1975. Furthermore, the proportion of respiratory tumours to all tumours was considerably higher for the earlier period.

#### DISCUSSION

During the period 1951-1975 there was no increase in the observed number of deaths from tumours in relation to the expected number. The total number of respiratory tumours was also smaller than expected during this period. However, maintenance workers as a group showed an increased death rate from tumours and also an increased number of respiratory tumours when the unspecified case and the mesothelioma case were added. Three of the five workers in this group worked in this plant for five years or less. Nothing is known about their other employments. The unspecified case was diagnosed three years after the subject's first employment in this factory. The presence of one case of mesothelioma in this group indicates that asbestos could be responsible for the increase in respiratory tumours. It is known that asbestos has been used in the plant, especially in the period 1935-1940.

The high proportion of respiratory cancer among those who died before 1951 could be caused by different exposures. Very little is known of the production process around the year 1915, but it is probable that much of the work which is done automatically today was done manually at that time. From retired workers it is known that the dust level was much higher in the period 1920-1930 than it is today.

Concerning that lung cancer was a rare disease in the period 1930–1950, because of less cigarette smoking the proportion of respiratory cancer in this plant during this period is remarkably high.

In conclusion no increase was found for respiratory tumours among the heavily exposed workers at the arc furnaces as compared to the expected value. As the confidence interval of the standard mortality rate (SMR) of this disease is large, due to the small number of cases present in the material, up to a threefold risk could still be present.

The chromium exposure at the investigated plant concerned mainly Cr<sup>3+</sup>. The proportion of Cr<sup>6+</sup> was estimated to be up to 10 per cent of the total chromium exposure.

At an earlier period when the exposure level was judged to be high, an increased incidence of tumours in the respiratory tract was found. During a later time period no respiratory tumours were found although the total chromium exposure was still substantial. The risk from exposure to the levels of total chromium as present in this industry is thus smaller than the risk of developing respiratory tumours after chromium exposure in a chromate industry.

#### ACKNOWLEDGEMENT

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