CANCER INCIDENCE AND CAUSE SPECIFIC MORTALITY AMONG WORKERS IN THE NORWEGIAN ALUMINIUM INDUSTRY

Results from a combined study of six Norwegian aluminium smelters

DNN – Eydehavn (1914 – 75)
DNN – Tyssedal (1915 – 82)
Hydro Aluminium – Høyanger (1919 –)
Hydro Aluminium – Årdal (1947 –)
Hydro Aluminium – Sunndal (1954 –)
Elkem Aluminium – Mosjøen (1958 –)

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Institute of Population-based Cancer Research

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AIM

The aim of the study was to investigate possible associations between exposures in the work environment and cancer incidence and cause specific mortality.

BACKGROUND

Several groups of workers in the aluminium industry have been extensively exposed to coal tar pitch volatiles (CTPV) which contain considerable amounts of organic carcinogenic compounds such as polycyclic aromatic hydrocarbons (PAH). Experimentally these compounds have shown mutagenic and carcinogenic properties. Epidemiological studies of workers exposed to CTPV have provided evidence that exposure to high levels may entail a substantial risk of lung and bladder cancer and possibly elevated risk of kidney and pancreatic cancer.

An earlier study including employees from four Norwegian aluminium smelters indicated an increased risk of lung cancer among workers in the process departments. Studies from Canada showed a marked increased risk of bladder cancer among workers in Søderberg potrooms. Based on these findings, the Nordic Aluminium Industry's Secretariat for Health, Environment and Safety and the Cancer Registry of Norway launched in 1989 the project: "Cancer among workers in the Norwegian aluminium industry".

The project has received financial support from the Nordic Aluminium Industry's Secretariat for Health, Environment and Safety, the Confederation of Norwegian Business and Industry and the Cancer Registry of Norway.

MATERIAL

The present study combining data from six Norwegian aluminium smelters included 11 103 men employed for more than three years in one of the smelters. Information on each employee was obtained from company records giving name, date of birth, departments, job types and dates for all changes of job. Since very few women had been employed in exposed work, only men were included in the analyses. Smoking status were abstracted from medical files at the health departments and supplemented with information from long-term employees. Information on cancer morbidity was received from the Cancer Registry of Norway for the calendar period between 1953 and 1996, and cause specific mortality was retrieved from Statistics Norway in the calendar period from 1962 to 1996.

SUMMARY

The study showed that the overall cancer morbidity and overall cause specific mortality was close to the Norwegian average.

There was, however, a higher incidence of bladder cancer among aluminium workers than the average incidence among Norwegian men in the same age groups. Furthermore, the risk of bladder cancer increased by increasing exposure to coal tar pitch volatiles (CTPV).
The incidence of lung cancer was close to the expected numbers calculated from average Norwegian figures and showed no increasing tendency by increasing exposure to CTPV.

The study also showed a higher mortality of chronic obstructive lung diseases (asthma, chronic bronchitis and emphysema) compared to the average Norwegian figures. For these diseases the mortality increased by increasing exposure to fluoride.

The mortality of circulatory diseases was somewhat lower than the Norwegian average.

Exposure to coal tar pitch volatiles in the working environment is a likely explanation for the increased risk of bladder cancer. The increased mortality of chronic non-malignant respiratory diseases is probably caused by exposure to irritating dust and gas in the potroom environment.

The associations found between the work environment and cancer incidence and mortality could not be explained by smoking habits.

ESTIMATION OF EXPOSURE

Cumulative exposure for each of the workers was estimated by linking information on job history, duration of jobs and exposure in the jobs. The estimation of exposure in the various jobs was based on more than 30 000 industrial hygiene measurements and on descriptions of changes in the process over time.

Cumulative exposure was calculated by multiplication of the concentration in air by duration of exposure. For instance would a person working ten years in a job with an average of 100 $\mu g/m^3$ PAH and 0.5 mg/m^3 fluoride received a cumulative

- PAH exposure of
  10 years $\cdot$ 100 $\mu g/m^3$ = 1000 $\mu g/m^3 \cdot$ years

- Fluoride exposure of
  10 years $\cdot$ 0.5 mg/m^3 = 5 $mg/m^3 \cdot$ years.

HOW WE MEASURED RISK

Risk is defined as a person's chance of getting a disease or dying over a certain period of time. The risk of cancer and death were measured as **relative risk (RR)**. Relative risk is the ratio between the risk in the investigated group and the risk in a representative comparison group. The relative risk indicates the likelihood of developing the disease in the group of interest relative to a comparison group.

Relative risks close to **1.0** means that the cancer incidence or the mortality is close to the comparison group. A relative risk **below 1.0** indicates that the risk is lower in the group of interest than in the comparison group and a relative risk **above 1.0** indicates an increased risk.

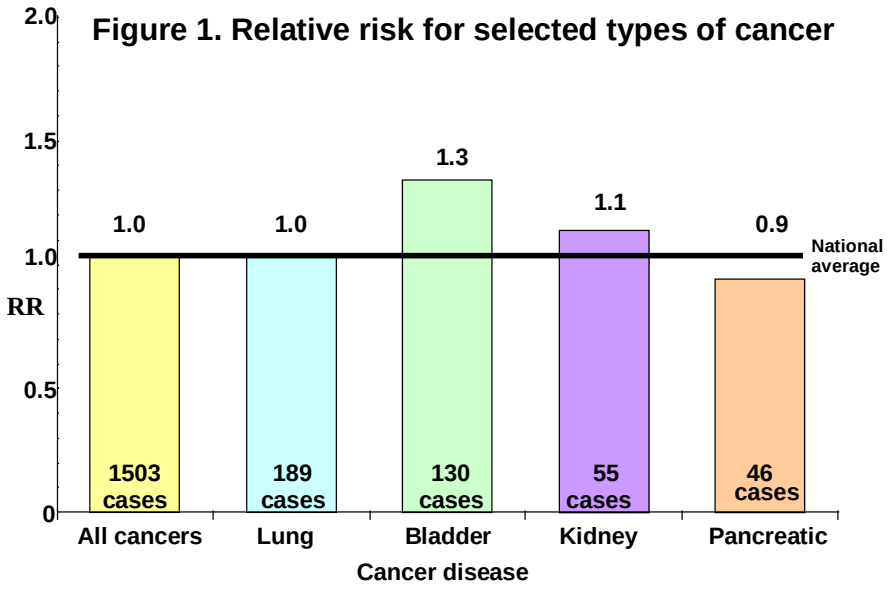
When the relative risk increases by increasing exposure, there may be a causal relationship between exposure and disease.

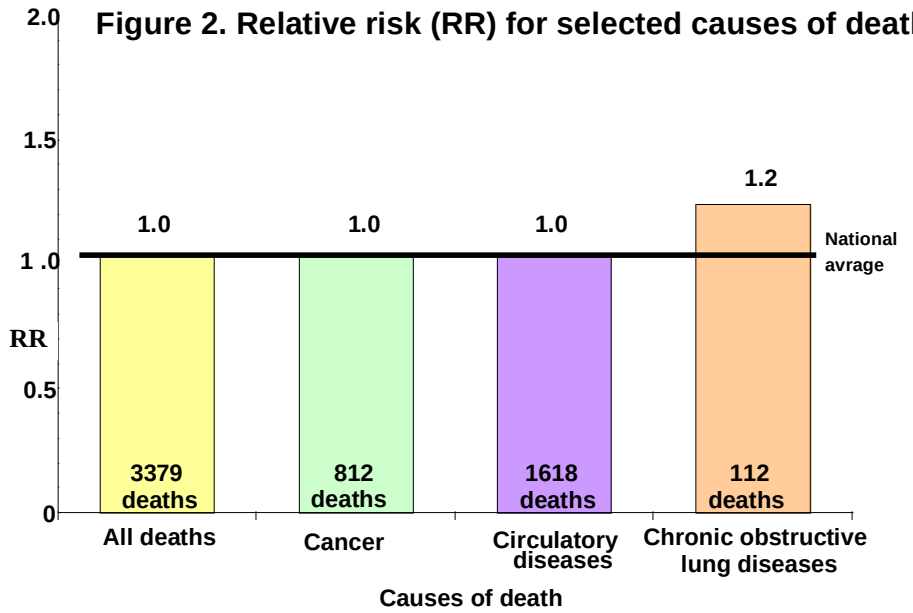
The choice of a comparison group is of major importance in the estimation of relative risk. In the present study we have performed comparisons both with the average of the total Norwegian population (adjusted for age) and between groups of workers with different levels of exposure. In the present study, the two methods showed similar results. This increased the credibility of the study findings.

RESULTS

OVERALL INCIDENCE OF CANCER AND OVERALL MORTALITY

The total number of cancer cases was close to the number expected from a similar age distributed group of the average Norwegian male population. A total of 1503 cases of cancer were observed versus 1453 expected from national numbers. The number of deaths was also close to the expected with 3379 deaths in the study group compared to 3450 expected deaths based on the Norwegian average. In figure 1 and 2 below, the relative risks among aluminium workers versus the Norwegian male population are presented for selected types of cancers and selected causes of deaths.





EXPOSURE TO PAH AND LUNG AND BLADDER CANCER

The risk of lung cancer did not seem to increase by increasing exposure to PAH (figure 3). The risk of bladder cancer, however, increased by increasing exposure to PAH (figure 4). Thus there was no evidence of an association between PAH exposure and lung cancer in the present study, but evidence of an association between PAH exposure and bladder cancer.

Figure 3. PAH exposure and relative risk (RR) of lung cancer

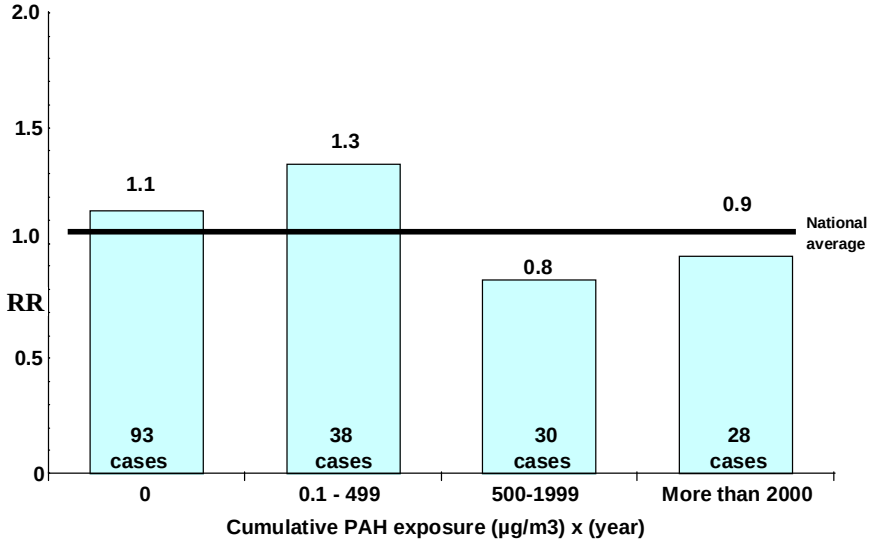
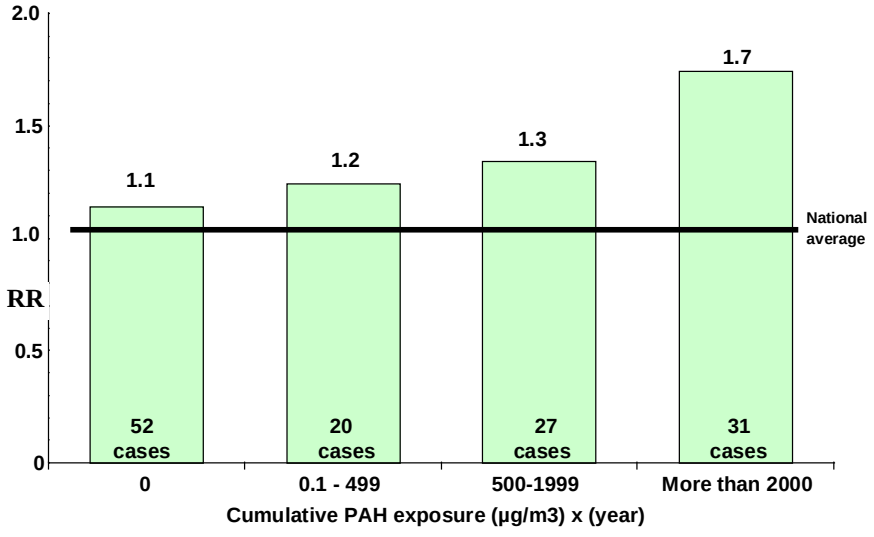


Figure 4. PAH exposure and relative risk (RR) of bladder cancer



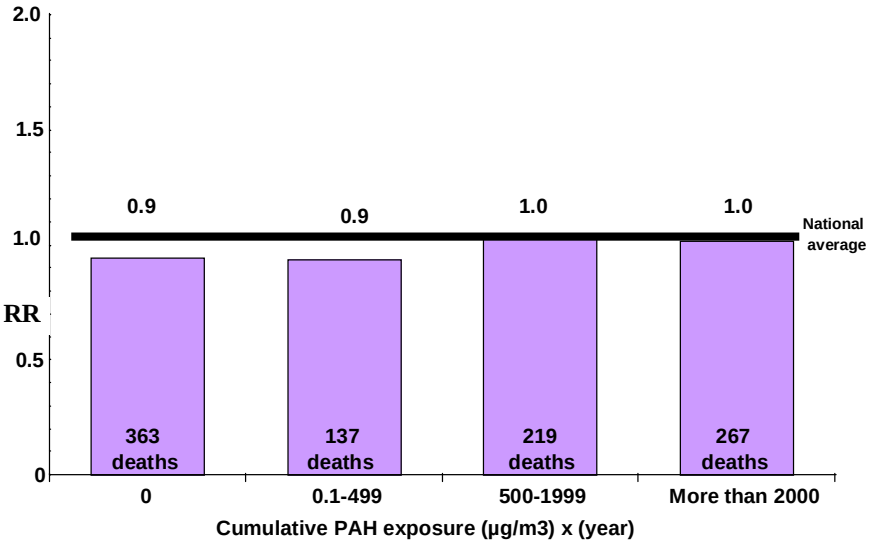
PANCREATIC AND KIDNEY CANCER

The study indicated a possible increased risk of kidney and pancreatic cancer linked to PAH exposure. The evidences for these possible relationships were, however, weak due to a variation in the findings between the plants, and due to relatively few numbers of these cancer types.

MORTALITY OF CIRCULATORY DISEASE

The mortality of circulatory disease was on the same level as, or slightly below, the national average. The study did not reveal any associations between exposure to PAH or fluoride and mortality from ischemic heart disease or cerebrovascular disease.

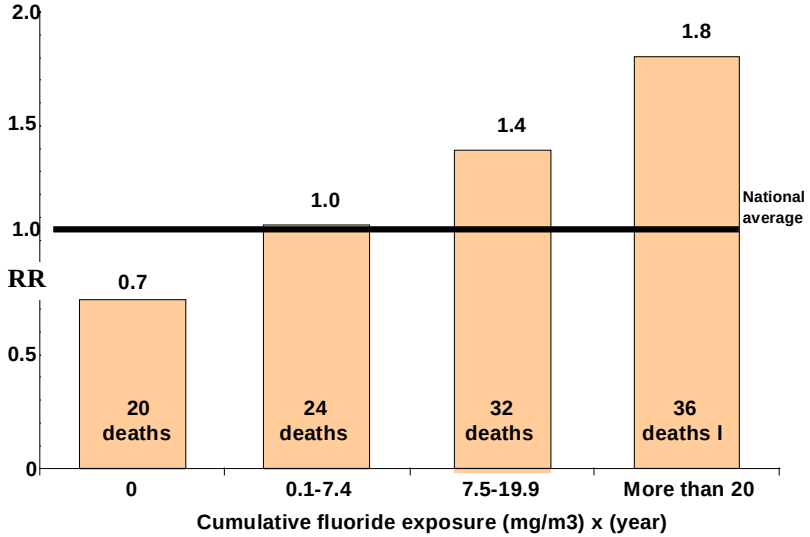
Figure 5. PAH exposure and mortality from ischemic heart disease



MORTALITY OF NON-MALIGNANT RESPIRATORY DISEASE

The study showed an increasing mortality from chronic obstructive lung diseases (asthma, chronic bronchitis and emphysema) by increasing exposure to fluoride (figure 6). A possible explanation for the increased mortality is the combined exposure to various agents in the potroom atmosphere (irritating dusts and gases).

Figure 6. Exposure to fluoride and mortality (RR) from asthma, chronic bronchitis and emphysema



SMOKING

Persons who smoke cigarettes have a much higher risk of lung cancer than a non-smoker has. In fact, nine out of ten lung cancers occur in persons who smoke. The more a person smokes, the higher is the risk. Soon after quitting, the risk begins to drop. Persons who smoke cigarettes also have a higher risk of cancers of the bladder, kidney, pancreas, lip, mouth, tongue, larynx, throat and oesophagus. Persons who smoke do also have a higher risk of other diseases like heart disease, diabetes, stroke, bone loss (osteoporosis), emphysema and bronchitis.

It is therefore important to evaluate the possible effects of smoking on the results of this study. To investigate whether smoking may have influenced the findings in the present study we used information on smoking habits that had been collected at three of the six plants. The analysis from these three plants showed that smoking was an important risk factor, but the analyses also showed that the findings related to the work environment were still present after controlling for smoking. Thus we could conclude that smoking was an unlikely explanation for the study findings.

RISK OF DEVELOPING A DISEASE RELATED TO OCCUPATION AMONG THOSE WORKING IN THE ALUMINIUM INDUSTRY TODAY

The development of cancer is a very slow process. It may take decades from the first exposure to a carcinogenic substance to the time when the symptom appears and cancer can be diagnosed. Usually it will take 10 to 30 years or more for developing a symptomatic cancer. The present study can therefore only tell us something about the cancer risk among those employed more than 25 years ago. The risk of an occupationally related cancer among those currently working in the aluminium industry is uncertain, but is probably lower today than before 1985 due to a marked reduction in PAH exposure in the calendar period from 1985 to 1990. Exposure to PAH has been reduced by more than 70 per cent in the most heavily exposed jobs. Exposure to fluoride and dust has been reduced by more than 50 per cent compared to the levels before 1985. Still, a further reduction in the exposure levels is desirable. New cases of occupational related non-malignant respiratory diseases (potroom-asthma) are reported every year. This suggest that the hygienic efforts should be directed, not only towards PAH exposure, but in particular towards the fluoride and dust exposures.