Gastric cancer in coal miners: a case-control study in a coal mining area

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ABSTRACT In collaboration with three pathology departments a case-control study was conducted in the southern part of the Netherlands to investigate the risk of gastric cancer in coal miners. Between 1 January 1973 and 31 December 1983, 323 male patients were diagnosed as having a malignant neoplasm of the stomach. For each case a control was selected from the same pathology department, matched on year of birth and regardless of diagnosis. The archives of the Central Coal Miners Pension Fund were searched to obtain information about whether or not a patient had ever worked for a coal mining company in the Netherlands. Twenty two per cent of the patients had been registered as an underground coal miner, compared with 20% of the control group (odds ratio of 1.14, 95% confidence interval: 0.33-1.73). Those with gastric cancer who had ever worked underground in a coal mine did so for an average period of 16.9 years compared with an average of 19.7 years in the control group. The study gives no indication that the underground workers of the Dutch coal mines had a raised risk of developing a malignant neoplasm of the stomach.

Coal is of great importance to our industrialised society and will remain so in the near future. It is a major energy source for electrical power stations. Specific coals or mixtures may be carbonised into coke, which is indispensable for the iron and steel industry. Although the number of coal miners has decreased substantially during the past decades, many still work in underground coal mining all over the world. In 1983 about 300 000 workers were employed in underground coal mining operations in the European Community.¹ Various carcinogenic substances have been identified in coal, such as benz(o)pyrene and benz(a)anthracene derivatives,² but also inorganic carcinogens such as arsenic, cadmium, and chromium.³ It has also been postulated that dust in general is a risk factor for gastric cancer.⁴

Inhaled coal dust reaches the gastrointestinal tract by the pulmonary clearance system, in which the bronchial mucus is moved upwards towards the pharynx and then swallowed. Some investigators have noted a high incidence or mortality of gastric cancer in coal mining areas. In a coal mining region in Utah, United States, the incidence of gastric

cancer was three times that of the rest of the state.⁵ In a repeat study five years later, however, this high incidence of gastric cancer did not show up.⁶ The investigators concluded that, "the previous suggestion that the high incidence of gastric cancer could be related to frequent exposure to coal carrying hydrocarbons appears to be unwarranted." A British investigation also showed a positive relation between the incidence of gastric cancer and the dusty coal and textile industries,⁷ a relation reported earlier by Stocks⁸ and by Enterline in the United States.⁹ Enterline reported a standardised mortality ratio of 275 for gastric cancer in coal miners. In the United States a large follow up study of 23 000 coal miners was conducted. This 10% sample of all coal miners covered by the United Mine Workers Health and Retirement Fund on 1 January 1959 was followed up until 1971.¹⁰ During the follow up period, 129 died from gastric cancer compared with 92 expected. The investigator concluded that, "elevated gastric cancer is the third most consistent mortality finding for coal miners behind accidents and pneumoconiosis mortality."

In a recent listing of carcinogenic agents and occupations coal mining was classified as an occupational group associated with a raised risk for gastric cancer.¹¹ Some investigators have drawn attention to the possible confounding effect of other factors that

Table 1 *Distribution of the control group over eight broad disease categories*

<i>Disease category</i>	<i>No of controls</i>
No abnormality	62
Circulatory diseases	15
Respiratory diseases	31
Digestive diseases	83
Urogenital diseases	68
Diseases of skin and limbs	48
Diseases of internal secretion and sensory organs	2
Other diseases	14
Total	323

play a part in the aetiology of gastric cancer, such as socioeconomic status.^{12,13} Meyer postulated that the risk of gastric cancer among coal miners is greater in those workers whose pulmonary clearance system is not impaired by cigarette smoke.¹⁴ No evidence, however, exists in favour or against this hypothesis. Coal mining in the south east part of the Netherlands has been carried on since the twelfth century and has reached its largest scale this century. In 1950 over 50 000 workers mined underground coal. At the end of the 1960s the coal mines were closed since they could not operate profitably. Many different types of coal were mined in the area, varying from anthracite to bituminous coals. The bituminous coals were carbonised into coke. Coal was mined to depths of 3000 feet and one of the coal mines was the largest two shaft coal mine in Europe.

Because of the availability of documentation about workers who had been employed in underground coal mining and the occurrence of exposure to coal dust in the past, we regarded the area as particularly suitable for the conduct of a case-control study to investigate the risk of gastric cancer in coal miners.

Material and methods

Altogether 323 male cases of gastric cancer were obtained from three pathology departments located in the area. The cases were all histologically confirmed between 1 January 1973 and 31 December 1983. For each case a control was selected from the same pathology department with approximately the same date of birth. The controls were matched on date of birth in order that both cases and controls would have had an equal chance of working in a coal mine. Since the number of coal miners varied greatly through time, the date of birth of the cases and controls *a priori* influences the chance of having been a coal miner in the past. The average difference between the dates of birth for each matched pair was 30 days. The controls were selected regardless of their diagnosis. Table 1 gives

the distribution of the controls over eight disease categories.

Bias may occur if the control group consists largely of patients with diseases that are also related to coal mining. In the control group, however, there were no patients with diagnosed pneumoconiosis, although they had not been omitted by us. Table 2 gives the age distribution of the study population.

For all 646 patients enrolled in the study, information was obtained about underground mining work through the files of the General Mining Fund, which is a collaborative pension and disability fund for all Dutch coal mines. Each worker of the Dutch coal mines had to pay dues to this fund from his salary. Records of these payments have been accurately kept, since the retirement benefits of the coal miners depended on them. These records still exist for all workers who were employed by the Dutch mining companies and available for this study. For each person in the study the files of the General Mining Fund were searched in a standard manner. The first personal identification used in this search was the date of birth. In the case of a match on this variable the family name was compared. To check the accuracy of the collected dates of birth, the first 500 patients were checked with the population registries. Of these 500 patients, only one had a wrongly recorded date of birth. Errors in the spelling of the family names have not resulted in an underestimation of exposure, since even if the name of the patient was spelt incorrectly we were able to find his file at the General Mining Fund and subsequently obtain information about the occupational exposure to coal dust.

Results

For all 323 cases and 323 controls the archives of the General Mining Fund were searched. Table 3 shows the distribution of underground coal miners as they were observed in the 323 pairs.

The odds ratio and the 95% confidence limits were calculated by the Mantel and Haenszel method for matched pairs¹⁵; from the data given in table 3 a value of 1.14 (95% confidence limits: 0.34–1.73)

Table 2 *Age distribution of the 323 age matched pairs in the study*

<i>Age category</i>	<i>No of pairs</i>	<i>%</i>
<40	3	1
40–49	22	7
50–59	52	16
60–69	108	33
70–79	100	31
≥80	38	12
Total	323	100

Table 3 Distribution of underground coal miners within 323 matched pairs of cases and controls

	Controls		Total
	With history of underground coal mining	Without history of underground coal mining	
Cases:			
With history of underground coal mining	24	48	72
Without history of underground coal mining	42	209	251
Total	66	257	323

was obtained. To investigate the existence of a dose response relation a break down was made by duration of underground coal mining work (table 4).

The distribution of cases over the duration categories of underground coal mining did not differ from the controls and the average duration of underground coal mining for the controls was, in fact, longer than for the cases (19.7 years for the controls compared with 16.8 for the cases).

Discussion

Previous epidemiological studies of the risk of gastric cancer among coal miners have been contradictory. Some studies have supported this hypothesis and some have not. The distribution of other factors that play a part in the aetiology of gastric cancer may account for these discrepancies. One of these factors, social class, is inversely related to the risk of gastric cancer.^{16 17} Information about social class for the individual cases and controls in this study is not available. Nevertheless, it is known that the Dutch coal miners as a group earned less than the average employee before 1947 (L Kreukels, personal communication, 1984), and 79% of the coal miners in our study were employed underground before 1947. If social class had affected the findings of our study it is more likely to have resulted in an overestimation of the risk of gastric cancer rather than an underestimation. Another factor that could have influenced our results is diet since some nutritional constituents are suspect of having carcinogenic properties.^{18 19} We did not collect information on the diet of our subjects and thus cannot exclude diet as a possible

confounder in this study. Nevertheless, the risks for gastric cancer associated with dietary factors are small and, in order to function as a confounder, the diet of the coal miners must have differed greatly from that of the general population and must have had a preventive effect.

Further studies of the risk of gastric cancer and exposure to coal dust are needed, and we think that it is premature to regard exposure to coal dust as a risk for gastric cancer in man.

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References

- Coal. *Eurostatistics Monthly* 1984;1:1-6.
- Tye R, Horton AW, Rapien I. Benzo(a)pyrene and other aromatic hydrocarbons extractable from bituminous coal. *Am Ind Hyg Assoc J* 1966;27:25-31.
- Bolton NE, van Hook RI, Fulkerson W, et al. *Trace element measurements at the coal-fired Allen steam plant*. Progress Report June 1971-January 1973. (ORNL-NSF-EP-43.)
- Fox AJ, Goldblatt P, Kinlen LJ. A study of the mortality of Cornish tin miners. *Br J Ind Med* 1981;38:378-80.
- Matolo NM, Klauber MR, Gorishek WM, et al. High incidence of gastric carcinoma in a coal mining region. *Cancer* 1972;27:733-7.
- Klauber MR, Lyon JL. Gastric cancer in a coal mining region. *Cancer* 1978;41:2355-8.
- Ashley BJB. Environmental factors in the aetiology of gastric cancer. *Br J Prev Soc Med* 1969;23:187-9.
- Stocks P. On the death rates from cancer of the stomach and respiratory diseases in 1949-53 among coalminers and other male residents in counties of England and Wales. *Br J Cancer* 1962;16:592-8.
- Enterline PE. Mortality rates among coal miners. *Am J Public Health* 1964;54:758-68.
- Rockette HE. Cause-specific mortality of coal miners. *J Occup Med* 1977;19:795-801.
- Decoufle P. Occupation in Schottenfeld and Fraumeni. In: *Cancer epidemiology and prevention*. London: WB Saunders Company, 1982.
- Ames RG. Gastric cancer in coal miners: some hypotheses for investigation. *J Soc Occup Med* 1982;32:73-81.
- Creagan ET, Hoover RN, Fraumeni JF. Mortality from stomach

Table 4 Distribution (%) of the duration of underground employment in Dutch coal mines

Duration of underground employment (years)	Cases	Controls
<1	10	8
1-5	13	18
5-10	20	11
10-20	17	14
20-30	15	25
30-40	21	20
>40	4	4
Total	100	100

- cancer in coal mining regions. *Arch Environ Health* 1974;**28**:28–30.
- ¹⁴ Meyer MB, Luh GD, Sotelo JM, *et al*. Hypothesis: the role of the lung in stomach carcinogenesis. *Am Rev Respir Dis* 1980;**121**:887–92.
- ¹⁵ Fleis JL. *Statistical methods for rates and proportions*. New York: John Wiley and Sons, 1981.
- ¹⁶ Haenszel W, Kurihara M, Segi M. Stomach cancer among Japanese in Hawaii. *JNCI* 1972;**56**:265–78.
- ¹⁷ Hirayama T. Epidemiology of stomach cancer. *Gann* 1971;**11**:3–19.
- ¹⁸ Higginson J. Etiological factors in gastro-intestinal cancer in man. *JNCI* 1966;**37**:527–45.
- ¹⁹ Bjelke E. Epidemiologic studies of cancer of the stomach, colon and rectum; with special emphasis on the role of diet. *Scand J Gastroenterol* 1974;**9** suppl 31:42–53.

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- ¹ International Steering Committee of Medical Editors. Uniform requirements for manuscripts submitted to biomedical journals. *Br Med J* 1979;**1**:532–5.
- ² Soter NA, Wasserman SI, Austen KF. Cold urticaria: release into the circulation of histamine and eosinophil chemotactic factor of anaphylaxis during cold challenge. *N Engl J Med* 1976;**294**:687–90.
- ³ Weinstein L, Swartz MN. Pathogenic properties of invading micro-organisms. In: Sodeman WA Jr, Sodeman WA, eds. *Pathologic physiology: mechanisms of disease*. Philadelphia: W B Saunders, 1974:457–72.