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Preliminary study of lung cancer mortality among Western Australian gold miners exposed to silica

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Gold miners from Western Australia were surveyed in 1961. Data were collected on respiratory symptoms, smoking habits, employment history, and chest X-ray signs. Eighty-four percent of the men had smoked at some time, and 66% were current smokers. The prevalence of chronic bronchitis was over 20% at the time of the survey. A follow-up to the end of 1991 has been started which showed that, from 1969 to 1991, 999 miners died. Because vital status has not been ascertained for the whole cohort, a proportional mortality analysis was undertaken as a case-referent study. A strong effect of smoking on the risk of lung cancer was found, along with a slight, but nonsignificant increase in the lung cancer risk for the subjects employed underground for ≥ 40 years after adjustment for smoking. A complete follow-up and a full cohort analysis will enable these effects to be estimated more precisely.

Key terms Australian gold miners, chronic bronchitis, follow-up study, proportionate mortality, record linkage, smoking, tuberculosis.

The International Agency for Research on Cancer has concluded that silica is carcinogenic to animals and that there is "limited" evidence for similar effects in humans (1). The evidence supporting this classification is however not consistent (2). The evidence to date has been interpreted by some as suggesting an association between the presence of silicosis and the occurrence of lung cancer rather than simply between silica exposure and lung cancer. The justification for postulating that fibrosis is the cause of cancer rather than silica itself is not clear. Tuberculosis may also be a confounding factor in some studies. Much of this evidence comes from studies of lung cancer among subjects with silicosis, and findings are difficult to interpret because factors such as smoking are related to both the occurrence of respiratory symptoms (which may then bring subjects with silicosis to medical attention and therefore enhance the likelihood that they will be found to have silicosis) and also to the occurrence of lung cancer.

A recent extensive review has concluded that the overall evidence is sufficient, using standard criteria, to establish causality between exposure to silica and lung cancer (3), although this conclusion remains controversial. Nurminen et al (4) combined dose-response estimates from epidemiologic studies and concluded that silica-exposed workers in Australia had an average excess lifetime risk of 0.5% for lung cancer at the current estimates of quartz dust exposure.

For Kalgoorlie gold miners it has been shown that silica exposure is significantly related to evidence of airway disease (5) and also impaired gas transfer in the lungs (6). Chest X-ray abnormalities have also been shown to be associated with silica and smoking history in the same population (7). It may be that these associations reflect the presence of a common pathway of fibrosis existing between exposure and cancer. Thus the mechanism for a relationship between silica exposure or silicosis and lung cancer remains speculative.

A cohort study of 1974 Kalgoorlie Western Australia gold miners followed from 1961 to 1975 estimated a significantly raised standardized mortality ratio (SMR) of 1.4 for lung cancer; the increased risk was however thought to be due to a higher prevalence of smoking among miners than among other men (8). The aim of this study was to extend the follow-up on this original cohort from 1975 to 1991 and establish whether there was an increased risk of lung cancer for Kalgoorlie gold miners in association with duration of underground employment, smoking, and preexisting bronchitis.

Subjects

There were 1971 subjects who participated in surveys of respiratory symptoms and lung function in Kalgoorlie in 1961 and 1962, and they were included in the current study. Three subjects from the previous report (8) were excluded because their identifying information was lost.

Methods

Records from the surveys held on microfiche were abstracted to provide name, gender, date of birth, response to the questionnaire of the British Medical Research Council on respiratory symptoms, height, job description, duration and time spent at work, smoking

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history, and chest X-ray category of pneumoconiosis. Bronchitis was defined as positive answers to questions about cough or phlegm for at least three months in the year. All the subjects were traced via Western Australia death records from 1969 to 1991 using computerized linkage procedures (9). A proportional mortality analysis was carried out whereby the cases were all deaths from lung cancer and the referents were all deaths from other causes excluding deaths from tuberculosis, other respiratory diseases, and cancers of the larynx or unknown primary site. The latter causes of death were discounted because they may include diseases associated with exposure to silica. This approach differs from the usual proportional mortality analysis, in which expected numbers are calculated, but has been shown to be directly equivalent (10). Analysis was by unconditional logistic regression using the computer program EGRET (11), with age at death, smoking habits, duration of underground employment, and presence of bronchitis at the time of the survey as the covariates.

Results

Table 1 lists 157 deaths excluded from the analysis as being possibly related to silica exposure. There were 98 deaths from lung cancer and 744 reference deaths from other causes. The average age of the study subjects at death was 71 years with a range from 46 to 92 years. The total duration of underground employment ranged from 0 to 48 years.

Table 2 shows that 62% of the cases had bronchitis at the time of the survey compared with 50% of the referents. One case (1%) had never smoked, compared with 113 (15%) referents. The cases had also worked longer underground than the referents, though not significantly so, and fewer of them had never worked underground (20% compared with 24%).

As seen in table 3, there was a strong effect of smoking habit on the risk of lung cancer. The effect of duration of underground employment on the risk of lung cancer appeared to be limited to those employed underground for 40 or more years and was not statistically significant. Because only one lung cancer death occurred among the nonsmokers, the reference category for smoking was changed to smoking less than 15 cigarettes per day to avoid instability in the relative risk estimates. For comparison with other studies, however, estimates with the never smoked group as the base line could be made by dividing the relative risks for all other categories by that for the never smoked group (ie, 0.06). Without adjustment for smoking, the effect of duration of employment was slightly stronger, but again only in the 40 years or more employment group [relative risk 2.5, 95% confidence interval 0.9—7.0). The presence of bronchitis at the time of the initial survey and age at death were not associated with the risk of lung cancer after adjustment for smoking habit.

As a further comparison with previous studies, a cross-sectional analysis indicated a highly significant, mutually adjusted effect of both smoking habit and duration of employment on the prevalence of bronchitis at the time of the survey.

Discussion

Although this study must be considered preliminary, analyses carried out in this way are often a good guide to the results expected in more complete studies in which full follow-up has been completed (12). This study has shown a strong effect of smoking on the relative risk of lung cancer and a possible effect of duration of underground employment among subjects employed for 40 years

Table 1. Deaths among Western Australian gold miners in 1969—1991.

	N
Exclusions	
Pneumoconiosis	37
Other respiratory	101
Tuberculosis	5
Laryngeal cancer	6
Cancer (unknown primary)	8
Cases	
Lung cancer	98
Referents	
Ischemic heart disease	340
Other circulatory disease	179
Other cancer	82
Accidents, poisoning and violence	39
Other causes	104
Total	999

Table 2. Characteristics of the cohort.

	Cases[a] (N = 98)		Referents[b] (N = 744)	
	Number	%	Number	%
Bronchitis at initial survey	61	62	370	50
Smoking habit				
Never smoker	1	1	113	15
Ex-smoker	10	10	130	17
Current smoker				
1—14 cigarettes/day	21	21	135	18
15—24 cigarettes/day	44	45	254	34
≥ 25 cigarettes/day	21	21	95	13
Pipe or cigar only	1	1	17	2
Duration of underground employment				
None	20	20	177	24
0—4 years	8	8	67	9
5—9 years	7	7	54	7
10—19 years	19	19	130	17
20—29 years	21	21	181	24
30—39 years	17	17	114	15
≥ 40 years	6	6	21	3

[a] Mean age at death 69 (SD 8) years.
[b] Mean age at death 71 (SD 9) years.

Table 3. Relative risks of lung cancer, all variables included together in one model.

	Relative risk	95% confidence interval
Smoking habit		
Never smoker	0.06	0.01—0.4
Ex-smoker	0.5	0.2—1.2
Current smoker		
1—14 cigarettes/day	1.0	
15—24 cigarettes/day	1.1	0.6—1.9
≥ 25 cigarettes/day	1.4	0.7—2.7
Pipe or cigar only	0.4	0.05—3.1
Duration of underground employment		
None	1.0	
0—4 years	0.9	0.4—2.1
5—9 years	0.9	0.4—2.3
10—19 years	1.1	0.6—2.3
20—29 years	0.9	0.4—1.7
30—39 years	1.1	0.6—2.3
≥ 40 years	2.3	0.8—6.5

or more underground. Since all the subjects employed underground for 40 or more years in 1961 would have worked in mines during periods when little if any industrial hygiene precautions were taken, they were likely to have been exposed to very dusty conditions (13). The fact that 4% of all deaths were due to silicosis is consistent with this assumption.

Further information needs to be obtained before this study can reach more definite conclusions, and complete follow-up will enable a more powerful analysis. Full vital status follow-up requires manual searching of all Australian public and health records and will require at least 12 months. Data on the intensity of exposure have been collected in periodic surveys of respirable dust in the different mines, and this information will permit estimates of average and cumulative dust exposure for all the subjects. Changes assessed from compulsory periodic miners' X rays held in perpetuity at the Perth Chest Clinic will also enable us to provide an estimate of the effect of established silicosis on the risk of cancer in this group without the possible selection bias involved for subjects with compensated silicosis. The effects of dust exposure on the incidence of radiographic silicosis will also be assessed.

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