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An update of cancer mortality among chrysotile asbestos miners in Balangero, northern Italy

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Abstract

The mortality experience of a cohort of chrysotile miners employed since 1946 in Balangero, northern Italy was updated to the end of 1987 giving a total of 427 deaths out of 27 010 man-years at risk. A substantial excess mortality for all causes (standardised mortality ratio (SMR) = 149) was found, mainly because of high rates for some alcohol related deaths (hepatic cirrhosis, accidents). For mortality from cancer, however, the number of observed deaths (82) was close to that expected (76·2). The SMR was raised for oral cancer (SMR 231 based on six deaths), cancer of the larynx (SMR 267 based on eight deaths), and pleura (SMR 667 based on two deaths), although the excess only reached statistical significance for cancer of the larynx. Rates were not increased for lung, stomach, or any other type of cancer. No consistent association was seen with duration or cumulative dust exposure (fibre-years) for oral cancer, but the greatest risks for laryngeal and pleural cancer were in the highest category of duration and degree of exposure to fibres. Although part of the excess mortality from laryngeal cancer is probably attributable to high alcohol consumption in this group of workers, the data suggest that exposure to chrysotile asbestos (or to the fibre balangeroite that accounts for 0·2-0·5% of total mass in the mine) is associated with some, however modest, excess risk of laryngeal cancer and pleural mesothelioma. The absence of excess mortality from lung cancer in this cohort is difficult to interpret.

The mortality up to 1975 of a cohort of asbestos workers in the only open air asbestos mine still active in Europe, at Balangero (near Turin, northern Italy), was reported in 1979.[1] The analysis, based on a total of 332 deaths, showed an excess mortality from all causes (standardised mortality ratio (SMR) = 155), mainly due to hepatic cirrhosis, accidents, and other causes potentially related to alcohol, although a substantial excess was also seen for cardiovascular diseases.

By contrast, there was no significant excess mortality from all cancers (50 observed v 47 expected deaths), nor for cancer of the lung or pleura (11 observed v 10·4 expected deaths) but a significantly increased SMR for laryngeal cancer was found (six observed v 1·9 expected deaths).

In this paper we present the results of 12 more years of follow up on this cohort, to provide further quantitative information on the risk of cancer associated with mining of chrysotile asbestos.

Subjects and methods

The cohort comprised men who had worked for at least one year at the factory between 1946 and 1987. Of these, 36 (3%) who could not be traced were excluded leaving 1058 subjects under study.

Dates of birth and employment, last known address, and job categories were obtained from personnel records at the factory. Quantification of the data on exposure was based on cumulative dose of inhaled fibres expressed as fibre-years. This was estimated from environmental measurements carried out from 1969 onwards, and from artificially recreated working conditions for earlier periods.[2]

Vital state after termination of employment was ascertained through population registers and copies of death certificates were obtained.

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up began on 1 January 1946 and ended on 31 December 1987. A total of 427 deaths was registered in this period, which encompassed 27 010 man-years of observation.

Expected numbers of deaths were computed using national death rates for each five year calendar period and age group. National numbers of certified deaths for each cause and quinquennium of age are published by the Central Institute of Statistics (ISTAT) from 1955.[3,4] Rates for the late 1950s were applied to the period 1946-54. Observed and expected numbers were tabulated by age at first employment, duration of employment, period since start and end of employment, and estimated cumulative dust exposure.

As retirement or change of job may have been due to the disease itself in some cases, employment dates were lagged by one year in calculating exposures. Changing this to two or three years did not appreciably modify the results.

Results

Table 1 shows the observed and expected numbers of cancer deaths by duration of employment in the mine. The SMR was increased for oral (231), laryngeal (267), and pleural (667) cancer, although this was significant only for laryngeal cancer (eight observed v three expected deaths, $p < 0.05$). The SMRs for alcohol related diseases are probably overestimated slightly since national mortality rates were used to compute expected numbers. In the mid-1970s the province of Turin had SMRs compared with the whole of Italy of 133 for oral cancer, 117 for laryngeal cancer, and 115 for hepatic cirrhosis,[5,6] and an excess mortality from laryngeal cancer was evident in the general population round Balangero.[6] Mortality in the cohort was not increased for lung, stomach, or any other type of cancer. For these sites, the use of national mortality rates should not have introduced material bias, as the SMR of the province of Turin was 99 for stomach cancer and 93 for lung cancer.[4]

No association with duration of exposure was found for oral cancer. Risks for cancers of the larynx and pleura were highest in the categories with the longest duration of exposure (five observed v 1·1 expected for larynx, two observed v 0·2 expected for pleura), although neither showed a statistically significant trend with increasing duration. The SMR for total cancer mortality was 108 (95% confidence interval (CI) = 86-135).

Table 2 shows results for selected non-neoplastic causes of death and mortality from all causes. An excess in total mortality existed, with 427 observed v 286·3 expected deaths (SMR = 149), together with substantial excesses in mortality from asbestosis (16 observed deaths), hepatic cirrhosis, and other causes such as accidents (47 observed v 24·3 expected deaths), and unspecified cardiovascular diseases (100 observed v 61·4 expected deaths). None of these causes, however, showed a duration risk relation and the SMRs for cirrhosis and accidents were highest for the workers with the shortest duration of employment.

Table 3 gives mortality from cancers of the larynx, lung, pleura, from all cancers, and from all causes in separate categories of age at first exposure, time since first and last exposure, and cumulative dust exposure. For laryngeal cancer, the risk was apparently greater for workers exposed at a younger age, and within shorter periods since first or last exposure. It should be noted, however, that these three time factors are closely interrelated, and it is difficult, on the basis of only eight deaths, to distinguish which, if any, is the main component. There was a trend towards greater risk with increasing cumulative dust exposure that approached significance ($p = 0.05$, one sided).

On the basis of 22 observed deaths, no consistent

Table 1 Mortality experience from selected cancer sites in a cohort of chrysotile asbestos miners in Balangero, northern Italy. Expected numbers are based on national death rates in each five year calendar period and age group. Deaths and man-years beyond age 80 are excluded.

	No of observed and expected deaths by duration of exposure (y)											
	< 10			10-20			> 20			Total		
Cause of death	O	E	O/E	O	E	O/E	O	E	O/E	O	E	O/E
Oropharyngeal cancer	5	1·1	4·5	1	0·5	2·0	0	0·9	-	6	2·6	2·3
Gastric cancer	4	5·8	0·7	5	2·8	1·8	3	4·0	0·8	12	12·7	0·9
Intestinal cancer	5	2·9	1·8	0	1·1	-	1	2·1	1·3	6	6·6	0·9
Liver cancer	0	0·7		0	0·1		1	0·7	1·3	1	1·7	1·0
Laryngeal cancer	3	1·3	2·3	0	0·6	-	5	1·1	4·6	8	3·0	2·7
Lung cancer	10	8·5	1·2	4	3·8	1·1	8	7·6	1·2	22	19·9	1·1
Pleural cancer	0	0·1		0	0·0		2	0·2	10·0	2	0·3	6·7

Table 2 Mortality experience from selected non-neoplastic diseases and all causes of death in a cohort of chrysotile asbestos miners in Balangero, northern Italy. Expected numbers are based on national death rates in each five year calendar period and age group. Deaths and man years beyond age 80 are excluded

	No of observed and expected deaths by duration of exposure (y)											
	< 10			10-20			≥ 20			Total		
Cause of death	O	E	O/E	O	E	O/E	O	E	O/E	O	E	O/E
Ischaemic heart disease	16	20·6	0·8	11	9·8	1·1	10	15·6	0·6	37	45·9	0·8
Stroke	20	13·9	1·4	2	6·4	0·3	9	9·8	0·9	31	30·1	1·0
Asbestosis	3	0	..	5	0	~	8	0	..	16	0	..
Chronic respiratory disease	8	5·6	1·4	3	2·6	1·2	5	4·4	1·1	16	12·6	1·3
Hepatic cirrhosis	23	8·2	2·8	11	3·2	3·4	11	5·4	2·0	45	16·8	2·9
Accidents and violence	33	12·8	2·7	8	5·7	1·4	5	5·7	0·9	47	24·2	1·9
All causes	225	133·6	1·7	83	62·1	1·4	117	91·6	1·3	427	280·3	1·5
Man years (Number of subjects)	15 025 (4591)			6643 (2931)			5344 (506)			27 010 (1058)		

O = Observed deaths, E = expected deaths

pattern of risk for lung cancer was evident for any of the time factors considered, nor for cumulative exposure to fibres. The two deaths from pleural cancer were in the highest categories of cumulative dust exposure.

None of the temporal factors considered or the measure of cumulative exposure to dust showed a clear pattern of risk with total mortality from cancer or all causes of death.

Discussion

The update on data for this cohort of chrysotile miners confirmed a substantial excess in total mortality, and the absence of important associations with mortality from cancer. The SMR for total mortality from cancer was only just above unity, and no significant excess was found in mortality from lung cancer.

This varies from the pattern commonly found in cohorts of workers, as total mortality, and particularly mortality from cardiovascular disease, tend to be lower than expected (the healthy worker effect), whereas mortality from cancer is usually less affected by this selection mechanism.[1] A possible explanation for this peculiarity in the current study may relate to the drinking habits of the miners.[1]

For the two deaths reported as due to pleural mesothelioma, the diagnosis was based on clinical and radiological findings and examination of pleural fluid in one case and on histological examinations of specimens from thoracotomy in the other. The expected value for mesothelioma was 0·3. The SMR is of borderline statistical significance, and this, together with the observation that both deaths were found among the group of workers exposed for more than 20 years, suggests that exposure to this

Table 3 Mortality experience from selected cancer sites and total mortality in a cohort of chrysotile asbestos miners in Balangero, northern Italy according to various exposure measures. Expected numbers are based on national death rates in each five year calendar period and age group. Deaths and man-years beyond age 80 are excluded

	Larynx			Lung			Pleura			All cancer			All causes			Man years (No of subjects)
Variables	O	E	O/E	O	E	O/E	O	E	O/E	O	E	O/E	O	E	O/E	
Age at first exposure (y)																
< 30	5	1·5	3·6	8	10·1	0·8	1	0·1	10·0	34	34·3	1·0	185	139·1	1·5	17 478 (6249)
≥ 30	1	0·6	1·9	13	9·9	1·3	1	0·1	10·0	48	41·9	1·1	244	167·3	1·5	9532 (4291)
Time since first exposure (y)																
< 20	2	0·5	4·0	3	2·6	1·2	0	0·0	..	14	13·2	1·1	130	61·0	1·8	14 983 (5327)
20–30	2	0·8	2·5	7	4·7	1·5	1	0·1	10·0	22	19·6	1·1	119	73·5	1·6	6325 (2139)
30	4	1·7	2·4	11	12·6	1·0	1	0·2	5·0	16	43·4	1·1	196	119·9	1·3	5702 (5112)
Time since last exposure (y)																
During exposure	2	0·5	4·0	2	2·7	0·7	1	0·0		11	11·5	1·0	99	47·2	1·5	13 651 (2290)
< 10	3	0·7	4·3	6	5·5	1·1	1	0·1	10·0	25	16·9	1·5	109	61·6	1·8	5963 (2604)
10	1	1·8	1·7	14	12·7	1·1	0	0·2		36	47·9	1·0	219	137·6	1·6	9396 (5844)
Cumulative dust exposure (fibre-years)																
< 150	1	0·3	3·4	4	5·1	0·8	0	0·1		13	19·1	0·7	93	70·9	1·3	9036 (4410)
150–800	2	0·9	2·2	8	6·3	1·3	1	0·1	10·0	27	23·8	1·1	162	91·2	1·8	8195 (3227)
800	3	1·3	2·4	10	8·7	1·1	1	0·1	10·0	41	33·3	1·2	172	121·2	1·4	9279 (3211)

chrysotile asbestos, or to other fibres contaminating chrysotile, or both, is associated with moderate, excess risk of mesothelioma. Similarly, it was suggested that the excess risk of mesotheliomas found among Quebec chrysotile workers may have been due to contamination with tremolite.[8,9] This suggestion was also made for mesothelioma cases found in Cyprus.[10]

In our study, examination of several samples of chrysotile from the mine ruled out the presence of contamination with fibrous amphiboles at detectable concentrations. A fibrous silicate (balangeroite) was characterised, however, consisting of brown, rigid, and brittle xyloid fibres with a complex structure similar to gageite, usually intergrown with chrysotile.[11]

Compagnoni *et al*[11] reported the empirical formula for the unit cell of balangeroite to be:

$$(Mg_{n}Fe^{2+}_{n}Fe^{3+}_{n}Mn^{2+}_{n}\square_{n})_{42}Al_{n}Ca_{n}Cr_{n}Ti_{n}Si_{n}O_{n}(OH)_{n}$$

Figure 1 shows the morphological aspects of these fibres from scanning electron microscope studies. The smallest diameters for elemental balangeroite fibres are of the same order as those of amphibole asbestos—namely, 0·1–2·0 μ, by contrast with chrysotile, the fibrils of which have diameters as low as 0·02 μ.

Figure 2 shows the spectrum resulting from energy dispersive x ray analysis of balangeroite, with peaks of Fe and Mn, two cations prominent in its chemical composition.

Balangeroite accounts for 0·2–0·5% of the total mass of samples of chrysotile as commercialised from the Balangero mine. Nothing is at present known about its adverse effects, although they can be suspected on the basis of its fibre dimensions being similar to those of amphiboles. A contribution from these fibres in inducing the two cases of mesothelioma cannot, therefore, be ruled out.

The absence of excess mortality from lung cancer is more difficult to interpret, as there is no clear evidence that chrysotile causes a smaller risk than amphibole asbestos,[12,13] although excess of lung cancer was low or absent in workers using only chrysotile, for example, those employed in production of friction material.[14,15] In other groups of chrysotile miners, such as the large Quebec cohort,[16] the SMR for respiratory cancers was in agreement with the results of our study only in the overall data (SMR = 125, based on 230 observed v 184 expected deaths); the estimated excess risk for Quebec miners was 2·6 in the subgroup with the highest exposure and duration of employment, by contrast with our study where there was little increased risk even in the most heavily exposed workers.

Substantial excesses for lung cancer, on the other hand, were seen in textile plants using chrysotile,[17,18]

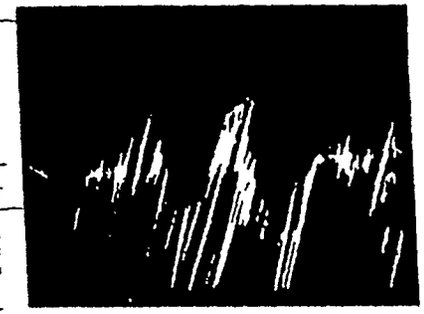

Figure 1 A scanning electron microscope view of a typical balangeroite fibre consisting of elemental units with various diameters ranging from 0·2 to 1·5 μ

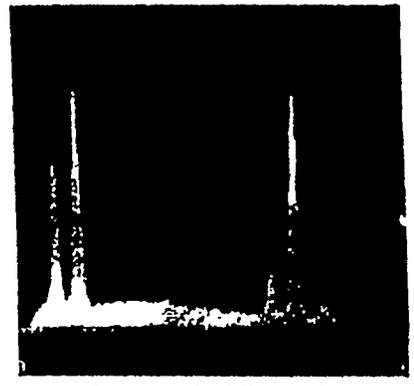

Figure 2 Element peaks identified by energy dispersive x ray analysis. The peaks, ranging from 0–9 are: 1·2 Mg, 1·8 Si, 4·4 Ca, 5·8 Mn (primary peak), 6·4 Mn (secondary peak) and Fe (primary peak), 7·1 Fe (secondary peak)

these factories.[17,18] The results of the present study, none the less, are compatible with a risk of lung cancer some 60% greater than normal (upper 95% CI of the SMR = 167), and probably even with a somewhat higher risk, as rates in the late 1940s were lower than those of the mid-1950s utilised for the computation of expected values in our analyses. The low incidence of lung cancer found in our cohort, particularly in men whose cumulative exposure exceeded 800 fibres per ml year, is inconsistent with the dose specific risk estimate proposed by Doll and Peto (a 10% increase in relative risk per fibre

further unusual aspect of these data is the ratio of asbestosis to lung cancer, although this can be partly explained in terms of overdiagnosis of asbestosis

Exposure to asbestos has been linked to increased risk of laryngeal cancer (although conclusions were not definite)[9 21] but there was no clear evidence for increased risk of cancer of digestive sites.[21] As mortality was increased for alcohol related disease, including cancer of the oral cavity, pharynx, liver, hepatic cirrhosis, and accidents in this cohort, it is conceivable that at least part of the excess risk for laryngeal cancer can be attributed to high alcohol consumption Comparison of the duration risk relation for hepatic cirrhosis and laryngeal cancer, however, suggests that some direct relation with occupational exposure is possible For laryngeal cancer the SMR was 158 for less than 20 years of exposure and 456 for longer duration, whereas for hepatic cirrhosis the SMR was greater for workers with short (343) rather than long (204) exposure

Thus although the number of deaths from cancer were still too limited to allow us to draw definite conclusions, updated analysis of the mortality of this cohort of chrysotile miners and inspection of duration and amount of exposure indicates that some excess of laryngeal and pleural cancer (but not of other causes of death except asbestosis) may be related to occupational exposure. On the other hand, there was little evidence of excess mortality from lung cancer. This finding, and the substantial excess in non neuplastic mortality, possibly explained by alcohol related deaths, represent peculiarities for this cohort of chrysotile miners

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Cancer risk among glass factory workers: an excess of lung cancer?

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Abstract

A total of 3749 workers employed for at least three months in two Finnish glass factories (cohorts A and B) were followed up for cancer in 1953–86 through the Finnish Cancer Registry. In cohort A (1353 men, 1261 women), 106 primary cancers were diagnosed among men, and their standardised incidence ratio (SIR) for all cancers was 99. Among women the risk was low (65 cases, SIR 64). In cohort B (450 men, 685 women), the relative risk of cancer was close to unity for both men (57 cases) and women (75 cases). The risk of cancer was analysed by primary site, type of work, years since first exposure, and age at diagnosis. The only significantly increased risks were those of lung cancer among men (SIR 130, 95% CI 100–167, cohorts A and B combined), and skin cancer among glass blowers (SIR 625, 95% CI 129–1827). An increased risk of lung, stomach, and colon cancer as well as of brain tumours has been reported in previous studies. It is postulated that the excess risk of lung cancer, detected in this study, can also be accounted for by lifestyle, and not only by possible occupational exposures, because a similar excess risk of lung cancer has been found previously for all industrial workers in Finland. Although the risk of stomach cancer in this study was increased among glass blowers, it was not high in the largest groups of plain glass workers. The risks of tumours of the central nervous system and colon were not increased either.

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Little of a definitive nature is known about the risk of cancer for glass factory workers, although several potential carcinogens, such as arsenic, asbestos, and chromium, are used or have been used in the production of glass.[1] There are two Swedish case-referent studies in which an increased risk of death from cancers of the lung,[2 3] stomach,[2 3] and colon[3] were found The International Agency for Research on Cancer monograph *Silica and some silicates*[4] refers to only one study indicating a raised risk of lung cancer among glass workers.[5] Among men a significant positive association was found between mortality from lung cancer and glass manufacturing in Alameda County, California.[6] In a Nordic register linkage study of occupational groups exposed to silica dust an increased risk of lung cancer was detected among Danish glass workers, but not among men in the other Nordic countries working in manufacture of glass, porcelain, ceramics, and tiles.[7] In a case-control study conducted in urban Shanghai the largest excess risk of lung cancer found for women was among glass products workers.[8] There are Swedish census based record linkage studies indicating significantly increased risks for meningiomas[9] and gliomas[9] among Swedish glass, porcelain, or ceramic workers A high risk of brain cancer among workers manufacturing glass products has also been reported in Illinois.[10]

The purpose of this cohort study was to assess the risk of cancer among workers in the plain glass manufacturing industry

Subjects and methods

The workers in two glass factories (A and B) in southern Finland were followed up for incidence of cancer in 1953-86 The cohorts were formed using the factory's employment records Only workers with at least three months of continuous employment were included

Cohort A was collected in 1973, and consisted of 2614 workers (1353 men, 1261 women) who had been employed between 1 January 1953 and 31 December 1971, although employment may have started earlier. The workers in this factory were divided into three