

Mesothelioma and fiber type in three American asbestos factories — Preliminary report

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MC DONALD AD, FRY JS. Mesothelioma and fiber type in three American asbestos factories — Preliminary report. *Scand j work environ health* 8 (1982): suppl 1, 53—58. Preliminary findings are reported from three cohort studies in two asbestos factories (A and B) where chrysotile only was processed and a third (C) where chrysotile, amosite, and crocidolite were used. A total of 10,763 men and 3,118 women has been studied, of whom 97 % and 89 %, respectively, have been traced and 36 % and 16 % have died. Death certificates have so far been obtained and coded for 89 % of the deaths. The standardized mortality ratios (SMRs) for persons employed less than a year varied greatly between plants. For men employed at least 1 a, an SMR of 129 for all causes and one of 285 for respiratory cancer were found in the chrysotile textile plant (A). The experience of respiratory cancer in this textile plant appears much worse in relation to fiber exposure levels than that observed in chrysotile mines and mills. Other findings in the three plants await clarification by analyses of exposure-response relationships. Among 2,341 deaths from the two chrysotile factories there has been one mesothelioma (0.4 per 1,000); among 1,429 deaths at factory C, which used mixed fibers, there have been 18 (12.6 per 1,000). This finding supports much other evidence that amphiboles are mainly responsible for mesothelioma, whereas chrysotile has little or no mesothelioma-producing potential.

Key terms: amosite, amphiboles, chrysotile crocidolite, occupational cohort mortality analysis.

When this study was planned in 1976, it seemed clear that the three main mineral types of asbestos used commercially differed substantially in their mesothelioma-producing potential, being highest for crocidolite, intermediate for amosite, and much lower for chrysotile (13). For two amphiboles, crocidolite and amosite, information was mainly derived from cohort studies of persons employed in manufacturing (14) and insulation (17); many of these exposures were to amphiboles mixed with a large proportion of chrysotile. The effect of crocidolite alone was observed in persons who had packed military gas masks with filters containing this material

(7, 10), and recently in miners and millers of crocidolite in Western Australia (6). The evidence for chrysotile alone has come mainly from the primary industry — mining and milling (12). No mesothelioma was found in two small plants in which only chrysotile had been manufactured (3, 18), but no large chrysotile plant had been studied. Therefore it remained uncertain whether, during processing, the much finer chrysotile fibers produced might be more liable to cause mesothelial tumors than the relatively coarse fibers in the mills.

Recently, strong evidence on asbestos fiber type and mesothelioma was found in an analysis of the mineral fiber content of lung tissue in a case-referent study of malignant mesothelioma in North America (11). Cases and referents had similar quantities of chrysotile, but there was a substantial excess of amosite and crocidolite in the cases compared with the referents.

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The present study was planned to obtain further information on the health effects (especially mesothelioma) of manufacturing chrysotile asbestos. Two large chrysotile manufacturing plants — one (A) a textile factory and the other (B) a friction materials factory — were studied; for comparison, a third factory (C), which manufactured textiles and friction materials using chrysotile, crocidolite and amosite, was included. Our aims were to compare mortality from malignant mesothelioma in the three plants and to estimate exposure-response relationships for malignant respiratory and digestive diseases and for nonmalignant respiratory disease. Ninety-five percent of the total of 13,881 persons in the three cohorts have so far been traced; death certificates have been obtained and coded for 89 % of the 4,234 deaths reported. Work is still proceeding on the tracing and on the quantifying of fiber exposures. In this preliminary report we describe (i) initial findings on mortality and some of the problems raised and (ii) the deaths from mesothelioma.

Materials and methods

The factories

Factory A, in South Carolina, manufactured yarn, cloth, packings, and gaskets (some rubberized) using chrysotile from Canada and Rhodesia. A very small amount of crocidolite yarn was imported in the early 1950s and handled in one location only. Factory B, in Connecticut, manufactured brake linings, other friction materials, and paper from chrysotile, mainly from Canada. A little anthophyllite was used from 1957 for making paper discs and bands. Factory C, in Pennsylvania, manufactured asbestos textiles, much of the output later being processed into friction materials, packings, and gaskets. In this plant, since 1925, amosite and some crocidolite were used in addition to chrysotile.

The cohorts

From the personnel files, all employees whose social security (SS) numbers were recorded and who had worked in the

plants for one calendar month or more before 1 January 1959 were listed. All persons whose SS number and surname were entered at any time in Social Security Administration (SSA) files were accepted for study. These totaled 2,565 men and 1,182 women in factory A, 4,028 men and 931 women in factory B, and 4,170 men and 1,005 women in factory C.

The cohorts in factories B and C were very similar in size (4,959 and 5,175), in proportion of males (both 81 %), in color (nearly all white), and in the period in which they were first employed, 21 and 19 %, respectively, being employed before 1938 and 54 and 55 %, respectively, between 1938 and 1948. The cohort from factory A was smaller (3,747) and had a higher proportion of women (32 %) and a large proportion (19 %) of blacks (668 males and 27 females).

Tracing

The vital status of the cohort members on 31 December 1977 was sought. The methods used will be detailed elsewhere. Of 10,763 males in the three cohorts, 10,401 (96.6 %) were traced and 3,784 (36.4 %) had died (table 1). Rather fewer females were traced, and their mortality was lower (16.2 %).

To date, death certificates have been received for 3,770 (89 %) of the deaths, and the registered cause coded by a qualified nosologist, using the seventh revision of the International Classification of Diseases (ICD). Certificates for some 200 (5 %) deaths await copying or coding, and the remainder are still being sought.

Identification of malignant mesothelioma

It is impossible to identify malignant mesotheliomas simply by the ICD (7th revision) code. Primary malignant tumors of the peritoneum should be identified by code 158, but those of the pleura are included with malignant tumors of the trachea, bronchus, and lung under codes 162 and 163. If the term "malignant" is omitted by the certifying doctor, causes are classified (correctly) under benign tumors of connective tissue (ICD 227) or other unspecified organs and tissues (ICD

229). So that all cases in which a diagnosis of mesothelioma was given as the cause of death could be identified, all certificates were inspected by one of the authors (ADM). One case only was found in factory A, none in factory B, and 18 in factory C. In one additional case from factory C, a benign pleural mesothelioma was mentioned as a contributory cause of death. It was accepted as a benign tumor and not included with the malignant mesotheliomas.

Statistical analysis

With the use of age- sex- and cause-specific deaths and populations for the three states, standardized mortality ratios (SMRs) were calculated according to the method of Hill (5). For South Carolina, SMRs were calculated separately by color but not in the other two states. The 11 % of deaths so far without a known cause were allocated proportionally. Data for the armed services were not included in the state vital statistics, so persons who died in active service were treated as being lost from view at that date. For persons

employed before 1938, person-years of observation were started on 1 January 1938. To allow for the long periods of latency in asbestos-related diseases, the SMRs were calculated from 20 a from first employment.

Findings

The SMRs for all causes of death are shown in table 2. The cohorts comprised persons with a wide range of duration of employment. One-third had been employed less than 1 a, whereas only 21 % of the men and 15 % of the women had worked for 20 or more years. For reasons yet unknown, SMRs for persons who worked for less than a year differed enormously between plants. For men who had worked at least 1 a, the highest SMR (128.6) was in the chrysotile textile factory (A) and the lowest (105.9) in the chrysotile friction materials factory (B).

We know that the environmental exposure in factory C was somewhat higher than in factory A and both were higher than in factory B. The SMRs were, there-

Table 1. Results of tracing in the three cohorts.

	Factory A (chrysotile)	Factory B (chrysotile)	Factory C (mixed fibers)
Men			
Total	2,565	4,028	4,170
Traced (% of total)	2,450 (95.5 %)	3,890 (96.6 %)	4,061 (97.4 %)
Dead (% of traced)	866 (35.4 %)	1,508 (38.8 %)	1,410 (34.7 %)
Women			
Total	1,182	931	1,005
Traced (% of total)	937 (82.3 %)	848 (91.1 %)	948 (94.3 %)
Dead (% of traced)	157 (16.1 %)	122 (14.4 %)	171 (18.0 %)

Table 2. Standardized mortality ratios for all causes of death of men 20 or more years from first employment.

Factory	Length of employment ^a	
	< 1 a	≥ 1 a
A Chrysotile (textiles)		
White	96.4 (133.8)	128.8 (209.7)
Nonwhite	49.2 (71.2)	80.0 (128.2)
B Chrysotile (friction materials)	131.2 (216.5)	105.9 (560.9)
C Mixed fibers (textiles and friction materials)	88.9 (204.8)	109.5 (555.1)

^a Expected deaths in parentheses.

Table 3. Standardized mortality ratios (SMRs) for white males employed at least 1 a in chrysotile textile factory A, 20 or more years from first employment.

ICD ^a number	Cause of death	SMR	Expected deaths
140—209	All malignant disease	168.4	35.8
150—159	Digestive	82.0	8.3
160—264	Respiratory	285.3	14.1
Remainder	Other	98.7	13.4
330—334	Cerebrovascular	104.0	17.8
400—443	Cardiovascular	114.3	93.2
800—989	Accidents	85.6	18.3
Remainder	All other	154.7	43.9
	All causes	128.8	209.7

^a ICD = International Classification of Diseases (Seventh revision).

fore, not those which we expected to find; this result caused us to check carefully for errors in the population and death data for each state. No mistake was found, but we observed that age- and cause-specific rates were lower in Connecticut than in Pennsylvania. For curiosity we applied Connecticut rates to cohort C and Pennsylvania rates to cohort A. The result was SMRs (all causes) of 100 for the men in factory B, and 118 for those in factory C.

The SMRs for textile plant A are shown in table 3. Persons employed 1 a or more had raised SMRs for malignant disease, wholly attributable to respiratory cancer, and for the group "all other," which included nonmalignant respiratory disease (ICD 440—470). The SMR for respiratory cancer in this factory was 224.6 for men who worked 1—4 a (expected 4.7 deaths) and 314.9 for those who worked 20 or more years (expected 5.8 deaths).

In the friction materials plant (B) the respiratory cancer SMR for 1—4 a of employment was 149.3 (expected 14.1 deaths), and for 20 or more years of employment 168.4 (expected 15.5 deaths). In factory C the corresponding SMRs were 40.8 (expected 10.2 deaths) for 1—4 a of employment and 139.8 (expected 15.0 deaths) for at least 20 a of employment. Ignoring the levels of the SMRs which remain difficult to interpret, their relativities suggest that respiratory cancer was related to exposure in factory C, but not in factory B. Although the cohorts of women were small, high SMRs for respiratory cancer

were found for factories A, 234.4 (expected 2.8 deaths), and C, 347.9 (expected 2.7 deaths), but not for factory B, SMR 52.1 (expected 2.5 deaths).

The distribution of mesothelioma deaths among the three plants was striking — 18 cases (1.26 %) among 1,429 deaths in factory C, compared with one case (0.04 %) among 2,341 deaths in factories A and B combined. Eight mesotheliomas were given the ICD code 277 (benign connective tissue neoplasms); two were coded 199 (malignant, other and unspecified sites). In factory C, 37 (2.6 %) additional deaths were given this code (ICD 199) compared with 32 (1.4 %) in the two chrysotile plants (A and B) combined. It thus seems possible that among the deaths in factory C, some may have been unrecognized mesotheliomas, especially as they included such diagnoses as "cancer of the abdominal cavity." The true proportion of deaths from mesothelioma in the chrysotile factories (A and B) compared with the mixed factory C may therefore be even greater than the 1:30 (0.04:1.26) observed.

Discussion

Since the present research was planned, a smaller cohort in the same chrysotile textile plant (A) was studied by Dement et al (2), who made use of data collected in 1968 by the National Institute for Occupational Safety and Health. Findings for 768 white male employees, already reported, have shown a linear exposure-response relationship with respiratory cancer, with much higher SMRs, dose for dose, than previously observed by Henderson & Enterline (4) for asbestos factory workers or by McDonald et al (12) for chrysotile miners and millers. The SMR of 285.3 for respiratory cancer found in factory A for white males employed 1 a or more in the present study appears to be compatible with the SMR of 380 found by Dement et al (2), given that these investigators excluded clerical employees and persons who had worked for less than six months; the exposure levels in this plant will therefore be of critical importance in our later analyses.

The substantial risk of mesothelioma in factory C was similar to that found in

another study of this plant by Robinson et al (16), reported since the present survey was planned. The possibility that cases were missed in factories A and B requires consideration. Dement and his colleagues found only one mesothelioma in factory A (the same case as was found in this study), and they carried out a search of all reports available in the Department of Pathology at the University of South Carolina for possible missed cases — they found none. The five large hospitals in the area have a long-standing interest in asbestos diseases; the first association between lung cancer and asbestosis was reported by Lynch & Smith (9) in 1935, and, when mesotheliomas were reported in the 1960s, special attention was given to the possibility of their occurrence. The high incidence of respiratory cancer in this plant (A), and the probability that mesotheliomas would have been detected, add significance to their virtual absence.

The opportunity for recognition of mesotheliomas was also very good at the chrysotile friction materials plant (B), as the state of Connecticut has maintained a renowned cancer register. A recent report (1) stated that the incidence of mesothelioma has risen steadily in the state over the years 1935–1975 with the increasing use of asbestos. The failure to find a single mesothelioma among 1,469 deaths in 4,738 employees of the largest and oldest asbestos factory in the state suggests that chrysotile in the manufacture of friction materials was not responsible for the problem.

In a recent cohort study in a large British friction materials plant, where mainly chrysotile had been used, Newhouse et al (15) found a total of 10 cases of mesothelioma. However, all but two had worked with crocidolite during a relatively short period when this fiber type was processed, and one of the two had worked close by. No statistical association was found between mesothelioma and exposure to chrysotile, and there was no excess of respiratory cancer deaths.

The inclusion of short and low exposure in our three cohorts, to examine the range of exposure-response relationships, raises some methodological problems. Exposure of less than 1 a contributes relatively little to most asbestos-related disease; yet large

variations in mortality were seen in short-term workers in the three cohorts, presumably due to some form of selection bias. There seems to be no easy way of dealing with this problem in the analysis.

The choice of an appropriate reference population for industrial cohorts is also a vexed one, especially when comparisons entail large geographic and social differences. [See the report of Liddell & McDonald (8)]. In the present study, the use of local mortality rates illustrates the problem, at least as regards factories B and C. The location of plant C in Pennsylvania in a region mainly inhabited by Menonites may perhaps explain the unexpectedly low SMRs in factory C. In contrast, the high SMRs in factory B at all durations of employment are even more difficult to explain. These difficulties may be reduced once we have been able to classify the subjects by exposure, since the relativities in exposure-response are likely to be more revealing than absolute levels.

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