

Malignant Mesothelioma Among Employees of a Connecticut Factory that Manufactured Friction Materials Using Chrysotile Asbestos

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There is ongoing argument about the potency of chrysotile asbestos to cause malignant mesothelioma. Risk assessment for chrysotile is influenced by the alleged absence of mesotheliomas among workers at the Raybestos Manhattan friction products plant in Connecticut, a plant that essentially used only chrysotile asbestos. Regrettably, the statement that there is an absence of mesothelioma deaths in the Connecticut plant is false. In this paper, we report on our review of the work histories and pathological reports of five individuals from the Connecticut plant who were diagnosed with mesothelioma. We discuss the Connecticut plant in relation to the most recent epidemiological information for chrysotile. Calculation suggests that mesothelioma rates at this plant were similar to those observed among Quebec miners and the South Carolina textile plant. We urge everyone concerned with the risk assessment of chrysotile asbestos to make use of all available data.

Keywords: asbestos epidemiology; chrysotile; Connecticut; friction materials; mesothelioma; Raybestos; risk assessment

INTRODUCTION

There is ongoing argument about the potency of chrysotile asbestos to cause malignant mesothelioma. This controversy was highlighted by the recent apparent suppression of an expert panel report on the health effects of chrysotile commissioned by the Government of Canada (Ogden, 2009). The expert panel in Canada relied on two meta-analyses of asbestos epidemiological studies for which exposure-response relationships could be estimated, the studies of Hodgson and Darnton (2000) and of Berman and Crump (2008a,b). In both these meta-analyses, there were no mesotheliomas counted among workers at the Raybestos Manhattan friction

products plant in Connecticut. As recently as late 2009, Hodgson and Darnton wrote about 'the absence of mesothelioma deaths' in the New Orleans and Connecticut cohorts (Hodgson and Darnton, 2009). Regrettably, the statement that there is an absence of mesothelioma deaths in the Connecticut plant is false. In 2005, Egilman published a paper in which he presented descriptions of six cases of mesothelioma among workers at this plant (Egilman and Billings, 2005). Egilman's paper has been overlooked by Hodgson and Darnton and by Berman and Crump, perhaps because the cases reported by Egilman fall outside of the observation period of the original report on the Raybestos plant.

In this paper, we report on our review of the work histories and pathological reports for the cases from the Connecticut plant and discuss the Connecticut plant in relation to the recent epidemiological results for chrysotile. The goal of this paper was to bring the

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occurrence of mesotheliomas among workers at the Connecticut plant to the attention of the wider community and to re-examine risk assessment for chrysotile using the most recent epidemiological data.

METHODS

The factory

Our description of the factory is based upon the work of McDonald *et al.* (1984) who published an epidemiological report in 1984. The factory began work in 1913. From the late 1930s, dry moulded and roll extruded wire back brake linings were made. The dry process was discontinued about 1970, but the roll extruded process continued at least into the 1980s. In the 1940s, automatic transmission friction materials, friction discs, and bands were introduced in substantial volume. Chrysotile, mainly from Canada, was the only mineral type of asbestos used until 1957, when some anthophyllite was added in making paper discs and bands. About 400 pounds of crocidolite was handled experimentally on a few occasions in the laboratory but only between 1964 and 1972. According to records in our possession, >5000 tons of asbestos was ordered from Canadian suppliers in 1968. One Canadian supplier shipped between 124 and 825 tons of chrysotile annually between 1967 and 1983.

The McDonald cohort

A research team led by Alison McDonald conducted an epidemiological study of the Raybestos Connecticut plant (McDonald *et al.*, 1984). A worker cohort was created that included everyone who had been employed for a calendar month or more before 1 January 1959 and who had a social security number that matched with data in the US social security files. Vital status was established as of 31 December 1977. Causes of death were coded using the seventh revision of the International Classification of Diseases.

Records reviewed here

Six workers diagnosed with mesothelioma sought legal representation from Early, Ludwick & Sweeney, LLC of New Haven, Connecticut. We reviewed the work history and medical information from their case files for the preparation of this report. We note that these are the same individuals who were discussed by Egilman in his 2005 report (Egilman and Billings, 2005). It will be seen that one of the six was, in fact, not employed at the Connecticut plant.

Risk assessment

We utilized the methodology of Hodgson and Darnton (2000) to compute mesothelioma risk ex-

pressed as the percentage of total expected mortality attributable to mesothelioma per fibre-year ml^{-1} 'average' cumulative exposure. Risk estimates were compared using the 'metan' programme in the Stata software package (StataCorp. 2009).

RESULTS

The subjects and their diseases

Table 1 gives information about the subjects, their work histories, and the details of their diagnoses.

Subject 1 was a female who began work at the plant (at its old location in Bridgeport, Connecticut) in approximately 1926 and who worked through 1937. She worked in an office on the second floor above the manufacturing plant and recalled the pervasive presence of asbestos dust in the plant, even in the office where she worked. Her job would take her on a regular basis throughout the manufacturing areas and she was able to witness several of the manufacturing operations. She started work again (at the new plant location in Stratford, Connecticut) sometime during the Second World War and worked through the end of the war in the Pacific. She is not known to have had any other exposures to asbestos. At thoracotomy in 1980, a biopsy specimen was diagnosed as fibrous mesothelioma. She died in 1980. Because she was a female, she would not have been included in the report of the McDonald cohort.

Subject 2 was a man who worked at the plant from 1940 to 1980 as a maintenance worker and foreman. He reported asbestos exposure throughout his 40 years of employment at the plant. He reported no other history of asbestos exposure and his available work records reveal no other likely sources of exposure. A diaphragmatic biopsy in 1985 was diagnosed as mesothelioma, sarcomatous variant. His period of employment makes him eligible for the McDonald cohort, but he died after the end of the original follow-up period.

Subject 3 worked at the plant from 1983 to 1984 following a 20-year career as a navy machinist and chief machinist from 1948 to 1968. Tissue analysis revealed amosite in his lungs. Because he began work in 1983, he would not have been eligible for the McDonald cohort. Since he had exposure to amosite in the navy, we consider him to have had mixed fibre exposures.

Subject 4 worked at Raybestos from 1937 to 1967 and again from 1971 to 1979. He retired from the hot press department as a work leader and had been a plant worker his entire career. He is not known to have had any other exposures to asbestos. At surgery in 1996, tissue was obtained from a parietal pleural

Table 1. Raybestos Manhattan employees, with a pathological diagnosis of mesothelioma, in the files of a Connecticut law firm

Subject	Work history	Pathology
Case 1 (Female); date of birth 1908, died November 1980	Clerical worker at old location in (Bridgeport, Connecticut) 1926–1937. New plant about 1942–1945.	Thoracotomy, 1980. Surgical pathology of pleural biopsy: fibrous mesothelioma.
Case 2 (Male); date of birth 1914, died January 1986, McDonald cohort eligible	Maintenance worker and foreman 1940–1980.	Diaphragmatic biopsy, 1985. Surgical pathology: mesothelioma, sarcomatous variant.
Case 3 (Male); died May 1994	History of asbestos exposure in the navy. Amosite asbestos on tissue digestion.	1994: fine needle aspiration: mesothelioma.
Case 4 (Male); date of birth 1918, died December 1996, McDonald cohort eligible	Plant worker and hot press department, 1937–1967 and 1971–1979.	Diagnosis from surgical pathology (1996) of parietal pleura biopsy and visceral pleural peel. Malignant mesothelioma based upon histological appearance and immunoperoxidase studies.
Case 5; born 1921, died September 2000	Worked in Pennsylvania plant	Autopsy (2000). Right-sided pleural plaques. Multifocal areas of fibrosis right lung. Malignant mesothelioma left pleura.
Case 6; date of birth: 1930, died March 2000, not McDonald cohort eligible (started 1965)	Machine operator 1965–1985	X-ray: bilateral interstitial fibrosis consistent with asbestosis Autopsy 2000. Mesothelioma.

biopsy and a visceral pleural peel. Malignant mesothelioma was diagnosed based upon histological appearance and immunoperoxidase studies. Because of his period of employment, he was eligible for the McDonald cohort, but he died after the end of the original follow-up period.

Subject 5 worked from 1940 to 1941 at the Raybestos plant in Mannheim, Pennsylvania. At autopsy in 2000, there were right-sided pleural plaques and multifocal areas of fibrosis in the right lung. Malignant mesothelioma of the left pleura was diagnosed. This man was not employed at the Raybestos Connecticut plant and was mistakenly included in Egilman's list of mesothelioma cases from that plant.

Subject 6 worked from 1965 to 1985 as a machine operator throughout his career. He is not known to have had any other exposures to asbestos. He began work at Raybestos too late to be included in the McDonald cohort.

Other mesothelioma cases at the plant

Two additional cases of mesothelioma have previously been identified among workers from this plant (McDonald, 1986), based on data collected by Teta *et al.* (1983) from the Connecticut Tumor Registry. Both individuals were female clerical workers. One subject died of pleural and the other of peritoneal mesothelioma.

Risk assessment

Combining the previous observations by Teta with the records in our files, we count seven cases of me-

sothelioma from this plant. Because Subject 3 had mixed exposure to chrysotile and the amphiboles, we exclude him from our discussion, which is concerned with mesothelioma following exposure to chrysotile. That leaves six workers, three women and three men, with the diagnosis of mesothelioma.

In this section of the paper, we calculate an estimate of mesothelioma risk at the Raybestos plant and compare this estimate to those derived from American textile plants and Quebec miners and millers. In order to make our calculations, we need information about the population of plant workers. This is available for the subset of plant employees included in the McDonald cohort, namely those male workers who had been employed for a calendar month or more before 1 January 1959. As shown in Table 1, most of the subjects with mesothelioma do not meet this cohort definition, either because they were female or because they had been hired after the cut-off date for entry to the cohort. There were two cases of mesothelioma among men who would have been eligible for the McDonald cohort. For the Hodgson–Darnton type risk calculation, we need to know the total 'expected' mortality. This is not directly available. McDonald *et al.* (1984) reported that 36% of their cohort had died by the end of 1977. Given the rapid increase in mortality rates with age, we will assume that 80% of the cohort had died by the end of 2000. This estimate is probably accurate to within 10%. According to Hodgson and Darnton, the mean cumulative exposure among cohort members was 46 fibre-years ml^{-1} . With these assumptions, Table 2

Table 2. Estimates of excess mortality due to mesothelioma per fibre-year ml^{-1} cumulative exposure

Plant	Number of mesothelioma deaths	Total expected mortality	Estimated mean cumulative exposure (fibre-year ml^{-1})	Mesothelioma risk (and 95% confidence limits) expressed as percentage of total expected mortality per fibre-year ml^{-1}
Raybestos (This report)	2	2800	46	0.002 (0.0002–0.006)
South Carolina Hein <i>et al.</i> (2007)	3	1470	29	0.007 (0.001–0.021)
North Carolina Loomis <i>et al.</i> (2009)	8	1758	17.1	0.027 (0.008–0.045)
Quebec miners	33	5912	600	0.001 (0.0006–0.0012)

shows the calculated estimate of risk for the cohort-eligible subjects at the Raybestos plant. Confidence limits were computed assuming a Poisson distribution of the observed number of mesothelioma deaths.

Table 2 also shows the results of similar calculations made for the North and South Carolina textile plants. The results for the Quebec miners and millers were taken from Table 1 of Hodgson and Darnton.

DISCUSSION

Recent risk assessments have made the statement that there were no cases of mesothelioma among workers at the Raybestos Manhattan friction products plant in Connecticut.

We have presented information about five cases of mesothelioma among individuals who had worked at this plant. These cases were reported by Egilman and Billings in 2004, but their paper has been overlooked by other authors. We have relied not on the death certificate but on a 'best evidence' review to identify cases from the plant. This is in accord with the recommendation of Hodgson and Darnton (2000) for the ascertainment of mesothelioma. Combining the previous observations by Teta with the records in our files, we count seven cases of mesothelioma from this plant. We note that our count of cases from this plant is a minimum estimate, given that we were able to identify only those cases seeking legal assistance from the law firm at which one of us works. Because Subject 3 had mixed exposure to chrysotile and the amphiboles, we exclude him from our discussion, which is concerned with mesothelioma following exposure to chrysotile.

This leaves, at a minimum, six workers, three women and three men, who died of mesothelioma. Any risk assessment that assigns no cases of mesothelioma to this plant is thus in error and will under-

estimate the risk of mesothelioma attributable to chrysotile exposure. Since the publication of the risk assessments by Hodgson and Darnton (2000) and of Berman and Crump (2008a,b), new information about the outcome of workers exposed to chrysotile in American factories has become available. The study of the South Carolina textile plant has been updated (Hein *et al.*, 2007) and a new study of four North Carolina textile plants has been published (Loomis *et al.*, 2009). At latest update, there were three cases of mesothelioma in the South Carolina plant (118 000 person-years at risk) and eight cases of mesothelioma in the North Carolina plants (182 000 person-years at risk). These plants all used chrysotile asbestos imported from Canada. We computed mesothelioma risk estimates for these three plants and compared them to the estimate computed for Quebec miners and millers by Hodgson and Darnton. Because of the small number of deaths in the manufacturing plants, the confidence limits are quite wide. Other sources of uncertainty include possible under ascertainment of deaths from mesothelioma (reliance on the death certificate is likely to lead to under ascertainment) and reliance on sometimes scanty historic exposure measurements for the computation of cumulative exposure. We have assumed that 80% of the Raybestos cohort had died by the end of 2000. The error in this assumption is likely to be small in comparison with the uncertainties of case ascertainment and exposure estimation.

The mesothelioma risk estimate among the Quebec cohort was $\sim 0.001\%$ of total expected mortality per fibre-year ml^{-1} . The estimates from the Raybestos and South Carolina plants are several-fold larger, but because of the small number of deaths, they are not significantly different from the Quebec estimate ($P = 0.50$ for Raybestos versus Quebec; $P = 0.24$ for South Carolina versus Quebec). The risk estimate for the North Carolina

plants is substantially higher than for Quebec. The proportion of mesothelioma deaths was the same, but the average cumulative exposure in North Carolina was estimated to be only ~3% of the cumulative exposure in Quebec.

CONCLUSIONS

The oft-repeated statement that there were no cases of mesothelioma from the Connecticut friction materials plant studied by McDonald *et al.* (1984) is not correct. We have described five cases of mesothelioma from the files of a Connecticut law firm and mentioned two cases previously identified by Teta *et al.* (1983). Calculations suggest that mesothelioma rates at this plant were similar to those observed in the South Carolina textile factory and in Quebec mining and milling.

These observations have implication for the risk assessment of chrysotile asbestos. They also have political implications for the Government of Canada, which has been called upon to ban the export of chrysotile (Attaran *et al.*, 2008). We urge everyone concerned with the risk assessment of chrysotile asbestos to make use of all available data.

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REFERENCES

- Attaran A, Boyd DR, Stanbrook MB. (2008) Asbestos mortality: a Canadian export. *CMAJ*; 179: 871–4.
- Berman DW, Crump KS. (2008a) A meta-analysis of asbestos-related cancer risk that addresses fiber size and mineral type. *Crit Rev Toxicol*; 1: 49–73.
- Berman DW, Crump KS. (2008b) Update of potency factors for asbestos-related lung cancer and mesothelioma. *Crit Rev Toxicol*; 1: 1–47.
- Egilman DS, Billings MA. (2005) Abuse of epidemiology: automobile manufacturers manufacture a defense to asbestos liability. *Int J Occup Environ Health*; 11: 360–71.
- Hein MJ, Stayner LT, Lehman E *et al.* (2007) Follow-up study of chrysotile textile workers: cohort mortality and exposure-response. *Occup Environ Med*; 64: 616–25.
- Hodgson JT, Darnton A. (2000) The quantitative risks of mesothelioma and lung cancer in relation to asbestos exposure. *Ann Occup Hyg*; 44: 565–601.
- Hodgson JT, Darnton A. (2009) Mesothelioma risk from chrysotile. *Occup Environ Med*; doi:10.1136/oem.2009.052860.
- Loomis D, Dement JM, Wolf SH *et al.* (2009) Lung cancer mortality and fibre exposures among North Carolina asbestos textile workers. *Occup Environ Med*; 66: 535–42.
- McDonald AD. (1986) Mesothelioma in Connecticut. *J Occup Med*; 28: 808–9.
- McDonald AD, Fry JS, Woolley AJ *et al.* (1984) Dust exposure and mortality in an American chrysotile asbestos friction products plant. *Br J Ind Med*; 41: 151–7.
- Ogden TL. (2009) Canadian chrysotile report released—at last. *Ann Occup Hyg*; 53: 307–9.
- StataCorp. (2009) Stata statistical software. Version 11.0. College Station, TX: Stata Corporation.
- Teta MJ, Lewinsohn HC, Meigs JW *et al.* (1983) Mesothelioma in Connecticut, 1955–1977. Occupational and geographic associations. *J Occup Med*; 25: 749–56.