Asbestos Lung Fibre Analysis in the United Kingdom, 1976–96

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Received 16 January 2002; in final form 12 April 2002

Objectives: To summarize data on changes in lung contents of asbestos types between 1976–77 and 1990–96 for mesotheliomas and controls in the UK.

Methods: Data were extracted from published studies of the years 1976, 1977 and 1990–96.

Results: Between 1976–77 and 1990–96 there was a large reduction in the amount of crocidolite in the lungs of both mesotheliomas and controls.

Conclusion: The results are consistent with the use of the different asbestos types in the UK, after taking into account the period of exposure and elimination of fibres from the lung in the time elapsed since exposure.

Keywords: lung fibre analysis; mesothelioma

INTRODUCTION

McDonald et al. (2001a,b) have given results for lung fibre analyses of mesotheliomas in young adults and controls for the UK for the period 1990–96. They noted that amosite was relatively more prominent than in previous studies but that crocidolite was still important in this age group. The purpose of this paper is to provide more analysis of the changes in lung fibre analysis of mesotheliomas and controls between earlier studies in 1976 and 1977 and the recent study of McDonald et al.

MATERIALS AND METHODS

Data have been extracted from three studies.

1976 study
Details were given by Jones et al. (1980) and in Berry et al. (1989). In brief, lung tissue was received from pathologists for 86 mesotheliomas and from 56 controls. Of the mesotheliomas, 82% were in men, with an average age of 63 yr and of whom 74% had occupational exposure to asbestos, 3% had no exposure and for 23% the occupational history was unknown.

1977 study
Details were given by Wagner et al. (1982) and in Berry et al. (1989). Briefly, lung tissue was obtained from 145 mesotheliomas (all men) reported to Pneumoconiosis Medical Panels (PMP), because exposure to asbestos was considered a factor in the cause of death, and from 25 mesotheliomas submitted by pathologists. These sources have been combined to form a set of 170 mesotheliomas. Lung tissue was collected from 94 controls consisting of consecutive necropsies in adults from six hospitals in towns representing serious and moderate environmental pollution and from two towns with little industry.

1990–96 study
Details were given by McDonald et al. (2001a,b). Cases of malignant mesotheliomas were those reported by chest physicians to the Surveillance of Work-related and Occupational Respiratory Disease scheme (SWORD) between 1990 and 1996 whose year of birth was 1943 or later. There were 69 cases in men with an age range of 36–52 yr and 57 controls in the same age range. Although SWORD is an occupational surveillance scheme, mesotheliomas were reported whether considered occupational or not. There was clear evidence of occupational exposure for at least 70% of the mesotheliomas.
Lung tissue analysis

In all three studies lung tissue analysis was carried out using a consistent methodology for sample preparation and asbestos analysis using an analytical transmission electron microscope (TEM) (Pooley and Clark, 1979; Gibbs and Pooley, 1996). All fibrous structures with an aspect ratio of 3:1 or greater were analysed using energy dispersion X-ray analysis.

Presentation of results

Fibre counts are expressed as fibres/µg dry tissue (equivalent to millions of fibres per gram, as used in the earlier publications). The distribution of crocidolite, amosite and chrysotile asbestos in the lungs of mesotheliomas and controls are given as frequencies in the categories <0.1, 0.1–0.9, 1.0–9.9, 10–99.9 and ≥100 fibres/µg dry tissue (for the 1990–96 study the last two categories were combined). Median fibre counts were determined from the original data or by interpolation within a category using the normal equivalent deviate of cumulative probability and the logarithm of fibre count.

Comparisons between the three surveys, 1976, 1977 and 1990–96, were decomposed into two orthogonal comparisons, 1990–96 compared with 1976 and 1977 combined, and 1976 compared with 1977. Each of these was assessed with a trend \( \chi^2 \) test with one degree of freedom (Armitage et al., 2002, pp. 504–9). Since the methodology for the selection of mesotheliomas and controls differed between surveys, significant differences between years cannot necessarily be ascribed to year. Very little difference would be anticipated due to the elapse of just 1 yr from 1976 to 1977, so that the main test statistic is that representing the comparison of 1976 + 1977 combined with 1990–96. A difference over the 20 yr period was not considered to be established unless this statistic was significant and clearly exceeded the test statistic for the 1976 versus 1977 comparison. In other words, the majority of the difference between the three years had to be between 1976 + 1977 and 1990–96.

RESULTS

The cumulative probability distributions are shown in Fig. 1 for crocidolite, amosite and chrysotile for mesotheliomas and controls.

For crocidolite in mesotheliomas there was a highly significant difference between 1976 + 1977 and 1990–96 (\( \chi^2 = 56.31, 1 \text{ df}, P < 0.001 \)) but not between 1976 and 1977 (\( \chi^2 = 3.09, 1 \text{ df}, P = 0.08 \)). For amosite in controls the difference between 1976 + 1977 and 1990–96 was highly significant (\( \chi^2 = 20.04, 1 \text{ df}, P < 0.001 \)) whilst the difference between 1976 and 1977 was marginally significant (\( \chi^2 = 4.26, 1 \text{ df}, P = 0.04 \)). Thus, in both mesotheliomas and controls, the highly significant difference between 1976 + 1977 and 1990–96 accounted for the majority of the difference between the three surveys. There were no significant differences for amosite in either mesotheliomas or controls. For chrysotile in mesotheliomas the difference between 1976 + 1977 and 1990–96 was highly significant (\( \chi^2 = 13.37, 1 \text{ df}, P < 0.001 \)), as also was the difference between 1976 and 1977 (\( \chi^2 = 25.16, 1 \text{ df}, P < 0.001 \)). For chrysotile in controls the difference between 1976 + 1977 and 1990–96 was highly significant (\( \chi^2 = 39.57, 1 \text{ df}, P < 0.001 \)), as was the difference between 1976 and 1977 (\( \chi^2 = 17.92, 1 \text{ df}, P < 0.001 \)). Thus, for chrysotile the interpretation of the nominally highly significant reduction in lung content between 1976 + 1977 and 1990–96 is attenuated by the highly significant difference between 1976 and 1977.

DISCUSSION

The consistency in methodology and instrumentation over the 20 yr period would have minimized analytical variability that has been observed between laboratories using different methods and instruments (Gylseth et al., 1985). The TEM instrumentation and high resolution X-ray spectrum analysis allowed discrimination between fine crocidolite and amosite fibres. Separation of amphibole fibre types is not always carried out and in some instances only a combined crocidolite + amosite category has been reported (for example in Tuomi, 1992; Karjalainen et al., 1994).

From the results presented in Fig. 1 it is clear that the amount of crocidolite in the lungs of mesothelioma cases has decreased between 1976 + 1977 and 1990–96, but the amount of amosite has changed much less. These findings are consistent with the use of amphibole asbestos in the UK. Importation of crocidolite was discontinued by 1970 whilst the importation of amosite continued with little decrease
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throughout the 1970s (Peto et al., 1995). McDonald et al. (2001b) noted that >90% of the mesothelioma cases started work before 1970 and mainly before 1965 and so may have been exposed to crocidolite in that period. In view of the continuing use of amosite for a further 10 yr after the discontinuation of

Fig. 1. Distributions of the amounts of crocidolite, amosite and chrysotile in the lungs of mesotheliomas and controls for 1976, 1977 and 1990-96 in fibres/µg dry tissue.
crocidolite use, the observation of McDonald et al. (2001b) that amosite is now relatively more prominent than in earlier studies is indeed not surprising.

The amount of asbestos in the lungs at death is a consequence both of exposure during life and elimination of fibres following exposure. For the 1976 + 1977 mesotheliomas exposure to crocidolite probably occurred mainly from the 1940s to the 1960s. For those exposed up to 1969 there were only 6 or 7 yr following the end of exposure during which elimination would have occurred in the absence of new deposition. In contrast, for the 1990–96 mesotheliomas the period of exposure to crocidolite would have been shorter and there was a period of >20 yr after exposure for elimination to continue.

Although a precise analysis cannot be conducted because of the limited amount of information available on when exposure occurred for the 1976 + 1977 mesotheliomas, the following example is illustrative of the combined effect of a shorter exposure and a longer period of elimination. Suppose for mesotheliomas occurring in 1976 or 1977 there had been exposure at a uniform concentration between 1945 and 1970 followed by 7 yr without further exposure, and for mesotheliomas in 1990–96 there had been the same level of exposure from 1960 to 1970 followed by 23 yr without further exposure. There is evidence that the rate of elimination of crocidolite in humans is of the order of 10–15% per yr (Berry, 1999). Using the former figure the amount of crocidolite in the lungs for 1990–96 cases would have been ~14% of the amount in the 1976 + 1977 cases; due to the shorter exposure the amount deposited would be 40%, and the further reduction is due to the longer time elapsing since exposure, 28 yr compared with 20 yr on average.

The amount of crocidolite in the lungs of controls declined between 1976 + 1977 and 1990–96 and this may be due to a reduction in crocidolite in the general environment.

Chrysotile is much less biopersistent than the amphibole fibres so that the amount in the lungs at death is mainly a reflection of recent exposure. Chrysotile imports into the UK declined markedly between 1980 and 1995 (Peto et al., 1995) and this may explain the lower chrysotile content in the lungs of controls in 1990–96 compared with 1976 + 1977. However, the significance of this finding is unclear since there was also a significant difference between 1976 and 1977.

The analysis of the data from the SWORD scheme by McDonald et al. (2001a,b) has provided very useful information on the continuing mesothelioma toll resulting from past exposure. A similar study after a further 10 yr would provide evidence of whether exposure to crocidolite was mainly eliminated by 1970, and after a further 10 yr on whether amosite exposure ceased after 1980. However, if it is correct that chrysotile accounted for very few of the mesotheliomas (McDonald et al., 2001b), the latter study may prove infeasible because of very few mesothelioma in young adults at that time.

Acknowledgements—I am grateful to Ms Siew Chan who prepared the figure and to the referees who suggested some improvements to the text.

REFERENCES


