

(30) reported that lung cancer was not significantly increased in incidence among asbestos workers with no history of cigarette smoking, although when such history was present, the incidence of lung cancer increased markedly over what would be expected among other cigarette smokers. In the absence of asbestos exposure. Thus, these scientists calculated that an asbestos worker who smoked cigarettes had 92 times the risk of dying of lung cancer, as compared with like individuals without cigarette smoking or asbestos work. This finding has been confirmed by larger studies (Hammond and Selikoff, 1973 (17)) where, again, it was found that non-smoking asbestos workers had few lung cancers while those who smoked had much more lung cancer than would have been expected had they not been asbestos workers. Calculations suggest that cigarette-smoking asbestos workers have approximately eight times the risk of developing lung cancer compared to other cigarette smokers who are not occupationally exposed to asbestos.

(2) Pleural and peritoneal mesothelioma. In 1960 Wagner, Siegel and Marchand (47) demonstrated an important association between asbestos exposure and pleural mesothelioma. This cancer, which appears to be unrelated to smoking, had previously been considered to be a very rare tumor. Numerous reports have confirmed the finding of Wagner and his colleagues that mesothelioma can be commonly associated with asbestos exposure. A subsequent report by Enticnap and Smither, 1964, (13) concerning workers in a British asbestos factory demonstrated that the same tumor could be commonly found in the abdomen (peritoneal mesothelioma), as well as in the chest.

The exact risk of death of these invariably fatal neoplasms has not been as well defined as has lung cancer, although records of cases from hospitals near one large asbestos factory indicate that it must be very common (Barrow, Conston, Livornese and Schalet, 1967, (8)). Information available from the experience of asbestos insulation workers suggests that approximately five to seven percent of deaths may be due to this neoplasm (Hammond, Selikoff and Churg, (17); Selikoff, Hammond and Seidman, 1973, (41)). More recently, it has been suggested that this estimate is too low, on the basis of the experience of workers in a British asbestos factory where calculations predicted that between 10 and 11 percent of deaths would be due to mesothelioma (Newhouse and Berry, 1976, (30)).

A recent study of mesotheliomas diagnosed in a hospital located in the vicinity of a shipyard reported an increased incidence of diffuse malignant mesothelioma since World War II, not only among exposed shipyard workers, but also among individuals with no occupational exposure. (Hasan, (20)).

(3) Gastro-intestinal cancer. Gastro-intestinal cancers (cancer of the stomach, colon and rectum) are also increased in incidence among asbestos

workers. A number of studies now indicate that the increase is on the order of two or three times the number of expected tumors (Selikoff, Hammond and Seidman, 1973, (41); Elmes and Simpson, 1971, (9)). Although this increased risk is relatively limited, especially when compared with lung cancer and mesothelioma, it is nevertheless of considerable importance since a two- or three-fold increase in such common tumors becomes an important cause of death for the workers involved.

It has been suggested that other tumors are also increased in incidence among asbestos workers, particularly cancers of the larynx (Stell and McGill, 1973, (45); Newhouse and Berry, 1973, (34)), and of the esophagus (Selikoff, Hammond, and Seidman, 1973 (41)). However, data concerning these neoplasms are less extensive than for lung cancer, mesothelioma and gastro-intestinal cancer and further experiences are awaited. In any case, they are not very common tumors in general and any increase does not weigh heavily on the overall cancer risk of asbestos workers.

OCCUPATIONAL EXPOSURE

Reports of pulmonary fibrosis or lung scarring, from inhalation of asbestos dust in factories began to appear in the literature in the early part of this century and by 1927 this lung scarring disease was known as "asbestosis" (Newhouse, 31)).

In 1930, the British Home Office Survey by Merewether and Price (28), found that approximately half of a population of asbestos factory workers were suffering from pulmonary fibrosis, leading to the introduction of the Asbestos Factory Regulations of 1931. The objective of the Regulations, implemented in 1933, was to reduce the risk of asbestosis.

It was recognized, however, that in addition to asbestos-induced lung scarring, there was also increasing evidence of cancer associated with asbestos exposure. Some workers whose deaths were attributed to asbestosis were also found to have had lung cancer. (Nicholson, (35)).

By 1960, through epidemiological studies, an association between asbestos exposure and mesothelioma had been demonstrated (Wagner (47)) and was soon substantiated by additional epidemiological studies (Newhouse (31), Selikoff (37)) and clinical diagnosis.

In 1968, the Committee of the British Occupational Hygiene Society evaluated worker exposure data in a large asbestos textile mill dating from implementation of the Asbestos Regulations of 1933 which indicated that there was "comparatively little clinical and/or roentgenological evidence of asbestosis" at that factory in a survey completed in 1966. Based on that data, the Committee concluded by setting a dust exposure level at 100 fiber-years/ml (or 2 fibers/ml for 50 years) it would provide a full working lifetime without substantial risk of developing asbestosis. (OSHA, 1975, (6)).

Note Time factor.

The National Institute of Occupational Safety and Health (NIOSH) relied heavily on the British Standard in its recommendation for promulgation of the asbestos standard set by OSHA in 1972.

Subsequent to the implementation of the OSHA permanent asbestos standard in 1972, results of a new evaluation of the earlier British factory worker population showed many abnormal X-ray findings of the lungs and pleura.

It is reported that there is now an excess lung cancer mortality rate among workers who became employed at the textile mill after 1933 and whose lack of clinical or X-ray evidence of asbestosis led to the development of the British asbestos standard.

Another report of an ongoing study of workers (and their family members) in a factory producing amosite asbestos between 1941 and 1954, when the factory closed, has shown a high incidence of X-ray abnormalities and 2 pleural mesothelioma deaths have thus far been identified (1).

It is also reported that clinical data are becoming available concerning asbestos lung scarring in individuals exposed at much lower than occupational levels. (Anderson, (1)).

It therefore appears that an exposure thought sufficiently low to reduce the risk of asbestosis has not prevented pathogenic changes, including lung cancer and mesothelioma. (Anderson, (1)).

NON-OCCUPATIONAL, INDIRECT OCCUPATIONAL EXPOSURE, OR INTERMITTENT OR BRIEF EXPOSURES

Recent data indicate the occurrence of asbestos cancer from exposure to low levels of asbestos, as in environmental circumstances, or from brief or intermittent exposures to higher levels.

In inhalation exposure experiments, rats exposed to asbestos dust were reported to have developed tumors, including mesotheliomas, from as little as a single 7 hours exposure (48).

Analysis of the history of asbestos exposure among individuals in a large series of cases of mesothelioma in Great Britain and South Africa have provided evidence that brief or intermittent exposure to asbestos may, after the passage of decades, result in mesothelioma (Greenberg and Davies, 1974 (16); Webster, 1973, (49)). In such circumstances, it appears that the lifetime exposure was less than 100 fibers-years/ml. The same discrepancy between present projected exposures and the risks of asbestos cancer exists when considering cases of mesothelioma resulting from household contact with asbestos among members of families or asbestos workers (Lillingston, 1974 (25)), or among residents living in the vicinity of asbestos plants. Of considerable industrial importance has been the recent description of asbestos disease among shipbuilding and ship repair workers, few of whom actually work with asbestos, but many of whom were, in the past, inadvertently exposed to the asbestos dust resulting from the use of asbestos products by a relatively few of their workmates. In 1988, Harries of