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ASBESTOS-ASSOCIATED DISEASES IN A COHORT OF CIGARETTE-FILTER WORKERS

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Abstract To estimate the effects on health of occupational exposure to crocidolite, a highly toxic form of asbestos, we studied a cohort of 33 men who worked in 1953 in a Massachusetts factory that manufactured cigarette filters containing crocidolite fibers from 1951 to 1957.

Twenty-eight of the men have died, as compared with 8.3 deaths expected. This increased mortality was attributable to asbestos-associated diseases. Fifteen deaths were caused by cancer, as compared with 1.8 expected (relative risk, 8.2; 95 percent confidence interval, 4.6 to 13.4), including eight from lung cancer, five from malignant mesothelioma, and two from other types of cancer.

THE inhalation of asbestos may result in pulmonary fibrosis (asbestosis),¹ lung cancer,² or malignant mesothelioma.³ We recently observed three cases of malignant mesothelioma among former employees of a Massachusetts company that manufactured cigarette filters containing crocidolite asbestos from 1951 to 1957.⁴ We now report a marked excess in mortality and morbidity from asbestos-related diseases in an independent cohort of 33 workers who made these filters.

METHODS

From 1951 to 1957, a subsidiary of a Massachusetts company manufactured cigarette filters according to a patented "dry" and dusty process in which asbestos, cotton, and acetate fibers were mechanically mixed, carded, and deposited on crepe paper.⁵ The parent company produced other asbestos-containing products between 1942 and 1971 by the conventional "wet" papermaking process, in which asbestos was added to a pulp. Crocidolite, a member of the amphibole family of long, straight asbestos fibers, was the primary type of asbestos used. It is strongly associated with asbestosis, lung cancer, and malignant mesothelioma,^{3,6} presumably because of its unusual resistance to degradation in the lung.⁷ Measurements at six production locations in the factory on October 27, 1952, showed an average of 80 particles of asbestos dust per milliliter of air, which was within the then-current Massachusetts standard of 175 particles per milliliter. These levels greatly exceed the current National Institute for Occupational Safety and Health standard of 0.1 asbestos fibers (not particles) per milliliter.

A list of all employees directly involved in manufacturing cigarette filters at the factory on September 22, 1955, was obtained from the records of the Massachusetts Division of Occupational Hygiene. The cohort included none of the factory workers previously described by us.⁴ The median age of these 33 white men on that date was 34 years (range, 21 to 67). The subjects were studied from that date until their death or until December 31, 1988, the closing date of

the study (the mortality analysis), or until the diagnosis of a first cancer (the morbidity analysis). There were 773 and 766 person-years of follow-up in the mortality and morbidity analyses, respectively.

We conclude that the extremely high morbidity and mortality in these workers were caused by intense exposure to crocidolite asbestos fibers. (N Engl J Med; 321:1220-3.)

We attempted to contact each worker, or his next of kin if the worker had died. We requested information about the worker's employment and health history and asked permission to review his medical records. For 18 workers, this information was supplemented with data gathered in an ongoing health survey of company employees begun by one of us in 1971. For 29 workers we were able to determine the total duration of employment by the company; for 23, the length of time spent manufacturing cigarette filters was known.

An experienced nosologist determined the underlying cause of death from the death certificates of all deceased workers. Medical records establishing the cause of death independently were available for 22 of the 28 deceased workers, including all those whose death was possibly related to asbestos. These included the results of a postmortem examination in 8 workers, other pathology reports for 10, and other medical records for 4. Only death-certificate diagnoses were obtained for six workers. All diagnoses of cancer were verified by a pathology report (18 workers) or radiographic and endoscopic studies (1 worker). Asbestosis was diagnosed in deceased workers on the basis of the presence of pulmonary fibrosis and asbestos bodies (in 12 workers) or clinical studies (in 3 workers). In living workers, asbestosis was diagnosed on the basis of a chest radiograph scored by one of us as 1/0 or more, according to the International Labour Office's scheme for the classification of pneumoconioses.⁸

Relative risks for mortality, or the ratio of the numbers of deaths observed to the numbers expected, were based on death rates specific to age and calendar time, according to cause, among the U.S. male population.⁹ The numbers of newly diagnosed (incident) cancers observed, other than malignant mesothelioma, were compared with those expected on the basis of incidence rates specific to age and calendar time, according to site, from the Connecticut Tumor Registry.¹⁰ More stable expected values for malignant mesothelioma, an uncommon tumor, were calculated with data from the Surveillance, Epidemiology, and End Results program of the National Cancer Institute, which provided rates in approximately 10 percent of the U.S. population for the time periods 1973 to 1976 and 1977 to 1980^{11,12} (and Connelly R: personal communication). In the calculations of significance and confidence intervals, an underlying Poisson distribution was assumed.¹³

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RESULTS

Twenty-eight (85 percent) of the 33 workers had died, and 5 were alive. The 28 deaths observed were 3.4 times the number expected (8.3 deaths) on the basis of mortality rates for the U.S. white male population.

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