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Possible differences in the disease potential of the several commercially important asbestos fiber varieties has been considered important, since the industrial use of asbestos might be guided accordingly.¹ Experimental observations have not indicated any critical variation, at least insofar as mesothelioma is concerned. The tumors can be produced easily by intrapleural inoculation of various types of asbestos, and there is no significant difference in the incidence of tumor production if chrysotile or crocidolite is used.² There is less information concerning experimental lung cancer.

There are few data concerning the cancer hazard of amosite in human populations, although some information has been available for chrysotile,³ crocidolite⁴ and anthophyllite.⁵ In large part this has been the result of epidemiological difficulties. Since, under industrial circumstances, there is often admixture of fiber varieties, the experiences of employed populations are not readily ascribed to a single fiber variety. Diligent efforts have been made to investigate the occurrence of disease in the Transvaal in South Africa, where populations exposed only to amosite could be identified. Environmental studies in this area, reported in 1964, showed no instance of mesothelioma in amosite miners and only isolated instances of carcinoma of the bronchus, although asbestosis was found.⁶ This survey has since been complemented by a study of miners in the area. The fate of white miners employed between 1954 and 1958 was investigated. Unfortunately, the records turned out to be imperfect and incomplete; since the caucasian workforce in these mines was fairly unstable. Moreover, no attempt was made to study the Bantu workmen, who are in the majority, since labor turnover is very high and "...records kept are such that follow-up of individuals over a period of time is impossible."⁷ Only 147 white miners could be followed at all, and only 20 of these were observed for more than 20 years after first exposure to asbestos. Of these 20, there

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was 1 instance of lung cancer and none of mesothelioma. Elsewhere, comment is made that "The position of amosite is not clear...." with only 1 pleural mesothelioma stated to be known in the Transvaal.⁸

Current Investigation

We have investigated the mortality experience of a group of workmen occupationally exposed solely to amosite, whose employment started June, 1941 - December, 1945. This cohort has been followed to June 30, 1971. Although this period of observation is still short for full evaluation of asbestos-related disease,⁹ the data already demonstrate a significant cancer hazard associated with this employment.

Employed population

933 men were employed for varying periods of time in a factory in an eastern city of the United States, starting work at some time between June, 1941, when the factory began production, and December, 1945. The plant continued production until November, 1954, when it closed its doors. It manufactured amosite asbestos insulation, primarily for use in shipbuilding and shiprepair.

We have sought to trace each of these men and have successfully done so in 866 instances. In 67, tracing is still incomplete. Data concerning date of birth, onset of employment, duration of employment and type of work are known.

For the purposes of this report, we have investigated the mortality experience of those individuals who had at least one year of exposure. There were 333 such men who began work, as noted, 1941-1945. 88 had died by Dec. 31, 1959. 15 were lost to follow-up. 230 were alive on Jan. 1, 1960 and each of these men has been followed since.

We have calculated expected death rates for these men Jan. 1, 1960 - June 30, 1971, using age, year and sex specific rates for U.S. white males. Expected deaths were then compared with those observed.

Amosite exposure

No information is available concerning dust levels in this plant. Although exhaust ventilation was used, discussions with surviving workmen and plant management indicate that dust exposures, at least in some circumstances, could have been high. Respirators were issued to the workforce but were inconstantly used. For the men examined, we have recorded an estimate of such utilization.

We have ascertained that only amosite asbestos was used in this factory, in several ways:

1. Review with plant management indicated that only this fiber variety was purchased and utilized. This is consistent with the ship insulation specifications under which the products were made.
2. We have obtained samples of the products made and examination by polarized light microscopy, electron microscopy, electron diffraction and electron microprobe analysis, showed only amosite to be present.
3. Asbestos was still present in the factory building's storeroom. When retrieved and examined, this was found to be amosite, using the same analytical methods.
4. Several workmen had kept the respirators used by them during their period of employment. The filters in these respirators were studied. Fibers retained on the filters were removed and analyzed. They were invariably amosite.
5. We have extracted mineral fibers from the lungs of individuals in this cohort, who had died. Very large numbers of fibers were present. Electron diffraction and electron microprobe analysis showed them to be amosite,¹⁰ except for the occasional chrysotile fibril expected to be present in the lungs of urban dwellers in this area.¹¹

Results

The mortality experience of this group of workmen, 1960-1971, demonstrates that a serious health hazard was associated with this industrial use of amosite. Table 1 records expected and observed deaths.

Total deaths were more than twice anticipated; 46.4 were expected and 105 occurred. This excess mortality was limited to two categories, cancer of various sites, and asbestosis.

14 deaths were due to asbestosis, whereas virtually none were expected. That amosite could result in asbestosis has, of course, been well recognized.⁷ In physiological studies of a select group of amosite workmen (in this factory) from 1954,^{12,13} serious pulmonary insufficiency was demonstrated.

Both lung cancer and mesothelioma were also found in considerable excess. 2.4 deaths of lung cancer were anticipated, 25 occurred. In calculating expected rates, smoking habits have been disregarded, since the smoking habits of individuals not examined by us are not accurately known. In prospective studies from this point on, smoking habits will be taken into account.¹⁴

Mesothelioma caused 5 deaths; 2 pleural and 3 peritoneal. Each has been histologically verified, in material obtained at operation in 2 instances and at autopsy in 3. In one case, there had been prior chrysotile exposure; in 4 only amosite asbestos exposure had occurred. Parenthetically, other instances of mesothelioma have occurred among men working in this plant, other than in the cohort reported here.

It may be of interest that more deaths of cancer of stomach, colon and rectum have occurred than expected. The increase is only threefold, however. As with previous groups, it is considered that further observations are required before this association is clearly established.¹⁵

These data indicate that industrial exposure to amosite asbestos is associated with serious hazard of lung cancer, pleural and peritoneal mesothelioma, pulmonary asbestosis, and perhaps cancer of stomach, colon and rectum.

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Table 1

Causes of death among 230 amosite asbestos factory workers, Jan. 1, 1960 - June 30, 1971*

<u>Cause of death</u>	<u>Observed deaths</u>	<u>Expected deaths**</u>
Total cancer, all sites	43	8.5
Cancer of lung, pleura, bronchus, trachea	27	2.4
Lung cancer	25	+
Pleural mesothelioma	2	+
Peritoneal mesothelioma	3	+
Cancer of stomach, colon, rectum	5	1.6
Cancer of all other sites	8	4.5
Asbestosis	14	+
All other causes	48	37.9
Total deaths	105	46.4

*333 workmen were employed in this factory one year or longer, 1941-1945. 88 died by Dec. 31, 1959: 15 were lost to follow-up. The remainder, 230, have been studied to June 30, 1971. Analysis of lifetime work experience indicates that, for the very large majority, this was the only occupational asbestos exposure.

**Expected deaths 1960-1964 are based on U.S. age-specific rates for white males in 1962. For 1965-1971, rates for 1968 were utilized. Smoking habits are disregarded.

+United States data not available, but figure should be only slightly less than 2.4

+United States data not available but these are rare causes of death
+in general population