ENVIRONMENTAL RESEARCH 59, 159–166 (1992)

A Radiographic Survey of Public School Building Maintenance and Custodial Employees

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Received May 15, 1992

Analyses of radiographs from a cohort of 457 school maintenance and custodial workers (90 had no employment other than at a school) demonstrated an increased prevalence of abnormalities consistent with asbestos-caused disease. Pleural abnormalities predominated (24 of 29). The abnormalities could not be explained by occupational asbestos exposures which may have occurred prior to school employment. Abnormality prevalence ranged from 1.7% among those with less than 10 years to 37% among those with 30 or more years of public school employment. Laborers and skilled tradesmen with more than 20 years of school employment had a higher prevalence of abnormality (40 and 28%) than the building engineers (14%). In order to ensure that future asbestos exposure and disease risk is minimized in buildings constructed with asbestos-containing materials (ACM), implementation of asbestos hazard identification and abatement must include a rigorous operations and maintenance program. Control of asbestos exposure from in-place ACM is a public health priority.

INTRODUCTION

Asbestos-containing boiler insulation products were introduced in 1890 and were expanded to include pipe wrap in 1910 (Selikoff and Lee, 1978). A new technology for spray application of asbestos-containing material (ACM) was introduced in the 1930s and resulted in many new fireproofing products as well as decorative and acoustical applications (McLaughlin, 1953; Lumley *et al.*, 1971). One such spray-on asbestos-containing building material was developed in 1932 and used in the London subways. Immediate warnings of the health hazard potential followed (Annotations, 1932).

Extensive investigation and hazard evaluation of the in-place products did not occur until after ACM had been in wide use and an estimated 500,000 tons of asbestos had already been sprayed in the United States (Sawyer and Sponner, 1978). In 1984 the United States Environmental Protection Agency (EPA) conducted a national survey of buildings to estimate the extent of friable ACM in existing structures. They concluded that approximately 31,000 schools and 733,000 public and commercial buildings were likely to contain such materials (USEPA, 1984).

Most buildings, if carefully maintained, can be expected to provide half a century or more of useful service. Repair, renovation, and remodeling provide the means to meet changing occupant needs or to replace aging or failed building components. Such activity frequently results in ACM being disturbed.

0013-9351/92 $5.00

We conducted this investigation to determine whether past exposure to asbestos fibers attributable to ACM (thermal insulation on pipes and boilers, fireproofing, acoustical insulation, and miscellaneous materials such as floor tile) in public school buildings had resulted in asbestos-associated morbidity.

METHODS

1. Cohort Identification

Clinics and physicians were contacted by the Wisconsin Pneumoconioses Consultation Program (PCP) (Schirmer *et al.*, 1990) to determine whether they had been contracted to systematically survey any groups of school maintenance or custodial workers. One clinic had conducted two surveys. All current maintenance and custodial employees at the schools, regardless of length of employment, were eligible to participate and had been invited.

The clinic agreed to confidentially abstract the medical records of all survey participants (both radiographically normal and abnormal). Information provided included, age, sex, year of first school employment, length of school employment, current job classification/description, history of employment prior to school hire—searching specifically for additional occupational exposure to fibrogenic dusts—current cigarette smoking status, and ILO 1980 Pneumoconioses Classification of the chest radiograph by a "B" reader. No information was available on the nonparticipants.

2. Case Definition

In this study, radiographs were considered consistent with asbestos-caused disease if a currently NIOSH certified "B" reader using the 1980 ILO Classification of Pneumoconioses classified the radiograph as exhibiting irregular small opacity profusion 1/0 or greater and/or exhibited pleural abnormalities other than blunting of the costophrenic angle.

All radiographs were read by a single "B" reader and 69 radiographs (considered by the clinic consultant to have a small opacity profusion of 0/1 or greater and/or pleural abnormalities) had a second independent interpretation by the PCP "B" reader (HAA). To increase epidemiologic specificity, an analytic case definition was adopted. In the presented analyses, a radiograph was considered abnormal only when both readers agreed on the presence of the abnormality. If the only pleural abnormality present was blunting of the costophrenic angle, the radiograph was considered "normal" in the analysis, even if described by both readers.

3. Statistical Methods

Student's t test was used to determine whether means of continuous variables differed significantly between two groups. Analysis of variance was used to determine the significance of differences in continuous variables between multiple groups. Mantel–Haenszel χ^2 or Fisher's exact test was used to compare categorical data. A level of $P < 0.05$ was selected as statistically significant.

RESULTS

There were 494 school maintenance and custodial workers eligible to have an exam. Ten individuals declined to participate and one had an unreadable radiograph. 1980 ILO Pneumoconioses Classification interpretations by a "B" reader with current NIOSH certification were provided for 483 workers. An additional 26 examination records missing age or year of first employment/total years of school employment were excluded from the analysis (2 of the 26 had abnormal X-rays), leaving a study group of 457.

Approximately one-third of the cohort were current cigarette smokers. Detailed lifetime smoking histories were available for 130 examinees. For the remainder, it was not possible to separate the never smokers from the former smokers. In the subgroup with complete smoking histories, cigarette smoking was not a significant predictor of radiographic abnormalities.

The demographic characteristics of the 457 current school maintenance and custodial workers are provided in Table 1. Review of the occupational histories found that 90 individuals had no employment listed before joining the schools' maintenance/custodial staff. Those with "school-only" employment had significantly longer school employment and were significantly younger than those with employment before school service.

1. Interreader Variability

Independently, two "B" readers, blinded to occupational or exposure information, and without knowledge that a second "B" reader would interpret the chest radiographs, graded 69 of the 457 radiographs. In only two instances did the readers disagree by two minor categories of profusion. Reader 1 described 33 radiographs with irregular small opacities at profusion 0/1, 11 radiographs at profusion 1/0 or greater, and 29 radiographs with pleural abnormalities. Thirty-seven of Reader 1 interpretations met our definition of abnormalities consistent with asbestos-caused disease. Reader 2 interpreted 29 radiographs at profusion 0/1, 13 films at profusion 1/0 or greater, and 26 radiographs with pleural abnormalities.

TABLE 1
SCHOOL MAINTENANCE AND CUSTODIAL WORKER DEMOGRAPHICS

Characteristic	Total	School employment only	*P* Value[a]
Examined	457	90	
Age			
Mean	43 ± 10.0	37 ± 8.6	<0.01
Range	20–65 years	20–61 years	
Years of school employment			
Mean	13 ± 8.9	18 ± 8.6	<0.01
Range	1–43 years	2–43 years	
Age at hire			
Mean	30 ± 9.2	19 ± 1.5	<0.01
Range	15–59 years	15–21 years	

[a] School employment only vs all others.

Reader 2 found 35 radiographs met our definition of abnormalities consistent with asbestos-caused disease.

Eight radiographs met the analytic criteria for the presence of irregular opacities (1/0 or greater) and 24 for pleural abnormalities. Three radiographs had both small opacities and pleural abnormalities, resulting in 29 radiographs meeting our case definition.

2. *Chest Radiographs*

Table 2 summarizes the prevalence of radiographic changes consistent with asbestos-caused disease by duration of school employment. Five instances of pleural calcification were seen. The prevalence of abnormalities increased with length of employment ($P < 0.001$).

Figure 1 compares the prevalence of abnormalities between those with no employment other than at the schools and those who had held employment before joining the school staff. While the prevalences of abnormality are somewhat different, they did not meet the $P < 0.05$ criterion. No abnormalities were seen among the 64 school-only workers with less than 20 years of school employment/latency. Among the school-only workers with more than 30 years working at the schools 46.2% displayed abnormalities. When compared to the group with employment prior to school work, differences did not reach statistical significance.

Duration of school employment was significantly positively associated with prevalence of radiographic abnormalities. Mean school employment was 12 ± 8 years for those without abnormalities, but 23 ± 11 years for those with abnormalities ($P < 0.001$).

Profusion of irregular opacities (only Reader 1 read all films) was positively associated with increasing mean years of employment ($P < 0.01$). Those with profusion 0/0 had mean school employment of 13 ± 9 years, those with profusion 0/1, 17 ± 11 years, and those with 1/0 or greater, 20 ± 8 years. Those with pleural abnormalities had mean school employment of 23 ± 11 years.

It was not possible to group workers by individual school buildings or contact with specific type of ACM as most had worked in all the buildings at one time or another. Workers could be grouped by their current employment category. Most workers had been hired into one job classification series and remained

TABLE 2
SCHOOL MAINTENANCE AND CUSTODIAL WORKER'S PNEUMOCONIOSIS SCREENING

School employment	*N*	≥1/0 only	Pleura only	Both	Pleura and/or parenchyma
1–9.9 years	173	0	2 (1.2%)	1 (0.5%)	3 (1.7%)
10–19.9 years	200	3 (1.5%)	5 (2.5%)	1 (0.5%)	9 (4.5%)
20–29.9 years	57	2 (3.5%)	5 (8.8%)	0	7 (12.3%)
30 + years	27	0	9 (33.3%)	1 (3.7%)	10 (37.0%)
Total	457	5 (1.1%)	21 (4.6%)	3 (0.7%)	29 (6.3%)

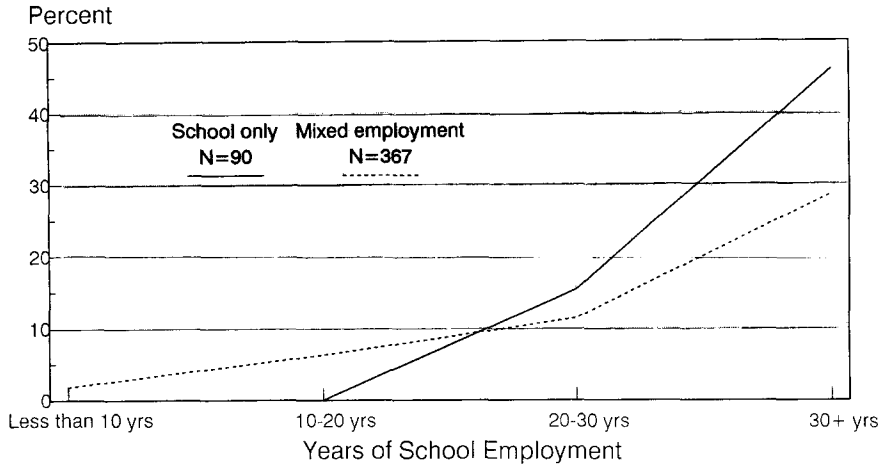

FIG. 1. Prevalence of asbestos-associated abnormalities. School employment only and mixed employment.

in that series. Skilled tradesmen remained in their trade throughout their employment.

Figure 2 shows the prevalence of abnormalities among the school occupational categories by length of school employment. No building services group workers had more than 20 years of school employment. In all other groups, those with more than 20 years had a higher prevalence of abnormalities than those with less than 20 years. Among the 20+ year workers, the laborers (N = 5) and maintenance trades grouping (N = 25) (carpenters, electricians, painters, plumbers, and plasterers) had the highest prevalence of abnormalities (40 and 28%). Among those with less than 20 years employment, the laborers (N = 26, 11.5%) were followed by the building services workers (N = 44, 9.1%).

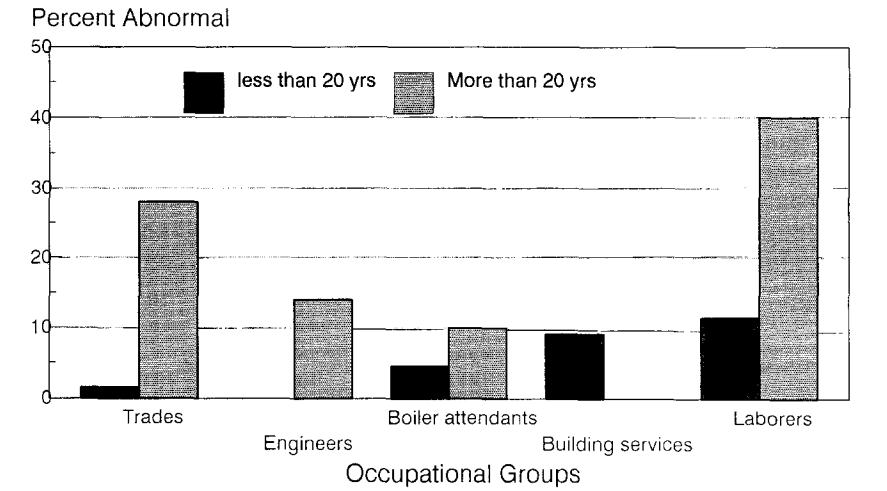

FIG. 2. Prevalence of asbestos-associated abnormalities by occupational groupings.

Employment histories prior to joining the school staff were reviewed to identify other occupational asbestos or silica exposures. Special attention was given to the lifetime occupational histories of the 29 individuals with abnormal radiographs. None of the 457 examined reported shipyard employment, or work in asbestos product factories. However, among the 367 workers with some employment prior to school work, 41 reported some employment in construction or industries with silica exposure. Of the 41 with potential confounding dust exposures, 7.3% had abnormal X-rays. This was not statistically significantly different from the 5.5% prevalence among the 326 with other types of employment before joining the school staff or from those with no employment other than in schools (8.9%).

DISCUSSION

The radiographic abnormalities described in the survey population, irregular small opacities and pleural thickening, plaques, and calcification are typical abnormalities caused by the inhalation of asbestos (Selikoff and Lee, 1978). None of the participants had rounded opacities suggestive of silica or coal exposure. Pleural abnormalities were the most prevalent.

The type and prevalence of abnormalities seen in this study group are similar to those reported by others in groups of maintenance workers and in occupations with intermittent asbestos exposures (Lilis *et al.*, 1979; Young *et al.*, 1981; Baker *et al.*, 1985; Oliver *et al.*, 1989; Levin and Selikoff, 1991). They are also similar to the prevalence seen among environmentally exposed groups such as family members of asbestos factory workers (Anderson *et al.*, 1979), family members of shipyard workers (Kilburn *et al.*, 1985), and asbestos insulator family members (Sider *et al.*, 1987).

It is noteworthy that two individuals had irregular opacities of profusion greater than 1/1 by both readers (2/2 and 1/2) and (2/1 and 1/2). The first was 53 years old and had worked as a school boiler attendant for 17 years. While he had held jobs prior to joining the school maintenance staff, no previous occupational asbestos exposure was identified. He had a restrictive pulmonary function defect with a vital capacity 45% of predicted. He had a 30 pack year smoking history. The second was a 56 year old who had only been employed in school maintenance. He had been a school laborer for over 35 years. He had a restrictive pulmonary function defect with a vital capacity 65% of predicted. He had not smoked cigarettes for 27 years. Such high profusion grades would suggest that a small proportion of the examined work force had experienced asbestos exposures which were more intense, frequent, and prolonged than those of their co-workers.

The school buildings contained friable thermal surfacing (both fireproofing and acoustical products) as well as nonfriable ACM. Much damaged material had been abated. The examinations were provided as part of an operations and maintenance plan. No personal or area industrial hygiene asbestos fiber measurements that would cover the relevant employment years were available. However, significant concentrations of respirable asbestos have been documented during typical building maintenance and renovation activities. (Lumley *et al.*, 1971; Sawyer, 1977; Pinchin, 1982; Paik *et al.*, 1983).

The increasing prevalence of abnormality by duration of school employment for the entire group as well as in the school-employment-only group (increasing from 0% among those with less than 10 years to 46% among those with 30+ years) supports the conclusion that the abnormalities are a result of past school-building maintenance and custodial exposures to asbestos fibers released from in-place ACM and not the result of prior, pre-school-employment asbestos exposure.

Three cases of malignant mesothelioma with long-term maintenance employment in these schools were identified among 10 such school maintenance cases investigated (Anderson *et al.*, 1991). Others have identified an increased risk of mesothelioma and lung cancer (Lilis, 1982; Davis and Martin, 1991) among building maintenance and custodial workers. Studies are needed to quantify the extent of the cancer risks caused by asbestos exposure experienced during routine building maintenance and custodial work.

CONCLUSION

The malignant and nonmalignant diseases caused by asbestos are well documented and have been known for decades (Selikoff and Lee, 1978). Our investigation confirms that school building maintenance/custodial workers are at risk of developing asbestos-caused disease. Radiographic evidence of such disease increased with length of school employment. Abnormalities were rare among workers with less than 20 years of employment/latency, but common among those with more than 30 years of school maintenance/custodian work. The prevalence of radiographic abnormalities among the school-building maintenance and custodial workers could only be explained by exposure during performance of usual employment activities to asbestos fibers released from in-place ACM.

It is of public health importance to implement asbestos hazard identification and abatement programs in buildings constructed using ACM. These programs need to rapidly implement rigorous operations and maintenance programs in order to minimize future asbestos exposure to this large work force and the even larger population of building residents whose health may be jeopardized by episodic environmental contamination by inadequate maintenance and operational precautions. Control of asbestos exposure from in-place ACM is a public health priority.

ACKNOWLEDGMENT

This report was partially supported by a cooperative agreement with the National Institute for Occupational Safety and Health, No. U50/CCU502661.

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