

The National Sheet Metal Worker Asbestos Disease Screening Program: Radiologic Findings

Laura S. Welch, MD, David Michaels, PhD, MPH, Stephen R. Zoloth, PhD, MPH, and The National Sheet Metal Examination Group

This report presents data gathered from a series of asbestos disease screening examinations of 9,605 United States sheet metal workers who were first employed in the trade at least 20 years before the examination. The overall prevalence of asbestos-related radiographic changes was 31.1%: 18.8% had pleural abnormalities alone, 6.6% had parenchymal abnormalities (International Labour Office (ILO) score of 1/0 or higher)

George Washington School of Medicine, Washington, D.C. (L.S.W.).

Department of Community Health and Social Medicine, The City University of New York Medical School, The Sophie Davis School of Biomedical Education, New York (D.M.).

Hunter College School of Health Sciences, The City University of New York, New York (S.R.Z.)

The National Sheet Metal Worker Examination Group: Victor Alexander, MD, New Orleans, LA; John Balmes, MD, MPH, San Francisco General Hospital/University of California at San Francisco, San Francisco, CA; Scott Barnhart, MD, University of Washington, Seattle, WA; Eddy Bresnitz, MD, Medical College of Pennsylvania, Philadelphia, PA; David Bonham, MD, St. Paul, MN; Peter Casten, MD, Oschner Clinic, New Orleans, LA; David Christiani, MD, Harvard School of Public Health, Boston, MA; Roger Cook, Union Health Care Corp, Buffalo, NY; Kevin Cooper, MD, Medical College of Virginia, Richmond, VA; Mark Cullen, MD, Yale University, New Haven, CT; Roy DeHart, MD, University of Oklahoma, Oklahoma City, OK; Ray Demers, MD, Wayne State University, Detroit, MI; Kathleen Fagan, MD, MPH, University Hospitals of Cleveland, Cleveland, OH; Howard Frumkin, MD, Emory University, Atlanta, GA; Arthur Frank, MD, University of Kentucky Medical Center, Lexington, KY; Gary Friedman, MD, Texas Lung Institute, Houston, TX; Ray Garman, MD, Guthrie Clinic, Sayre, PA; Michael Gibson, MD, Boise, ID; Jon Hake, MD, University of Oklahoma, Oklahoma City, OK; Robin Herbert, MD, Mt. Sinai School of Medicine, New York, NY; Steve Hessl, MD, Cook County Occupational Health Clinic, Chicago, IL; David Hincamp, MD, JOB MED, Chicago, IL; Michael Hodgson, MD, University of Pittsburgh, Pittsburgh, PA; Edwin Holstein, MD, Environmental Health Associates, Edison, NJ; Richard E. Johns, MD, University of Utah Medical Center, Salt Lake City, UT; Melody Kalamoto, MD, Barlow Occupational Health Center, Los Angeles, CA; David Kern, MD, Roger Williams Hospital, Providence, RI; Kay Kreiss, MD, National Jewish Hospital, Denver, CO; Eric Lang, MD, Miami, FL; James R. Langworthy, MD, Honolulu, HI; James Lockey, MD, University of Cincinnati Medical Center, Cincinnati, OH; James Merchant, MD, University of Iowa, Iowa City, IA; Ken Miller, MD, Portland, OR; Linda Morse, MD, San Jose, CA; Karen Mulloy, DO, Marshall University School of Medicine, Huntington, WV; Chris Oliver, MD, Massachusetts General Hospital, Boston, MA; Linda Rosenstock, MD, University of Washington, Seattle, WA; Paul Roundtree MD, University of Arkansas, Little Rock, AR; Mark Schenker, MD, University of California at Davis, Davis, CA; Isabella Sharpe, MD, Jacksonville, FL; David Schwartz, MD, University of Iowa, Iowa City, IA; Jerry Simmons MD, Meharry Medical College, Nashville, TN; Jane Sliwinski, MD, Green Bay, WI; Carol Stein, MD, University of Rochester Medical School, Rochester, NY; Ann Tencza, RN, Eastern New York Occupational Health Program, Latham, NY; Nina Wallerstein, MPH, University of New Mexico School of Medicine, Albuquerque, NM; Greg Wagner, MD, Division of Respiratory Disease Studies, NIOSH, Morgantown, WV.

Accepted for publication March 24, 1993.

alone, and 5.7% had both. Among those with 40 years or more since entering the trade, 41.5% had radiographic signs of asbestos-related disease, 24.2% pleural alone, 7.7% parenchymal alone, and 9.6% both pleural and parenchymal abnormalities. After controlling for several surrogates for asbestos exposure level, cigarette smoking was found to increase risk of parenchymal, and more modestly, pleural abnormalities. Each pack-year was associated with a 1% increased prevalence odds ratios for parenchymal abnormalities (ILO category 1 compared to category 0), and 0.4% increased prevalence odds ratios for pleural abnormalities. A history of shipyard employment also produced significantly increased prevalence odds ratios for each radiographic category. More than 90% of chest radiographs were classified by A or B readers; after adjustment for other risk factors, A readers were more likely to report parenchymal abnormalities of category 1, but not more likely to report category 2 or pleural abnormalities, than B readers.

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Key words: asbestosis, pleural abnormalities, parenchymal abnormalities, shipyard worker, cigarette smoking, B reader, sheet metal workers

INTRODUCTION

The harmful effects of exposure to asbestos have been identified in numerous studies of asbestos miners, textile workers, paper workers, railroad workers, and construction workers [Selikoff et al., 1979; Hedenstierna et al., 1981; Sprince et al., 1985]. Nicholson et al. [1982] estimated that there will be 125,000 cancer deaths due to asbestos-related diseases from 1985 to 2009; Liliensfeld et al. [1988] project 130,000 deaths in the same period. Asbestosis is also a significant cause of morbidity among highly exposed workers [Becklake, 1982, 1992].

Sheet metal workers are members of a profession with well-documented exposure to asbestos. Sheet metal work involves fabrication or installation of metal products, such as sheet metal ventilation systems, metal roofing, and metal facades, as well as large-scale production of metal products, such as refrigerators and air conditioners. Sheet metal workers work in the construction industry, railroad industry, and shipyards, as well as in specialized sheet metal production shops.

Although the craft of sheet metal work does not itself use asbestos, sheet metal workers in construction were, for many years, exposed to asbestos while working in close proximity to insulation workers, while working in areas that were being sprayed with asbestos for fireproofing, by working on beams fireproofed with asbestos, and by retrofitting (renovating) asbestos-insulated metal ventilation systems. During spray application of asbestos, much of the asbestos did not adhere to the building surfaces and instead filled the air. Before 1973, when this application was banned, over half of the high rise buildings constructed in the United States used asbestos as fireproofing [Paik et al., 1973]. Levels as high as 100 f/cc were measured in the spray zone during application of asbestos, and as high as 4 f/cc 30 minutes after spraying stopped [Paik et al., 1973]. Currently, because of stringent regulations on its use, asbestos exposure in the sheet metal trade occurs only during retrofit work in existing buildings.

In addition to asbestos, respiratory hazards associated with sheet metal work include exposure to welding fumes and manmade mineral fibers, primarily fiberglass. Other exposures include glues, solvents, noise, and vibration.

Several studies have examined asbestos-related disease among sheet metal

workers employed in construction. Two analyses of mortality among New York City sheet metal workers found significantly elevated mortality ratios for all malignant neoplasms and for lung cancer [Zoloth and Michaels, 1983; Michaels and Zoloth, 1988]. Notably, mesothelioma was recorded on the death certificate of 9 of the 716 deaths (1.3%) in the two studies combined, providing strong evidence that sheet metal workers are at increased risk of mortality from asbestos-related disease. Further support for this finding is provided by the results of two screening programs among sheet metal workers. Baker et al. [1985] reported that 70% of Boston sheet metal workers with greater than 30 years in the trade had pleural abnormalities, and 4% had parenchymal abnormalities. Among New York City sheet metal workers who belonged to the union for 20 or more years, 29% had radiologic abnormalities consistent with parenchymal and/or pleural asbestosis [Michaels et al., 1987].

Following these reports, the Sheet Metal Workers International Association (SMWIA) and the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) formed the Sheet Metal Occupational Health Institute (SMOHI) to study the health hazards of the sheet metal industry. One of SMOHI's objectives is to increase the scientific understanding of the health effects of asbestos exposure; the size of this screening program enabled SMOHI and collaborating scientists to explore questions that might be difficult to address in studies of smaller populations.

The institute invited sheet metal workers and sheet metal contractors to participate in one of two national asbestos disease medical screening programs, offered without charge and at a convenient time and place. In 1986 and 1987, 1,330 workers in seven cities in the United States and Canada were examined under the direction of Dr. Irving Selikoff; radiologic changes consistent with asbestos exposure were found in 60% of the workers examined [Selikoff and Lilis, 1991; Lilis et al., 1992]. Radiograph-related findings from the screening program in the remainder of the United States are presented in this paper.

METHODS

Starting in 1986, SMOHI contracted with 61 different clinical facilities in the United States (56) and Canada (5) to offer a standardized asbestos disease screening program for sheet metal workers who were first employed in the industry at least 20 years earlier. The program was offered to every SMWIA local; the program continues to offer examinations on a periodic basis. In this first round of screenings, 12,454 individuals were examined (out of 26,329 eligible), representing a participation rate of 47%. Participation varied among the screened locals, with a range of 24–93% in the United States and 14–83% in Canada.

Examination results were forwarded by participating United States clinics for 10,395 sheet metal workers. Of these, 234 (2.3%) had illogical or incomplete age or employment information, and 333 (3.2%) were missing clinical or radiographic results. These were eliminated from the analysis, as were the 207 (2%) screened at one clinic with a malfunctioning radiographic machine and the 16 female sheet metal workers seen, resulting in a study sample of 9,605 U.S. male sheet metal workers reported here. The results from the Canadian screening program will be reported separately.

Participating facilities were selected by one of the authors (LSW) in consultation with the staff of the SMOHI, based on the clinic's experience in conducting

similar screening programs in the past. The physicians agreed to provide each screened sheet metal worker with a standardized examination that consisted of:

- completion of an occupational and medical questionnaire
- a limited physical examination (blood pressure determination, examination of the heart and lungs, and examination for digit clubbing)
- spirometry, performed according to American Thoracic Society (ATS) guidelines [American Thoracic Society, 1987]
- PA and lateral chest radiograph, interpreted using the International Labour Office (ILO) classification for pneumoconiosis [International Labour Office, 1980]
- stool guaiac for occult blood.

The questionnaires were self-administered and subsequently reviewed by the clinic staff. The questionnaire included several questions used to describe the history of exposure to asbestos and manmade mineral fibers, including data on the industries in which the sheet metal worker was employed (new building construction, renovation, shipyard, or railroad), and on asbestos exposure before entering the sheet metal trade and while in the military. Years since first exposure were used as surrogate for time since first exposure. The medical history included sections of the ATS respiratory disease questionnaire.

Questionnaire data were checked for consistency for age, years since first exposure, years worked, and pack-years of smoking; those with illogical or missing data were corrected or discarded. Incomplete or illogical cigarette smoking histories were provided by 189 participants whose work histories appeared to be correct. Data from these individuals were not included in any smoking-related analyses. In addition, one clinic, at which 1,211 sheet metal workers were screened (of whom 1,094 provided accurate data on years worked and smoking history), used a modified questionnaire that provided only partial exposure histories.

Each chest radiograph was read by one reader. The reader was either an A reader, a B reader, or a physician with proficiency in the use of the ILO classification but who had not received a NIOSH rating. Parenchymal abnormalities were defined as the presence of profusion of 1/0 or greater on chest radiograph reading. A participant was considered to have pleural abnormalities if there were any notations of pleural abnormalities on the NIOSH/ILO coding form (sections 3A–D). Overall, the quality of 96.1% of the chest X-rays was rated as good or acceptable, 3.5% were scored as poor, and .3% unacceptable. Only three clinics, contributing approximately 1% of the population screened, had a combined proportion of greater than 15% of poor or unacceptable films.

Results of the examinations were conveyed to the individuals screened using a standardized notification letter and discussed in a meeting held with all participants subsequent to the examinations.

After the examinations, copies of the questionnaire, the NIOSH-ILO coding form, and a form summarizing the results of the pulmonary function tests and physical examinations were sent to the Center for Occupational and Environmental Health at the City University of New York for keypunching and analysis. The clinical centers were asked to do a minimum of abstraction from clinical records, limited to recording on the coding form the results of the two best spirometric results. All original data

were retained by the clinical centers. No independent assessment of the validity of questionnaire data, nor of radiographic technique or quality, was undertaken.

Descriptive analyses of the data were conducted using t-tests to explore differences between means and chi-square tests for examining relationships between categorical data. Logistic regression models were constructed and prevalence odds ratios and 95% confidence intervals were calculated in order to identify and examine risk factors for radiological signs of asbestos-related disease [SPSS, 1990]. Cigarette pack-year history was examined as a continuous variable. Prevalence odds ratios for the effects of smoking and aspects of sheet metal employment were calculated after adjusting for age, years since entering the sheet metal trade, and years employed in the trade.

RESULTS

The mean age of the sheet metal workers who participated in the screening was 57.2, with a median age of 57. Participants had worked an average of 32.8 years in the industry, and an average of 35 years had passed since they first became sheet metal workers. Age at time of examination and years since entering the trade were correlated ($r = .68$). More than half (55.6%) of the participants were working at the time of the examination, and 32% were retired. A small proportion, 3.2%, reported they were disabled, and the remainder were unemployed. The vast majority of the workers screened were employed in the building trades; only 7.9% (640 of those answering this question) reported a history of shipyard sheet metal employment, with an additional 1% with any employment history in the railroad industry. Asbestos exposure in the military was reported by 8.4% of the participants, and 7.4% reported asbestos exposure before entering the sheet metal trade.

At the time of the exam, 2,687 (28%) of the sheet metal workers examined were self-reported current smokers, with an additional 4,637 (48.3%) being former smokers and 2,282 (23.8%) never-smokers. Among those who reported a history of smoking, the mean number of pack-years smoked was 34.2; current smokers averaged 42.6 pack-years.

Overall, asbestos-related radiographic changes were found in 2,984 individuals (31.1%): 1,806 (18.8%) had pleural abnormalities alone, 634 (6.6%) had parenchymal abnormalities alone, and 544 (5.7%) had both. Among the 2,552 participants with 40 years or more since entering the trade, 41.5% had radiographic signs of asbestos-related abnormalities, 24.2% pleural alone, 7.7% parenchymal alone, and 9.6% signs of both pleural and parenchymal abnormalities. The radiographic changes consistent with pneumoconiosis were primarily in major category 1 of the ILO classification system (Table I); less than 1% were classified as 2/1 or higher.

Figure 1 displays the prevalence of asbestos-related parenchymal changes on radiograph by years since entering the sheet metal trade. The proportion of participants with chest radiographs scored as 1/0 or higher increased in each increment of five years since first exposure, with the exception of the group with the second shortest latency. This group (25–29 years) has a lower proportion of films rated 1/0 or greater than the group with 20–24 years in the trade, although the longer latency group has a larger percent of 0/1 chest radiographs.

Much of the parenchymal abnormalities in the shortest latency group were seen

TABLE I. Distribution of ILO Scores in Survey of 9,605 Sheet Metal Workers With 20 or More Years Since Entering the Trade

ILO score	n	(%)
0/0	7317	76.2
0/1	1110	11.6
1/0	737	7.7
1/1	306	3.2
1/2	62	.6
2/1	25	.3
2/2	32	.3
2/3	13	.1
3/2	2	—
3/3	1	—
Total	9605	100.0

ILO, International Labour Office.

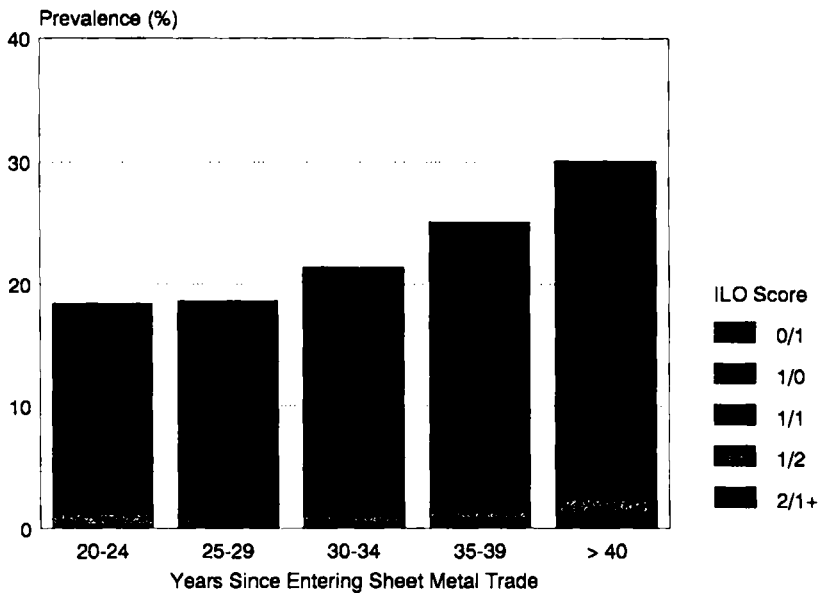


Fig. 1. Prevalence of parenchymal abnormalities among 9,605 sheet metal workers by ILO score and years since entering the trade (International Labour Office Classification of Radiographs of Pneumocociosis; ILO, 1980).

in older than average workers (Table II); thus the increased prevalence of parenchymal abnormalities in this group may be explained by the presence of a larger percent of older workers, who may have had asbestos exposure before joining the sheet metal trade. However, in the logistic regression model reported exposure before entering sheet metal trade was not significantly associated with increased prevalence of parenchymal abnormalities among the 20–24 year group. Figure 2 illustrates the increasing prevalence of pleural abnormalities with years since first exposure.

TABLE II. Mean Age of 9,605 Screened Sheet Metal Workers by Latency and ILO Score

Years since entering trade	ILO score				
	0/0	0/1	1/0	1/1-1/2	2/1 +
20-24 yrs	49.6	50.6	52.0	53.4	62.5
25-29 yrs	49.6	49.9	50.2	49.4	55.0
30-34 yrs	54.2	54.3	55.4	60.0	57.7
35-39 yrs	58.7	58.6	60.0	60.1	62.2
40+ yrs	65.3	65.0	66.6	67.5	68.3
Total	56.6	57.6	59.5	61.0	63.7

ILO, International Labour Office.

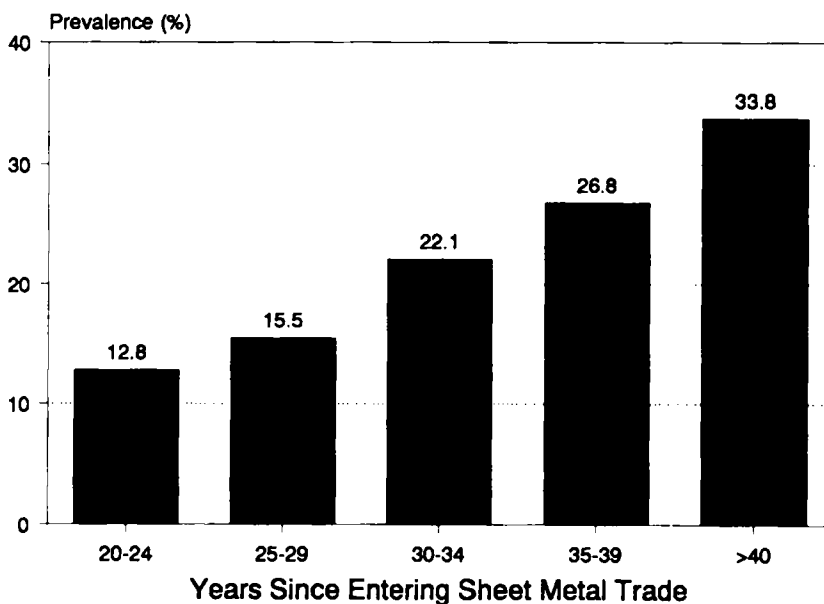


Fig. 2. Prevalence of pleural abnormalities among 9,605 sheet metal workers by years since entering the trade.

At each category of latency, sheet metal workers who had never smoked had a lower prevalence of parenchymal abnormalities than current smokers or those who had quit smoking; and those who quit generally had a lower prevalence than current smokers (Fig. 3). For the group as a whole, a significant trend of increasing risk was seen, comparing smokers with ex-smokers, and ex-smokers with never smokers, adjusting for latency ($p = .003$). This significant trend was also seen at each latency category.

While proportionally fewer never-smokers than ever-smokers had signs of pleural abnormalities as well (Fig. 4), the magnitude of the difference was much smaller than that seen for parenchymal abnormalities and the overall trend was not statistically significant.

Radiographs were classified by 62 readers, of whom 34 were B readers, 20 were A readers, and 10 were neither A nor B readers. Films of 7,075 (73.7%) participants

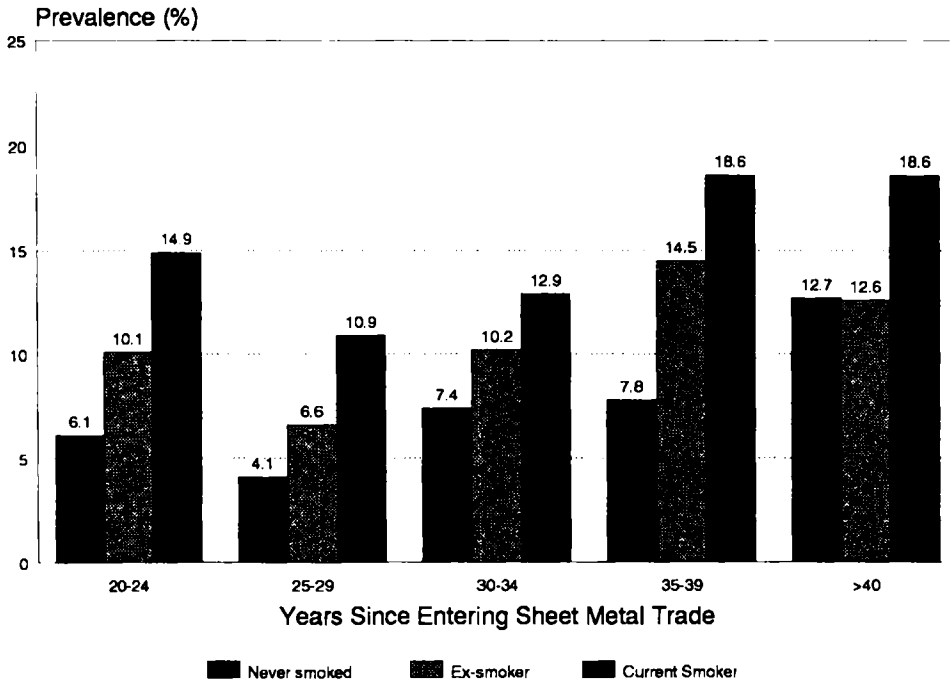


Fig. 3. Prevalence of parenchymal abnormalities (ILO score of 1/0 or higher) among 9,605 sheet metal workers by years since entering the trade and smoking status. See Figure 1 for definition of ILO score.

were read by B readers, 2,066 (21.5%) by A readers, and the remaining 464 (4.8%) by readers with no rating. The total prevalence of parenchymal abnormalities reported by all readers was 12.3%; among B readers the prevalence was 11.2%, among A readers 17.5%, and among other readers 4.9%. Pleural abnormalities were seen in 24.5% of the participants; among B readers, the prevalence was 25.3%, A readers 24.9%, and other readers 10.1%.

Table III presents the logistic regression model for parenchymal abnormalities scores 1/0–1/2, and for score 2/1 and higher, both compared with those with a score of 0/0 or 0/1. After controlling for age, years since entering the trade, and years worked, reported history of shipyard employment more than doubled the prevalence odds ratios for parenchymal abnormalities. Neither railroad employment nor asbestos exposure in the military or before entering the sheet metal trade was associated with increased risk of parenchymal changes. Cigarette smoking appears to increase the prevalence odds ratios of parenchymal abnormalities by approximately 1% for each pack-year smoked. Cigarette pack-years and shipyard employment history were both significantly associated with having a chest radiograph interpreted as 1/0 vs. 0/1, and 0/1 vs. 0/0 (not shown).

Table IV presents results of a similar logistic model for pleural abnormalities, again controlling for age and exposure history. Shipyard employment history increases risk of pleural abnormalities by approximately 30%; the effect of other exposure history-related variables (railroad, military, pre-sheet metal) are not statistically significant. Cigarette smoking is associated with increased risk, although the

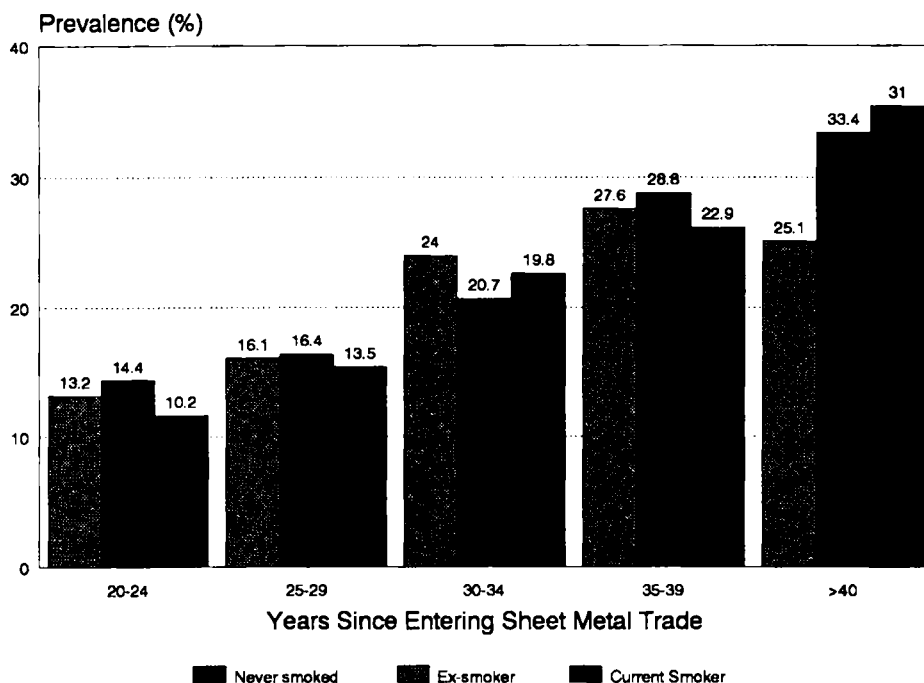


Fig. 4. Prevalence of pleural abnormalities among 9,605 sheet metal workers by years since entering the trade and smoking status.

TABLE III. Risk Factors for Parenchymal Abnormalities on Chest Radiographs in Survey of 9,605 Sheet Metal Workers

Risk factor	ILO score: 1/0-1/2		2/1 or higher	
	OR ^a	95% CI ^b	OR	95% CI
Cigarette pack-year	1.011 ^c	1.009-1.014	1.012 ^d	1.004-1.021
Shipyards employment history	2.28 ^e	1.84-2.83	2.42 ^c	1.23-4.77

^aPrevalence odds ratios for pack-year history adjusted for age, years since entering the sheet metal trade, and years employed in the trade. Prevalence odds ratios for shipyard employment adjusted for age, years since entering the sheet metal trade, years employed in the trade, and pack-year history.

^b95% confidence interval.

^cp < .05.

^dp < .01.

^ep < .001.

effect of smoking on pleural changes is less than half of that on parenchymal abnormalities.

To investigate whether the effect of shipyard exposure detected here was an artifact associated with the higher prevalence rates reported by clinics in coastal areas, separate regression models were constructed for the six sites (1,173 participants) at which 20% or more of the workers screened reported a history of shipyard employment and the 14 sites (1,668 participants) at which 10% or more had worked in shipyards. In both these analyses, the prevalence odds ratios for the association of

TABLE IV. Risk Factors for Pleural Abnormalities on Chest Radiographs in Survey of 9,605 Sheet Metal Workers

Risk factor	OR ^a	95% CI ^b
Cigarette pack-year	1.004 ^c	1.002–1.006
Shipyards employment history	1.33 ^d	1.11–1.59

^aPrevalence odds ratios for pack-year history adjusted for age, years since entering the sheet metal trade, and years employed in the trade. Prevalence odds ratios for shipyard employment adjusted for age, years since entering the sheet metal trade, years employed in the trade, and pack-year history.

^b95% confidence interval.

^c $p < .001$.

^d $p < .01$.

shipyards employment and pleural and parenchymal abnormalities were not different from those detected in the general model.

In order to determine if readers with different degrees of proficiency (as determined by the B reader examination) classified radiographs differently, we constructed a series of regression models that compared reader types (Table V). Controlling for other risk factors, we found that A readers reported more parenchymal abnormalities of ILO category 1 than B readers, and readers who were neither A nor B readers reported significantly fewer abnormalities in category 1 than either group. There were no differences among the three groups in reporting category 2 on the ILO scale. A readers and B readers reported the same adjusted prevalence of pleural abnormalities, while non-A, non-B readers reported significantly fewer pleural abnormalities than either of the other groups. Inclusion of reader type in a logistic regression model did not change the association of both pack-year history and shipyard exposure with parenchymal and pleural radiographic abnormalities (not shown).

DISCUSSION

In this study 31% of sheet metal workers with more than 20 years in the trade had chest radiographic abnormalities consistent with asbestos exposure; the prevalence of abnormalities increased with years of exposure and years since first exposure; and abnormalities were seen more frequently in those participants who reported a history of working in a shipyard at any point in their career. In addition, a higher prevalence of radiographic abnormalities, both pleural and parenchymal, was seen among participants who smoked.

Sheet metal workers ordinarily do not use asbestos directly, but a high prevalence of asbestos-related abnormalities is evident in this population. This is consistent with the finding of numerous surveys of members of the building trades who are exposed to asbestos during the course of construction and renovation activities. In these studies the prevalence of asbestos abnormalities varies widely among different trades and occupations surveyed [Hedenstierna et al., 1981; Lilienfeld et al., 1988; Rosenstock et al., 1988; Schwartz et al., 1990; Selikoff and Lilis, 1991; Oksa et al., 1992]. In this study history of employment in shipyards increased the prevalence odds ratio of radiographic abnormalities, particularly of the parenchymal variety, suggest-

TABLE V. Relationship Between Reader Type and Radiographic Abnormalities

Compared with B reader	ILO 1 vs. 0		ILO 2 vs. 0		Pleural changes	
	OR ^a	95% CI ^b	OR	95% CI	OR	95% CI
A reader vs. B reader	1.83 ^c	1.57-2.14	.82	0.44-1.53	0.92	0.81-1.04
Non-AB vs. B reader	0.75 ^d	0.64-0.88	.92	0.62-1.37	0.68 ^d	0.61-0.75
Non-AB vs. A reader	0.48 ^d	0.37-0.61	.88	0.45-1.69	0.57 ^c	0.48-0.67

^aPrevalence odds ratios adjusted for age, years since entering the sheet metal trade, years employed in the trade, and shipyard employment and pack-year history.

^b95% confidence interval.

^cp < .01.

^dp < .001.

ing that sheet metal worker exposure levels in the shipyards were higher than in construction.

The interaction between asbestos exposure and cigarette smoking in the development of parenchymal disease has been previously reported [Samet et al., 1979; Lillis et al., 1986; Blanc et al., 1988; Kilburn and Warshaw, 1992], and this study again demonstrates that smokers have a higher prevalence of radiographic parenchymal changes. In this population the risk of mild and severe parenchymal abnormalities increases with pack-year history.

The finding that cigarette smoking has an independent, albeit weak, association with pleural disease has been reported in another study of sheet metal workers [Baker et al., 1985], but has not been seen in most other analyses of asbestos disease prevalence [Rosenstock and Hudson, 1987]. It is possible that an effect as small as that suggested here, an increase in risk of pleural abnormalities by 0.3% with each pack-year smoked, might not have been detected in smaller studies. For example, Blanc et al.'s study of 294 shipyard workers reported an asbestos-smoking interactive effect for pleural disease that approached but did not reach statistical significance. Alternatively, since smoking has been associated with pleural disease in two studies of sheet metal workers but rarely in other occupational cohorts, pleural disease may be related to an interaction between asbestos, tobacco smoke, and some third toxic substance to which sheet metal workers are exposed. This question deserves further study.

It is important to note that the presence of either pleural or parenchymal abnormalities cannot be attributed to cigarette smoking alone. While several authors have suggested that smoking is independently associated with small opacities on chest radiograph, [Thériault et al., 1974; Amandus et al., 1976; Cockcroft et al., 1983], these studies did not include subjects without dust exposure, precluding the possibility of accurately identifying an independent effect of smoking. In one important investigation of this issue, NIOSH-certified B readers found a prevalence of parenchymal abnormalities (ILO score of 1/0 or greater) of less than 1% in a large population of blue collar workers with minimal exposure to occupational respiratory hazards [Castellan et al., 1985]. In that study, age, pack-years, and gender were significantly associated with small opacities, but the prevalence of small opacities was so low in the group without asbestos or other dust exposure that an independent effect of smoking, in the absence of dust exposure, can be considered insignificant. Thus, while history of tobacco consumption appears to increase risk of asbestos-

related pulmonary abnormalities among asbestos-exposed workers, these abnormalities would not have occurred in the absence of asbestos exposure.

Cross-sectional studies have several inherent sources of bias, and they are particularly susceptible to bias associated with selective participation [Checkoway et al., 1989]. Many of the abnormalities detected in this screening program, especially pleural and mild parenchymal abnormalities, may not be associated with overt symptoms. As a result, this study's finding of increased risk of both parenchymal and pleural disease among smokers is unlikely to be the result of selective participation among smokers with abnormalities. However, it remains possible that the overall rates of radiographic abnormalities in this population were affected by selective participation and inter-reader variability in radiographic classification.

The large number of radiograph readers may have resulted in a lack of uniformity in diagnostic criteria. This is likely to occur even among B readers, whose readings are considered to be the non-invasive gold standard for identifying asbestos-related pulmonary abnormalities [Jacobsen et al., 1983; Ducatman, 1988]. We did find an association between reader type and chest radiograph findings for parenchymal abnormalities, limited to category 1 films. When the analysis is restricted to B readers only, the other findings of this study do not change. Overall, the reported prevalence represents a rate of parenchymal abnormalities far above any background rate in the general population, and one consistent with studies of other asbestos-exposed populations. Importantly, the dose-effect relationship between smoking and signs of pleural and parenchymal abnormalities, and the finding that shipyard employment is associated with more radiographic abnormalities, do not change with the inclusion of B readers only.

We found that readers who were not designated as A readers or B readers reported fewer parenchymal and pleural abnormalities than either A or B readers. By and large, this set of readers were at clinical centers that examined small locals in more rural areas of the country; they averaged 46 films each, as compared to an average of 200 films per B reader. The difference in reported prevalence of abnormalities may be due to a difference in experience with the ILO system or due to different characteristics of the workers and their exposures in rural areas.

Four recent studies of the classification of profusion abnormalities in asbestos-exposed workers demonstrate that there is significant variation in ILO classification of the same radiographs among experts and B readers [Jacobsen et al., 1983; Musch et al., 1984; Ducatman, 1988]. Jacobsen et al. [1983] reported a range of 2.4-76.5% of readings of 6,100 equivalent films as 0/1 or higher by 18 readers; Ducatman (1988) reported a range of 0.22-7.55% of 100,000 films read as 1/1 or more by 23 readers. Musch et al. (1984) reported a range of 26-47% films classified as 1/0 or higher among three readers. These data remind us that limiting a program to B readers does not eliminate variability. In this report, with 34 B readers and 20 A readers participating, we present aggregate data, examining a mean prevalence across a range of clinical centers. Given that each film was classified by only one reader, and that variability exists between readers, our ability to compare results between participating centers is limited.

The examination program described here is continuing under the sponsorship of the Sheet Metal Occupational Health Institute. As examinations proceed, we will have the opportunity to study rates of disease in younger members who began work in the early 1970s. Examination of this group will allow us to determine if exposure after 1973, when the spray application of asbestos for fireproofing was discontinued,

results in significant disease. Sheet metal workers continue to be exposed to asbestos in repair and renovation work, and recent studies of workers exposed to asbestos only through building maintenance suggest that this type of work can result in significant disease [Oliver et al., 1991; Anderson et al., 1992].

The findings of this study confirm the value of large-scale screening programs for workers with historical exposure to asbestos. This survey shows a substantial prevalence of radiographic abnormalities in a group without direct occupational use of asbestos, a group that had been considered as having "light" exposure to asbestos. The results of this survey have been used to educate sheet metal workers and sheet metal contractors about the health effects of asbestos and possible sources of current exposure, so as to limit disease in the future.

ACKNOWLEDGMENTS

This study could not have been undertaken without the generous encouragement and financial support of the Sheet Metal Workers International Association (SMWIA) and the Sheet Metal Occupational Health Institute (SMOHI). In particular, Edward J. Carlough, General President, SMWIA; James Golden, Director, SMOHI; and Lynn McDonald, Special Assistant, SMOHI, provided invaluable assistance. The Center for Occupational and Environmental Health at the City University of New York served as the data center for the project. Margot Lacher, Roland Ledo, Charlotte Kratt, and Paula Diamond coordinated data collection, cleaning, and analysis. Gail Cavallo, at the George Washington University, coordinated arrangements for clinical examinations.

In addition, the authors would like to thank Drs. Eddy Bresnitz, Katherine Hunting, and James Robins for their helpful suggestions, and Dr. Carl Rosenberg for assistance in statistical analysis. This research was supported in part by a grant from PSC-CUNY to Stephen Zoloth. Computer support was provided by the City University of New York Computer Center.

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