

CHEST[®]

Official publication of the American College of Chest Physicians



Change in Prevalence of Asbestos-Related Disease Among Sheet Metal Workers 1986 to 2004

Laura S. Welch, Elizabeth Haile, John Dement and David Michaels

Chest 2007;131:863-869
DOI 10.1378/chest.06-1155

The online version of this article, along with updated information and services can be found online on the World Wide Web at:
<http://chestjournals.org/cgi/content/abstract/131/3/863>

CHEST is the official journal of the American College of Chest Physicians. It has been published monthly since 1935. Copyright 2007 by the American College of Chest Physicians, 3300 Dundee Road, Northbrook IL 60062. All rights reserved. No part of this article or PDF may be reproduced or distributed without the prior written permission of the copyright holder (<http://www.chestjournal.org/misc/reprints.shtml>). ISSN: 0012-3692.

A M E R I C A N C O L L E G E O F
 C H E S T
P H Y S I C I A N S[®]

Change in Prevalence of Asbestos-Related Disease Among Sheet Metal Workers 1986 to 2004*

Laura S. Welch, MD; Elizabeth Haile, MS; John Dement, PhD; and David Michaels, PhD, MPH

In 1985, the Sheet Metal Workers International Association and the Sheet Metal and Air Conditioning National Association formed The Sheet Metal Occupational Health Institute Trust to examine the health hazards of the sheet metal industry in the United States and Canada. Between 1986 and 2004, 18,211 individuals were examined. The mean age of this cohort was 57.9 years, and the participants had worked for a mean (\pm SD) duration of 32.9 \pm 6 years in the sheet metal trade. Twenty-three percent of participants were current smokers, 49% were former smokers, and 28% were never-smokers. A total of 9.6% of participants (1,745 participants) had findings that were consistent with parenchymal disease (International Labor Organization [ILO] score, \geq 1/0); 60% of those with an ILO score \geq 1/0 were classified as 1/0, 34% as 1/1 to 1/2, and 6% as \geq 2/1. A total of 21% of participants (3,827 participants) had pleural scarring. There was a lower prevalence of nonmalignant asbestos-related disease among those who began to work after 1970, when compared to workers who began to work before 1949; those who began to work between 1950 and 1969 had a prevalence between the other two groups. The strongest predictor of both parenchymal and pleural disease on a chest radiograph was the calendar year in which the worker began sheet metal work; work in a shipyard was also an important risk. The results of this study suggest that the efforts to reduce asbestos exposure in the 1980s through strengthened Occupational Safety and Health Administration regulation have had a positive public health impact. (CHEST 2007; 131:863–869)

Key words: asbestos; asbestosis; prevalence

Abbreviations: CI = confidence interval; f/cc = fibers per cubic centimeter of air; ILO = International Labor Organization; NIOSH = National Institute for Occupational Safety and Health; OR = odds ratio; OSHA = Occupational Safety and Health Administration

Numerous studies^{1–5} have documented the health effects of occupational exposure to asbestos. The federal government placed a moratorium on the production of many asbestos products in the early 1970s, and consequently experts have predicted a reduction in asbestos-related disease for cohorts beginning work after 1970.

Sheet metal work is one of the construction trades

with recognized exposure to asbestos.^{6,7} In 1985, the Sheet Metal Workers International Association and the Sheet Metal and Air Conditioning National Association formed the Sheet Metal Occupational Health Institute Trust to examine the health impact of asbestos exposure in the sheet metal industry in the United States and Canada. In a prior report⁸ on this program, 32% of the participants examined

*From the Center to Protect Workers Rights (Dr. Welch and Ms. Haile), Silver Spring, MD; Duke University (Dr. Dement), Durham, NC; and George Washington University (Dr. Michaels), Washington, DC.

This work was supported by the Sheet Metal Occupational Health Institute Trust.

Drs. Welch, Michaels, and Dement have worked as consultants for law firms representing individuals with asbestos-related disease. None of the authors have a financial interest in any organization that could profit from the research presented here.

Manuscript received May 4, 2006; revision accepted October 5, 2006.

Reproduction of this article is prohibited without written permission from the American College of Chest Physicians (www.chestjournal.org/misc/reprints.shtml).

Correspondence to: Laura S. Welch, MD, Center to Protect Workers Rights, 8484 Georgia Ave, Silver Spring, MD 20910; e-mail: lwelch@cpwr.com

DOI: 10.1378/chest.06-1155

between 1986 and 1990 were found to have either pleural or parenchymal radiographic abnormalities consistent with pneumoconiosis. Here, we present an updated analysis of this cohort, with results for 18,211 sheet metal workers examined between 1986 and 2004, and look at change in the prevalence of radiographic abnormalities for different decades of work in the trade.

MATERIALS AND METHODS

Starting in 1986, the Sheet Metal Occupational Health Institute Trust contracted with facilities in the United States and Canada to offer a standardized screening program for sheet metal workers who had first been employed in the industry at least 20 years earlier. The physicians agreed to complete standardized reporting forms, to classify the chest radiographs using the International Labor Organization (ILO) classification,⁹ and to follow the American Thoracic Society standards for conducting pulmonary function testing.¹⁰ A more detailed description of the methods of the examination program can be found in prior reports.^{8,11} The study was conducted in accord with the recommendations of the Helsinki Declaration¹² and was approved by the Institutional Review Board of the Center to Protect Workers Rights.

For the sheet metal program, each chest radiograph was classified by one reader who was an A reader, a B reader, or a physician with proficiency in the use of the ILO classification but who was neither an A or B reader; this last group was combined with the A readers for this analysis. National Institute for Occupational Safety and Health (NIOSH) B reader approval is granted to physicians who demonstrate proficiency in the classification of chest radiographs for pneumoconioses using the ILO classification through testing; an A reader has attended the American College of Radiology Symposium on Radiology of the Pneumoconioses.^{13,14}

Parenchymal abnormalities were considered to be present if the radiograph was classified with a profusion of $\geq 1/0$. A participant was considered to have pleural abnormalities if there were any notations on the NIOSH/ILO coding form in sections 3A to 3D.

There were a total of 21,865 examinations performed in the program. Approximately 12% of participants were examined more than once; this analysis includes only the last examination for those workers who have had more than one examination. After excluding the second examination and workers with missing ILO sheets, missing or illogical dates, and missing pertinent variables such as FVC and gender, our final sample consisted of 18,211 workers.

Statistical Analysis

Descriptive data are presented as number (%) or the mean \pm SD. Continuous variables were compared using the Student *t* test, dichotomous variables were compared with the χ^2 test of general association, and ordinal categorical data were compared with the Cochran-Armitage test for trends or the Spearman correlation test for variables compared with two or more categories. Logistic regression models were constructed to determine predictors for the presence or absence of parenchymal or pleural disease, and results are reported as prevalence odds ratios (ORs) and 95% confidence intervals (CIs). The risk factors incorporated in the models included the total number of years the participant had worked in the sheet metal industry, the calendar year during

which the participant had entered the sheet metal industry, age, smoking history (in pack-years), type of radiograph reader (*ie*, A reader or B reader), and a dichotomous variable for any history of shipyard work. The presence of multi-collinearity among the independent variables was checked using diagnostics such as the variation inflation factor and tolerance. Due to the small number of women in these data, logistic models were restricted to men. All statistical analyses were performed with a statistical software package (SAS for Windows, version 9.1; SAS Institute; Cary, NC).¹⁵ Tests of significance are presented only for the adjusted analyses.

RESULTS

Among these 18,211 individuals, the mean age was 57.9 years, and the median age was 57 years. The participants had worked for a mean duration of 32.9 ± 6 years in the sheet metal trade. About 50% of participants were working at the time of the examination, 38% were retired, 8% were unemployed, and 3.6% were disabled. Only 17 participants were women. Twenty-three percent of participants were current smokers, 49% were former smokers, and 28% were never-smokers. The mean number of pack-years smoked among current smokers was 40.7 ± 21.5 , and among former smokers it was 27.6 ± 21.4 . Among the entire group screened, 1,745 (9.6%) had findings that were consistent with parenchymal disease (ILO classification score, $\geq 1/0$); 60% of those with an ILO classification score of $\geq 1/0$ were classified as 1/0, 34% as 1/1 to 1/2, and 6% as $\geq 2/1$. A total of 21% of participants (3,827 participants) had pleural scarring.

Eighty four percent of the chest radiographs were read by B readers, 11.8% by A readers, and no reader classification was recorded for 4% of the readings. A readers were more likely than B readers to report parenchymal abnormalities (16.4% vs 7.8%, respectively) and pleural abnormalities (32.3% vs 20.0%, respectively). Chest radiographs read in the earlier years of the screening were more likely to have been read by A readers; as a result, A reading was correlated with shipyard work and with the calendar year the participant had entered the trade. A previous analysis¹¹ of a subset of the B readers found excellent specificity for abnormal radiograph findings and good agreement in a κ analysis.

Table 1¹⁶ presents an overview of the characteristics of the population, divided into the following three groups: those examined between 1986 and 1990; those examined from 1991 to 2000; and those examined from 2001 to 2004. The participants in the second and third rounds were slightly older than the ones examined in the first round, had worked for a slightly long time (in years) in the trade, and were more likely to be retired. The participants after 1991 were on the whole more likely to have normal lung

Table 1—Worker Demographics and Pulmonary Outcomes by Examination Period Among Sheet Metal Workers Examined From 1986 to 2004*

Variables	1986–1990 (n = 7,865)	1991–1999 (n = 5,719)	2000–2004 (n = 2,237)	p Value
Age, yr	57.18 ± 8.12	58.64 ± 9.26	58.57 ± 9.29	< 0.01†
Median (minimum to maximum)	57 (23–83)	58 (25–88)	57 (40–88)	
Male gender	7,856 (99.99)	5,714 (99.91)	2,234 (99.87)	0.99‡
Female gender	9 (0.11)	5 (0.09)	3 (0.13)	
FVC, % predicted	88.66 ± 16.06	89.20 ± 16.14	92.03 ± 16.69	< 0.01†
Normal lung function§	4,812 (61.18)	3,730 (65.22)	1,530 (68.40)	< 0.01†
Restrictive lung function§	937 (11.91)	695 (12.15)	228 (10.19)	
Obstructive lung function§	1,525 (19.39)	934 (16.33)	371 (16.58)	
Mixed lung function§	591 (7.51)	360 (6.29)	108 (4.83)	
Current smoker	2,231 (28.37)	1,214 (21.23)	368 (16.45)	< 0.01†
Ex-smoker	3,776 (48.01)	2,922 (51.09)	1,111 (49.66)	
Never-smoker	1,858 (23.62)	1,583 (27.68)	758 (33.88)	
Current smoker, pack-yr	42.56 ± 22.02	40.37 ± 20.74	36.61 ± 19.66	< 0.01†
Ex-smoker, pack-yr	30.31 ± 22.99	27.25 ± 20.53	23.46 ± 19.22	< 0.01†
Smoking history, pack-yr	34.86 ± 23.39	31.10 ± 21.44	26.74 ± 20.14	< 0.01†
Pleural disease present	2,098 (26.68)	1,329 (23.24)	239 (10.68)	< 0.01‡
Parenchymal disease present (ILO score > 1/0)	1,079 (13.72)	499 (8.73)	132 (5.90)	< 0.01‡
Parenchymal disease, based on ILO scores				< 0.01†
0/0–0/1	6,786 (86.28)	5,220 (91.27)	2,105 (94.10)	
1/0	640 (8.14)	316 (5.53)	75 (3.35)	
1/1–1/2	374 (4.76)	161 (2.82)	46 (2.06)	
≥ 2/1	65 (0.83)	22 (0.38)	11 (0.49)	
Duration of work in sheet metal trade, yr				
Mean (±SD)	32.89 ± 6.57	33.02 ± 6.79	33.22 ± 6.24	0.06†
Median (minimum to maximum)	33 (15–63)	33 (15–59)	33 (15–54)	
Work status at time of examination				
Working	4,015 (55.08)	2,582 (45.27)	1,161 (51.95)	< 0.01†
Retired	2,350 (32.24)	2,449 (42.94)	900 (40.27)	
Unemployed	681 (9.34)	409 (7.17)	107 (4.79)	
Disabled	244 (3.35)	263 (4.61)	67 (3.00)	

*Values are given as the mean ± SD or No. (%), unless otherwise indicated. Date of radiograph was missing for 2,390 patients, who were excluded from the study; therefore, the total sample was 15,821.

†Spearman correlation.

‡Cochran-Armitage trend test.

§Lung function was defined based on Beta-Carotene and Retinol Efficacy Trial.¹⁶

function, more likely to be a life-long nonsmoker, and more likely to have smoked less if they did smoke, and less likely to have any asbestos-related disease found on a chest radiograph.

To look at the relationship between the calendar year that the participant began sheet metal work and the prevalence of parenchymal and pleural disease, we divided the population into the following three groups: those who began work before 1949, a period that included work in shipyards during World War II; those who began work between 1950 and 1969, a period in which asbestos use became more widespread in the United States; and those who began work after 1970, a decade in which asbestos use was curtailed even if not completely controlled. In an unadjusted analysis, participants who began work before 1949 had more nonmalignant asbestos-related disease than those who began work between 1950 and 1969, and still more than those who began

work after 1970. Figure 1 shows this information in a graphic form with stratification by age group.

Table 2 presents the prevalence of parenchymal and pleural disease stratified by the duration of sheet metal work. There is an increasing risk of both parenchymal and pleural disease with the number of years of work in the sheet metal trade. The number of years worked in the sheet metal trade was inversely correlated with the year that sheet metal work was begun, making separation of the effects of these factors difficult. When these data were stratified by the year entering the trade, the parenchymal disease risk gradient with years of work in the trade was diminished. The same is true for pleural disease (data not shown).

Tables 3 and 4 present ORs from the logistic regression models, including covariates for age, number of years worked, shipyard work (yes/no), reader classification (A reader vs B reader), number

Prevalence of parenchymal abnormalities among 18,211 sheet metal workers by calendar year entered the trade and age

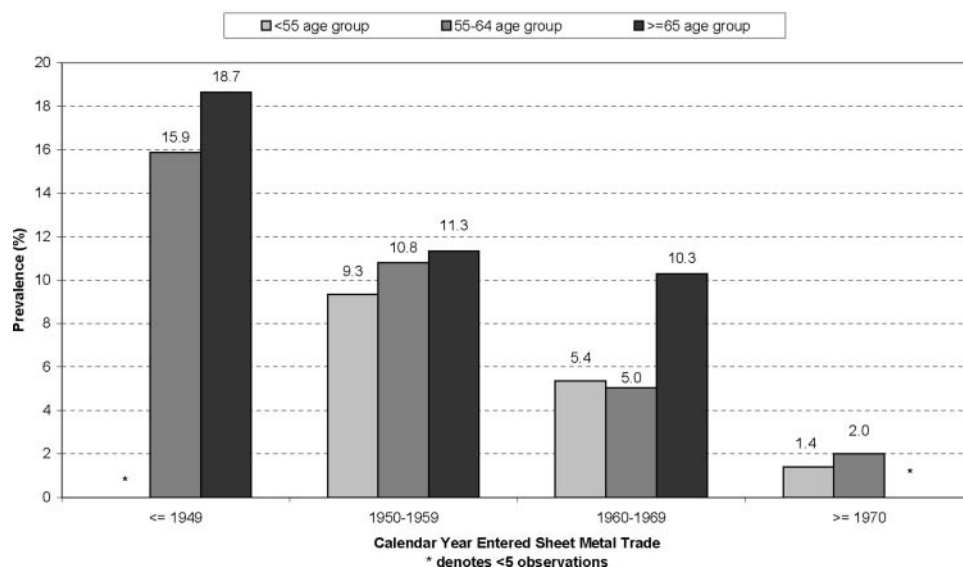


FIGURE 1. Prevalence of parenchymal abnormalities among 18,211 sheet metal workers who were examined from 1986 to 2004 by calendar year when they entered the trade and age.

of pack-years smoked, and calendar year entering the sheet metal trade (three groups). Those who began work in earlier years had more disease seen on chest radiographs than those who began work in a later decade. For example, Tables 3 and 4 show that sheet metal workers who began work before 1949 had an OR of 2.43 for parenchymal disease and 2.55 for pleural disease when compared to those who began work after 1970. Age, having ever worked in a shipyard, having a radiograph read by an A reader, and number of pack-years of smoking were also significant predictors of radiograph findings in the models, while the number of years of sheet metal work was not a significant predictor. As in our prior analysis,⁸ we found that work in a shipyard was a strong predictor of asbestos-related disease seen on a chest radiograph. Those participants who began work before 1949 were more likely to have worked in a shipyard; 13% of those who began work before

1949 had done so, compared to 3.6% of those beginning work from 1950 to 1969, and 2% of those beginning work in or after 1970 ($p < 0.01$ for trend).

We investigated alternative logistic models in an effort to better understand the interrelationship between the number of years of sheet metal work and the time periods in which the work was done. We distributed the years of work for each worker into years before 1950, years between 1950 and 1969, and years in 1970 or later. In logistic models adjusted for age and smoking, years of sheet metal work before 1950 (OR, 1.023; 95% CI, 1.009 to 1.038) and between 1950 and 1969 (OR, 1.045; 95% CI, 1.033 to 1.058) were found to be significant predictors of parenchymal disease risk. Similar patterns were observed for pleural disease. Years of work after 1970 was not found to be a significant predictor of parenchymal or pleural disease risk; however, the number of disease cases after 1970 resulted in limited statistical power to detect trends by work duration for this time period.

Table 2—Prevalence of Parenchymal and Pleural Disease by Years of Trade Work Among Sheet Metal Workers Examined From 1986 to 2004*

Duration of Sheet Metal Work	Prevalence of Parenchymal Disease (Profusion \geq 1/0)	Prevalence of Pleural Disease
< 30 yr	437 (7.5)	874 (15.0)
30–39 yr	895 (9.7)	2,042 (22.1)
\geq 40 yr	413 (13.2)	911 (29.2)
Total	1,745	3,827

*Values are given as No. (%).

DISCUSSION

This analysis documents a decreasing prevalence of nonmalignant asbestos-related disease among sheet metal workers who began work after 1970, when those workers are compared to sheet metal workers who began work before 1949; those who began work between 1950 and 1969 generally had a prevalence and severity of nonmalignant asbestos-

Table 3—Multivariable Logistic Regression Model for Parenchymal Disease Among Sheet Metal Workers Examined From 1986 to 2004*

Risk Factors and Contrasts	Prevalence OR	95% CI	p Value
Calendar year entered sheet metal trade			
Worked before 1949 vs worked after 1970	2.43	2.03–2.90	< 0.01
Worked 1950–1969 vs worked after 1970	1.32	1.14–1.53	< 0.01
Worked before 1949 vs worked 1950–1969	1.84	1.55–2.18	< 0.01
Duration of sheet metal work			
Worked ≤ 29 yr vs worked ≥ 40 yr	1.25	1.13–1.39	< 0.01
Worked 30–39 yr vs worked ≥ 40 yr	0.99	0.91–1.07	0.73
Worked ≤ 29 yr vs worked 30–39 yr	1.27	1.09–1.48	< 0.01
Age in yr	1.023	1.015–1.032	< 0.01
Shipyard work (yes vs no)	1.97	1.61–2.40	< 0.01
A Reader (vs B reader)	1.88	1.62–2.18	< 0.01
Smoking in pack-yr	1.012	1.010–1.015	< 0.01

*n = 14,530.

related disease that was between the other two groups. The results of this study suggest that reduced asbestos exposure in the 1980s through strengthened Occupational Safety and Health Administration (OSHA) regulation has had a positive public health impact. The strongest predictor of both parenchymal and pleural disease seen on a chest radiograph is the calendar year in which the worker began sheet metal work, with having worked in a shipyard also being an important risk.

In the United States from 1940 to 1979, 27.5 million workers were occupationally exposed to asbestos in shipyards, manufacturing operations, construction work, and a wide range of other industries and occupations; 18.8 million of these workers were thought to have had high levels of exposure.¹⁷ Exposures for some of these workers regularly exceeded 20 to 40 fibers per cubic centimeter of air (f/cc), levels that are 200 to 400 times the current OSHA standard of 0.1 f/cc¹⁸; exposures of several months resulted in an increased risk of mesothelioma and

lung cancer.¹⁹ Exposure to asbestos began to be regulated in the 1970s. New York City banned sprayed-on asbestos in 1972, and the Environmental Protection Agency followed suit with a national ban on sprayed-on asbestos in 1973. A permissible exposure limit of 12 f/cc for asbestos was included in the initial promulgation of OSHA standards in 1971 and was reduced the same year with an emergency temporary standard to 5 f/cc. OSHA subsequently reduced the permissible exposure limit to 2 f/cc in 1976, to 0.5 f/cc in 1983, to 0.2 f/cc in 1986, and to 0.1 f/cc in 1994. Figure 2 shows a steady decline in mean exposures measured by OSHA and the Mine Safety and Health Administration since 1979. Due to the long delay between the exposure to asbestos and the onset of most asbestos-related diseases, many of the cases of asbestos-related disease today are occurring among workers who were first exposed between 1940 and 1970.

Few reliable data are available in the United States on trends in nonmalignant disease. The 2002 Work

Table 4—Multivariable Logistic Regression Model for Pleural Disease Among Sheet Metal Workers Examined From 1986 to 2004*

Risk Factors and Contrasts	Prevalence OR	95% CI	p Value
Calendar year entered sheet metal trade			
Worked before 1949 vs worked after 1970	2.55	2.26–2.88	< 0.01
Worked 1950–1969 vs worked after 1970	1.39	1.26–1.53	< 0.01
Worked before 1949 vs worked 1950–1969	1.84	1.63–2.07	< 0.01
Duration of sheet metal work			
Worked ≤ 29 yr vs worked ≥ 40 yr	1.07	0.99–1.15	0.08
Worked 30–39 yr vs worked ≥ 40 yr	1.03	0.97–1.09	0.28
Worked ≤ 29 yr vs worked 30–39 yr	1.04	0.93–1.15	0.52
Age in yr	1.027	1.021–1.033	< 0.01
Shipyard work (yes vs no)	1.85	1.57–2.17	< 0.01
A Reader (vs B reader)	1.56	1.39–1.75	< 0.01
Smoking in pack-yr	1.006	1.004–1.008	< 0.01

*n = 14,530.

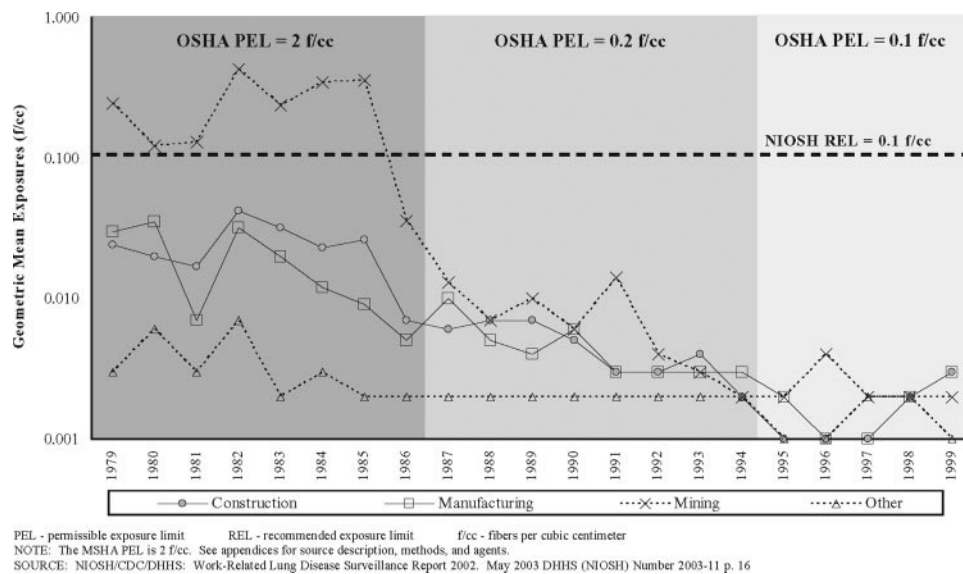


FIGURE 2. Geometric mean exposures by major industry division, Mine Safety and Health Administration and OSHA samples, from 1979 to 1999.

Related Lung Disease report from NIOSH²⁰ shows that the mortality rate from asbestosis increased between 1990 and 1999, with a median age of 77 years at death. The estimated number of hospital discharges with a diagnosis of asbestosis increased from 5,000 in 1990 to 20,000 in 2000. This is not inconsistent with our results; even though workers who began work after 1970 may have a lower prevalence of disease, the workers who began work before 1970 are aging, and the prevalence of lung disease increases with increasing latency. We can expect to see hospitalizations and deaths from asbestosis remain significant, and even continue to increase, as these cohorts age.

We found the presence of parenchymal disease to be a function of both the year of first work in the sheet metal trades and the duration of work, with a stronger relationship with the year of first work in the sheet metal trades. Due to the requirement of 20 years of sheet metal work for inclusion in the screening program, our reference cell for the OR analyses is composed of workers with significant exposure, limiting our ability to detect the true effect of work duration

Ohar et al²¹ reported that among 3,383 workers who were referred for an independent medical examination, asbestos-related disease diagnosed in this decade is characterized by longer latency than what was reported in studies from the 1980s. The latency for the group with an ILO score of < 1/1 with or without plaque was 40.5 years, and the latency for the group with an ILO score of ≥ 1/1 was 45.8 years. The longer latency period seen with the

higher disease rating could be due either to higher exposures 45 years ago than 40 years ago, or to the fact that the disease takes longer to become manifest after relatively lower exposures to asbestos.

Among our workers, latency and the number of years worked are highly correlated ($r = 0.54$). The results presented here do not allow the separation of the effects of latency and cumulative exposure, and, in fact, such a separation is not likely to be possible. In the past, for many occupations and industries, the number of years worked served as a surrogate for exposure to asbestos; a qualitative judgment could be made on cumulative exposure received during those years based on sparse knowledge from industrial hygiene measurements, job-exposure matrices, and population-based epidemiology. One can say that insulators as a group had higher exposures to asbestos than did sheet metal workers, but one cannot assign a cumulative exposure to each worker. While the intensity of exposure for some tasks has been characterized, the distribution of those tasks among individual workers or groups of workers is not known. The decrease in exposure over the past 3 decades means that workers with longer latency also had higher cumulative exposures in their early years of work.

Because of this complex relationship among cumulative exposure, age, and latency, it is likely that additional disease among workers who began work in the 1960s and 1970s will be manifested in future years. The mean latency period for those workers with ILO scores of 1/0 for chest radiographs reported by Ohar et al²¹ was 40 years; if such a long

latency period is the case for our population, we will see an increasing prevalence of asbestos-related disease in these sheet metal workers for at least another decade. Continued follow-up of this at-risk group will allow us to address this question.

REFERENCES

- 1 Becklake M. Asbestos-related diseases of the lung and other organs: their epidemiology and implications for clinical practice. *Am Rev Respir Dis* 1976; 114:187–227
- 2 Nicholson WJ, Perkel G, Selikoff IJ. Occupational exposure to asbestos: population at risk and projected mortality; 1980–2030. *Am J Ind Med* 1982; 3:259–311
- 3 Selikoff IJ, Hammond EC, Seidman H. Mortality experience of insulation workers in the United States and Canada, 1943–1976. *Ann N Y Acad Sci* 1978; 330:91–116
- 4 International Agency for Research on Cancer. Asbestos: monograph on the evaluation of carcinogenic risk to man. Lyon, France: International Agency for Research on Cancer, 1988
- 5 American Thoracic Society. Diagnosis and initial management of nonmalignant diseases related to asbestos. *Am J Respir Crit Care Med* 2004; 170:691–715
- 6 Zoloth S, Michaels D. Asbestos disease in sheet metal workers: the results of proportional mortality analysis. *Am J Ind Med* 1985; 7:315–321
- 7 Selikoff IJ, Lilis R. Radiological abnormalities among sheet-metal workers in the construction industry in the United States and Canada: relationship to asbestos exposure. *Arch Environ Health* 1991; 46:30–36
- 8 Welch LS, Michaels D, Zoloth SR. The National Sheet Metal Worker Asbestos Disease Screening Program: radiologic findings; National Sheet Metal Examination Group. *Am J Ind Med* 1994; 25:635–648
- 9 American Thoracic Society. Standardization of spirometry: 1987 update. *Am Rev Respir Dis* 1987; 136:1285–1298
- 10 American Thoracic Society. Standardization of spirometry: 1994 update. *Am J Respir Crit Care Med* 1995; 152:1107–1136
- 11 Welch LS, Hunting KL, Balmes J, et al. Variability in the classification of radiographs using the 1980 International Labor Organization classification for pneumoconioses. *Chest* 1998; 114:1740–1748
- 12 World Medical Association. World Medical Association Declaration of Helsinki ethical principles for medical research involving human subjects. Ferney-Voltaire, France: World Medical Association, 1975
- 13 Wagner GR, Attfield MD, Kennedy RD, et al. The NIOSH B reader certification program: an update report. *J Occup Med* 1992; 34:879–884
- 14 Attfield MD, Wagner GR. A report on a workshop on the National Institute for Occupational Safety and Health B reader certification program. *J Occup Med* 1992; 34:875–878
- 15 SAS Institute Inc. SAS for Windows, release 8. Cary, NC: SAS Institute Inc, 1999
- 16 Barnhart S, Keogh J, Cullen MR, et al. The CARET asbestos-exposed cohort: baseline characteristics and comparison to other asbestos-exposed cohorts. *Am J Ind Med* 1997; 32:573–581
- 17 Nicholson WJ, Perkel G, Selikoff IJ. Occupational exposure to asbestos: population at risk and projected mortality; 1980–2003. *Am J Ind Med* 1982; 3:259–311
- 18 Paik NW, Walcott RJ, Broagan PA. Worker exposure to asbestos during removal of sprayed material. *Am Ind Hyg Assoc J* 1973; 44:428–432
- 19 Seidman H, Selikoff IJ, Gelb SK. Mortality experience of amosite asbestos faculty workers: dose-response relationships of 5 to 40 years after onset of short-term work exposure. *Am J Ind Med* 1986; 10:479–514
- 20 Division of Respiratory Disease Studies. Work-Related Lung Disease Surveillance Report 2002. Cincinnati OH: National Institute for Occupational Safety and Health, 2003; publication No. 2003–111
- 21 Ohar J, Sterling DA, Bleecker E, et al. Changing patterns in asbestos-induced lung disease. *Chest* 2004; 125:744–753

Change in Prevalence of Asbestos-Related Disease Among Sheet Metal Workers 1986 to 2004

Laura S. Welch, Elizabeth Haile, John Dement and David Michaels
Chest 2007;131;863-869
DOI 10.1378/chest.06-1155

This information is current as of May 11, 2007

Updated Information & Services	Updated information and services, including high-resolution figures, can be found at: http://chestjournals.org/cgi/content/full/131/3/863
References	This article cites 15 articles, 3 of which you can access for free at: http://chestjournals.org/cgi/content/full/131/3/863#BIBL
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://chestjournals.org/misc/reprints.shtml
Reprints	Information about ordering reprints can be found online: http://chestjournals.org/misc/reprints.shtml
Email alerting service	Receive free email alerts when new articles cite this article sign up in the box at the top right corner of the online article.
Images in PowerPoint format	Figures that appear in CHEST articles can be downloaded for teaching purposes in PowerPoint slide format. See any online article figure for directions.

A M E R I C A N C O L L E G E O F



P H Y S I C I A N S[®]