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Lung Cancer in Mild Steel Welders

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To investigate lung cancer risk, the authors conducted a historical cohort mortality study of 4,459 mild steel welders who had been employed at three midwestern plants which manufactured heavy equipment. Follow-up began in the mid-1950s and extended through 1988. All welders had at least 2 years welding experience (average duration, 8.5 years). This cohort had no occupational exposure to asbestos or stainless steel fumes (containing nickel and chromium), two potential confounders in previous welders studies. A comparison population of 4,286 nonwelders, all with at least 2 years employment at the same plants, was also studied. Nonwelders had never been welders and were allowed to have no more than 90 days employment as a painter, foundryman, or machinist. Sampling data collected from 1974–1987 indicated that welders were exposed to 6–7 mg/m^3 of total particulate and 3–4 mg/m^3 of iron oxide, while nonwelders had negligible exposures to welding fumes. When compared with the United States population, both welders and nonwelders had elevated rates for lung cancer (standardized mortality ratios (SMRs): welders, SMR = 1.07; nonwelders, SMR = 1.17), but neither SMR was significantly elevated. Limited smoking data based on a 1985 survey indicated that both welders and nonwelders smoked more than the United States population, possibly accounting for part of their elevated lung cancer rates. There was no trend of increased risk for welders with increased duration of exposure. The only other cause of death significantly elevated was emphysema among welders. Nonmalignant respiratory disease was not elevated for welders (SMR = 0.96). When welders were compared with nonwelders directly for lung cancer, the rate ratio was 0.90. *Am J Epidemiol* 1991;133:220-9.

lung neoplasms; occupations; welding

There have been a large number of studies of welders and lung cancer. These studies have recently been reviewed by the National Institute for Occupational Safety and Health (NIOSH) (1). The NIOSH review concluded that "welders generally have a 40 percent increase in relative risk of developing lung cancer as a result of their work experiences. The basis of this excess risk is difficult to determine given uncertainties about smoking habits, possible interactions among the various components of welding emissions, and possible exposures to other carcinogens, particularly asbestos."

Some of these uncertainties exist because a number of past studies have failed to con-

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Abbreviations. ACGIH, American Conference of Government Industrial Hygienists; CI, confidence interval; ICD, *International Classification of Diseases*; NIOSH, National Institute for Occupational Safety and Health; SMR, standardized mortality ratio.

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This study would not have been possible without the efforts of the National Institute for Occupational Safety and Health clerical staff which spent 8 weeks photographing personnel records, and large amounts of time obtaining death certificates and coding death information. The management of the company involved was consistently helpful in providing all information requested.

trol for smoking, while other studies have been conducted in shipyard welders, among whom exposure to asbestos has been common.

Welding processes differ, but the most common is arc welding, in which an electrode (which may be a "stick" or a continuous wire) comes in contact with the base metal (1). Electricity provides the heat, which melts both the base metal and the electrode. The weld is usually shielded, either by a flux on the stick or wire, or by an inert gas. A variety of gases and metal fumes are produced by the process, depending on which base metal is used and on the type of electrode and shielding. Steel is among the most common of the base metals that are welded, and there has been some debate about whether the type of steel which is being welded (stainless vs. mild) determines lung cancer risk. Assuming that there is a lung cancer risk for welders which is independent of smoking and asbestos, some have suggested that this risk is confined to welders of stainless steel. Fumes from stainless steel, unlike fumes from mild steel, contain nickel and chromium (VI), possible lung carcinogens. Bacterial mutagenesis studies (2), and studies of chromosomal aberrations in Chinese hamster cells (3), tend to support the thesis that stainless steel welding fumes are mutagenic due to the presence of chromium (VI). Sjongren et al. (4) have observed an excess of lung cancer in stainless steel welders exposed to higher levels of chromium, and no excess in stainless steel welders exposed to lower levels. On the other hand, studies of sister chromatid exchange and chromosomal aberrations among stainless steel welders have been negative (5, 6).

To attempt to further clarify these issues, we have conducted a cohort mortality study among welders and nonwelders at three heavy equipment manufacturing plants from the 1950s through the 1980s. The welders at these plants were exposed to little or no asbestos and they welded only mild steel. The mortality of the welders was compared to that of the United States population. In an attempt to control indirectly for smoking, the welders were also compared to nonwelders at the same plants, under the assumption that welders and nonwelders at the same plants were likely to have smoked similar amounts.

MATERIALS AND METHODS

Study population

The exposed cohort was defined as hourly male workers who had worked either as production welders (arc welders) or as welder helpers (welder cleaners) for 2 or more years at any of three heavy equipment manufacturing plants in Illinois. These plants were owned by the same company and welding techniques were similar at all three plants. Records were originally obtained at a fourth plant as well. However, subsequently it was learned that the records obtained at the fourth plant were incomplete, and this plant was excluded from the analysis.

Welder helpers (welder cleaners) were included in the cohort because these men worked next to the welders and breathed many of the same fumes. Many men worked briefly as welder helpers (or cleaners), but then became welders. Welder helpers contributed only about 7 percent of the person-years at risk for the welder group. The cohort was restricted to those with at least 2 years in a welding job in order to focus on those with more cumulative exposure.

Men who worked only as flame cutters or burners were excluded from the exposed cohort. These men used acetylene gas in a process involving lower temperatures than arc welding. Also excluded were the few men who had worked only as maintenance welders doing a variety of welding jobs throughout the plants.

Only about 5–10 percent of the workforce at these plants were welders. The nonexposed cohort was chosen from among other hourly workers, and was defined as all hourly male workers who had never worked in any welding job (or as flame cutters or burners). The nonexposed also could not have worked in any machining job, as a painter, or in a foundry for more than 90 days, and had to have been employed at least 2 years at one of the three plants. Machinists, painters, and foundry workers were restricted because of the potential lung cancer risk of these jobs (cutting oils, lead chromate paints, polycylic hydrocarbons, silica). The majority of the nonexposed men had worked as assemblers, inspectors, packers, janitors, or vehicle operators (usually electric forklifts). This selection resulted in a cohort of about the same size as the welders, at each of the three plants.

The three plants first began operation in the 1950s (1951, 1955, 1957). All eligible hourly male workers, as described above, who had ever worked at these three plants entered the cohort.

Analytic methods

Person-years at risk for the welders began once they had completed 2 years of exposure (work in a welding job). For nonwelders, person-years at risk began once the men had completed 2 years of employment.

Standard life-table analysis methods were used (7). Death certificates were coded by a certified nosologist into the *International Classification of Diseases* (ICD) codes current at time of death, and ICD codes were apportioned into 92 NIOSH death categories (7). Person-years at risk ended when an individual was lost to follow-up. Follow-up was conducted via the Social Security Administration (through 1983 for two plants, 1984 for the third), the Internal Revenue Service, and the National Death Index (through 1988). Individuals who were known to be alive after January 1, 1979 (the beginning of the National Death Index) via any source, and were not located in the National Death Index were considered alive through the end of 1988 (when Social Security numbers are available, as in our study, the National Death Index has been shown to identify virtually all known deaths (8)). Thus, for most cohort members who had not died, the end of follow-up was the end of 1988.

Mortality rates of welders and nonwelders were compared (separately) to rates of the United States population for all causes, although the focus was on lung cancer. In addition, more detailed analyses were conducted by duration of employment and time-since-first-employment. For lung cancer among welders, we also conducted analyses "lagging" the duration of exposure for 5 years. In this procedure, the last 5 years of exposure were discounted in the analyses by duration of exposure. Finally, welders and nonwelders were compared directly for lung cancer mortality, using direct standardization (9), as calculated by the life table program. In these comparisons, the combined welder/nonwelder population was used as the standard and nonwelders were used as the referent group for welders, who were categorized into groups by duration of exposure. Poisson regression (10), using the Egret software package (11), was also used for direct comparison between welders and nonwelders. Finally, both welders and nonwelders were also compared to the population of Illinois (the state in which all three plants were located) for lung cancer mortality.

For indirectly standardized rate ratios, we assumed observed deaths were distributed as a Poisson variable. Approximate confidence intervals were based on a procedure suggested by Byar as described by Rothman and Boice (12). Tests for trend were done as suggested by Breslow et al. (13). For directly standardized rate ratios, confidence intervals were based on a Taylor series approximation, as described by Rothman (9).

Exposure data

Shielded metal arc welding (commonly called stick welding) was the primary technique used at all three plants until the mid-1960s. At that time, continuous wire shielded with inert or neutral gas (often carbon dioxide) was introduced at each of the three plants. This type of welding has remained the basic welding process through the present. Respiratory protection (other than the welding shield) was in general not worn by the welders. All welding was done on unpainted steel.

The company had conducted personal exposure monitoring for welders in all three plants from 1974–1987, using a uniform sampling approach. NIOSH industrial hygienists reviewed these data and inspected current welding processes. A closed-faced filter cassette was placed inside the welding hood. Samples were full shift samples with a flow rate of about 1.0 liters per minute. Samples for iron oxides and other metals were analyzed using atomic absorption, while total particulates were measured gravimetrically.

There were 309 samples of total particulates, and 380 samples of iron oxide, the two most common substances measured. Sampling was also done for chromium, manganese, copper, lead, and fluoride. There were no records of welding rate. We analyzed these data (log transformed) using analysis of covariance techniques to determine if differences existed between plants or over time (14).

No data were available to estimate earlier exposures when stick welding was used. Discussion with company industrial hygienists suggested that these earlier exposures were likely to have been similar to or perhaps slightly higher than post-1974 exposures.

With the continuous wire welding method which has been used since the mid-1960s, there have been no known exposures to asbestos for welders in these plants. In the past, some welding rods were coated with asbestos. We could not rule out the use of such rods at these three plants. However, even if such rods were used, the level of exposure to asbestos would have been slight. After a review of current and past processes by a NIOSH industrial hygienist (LE), we concluded that past exposure to asbestos was likely to have been of little consequence for the welders in this cohort when working at the plants studied. On the other hand, no data were available on possible asbestos exposure for cohort members before and after working at the plants studied here.

In addition to analyzing existing exposure data for welders, samples were collected by the company (at the request of and with the assistance of NIOSH), for a group of 28 nonwelders who worked in or near welding areas, but were not welders (e.g., inspectors, forklift operators, parts men, supervisors). The purpose of this sampling was to verify their nonexposed status, and to obtain a "worst case" estimate of exposure for the nonwelder cohort. Full shift personal samples for total particulate and iron oxides were collected, using the same sampling techniques used for welders (see above). Ten workers were sampled at two plants, and eight were sampled at the third.

Smoking data

While the primary control over smoking in this study was the use of an internal (nonwelder) comparison group, there were some smoking data available for current employees. These data were collected by the company for many hourly workers as part of a 1985 survey of men exposed to noise. Welders, who worked in noisy areas, were well represented in these studies while nonwelders in these plants participated only if they were in noisy areas. For most men surveyed, questions were limited to whether they had ever smoked and whether they were currently smoking. Ages of the men were also available. Smoking data were available for a total of 891 welders and 4,731 hourly nonwelders, representing approximately 76 percent of the current welders and 66 percent of the current hourly nonwelders at the three plants in 1985.

For most men, there were no details available regarding type of tobacco smoked, or amount smoked. We have considered that "smoking" as described in the company surveys referred to cigarette smoking, for purposes of comparison to national data. For those few men for whom data on type of tobacco were available, there was little difference between the proportion smoking cigarettes plus cigars or pipes, and the proportion smoking cigarettes alone.

We compared the smoking habits of the welders and nonwelders directly to each other, and also to the smoking habits of the United States population of the same ages available from the 1985 Health Promotion Survey conducted by the National Center for Health Statistics (15). Summary prevalences across age groups were calculated via direct standardization using the nonwelder population as the standard population. The United States data were restricted to cigarette smoking, and never smokers were defined as those who had never smoked more than 100 cigarettes.

Because these comparisons were restricted to employees current in 1985, they could not provide reliable estimates of past smoking differences which might have led to difference in more recent lung cancer rates. They provided only an indirect qualitative estimate of whether the past smoking habits of welders and nonwelders might have differed, and whether the smoking habits of these groups might have differed from the United States population.

RESULTS

Exposure

Exposure levels of metals such as chromium, lead, and manganese were usually nondetectable. The only substances for which samples were routinely detectable in the company data were total particulates and iron oxides, and we present data for these substances in table 1.

Analysis of covariance showed a small but significant decrease in levels over time at all plants, and also showed a significant difference between plants, with plant 2 being somewhat higher than plants 1 and 3. There were no significant interaction terms between plant and year of sampling. For ease of presentation, we present in table 1 the average levels of iron oxides and total particulate by plant over the entire period 1974–1987.

The data in table 1 indicate that exposures to welders have generally been within accepted norms. There is no Occupational Safety and Health Administration standard for total welding fume, although such fumes would be covered by the 15 mg/m^3 total dust standard. The Occupational Safety and Health Administration standard for iron oxides is 10 mg/m^3, while the standard recommended by the American Conference of Government Industrial Hygienists (ACGIH) is 5.0 mg/m^3 (1). NIOSH (1) has recently recommended minimizing exposure to welding fumes to the lowest feasible limit based on potential carcinogenicity. Other separate components of welding fumes have their own specific standards, but these components were generally nondetectable or minimal in our data.

Sampling was also conducted by the company for 28 nonwelders in the three plants. These nonwelders worked in or near welding areas, but were not welders. The average iron oxide level for these workers was 0.16 mg/m^3 (standard error (SE) = 0.09), while the average total particulate level was 0.53 mg/m^3 (SE = 0.32). These minimal levels, which represent a "worst case" for the nonwelders in our cohort (most of whom did not work adjacent to a welding area), indicate that our nonwelder cohort would have had minimal exposure or no exposure to welding fumes.

Description of study population

Table 2 provides data on vital status by plant, and for all plants combined. Overall

TABLE 1. Total particulate and iron oxide exposure levels (time-weighted averages, mg/m^3) for welders at three midwestern plants during 1974–1987, by plant*

Plant no.	Total particulate levels			Iron oxide levels		
	No.	Range	Geometric mean (SE†)	No.	Range	Geometric mean (SE)
1	97	0.4–37.7	6.1 (1.9)	145	0.18–18.3	3.0 (2.0)
2	88	0.2–28.2	7.4 (2.0)	87	0.10–21.6	4.1 (2.2)
3	124	0.8–31.5	5.5 (2.1)	148	0.33–12.5	3.0 (2.0)

* The Occupational Safety and Health Administration standards for total dust and iron oxide are 15 mg/m^3 and 10 mg/m^3, respectively. The average levels for 28 nonwelders working near welding areas, sampled at all three plants in 1988, were 0.53 mg/m^3 and 0.16 mg/m^3 for particulate and iron oxide, respectively.

† SE, standard error.

TABLE 2. Vital status of welders and nonwelders at three midwestern plants as of December 31, 1988, by plant

Plant no.	Welder			Nonwelder		
	Alive	Dead	Unknown	Alive	Dead	Unknown
1	1,150	63	12	1,696	121	20
2	1,844	282	50	661	261	23
3	987	65	6	1,221	275	8
Total	3,981	410	68	3,578	657	51
(%)	(89.3)	(9.2)	(1.5)	(83.5)	(15.3)	(1.2)

TABLE 3. Demographic and work history data for welders and nonwelders at three midwestern plants

	Welders	Nonwelders
Average year of birth	1940	1936
Average year of death (*n*)	1979 (410)	1978 (657)
Average year first employed	1966	1964
Average year first welding	1966	N/A*
Average years since first welding	20.4	N/A
% white	86.4	92.5
% black	10.3	5.1
Average duration of employment (years)	11.6	12.9
Average duration of welding (years)	8.5	N/A
Person-years at risk of dying	81,346	87,015

* N/A, not applicable.

TABLE 4. Standardized mortality ratios (SMRs) and 95% confidence intervals (CIs) for selected causes of death comparing welders and nonwelders at three midwestern plants to the United States population*

Cause	Welders			Nonwelders		
	Observed	SMR	(95% CI)	Observed	SMR	(95% CI)
Lung cancer	39	1.07	(0.76–1.46)	74	1.17	(0.92–1.47)
Larynx cancer	2	1.38	(0.17–5.00)	2	1.60	(0.45–4.09)
Bladder cancer	3	1.54	(0.32–4.53)	4	0.94	(0.26–2.42)
All cancers	105	1.02	(0.83–1.24)	172	0.97	(0.83–1.12)
Ischemic heart disease	98	0.77	(0.63–0.95)	195	0.79	(0.69–0.92)
Respiratory disease (nonmalignant)	24	0.96	(0.62–1.44)	44	0.91	(0.66–1.22)
Pneumoconioses	8	0.77	(0.34–1.53)	22	1.08	(0.68–1.64)
Emphysema	9	2.36	(1.07–4.48)	14	1.57	(0.86–2.64)
Bronchitis	2	2.46	(0.30–8.88)	3	1.62	(0.33–4.75)
All deaths	410	0.84	(0.77–0.93)	657	0.84	(0.77–0.91)

* Causes of death are presented here either because they were of a priori interest or because they showed a statistically significant excess at the 0.05 level. No other causes of death exhibited significant excesses or deficits.

follow-up was 98–99 percent successful. A higher percentage of nonwelders had died (15 percent vs. 9 percent), because they were somewhat older than the welders. Table 3 provides data on length of employment, duration of welding, first year of welding, race, year of birth, year of death, for the welder and nonwelder cohorts.

Mortality results

Table 4 lists the results for selected causes of death for all plants combined. Other causes not listed in the table were neither significantly elevated nor decreased.

When compared with the United States population, both welders (standardized mortality ratio (SMR) = 1.07, 95 percent confidence interval (CI) 0.76–1.46) and nonwelders (SMR = 1.17, 95 percent CI 0.92–1.47) showed an excess of lung cancer. Plant-specific analyses appear in table 5.

One death from mesothelioma was observed in the welder cohort, at plant 2. This man had been hired shortly after World War II, and had worked as a welder for a long period (23 years). His employment application indicated he had worked in a job with potential asbestos exposure prior to becoming a welder (20 years in a brewery).

Table 6 provides further data for lung cancer, comparing both welders and nonwelders to the United States population. Welders do not show a consistent trend of increased lung cancer with duration of exposure, or a significant increase with time-since-first-employment. In analyzing the lack of a trend with duration for welders, however, it is worth remembering that duration may not correlate with cumulative dose, since welders with high (and irritating) exposures may have been more likely to change to nonwelding jobs.

Table 7 shows the directly standardized comparison between welders and nonwelders for lung cancer. The overall rate ratio is 0.90, indicating a deficit of lung cancer in welders compared with nonwelders. There is no trend of increasing lung cancer rates for welders as duration of exposure increases (Poisson regression results for duration are presented in the footnote to table 7).

Use of 5- and 10-year lag periods for welders did not appreciably change the results for duration of exposure, and are not pre-

TABLE 5. Standardized mortality ratios (SMRs) and 95% confidence intervals (CIs) for lung cancer comparing welders and nonwelders at three midwestern plants to the United States population, by plant

Plant no.	Welders			Nonwelders		
	Observed	SMR	(95% CI)	Observed	SMR	(95% CI)
1	2	0.39	(0.05–1.41)	15	1.09	(0.61–1.81)
2	29	1.23	(0.83–1.70)	28	1.34	(0.89–1.95)
3	8	1.00	(0.43–1.99)	31	1.07	(0.73–1.53)
Total	39	1.07	(0.76–1.46)	74	1.17	(0.92–1.47)

TABLE 6. Standardized mortality ratios (SMRs) and 95% confidence intervals (CIs) for lung cancer mortality, by duration of exposure and time since first exposure for welders, and by duration of employment and time since first employment for nonwelders, at three midwestern plants, in comparison to the United States population

	Welders			Nonwelders		
	Observed	SMR	(95% CI)	Observed	SMR	(95% CI)
Duration of exposure or employment (years)*						
2–5	13	1.38	(0.66–2.22)	11	1.17	(0.58–2.09)
5–10	9	1.12	(0.51–2.12)	14	1.60	(0.87–2.68)
10–15	6	0.88	(0.32–1.91)	11	0.96	(0.48–1.71)
15–20	4	0.63	(0.17–1.61)	13	0.89	(0.47–1.52)
>20	7	1.19	(0.48–2.46)	25	1.31	(0.85–1.94)
Time since first exposure or employment (years)*						
0–20	13	0.95	(0.51–1.63)	25	0.97	(0.63–1.44)
>20	26	1.14	(0.74–1.66)	49	1.30	(0.96–1.72)

* Exposure for welders, employment for nonwelders.

sented. Use of state rates for lung cancer gave virtually identical results as United States rates.

Table 8 shows the data on smoking available for employees who were current in 1985. These data indicate that both welders and nonwelders were more likely to smoke than the United States population.

While more welders than nonwelders were current smokers, this difference stemmed from the fact that more nonwelders had quit. The dates of quitting are unknown. However, the percentages of ever-smokers among welders and nonwelders are about the same (78 percent vs. 79 percent). These percentages may be more relevant than data which include a category of former smokers. There were few former smokers in the 1950s and 1960s, the period of interest for the subsequent development of the lung cancer observed in our study. Finally, it is worth reiterating that we have no data on amount smoked.

TABLE 7. Lung cancer mortality: direct comparison between nonwelders (referent) and welders* at three midwestern plants

	Rate ratio	(95% CI†)
Nonwelders (referent group)	1.00	
Welders overall	0.90	(0.60–1.36)
Welders by exposure (years)		
2–10	1.13	(0.67–1.90)‡
10–20	0.66	(0.33–1.30)
>20	0.65	(0.29–1.42)

* Direct standardization using combined cohorts as the standard, and adjusting for age and calendar time. Confidence intervals are based on a Taylor series approximation (9).

† CI, confidence interval.

‡ Poisson regression led to rate ratios of 1.10, 0.70, and 0.96 for the three duration categories, respectively. Results are not strictly comparable due to slightly different age and calendar categorization in the Poisson regression. The last duration category (>20 years) had few person-years, making results unstable. Control over latency in Poisson regression led to little change in rate ratios.

DISCUSSION

Our data indicate that welding mild steel did not increase the rate of lung cancer in this cohort, when welders were compared with nonwelders at the same plants. Nor was there any trend of increased risk with increased duration of exposure in this direct comparison. This direct comparison of two worker populations in the same plants offers an indirect control over smoking, assuming that welders and nonwelders had somewhat similar smoking habits (16). Based on a review of plant processes, occupational exposure to asbestos was judged to have been minimal for this cohort. While one death from mesothelioma was observed among the welders, this man may well have been exposed to asbestos in work outside the plant.

Both welders and nonwelders showed an increase in lung cancer compared with the United States population. However, these increases were not statistically significant.

Some of the increase in welders and nonwelders compared with the United States population was likely to be due to the fact that both welders and nonwelders smoked more than the United States population, as would be expected for a blue collar population (17). Smoking data from our cohort show that as of 1985 about 22 percent of our cohort had never smoked, compared with 30 percent of the US population of the same age. Doing a crude adjustment of the type suggested by Axelson (18), this kind of difference would lead to an approximately 10 percent excess of lung cancer among our

TABLE 8. Smoking characteristics of welders and nonwelders at three midwestern plants and the United States population in 1985*

	Welders (%)	Nonwelders (%)	United States (%)
Current smokers	48.9	41.8	36.0
Former smokers	28.7	37.1	34.0
Never smokers	22.4	21.1	30.0

* All prevalences are age-adjusted using direct standardization with the nonwelders as the standard. Data for the United States were derived from the NCHS 1985 Health Promotion Survey (15), while data for 891 welders and 4,731 nonwelders came from company surveys conducted in 1985

cohort versus the US population. We had no data on amount smoked; among smokers, blue collar workers typically smoke more than the general population (17). Furthermore, we do not know when former smokers quit; if their quitting times differed from males in the US population, then this difference would also affect SMRs. Empirical data from numerous studies have shown that in comparing blue collar workers to the general population we might expect a lung cancer excess of perhaps 10–30 percent, absent any occupational carcinogens (19, 20). The excess of emphysema among both welders and nonwelders (table 4) tends to confirm the hypothesis of an excess of smoking, although the emphysema excess could also be related to occupational exposures.

Regarding welders, our study had reasonable power to detect an excess risk of lung cancer for welders (80 percent power to detect a true increase of 45 percent in the lung cancer rate of welders compared with the United States population), making lack of power not a very likely explanation for our largely negative findings. On the other hand, power was more limited for some subgroups of welders with long duration and long latency, or for the direct comparisons of welders to nonwelders.

The only other study of welders which has been able to separate mild steel welders from stainless steel welders is a recent European-wide cohort study of 11,000 welders (21). This study included shipyard welders, so that asbestos exposure was likely for some of these men. There were 116 lung cancers observed. Compared with the nonexposed general population, mild steel welders (only) had an SMR of 1.78 (95 percent CI 1.27–2.43, 40 observed), with no trends with duration and a slight upward trend with potential latency.

Stainless steel welders (ever) had an SMR of 1.28 (95 percent CI 0.91–1.75, 39 observed), with no trend with duration and an increasing trend with latency. No trend was seen in analyses of stainless steel welders by presumed level of exposure to chromium or nickel, although exposures to these metals were crudely estimated. Five mesothelioma deaths were observed in the total cohort, and were distributed among all subgroups. The authors concluded that asbestos was likely to have been present in most welding environments studied, and the excess lung cancer may have been partly a result of exposure to asbestos. Smoking habits were not known, and confounding by smoking was also possible. These results are somewhat difficult to interpret for these reasons.

In summary, our data suggest that mild steel welders in our cohort did not have an excess risk from lung cancer due to their specific occupation. However, our findings were complicated by the fact that some lung cancer excess was observed using the United States population as a reference group, by limited power in some of the subgroups studied, and by limited data on smoking habits. We will continue to follow this population, so that future analyses will have more power to observe any possible excess.

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