STUDY OF SHEET METAL WORKERS

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for

Occupational Safety and Health

by

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The health status of sheet metal workers (SIC-1711) was investigated in 50 sheet metal firms in California. Toxic exposure and mortality data was obtained from union records, interviews with workers, and environmental studies during sheet metal operations. The total population included 1,301 workers. Proportionate mortality was studied in 364 deaths that occurred in two cohorts of sheet metal workers from 1950 to 1970 and an additional 423 deaths identified from claims to a pension plan. In both sexes there was an excess of deaths due to malignant neoplasms; the excess was attributable to malignant tumors of the respiratory tract. There were also excesses in deaths due to accidents other than motor vehicle accidents, cirrhosis of the liver, and suicide. Standardized mortality ratios (SMR) were calculated for two cohorts of 1,670 and 1,031 men observed for 28,438 and 12,422 persons years, respectively. Analysis of 307 deaths in the first and 83 deaths in the second cohort showed that the overall SMR was better than expected in both groups, but there was an apparent excess of lung cancer. The authors suggest that the greatest factor contributing to the lung cancer risk was exposure to asbestos (1332214).

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STUDY OF SHEET METAL WORKERS
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FINAL REPORT

December 30, 1975

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SUMMARY

An environmental survey of 50 sheet metal firms in the San Francisco Bay area employing 1,301 sheet metal workers was carried out in 1971. The major environmental exposures of sheet metal workers were characterized and limited quantitative studies were done. Sheet metal workers' exposures depend to a considerable extent upon whether they are engaged in residential work, commercial heating and ventilation work, industrial fabrication, or miscellaneous construction. They have been subject to measurable asbestos exposures, some due to direct use of asbestos-containing materials, and some to indirect exposure on construction sites. In recent years there have been significant fibrous glass exposures, but fiber concentrations have been relatively low (0.1 to 1.0 fibers/ml peaks). Other significant problems are welding fumes, acid inhalation during soldering, a variety of solvents, and noise. There is a constant potential for minor and major accidents. Morbidity and mortality will reflect the composite effect of many environmental influences.

Proportionate mortality was studied in 364 deaths that occurred in two Cohorts of sheet metal workers during the period 1950-1970, and in an additional group of 423 deaths accompanying death claims to a pension plan. In both series there was an excess of deaths due to malignant neoplasms; 24.7% of deaths in the two cohorts were attributed to malignancy where 14.5% would have been expected, and 19.1% in the Death Claim group. This excess was largely attributable to malignant tumors of the respiratory tract. There were less dramatic excesses in accidents other than motor vehicle, and in cirrhosis of the liver and suicide.

Standardized Mortality Ratios (SMR's) were determined for two Cohorts of sheet metal workers, one being selected from the records of two local unions, and the other being from a 10% sample of the roster of all participants in the union pension plan. Only men with over 5 years in the trade were studied. There were originally 1,776 men in

the first Cohort, 1,134 in the second, with 1,670 and 1,034 being in the final study population. They were observed for 28,438 and 12,422 person-years respectively. Analysis of 307 deaths in the first group and 83 in the second, showed that the overall SMR for all causes combined was better than expected for both groups, but there was an apparent excess of lung cancer. That in the first Cohort, where 32 cases of lung cancer deaths were attributed to lung cancer, gave a corrected SMR of 174. There were minor, but not statistically significant excesses of deaths due to accidents other than motor vehicles, cirrhosis of the liver, and suicide. It is probable that the most important factor contributing to the lung cancer risk is exposure to asbestos, most of which probably occurred 20 or more years before death.

A prospective mortality study of sheet metal workers is feasible, but it is unlikely that it would provide information clearly relating etiologic factors with disease.

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In 1971 a study was begun to determine the occupational exposures of sheet metal workers in Northern California, and to collect and analyze data pertaining to their health status. The specific aims were:

(1) To describe qualitatively and quantitatively the occupational exposures of sheet metal workers, with special reference to fibrous glass, asbestos, solvents, and the products of soldering and welding;

(2) To determine the mortality experience of a cohort of sheet metal workers during the period 1950-1970, relating this to duration of employment or time from first employment in the trade;

(3) To determine the feasibility of a prospective study using a cohort defined in terms of occupational history, medical data and smoking history.

BACKGROUND. Studies of insulating workers have shown the

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greatly increased risk experienced by men in that trade with respect to chronic respiratory disease (particularly asbestosis), cancer of the lung, and mesothelioma. Recognition that asbestos is a major hazard to insulating workers has led to increasingly stringent standards of dust control. This hastened the substitution of other fibrous materials, such as fibrous glass and mineral wool in the insulating trade.

Increasing use of fibrous glass has raised justifiable questions as to the long-term effects of that material on the lungs. In view of the relatively short history of the fibrous glass industry (about 40 years) there have been few occupational groups with prolonged and well-defined exposures. Preliminary inquiries had made it seem possible that sheet metal workers, who work with fibrous glass in the preparation of pre-lined insulating ducts, might provide a potential useful group for study.

Balzer, Fowler and Cooper (1971) reported on the exposures of sheet metal workers to airborne fibrous glass in an unpublished report. They found that sheet metal workers engaged in the fabrication of lined sheet metal units were exposed to airborne fibrous glass concentrations from 0.11 to 1.6 f/liters with a geometric mean of 0.6. Area samples within fabrication shops ranged from 0.043 f/ml to 0.54 f/ml. The total dust, fibrous and non-fibrous, never exceeded 3.0 mg per cubic meter. They did not quantitate asbestos exposures.

Dunn and Weir (1968) included 3,013 sheet metal workers in a

prospective study of the mortality of a number of occupational groups. The workers aged 35 to 69 were observed from 1954-57 through Dec. 31, 1962, for a total of 23,008 person-years. There were 10 deaths from lung cancer observed, where 15.75 had been expected. In the same study, asbestos workers had over 3 times the expected number of lung cancer deaths. Detailed information on the Dunn and Weir study was made available to us, but it was not feasible to incorporate it in the study to be reported under this contract.

ARRANGEMENTS FOR STUDY. The use of union records, interviews with workers, and environmental studies during sheet metal operations required the cooperation and approval of many individuals. Mr. Edward J. Carlough, General President of the Sheet Metal Workers' International Association and MR. R. Van Gelderen of the Sheet Metal and Air Conditioning Contractors' National Association were helpful in developing general plans.

Local arrangements involved contractors and officials and staff members of local unions, notably Mr. Irv Ellenberger (Local #272), Mr. Russell Peterson (Local #420), Mr. Luther E. Lewis (Local #273), Mr. Alfred Teixeira (Local #355), Mr. Virgil H. Fox (Local #108), Mr. Thomas W. Dowrick (Local #104), Mr. Nelson Jolly (Tri-State Council of California, Arizona and Nevada). Ms. Elsa Gutierrez, Administratrix of the Sheet Metal Workers of Northern California Pension Trust Fund Welfare Plan provided invaluable information and assistance.

With the aid of the foregoing, agreement was reached with the Sheet Metal Workers' International Association in Northern California and with selected sheet metal contractors, to carry out a study with two parallel and closely-related components. The first was an appraisal of the work environment (conducted by William J. Popendorf), and the second was an historical-prospective mortality study, and study of proportionate mortality. Ms.Rebecca Black assembled and collated the information and Dr. Wm. R. Gaffey participated in the epidemiologic analysis. Able assistance was provided by Ms. K. Sodja, Ms. C. Lew, Ms. J. Hsu, and Ms. J. Ray.

ENVIRONMENTAL STUDIES

Between August and September of 1971, approximately 50 sheet metal shops and 24 field job-sites were visited in Alameda, Contra Costa, San Mateo and San Francisco counties. Workers in these shops belong to three different local unions, Nos. 104, 216, and 272. Some production workers were members of Local No. 355. As shown in table 1, the 50 firms surveyed represented 21 per cent of local sheet metal firms but employed 55 per cent of the workers. The shops were chosen so as to encompass most known sheet metal activities, and they represented all geographical areas in the Bay Area. There was some concentration on larger shops. The field sites were those associated with the activities of the shops chosen.

Information was collected on materials used, chemical exposures, and noise. It became clear that the sheet metal trade involves a broad spectrum of activities. The exposures of a worker installing ducts in a residence are quite different from those of a worker installing ducts in a high-rise building, or one working in a fabricating shop, or one constructing a gasoline service station. To permit systematic characterization, four categories of work place were defined: (1) Residential, (2) Commercial heat and ventilation, (3) Industrial fabrication, and (4) Other construction. Each employer and his workplace were assigned into one of these four categories. Local No. 355 is made up of production workers; their workplaces were nearly always characterized as industrial fabrication.

The distribution of workers in the categories varied from area to area (Table 2). In general, as one moved from the urbanized portion of the Bay Area to the rural portion, the emphasis was more on residential work. In plants studied, about 63 per cent of workers were engaged in field work rather than in fixed locations; this ranged from 86 per cent of those engaged in residential work, to 10 per cent of those in industrial fabrication (Table 3). This suggests the difficulties in defining work environments and in providing satisfactory occupational health controls.

It is important to stress that sheet metal workers do many things other than handle sheet metal. A journeyman in the trade is equipped not only to cut, solder, and weld metal, but also to handle a variety of lining materials and do certain kinds of construction work involving metal.

The exposures of workers in the Bay Area to fibrous glass were less than had been expected. Fibrous glass was introduced for insulation purposes about 1945, and as pipe wrapping between 1955 and 1965, operations usually performed by asbestos workers rather than sheet metal workers. Direct exposures of sheet metal workers came principally from the fabrication of ducts lined with fibrous glass materials, a process which began about 1965. The major potential exposures to glass were in those engaged in commercial work and in industrial fabrication (Table 4). In residential work, and to some extent in commercial work, it was found, however, that some sheet metal workers were engaged in duct-wrapping with materials containing

glass. On the average, about 35 per cent of workers were engaged in work involving fibrous glass. The levels of airborne glass fibers were relatively low, 0.1 to 1.0 fiber/ml as shown in Table 5.

Many sheet metal workers were also exposed to asbestos, as shown in Tables 4 and 5. There were two sources of this. The first was in the application of asbestos paper. Here levels of exposure were quite low, of the order of 0.1 to 0.2 fibers/ml. The second source was asbestos in construction sites secondary to the work of other trades, i.e. insulation workers, and those spraying asbestos products for fireproofing of structural steel. These factors will make it impossible to define a population, other than a few working solely in fixed-site industrial fabrication shops, who have not had asbestos exposures.

Other potential exposures which could have an effect upon interpretation of mortality data included those associated with welding fumes in each major work category (Table 6). Not only does the proportion of men welding and the amount of time spent welding vary between categories, but also the types of metals handled vary, e.g.

Commercial work is largely black iron and galvanized metal;

Industrial fabrication is largely stainless steel;

Other construction is primarily galvanized metal;

Spot welding was not considered a significant hazard, and the small amount of residential welding can probably be disregarded. The specific hazardous exposures include ozone, oxides of nitrogen, and metal fumes. Oxides of nitrogen predominate in oxyacetylene welding and cutting, although they are also produced by gas-shielded arcs.

Ozone is formed from oxygen in the atmosphere by ultra-violet light, as produced from argon-shielded electric-arc welding.

The most important hazardous fumes are zinc oxide from galvanized metal and various heavy metal fumes, including cadmium, from stainless steels. More of these fumes are produced by electric-arc welding because of the high temperatures of the metals.

In the survey of shops, a wide range of conditions was noted for the protection of welders. Some had well-designed exhaust systems, other relied on natural ventilation. The latter was dependent upon the size of the room, height of ceiling and weather conditions. Control is fairly easy in fixed fabrication shops, but welding done at dispersed construction and commercial sites, often within enclosed spaces, is much more difficult to control. No actual measurements of concentrations of gases or fumes during welding operations were made; there is abundant literature available on this, and it was clear that no quantitative relationships with mortality data would be feasible.

Soldering is a common activity of the sheet metal worker, as shown in Table 7, about 19% of workers interviewed were involved for over 1 hour per week with the largest proportion being in residential work. The average time per week was 2.8 hours. The principal chemical exposure during this activity was to hydrogen chloride, which is a significant hazard only in poorly ventilated sites, and when acid is applied to hot metals, with rapid vaporization.

Organic solvent exposures to sheet metal workers occur during the use of adhesives, and in a number of other minor uses. The most common use of adhesives is in bonding of fibrous glass to ducts. As shown in Table 8, flammable and non-flammable solvents were used in about equal proportions. The use of hexane and aliphatic solvents is particularly important because of the possibility that these may contain small amounts of benzene. The extensive use of trichloroethane is also noteworthy. The use of solvents was intermittent, but workers are frequently exposed to peaks exceeding acceptable ceiling limits. Examples of concentrations of solvents in breathing zones of sheet metal workers are shown in Table 9.

Another exposure common to sheet metal workers is noise (Table 10), principally associated with air hammer and grinding operations. Although not directly pertinent to a study of mortality, it is an important consideration in the industrial hygiene of sheet metal operations. This has been the subject of a recent report by Kenney and Ayer (1975).

SUMMARY OF ENVIRONMENTAL STUDY

In summary, the average sheet metal worker has a broad range of potential hazards, most of them not in high concentrations or of great severity. He is particularly subject to minor accidents and is subject to the general environmental hazards of the construction trades. It is unlikely that mortality evaluation can be clearly related to specific environmental hazards, such as fibrous glass, asbestos, or airborne chemicals. Mortality will reflect the composite effect of many influences. With respect to fibrous glass and asbestos, the group's experience will be intermediate between those of insulation workers and those of insulation workers and those of construction trades in general.

MORTALITY STUDIES

Methods. The basic population on which the mortality study was based was a master list of 24,593 men eligible for benefits under the Northern California Sheet Metal Workers Pension and Welfare Fund at any time during the period January 1, 1950 through December 31, 1970. For men who had died during this interval while they were eligible for benefits, the list included death claims, usually with an appended death certificate. The studies were based on the death claim certificates, plus additional data (including additional death certificates), obtained by a follow-up of two cohorts selected as described later.

Death Claim Group. There were 423 death claims, accompanied by death certificates, on file for men who were not represented in the two cohorts. These were subjected to separate analysis.

Cohort 1. This cohort, numbering 1,776 men, included all members of Locals No. 104 and 216 who were eligible for benefits as of January 1, 1950 and who were found to have worked for 5 or more years in the sheet metal trade, either before 1950, between January 1, 1950 and December 31, 1970 or any combination.

These workers were considered to have come under observation as of the date on which they had completed 5 years of employment in the trade or on January 1, 1950, whichever was later.

The fifth anniversary date was estimated from pension records which contained for each man the year he began work in the trade, the most recent year worked in the trade, and the number of years worked between the two dates. Because time worked before 1950 was recorded

in the records only if the worker reported that time with documentation to the fund, there could have been some under estimation of time In the trade for some who were included, and some could have been omitted from the cohort simply because of missing information.

Cohort 2. The second cohort of 1,134 men was developed by first taking a random start systematic sample of 10% of the master pension list of 24,593 names, i.e. every 10th name on the list. If a sample entry had joined the union after 1965 (providing insufficient time to have 5 years service by 1970) or if it were a female worker, the adjacent name on the list (alternately the name before or the name after) was substituted. From this sample those who had worked for 5 years or more were identified in the same manner as Cohort 1. The elimination of those who had worked less than 5 years reduced the 10% sample to a sample of less than 5% of the list. Since the list included men from Locals 104 and 216, the selection process picked up 245 individuals from those Locals, who therefore appeared in both cohorts. This overlap represented 14% of Cohort 1 and 22% of Cohort 2, and included 30 deaths.

Follow-up of cohorts 1 and 2 was by checking of union and pension fund records, and Social Security Administration files. For those found to have died, death certificates were obtained either from the pension records or the health department in the state where death occurred. Table 8 shows the result of the follow-up and of the search for death certification. Ninety-six percent of Cohort 1 and 94 percent

of Cohort 2 were successfully traced. Death certificates were obtained for 93 percent and 88 percent of the deaths, respectively.

The mortality experience of the populations was evaluated by determing the Proportionate Mortality Rate and The Standardized Mortality Rates.

For determination of Proportionate Mortality Rate (PMR) the distribution of causes* for all deceased workers in whom death certificates were available was compared with the distribution of the same causes among deaths in the total U.S. male population for the period 1959-61. Separate analyses were made of the 423 death certificates obtained from the master pension file in men not represented in the cohorts, and the 307 death certificates obtained from the follow-up study of the two cohorts, with elimination of 30 deaths which appeared in both cohorts.

Determination of proportionate mortality requires information only on causes of death and not on the characteristics of the population in which the deaths occur. A disadvantage of the method is that it does not provide information about the actual risk of death, but only about those causes which may be relatively over-represented in the study deaths compared with deaths in the general male population. In addition, comparisons between the study group and the general population cannot be adjusted for age of the population at risk. Nevertheless, causes which constitute an excess percentage of deaths in a study group are usually ones in which the true risk is

*Based on the 1955 revision of International Classification of Diseases

likely to be greater.

The second approach to mortality, determination of a STANDARDIZED MORTALITY RATIO (SMR) for all deaths and cause-specific deaths, took the form of a historical-prospective mortality study, to determine the actual risk of death in workers known to have been alive as of a given date in the past.

Tne risk of death for these cohorts was obtained as follows. Using the date of birth and date of entry into the trade, the number of years of observation contributed by each worker from that date until death or December 31, 1970, whichever was earlier, was calculated. These years were classified by the birth date and the age at which they occurred, and the figures were totalled for all workers. The death rate among U.S. males of the same age and birth date was used to calculate how many deaths would be expected out of the observed person years at that age and birth date. Mortality was then calculated by expressing the observed numbers of deaths as a percentage of the total which would have been expected on the basis of the above calculations. This figure, the Standardized Mortality Ratio (SMR) was calculated for total mortality and mortality from each of a group of 32 causes for which comparable national statistics are published.

RESULTS

Description of the populations

Cohort 1, derived from the records of Locals 104 and 216, contained

1,776 men for whom years in the sheet metal trade were known. Cohort 2, based upon the 10% sample of pension rolls, contained 1,134 men with such information. The distribution of years in the sheet metal trade, based upon December 31, 1970, or date of retirement or death, is summarized in table 11. Cohort 1 had a higher proportion of men with long service, 58% having been in the trade for 20 or more years; the corresponding figure for Cohort 2 was 27%. When 245 men common to both cohorts were excluded, the number with over 20 years in the trade was 1,173 or 44%.

The age distribution, based upon year of birth, showed a similar pattern. There were 1,633 men in Cohort 1 and 1,056 in Cohort 2 with birth year known; 230 appeared in both Cohorts. Table 12 shows the distribution of birth-years in the two groups. In Cohort 1, 330 men or 20.5% had been born before 1905, while in Cohort 2 only 92 or 8.7% had been born before 1905. This is the group who would have reached age 65 by the end of the study period. The corresponding figure for the entire 2,460 men for whom birth dates were known, i.e. excluding 230 men in both Cohorts, was 383 or 15.6%.

Follow-up Results. As shown in table 13, Cohort 1 originally included 1,776 men. The vital status as of December 31, 1970, was determined for 1,708. Of the group 1,378 (77.6%) were found alive, 330 (18.6%) dead, and 68 (3.8%) were not located. For the 330 deaths, 307 (93%) death certificates were received. Mortality analyses were made on a population of 1,670 individuals, for a total of 28,438 person years.

Cohort 2, originally numbered 1,134 men. As of December 31, 1970, 967 (85.3%) were alive, 94 (8.3%) dead, and 73 (6.4%) were not located. Death certificates were obtained for 83 (88%) of the known dead. After exclusion of individuals with missing information, analyses of mortality were based upon 83 deaths in 1,031 individuals, followed for 12,422 person-years. Due to the overlapping of Cohorts 1 and 2, there were 245 individuals who were in both groups and who contributed 4,123 person-years of observation, and 30 deaths for analysis. Of the 30 deaths, 26 had death certificates.

PROPORTIONATE MORTALITY ANALYSIS

As described earlier, the distribution of deaths was compared with the distribution expected in the U.S. male population for the years 1959 and 1967. The actual distribution of death years was as follows:

1950 - 54	---	5.5%
1955 - 59	---	20.6%
1960 - 64	---	29.8%
1965 - 69	---	36.5%
1970 -	---	7.8%
TOTAL		100.2%

Table 14 summarizes the distribution of causes of death. There is a consistent and probably significant excess of deaths due to malignant neoplasms and to accidents other than motor vehicle accidents,

which occur in both groups and in the Death Claim Group. The fact that the malignant neoplasm deaths proportion is less in the latter group can perhaps be explained by the great excess of deaths in this group attributed to "Other Accidents". At least one-third of deaths due to "Other Accidents" appeared job-related, e.g. falls, being struck by falling objects, or electric shock. There are also smaller, but noteworthy excesses in deaths from cirrhosis of the liver and suicide. There is a deficit in deaths attributed to cardiovascular and renal disease, a common finding in Cohort studies of occupational groups.

The excess cancer deaths are largely explained by the excess proportion of deaths due to malignancies of the respiratory tract, where the proportion in the two Cohorts was 10.7%; 3.4% would have been expected in 1959. The proportion of all cancer deaths due to lung cancer was 42% of Cohort 1, 41% of Cohort 2, and 36% of the Death Claim Group. This compares with an expected figure for all U.S. males of 16.1% in 1950, 23.2% in 1959, and 32.9% in 1969.

Only one death certificate mentioned mesothelioma of the pleura; this was in a 63 year old man who had been in the trade for 25 years at the time of death.

STANDARDIZED MORTALITY RATIOS

Table 15 is a summary of the deaths in Cohorts 1 and 2, in which observed deaths are compared with those expected.

The SMR for all causes combined is significantly below that of

all U.S. males for both Cohorts, that for group 1 being 88, and that for group 2 being 80. Such a finding is usual in studies made of employed groups.

The only cause-specific standardized mortality ratio found to be significantly elevated (at the 5% confidence level) is that for malignancies of the respiratory system in Cohort 1, where the SMR was 174. The corresponding SMR for group 2 was 161, but the numbers observed and expected were too small for statistical significance. There was one mesothelioma in Cohort 1.

There were statistically significant deficiencies in vascular lesions affecting the central nervous system, and in certain types of heart disease.

There were a number of other cause-specific SMR's that are elevated and which should be subjected to further investigation, concentrating on groups with longer exposures or better-defined exposures. These include the apparent excess of "other accidents", and an apparent excess of cirrhosis of the liver in Cohort 1.

DISCUSSION

Sheet metal workers have a heterogeneous pattern of exposures to a number of chemical and physical agents known to be carcinogenic, toxic, or nuisance-causing. These include asbestos, used directly or inhaled in the course of work on construction sites where asbestos is used by other trades. They have also in recent years been exposed to fibrous glass. Their work commonly involves the inhalation of solvent vapors,

metal fumes, hydrogen chloride. Thus it is impossible to relate mortality patterns to specific exposures. However, the asbestos exposures appear the most important with respect to the excess lung cancer deaths. The appearance of one mesothelioma of the pleura in the group of 364 deaths in the Cohort studies is probably significant in this regard. Deaths due to mesothelioma in sheet metal workers who have worked for 20 or more years in the trade, particularly if they have worked in construction sites or shipyards, should probably be judged as having arisen as a result of their employment.

SUMMARY

Proportionate mortality was studied in 364 deaths that occurred in 2 Cohorts of sheet metal workers during the period 1950-1970, and in an additional group of 423 deaths accompanying death claims to a pension plan. In both series there was an excess of deaths due to malignant neoplasms; 24.7% of deaths in the two cohorts were attributed to malignancy where 14.5% would have been expected, and 19.1% in the Death Claim group. This excess was largely attributable to malignant tumors of the respiratory tract. There were less dramatic excesses in accidents other than motor vehicle, and in cirrhosis of the liver, and suicide.

Standardized Mortality Ratios (SMR's) were determined for two Cohorts of sheet metal workers, one being selected from the records of two local unions, and the other being from a 10% sample of the roster

of all participants in the union pension plan. Only men with over 5 years in the trade were studied. There were 1,670 men in the first Cohort, 1,031 in the second. They were observed for 28,438 and 12,422 person-years respectively. Analysis of 307 deaths in the first group and 83 in the second, showed that the overall SMR for all causes combined was better than expected for both groups, but there was an apparent excess of lung cancer. That in the first Cohort, where 32 cases of lung cancer deaths were attributed to lung cancer, gave a corrected SMR of 174. There were minor, but not statistically significant excesses of deaths due to accidents other than motor vehicles, cirrhosis of the liver, and suicide. It is probable that the most important factor contributing to the lung cancer risk is exposure to asbestos, most of which probably occurred 20 or more years before death.

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TABLE 1: Sheet metal firms and sheet metal workers in San Francisco Bay Area, by union local, and percent included in the sheet metal workers study.

	LOCAL			
	#104	#216	#272	Total
Firms in local	65	114	51	230
Firms surveyed	13	24	13	50
Percent surveyed	20%	21%	25%	21%
Workers in local	759	1111	485	2355
Workers in firms surveyed	421	489	391	1301
Percent surveyed	55%	44%	81%	55%

TABLE 2: Percent distribution of workers in sheet metal study, by place category

	Residential	Commercial Heat & Vent.	Industrial Fabrication	Other Construction	Total
San Francisco, %	15	48	22	15	100
San Mateo, %	31	39	18	12	100
Alameda-Contra Costa, %	32	38	20	10	100
Other Northern California, %	43	46	9	2	100

TABLE 3: Percent distribution of workers in sheet metal study between shop and field, by work place category

	Residential	Commercial Heat & Vent.	Industrial Fabrication	Other Construction	Total
Shop, %	14	36	90	66	37
Field, %	86	64	10	34	63

TABLE 4: Percent of workers in sheet metal study exposed to airborne fibers, by work place category and fiber type.

	Residential	Commercial Heat & Vent	Industrial Fabrication	Other construction	Total
Asbestos %	63	37	0	0	33
Fibrous glass					
duct liner %	3	9	7	2	7
duct wrap %	69	19	0	1	28

TABLE 5

Representative concentrations of airborne fibers in work environment of sheet metal workers.

Description of job site	Sample		Asbestiform fibers	Glass fibers
	Time min.	Volume liters	f/ml	f/ml
Construction site, during installation of fibrous glass-lined duct	30	828 *	0.23	0.003
	25	644 *	0.11	<0.001
	60	1650 *	0.20	0.001
	30	828 *	0.23	<0.001
	20	61	0.43	<0.001
Construction site,during installation of fibrous glass-lined duct	22	75	1.61	0.03
	30	102	1.4	<0.001
Residential installation of flexible duct wrapped with fibrous glass & asbestos paper	22	66	0.12	0.18
Fabrication shop during application fibrous glass in a revolving duct	14	37	0.27	0.6
Fabrication shop during cutting of thermabestos	9	27	0.225	<0.001
Fabrication shop during installation fibrous glass duct lining	20	27	0.003	0.135

* Samples with asterisk were collected with high volume samplers on 47 mm filters; all others were collected with personal samplers.

TABLE 6: Percent of workers in sheet metal study exposed to welding fumes and average weekly exposure, by work place category.

	Residential	Commercial Heat & Vent.	Industrial Fabrication	Other construction	Total
Percent	2	11	27	24	12
Hours per week	<1	10	20	12	13

TABLE 7: Percent of workers in sheet metal study exposed to acid vapors in soldering for more than 1 hour per week, and average weekly exposure, by work place category.

	Residential	Commercial Heat & Vent.	Industrial Fabrication	Other construction	Total
Percent	49	9	8	21	19
Range of hours exposed	1-8	1-4	1-5	1-12	
Average hours exposed	2.7	3.2	2.8	2.6	2.8

TABLE 8: Adhesive solvents used by sheet metal workers in the San Francisco area.

Flammable		51%
hexane	(32%)	
aliphatic	(14%)	
ketones	(4%)	
Non-flammable		49%
trichloroethane	(35%)	
denatured alcohol	(12%)	
methylene chloride	(2%)	

TABLE 9: Examples of solvent concentrations experienced by sheet metal workers during typical operations.

Operation	Average conc. (ppm)	Peak conc. (ppm)
Spraying glue containing aliphatic petroleum distillate	200-300	800-900
Same operation, different site	150-180	400
Spraying adhesive containing hexane*	500-700	1200-1500
Applying adhesive containing hexane with brush	500-600	1100

* Current TLV for hexane is 500ppm but reduction to 100ppm has been recommended.

TABLE 10: Noise survey in a typical commercial sheet metal Fabrication Shop

Site	Operation	dBA*
Welding area	background	78-80
	abrasive grinding	98-99
	air hammers	90
Duct assembly area	hand hammering, half duct	97-100
	hand hammering, full duct	100-102
	air hammering, half duct	105-110
	air hammering, full duct	108-112
Automatic equipment	notching press operation	87-92
	shear operation, background	88
	shear operation, shear	100
	shear operation, air flow	99

*Using General Radio Model 1558 BP Octave Band Noise Analyser

TABLE 11: Distribution by number of years in the sheet metal trade.*

Years	Cohort 1	Cohort 2	Combined Cohorts**
5-9	215	358	557
10-14	237	275	481
15-19	293	196	454
20-24	431	147	506
25-29	340	94	380
30-34	166	39	182
35-39	52	14	57
40-44	20	5	24
45-49	19	6	21
50-55	3	0	3
TOTAL	1776	1134	2665

* As of date of termination or December 31, 1970, whichever came first. These include some men with missing birthdates or no followup.

** 245 men common to both cohorts not included.

TABLE 12: Distribution of years of birth for sheet metal workers.

Year of birth	Cohort 1		Cohort 2		Combined Cohorts**	
	Number	Cumulative %*	Number	Cumulative %	Number	Cumulative %
1870-1874	1	<0.1	-	-	1	<0.1
1875-1879	4	0.2	-	-	4	0.2
1880-1884	15	0.9	1	0.1	16	0.9
1885-1889	35	3.4	8	0.8	36	2.3
1890-1894	72	7.8	13	2.1	79	5.5
1895-1899	72	12.2	23	4.3	81	8.8
1900-1904	136	20.5	47	8.7	166	15.6
1905-1909	231	34.7	71	15.4	268	26.5
1910-1914	278	51.7	121	26.9	358	41.0
1915-1919	307	70.5	143	40.4	410	57.7
1920-1924	280	87.6	148	54.4	386	73.4
1925-1929	151	96.9	124	66.1	250	83.5
1930-1934	48	99.8	123	77.8	167	90.3
1935-1939	2	99.9	149	91.9	151	96.5
1940-1944	1	100.0	77	99.1	78	99.6
1945-1949	-	100.0	9	100.0	9	100.0
TOTAL	1633		1057		2460	

* Percentage of group born in or before indicated time period.

** 230 men common to both cohorts not included.

TABLE 13: Distribution of workers in sheet metal study by vital status as of December 31, 1970, by cohort.

Cohort	Total No.	Total (%)	Alive No.	Alive (%)	Dead No.	Dead (%)	Unknown No.	Unknown (%)	Death certificate obtained Yes	Death certificate obtained No
1	1776	(100)	1378	(78)	330	(19)	68	(4)	307	23
2	1134	(100)	967	(85)	94	(8)	73	(6)	83	11

TABLE 14: Percentages of deaths in sheet metal workers due to selected causes compared with percentages among U.S. adult males for 1959 and 1967 (proportionate mortality).

Cause of Death with I.C.D. Number	U.S. Males		Cohort 1		Cohort 2		Death claim group	
	1959 percent	1967 percent	No.	Percent	No.	Percent	No.	Percent
Malignant Neoplasms (140-205)*	14.6	16.2	76	24.8	22	26.5	81	19.1
Gastrointestinal (150-56,157-59)	4.2	4.9	20	6.5	5	6.0	29	6.9
Respiratory tract (160-164)	3.4	4.6	32	10.4	9	10.8	30	7.7
Urinary organs (180,181)	0.9	0.9	7	2.3	4	4.8	2	0.5
Leukemia (204)	0.7	0.8	1	0.3	0	0.0	4	1.0
Lymphoma (200-203,205)	0.8	0.9	7	2.3	1	1.2	0	0.0
Major Cardiovascular and Renal Diseases (330-334,400-468, 592-594)	53.9	53.0	138	45.0	35	42.2	185	43.7
Vascular lesions of CNS (330-334)	9.7	8.9	13	4.2	1	1.2	23	5.4
Hypertensive heart disease (440-443)	3.2	2.1	3	1.0	0	0.0	3	0.7
Other hypertensive disease (444-447)	0.7	0.5	2	0.7	0	0.0	0	0.0
Chronic and unspecified nephritis (592-594)	0.7	0.5	1	0.3	0	0.0	1	0.2
Cirrhosis of the Liver (581)	1.3	1.7	14	4.6	2	2.4	12	2.8
Motor Vehicle Accidents (810-835)	3.0	3.6	3	1.0	0	0.0	33	7.8
Other Accidents (800-802,840-962)	3.8	n.c.	17	5.5	8	9.6	56	13.2
Suicide (963,970-979)	1.5	1.5	13	4.2	4	4.8	16	3.8
All Other	21.9	n.c.	46	15.0	12	14.5	40	9.5
TOTAL	100.0	100.0	307	100.1	83	100.0	423	99.9

* These numbers represent classifications according to the 1955 Revision, International Classification of Diseases.
n.c. = not calculated

TABLE 15: Observed and expected deaths, and standardized mortality ratios, by cause in male sheet metal workers, January 1, 1950 through December 31, 1970.

Cause of death with I.C.D. Number	Cohort 1 obs/exp	Cohort 1 SMR[1]	Cohort 2 obs/exp	Cohort 2 SMR[2]
All Causes	307/373.7	88**	83/116.5	80**
Tuberculosis (001-019)	1/4.3	25	0/1.3	--
Malignant Neoplasms (140-205)	76/66.6	122	22/20.5	121
Buccal cavity & pharynx (140-148)	1/2.4	45	0/0.7	--
Digestive organs & peritoneum (150-156,157-159)	20/21.5	100	5/6.3	90
Respiratory system (160-164)	32/19.7	174*	9/6.3	161
Genital organs (170-179)	2/5.0	43	0/1.2	--
Urinary organs (180,181)	7/3.7	203	4/1.1	411
Leukemia & aleukemia (204)	1/2.7	40	0/0.9	--
Lymphomas (200-203,205)	7/3.8	198	1/1.3	87
Diabetes Mellitus (260)	1/5.2	21	0/1.6	--
Major Cardiovascular & Renal Diseases (330-334,400-468,592,594)	138/204.4	73**	35/59.4	67**
Vascular lesions affecting CNS (330-334)	13/29.3	47**	1/7.8	14
Rheumatic fever and chronic rheumatic heart disease (400-402,410-416)	1/4.5	24	0/1.5	--
Arteriosclerotic heart disease (420)	110/131.0	90	33/38.8	96
Nonrheumatic endocarditis (421,422)	3/8.4	38	0/2.2	--
Hypertensive heart disease (440-443)	3/10.3	31	0/2.9	--
Other hypertensive heart disease (444-447)	2/2.2	98	0/0.7	--
Chronic and unspecified nephritis, renal sclerosis (592-594)	1/2.9	36	0/1.0	--
Influenza and Pneumonia (480-492)	6/8.9	72	1/2.6	43
Ulcer of Stomach and Duodenum (540,541)	4/3.5	123	1/1.0	113
Appendicitis (550-553)	1/0.5	215	0/0.2	--
Hernia and Intestinal Obstruction (560,561,570)	2/1.5	143	1/0.4	282
Gastritis, Duodenitis, Enteritis and Colitis (543,571,572)	1/1.0	107	0/0.3	--
Cirrhosis of Liver (581)	14/8.9	169	2/3.2	71
Hyperplasia of Prostate (610)	0/1.0	--	0/0.2	--
Symptoms of senility, and Ill-defined Conditions (780-795)	7/4.8	157	2/1.6	141
Motor Vehicle Accidents (810-835)	3/10.7	30	0/4.9	--
Other Accidents (800-802, 840-962)	17/13.4	136	8/5.3	170
Suicide (963,970-979)	13/7.7	181	4/3.1	146
Homicide (964,980-985)	2/3.1	69	1/1.6	71
All Other Diseases (Residual)	21/28.1	76	6/8.8	77
Total Persons	1,670		1,031	
Total Person-years	28,438		12,422	

1. SMR for cohort 1 increased by 7.5% to correct for missing death certificates.

2. SMR for cohort 2 increased by 13.2% to correct for missing death certificates.

* Significant at 5% level

** Significant at 1% level