Scand J Work Environ Health 1981;7(4):147-155

**Lung cancer and other mortality patterns among foundrymen.**
by Egan-Baum E, Miller BA, Waxweiler RJ

**Corrections**

See 1982;8(1):0 for a correction.

**Key terms:** black; cancer; foundry; foundryman; lung; lung cancer; mortality; mortality pattern; pneumoconiosis; proportional mortality; respiratory disease

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/7330626

*Scand j work environ health* 7 (1981): suppl 4, 147—155

# Lung cancer and other mortality patterns among foundrymen

by Elizabeth Egan-Baum, MS,[1] Barry A Miller, MSPH,[2] Richard J Waxweiler, PhD [1]

EGAN-BAUM E, MILLER BA, WAXWEILER RJ. Lung cancer and other mortality patterns among foundrymen. *Scand j work environ health* 7 (1981): suppl 4, 147—155. This report updates a previous proportional mortality study of deaths among members of the International Molders and Allied Workers Union and includes new findings from a nested case-referent study of lung cancer. Death certificates were obtained for 99.2 % of the 3,013 deaths reported to the Union death benefits program between 1971 and 1975. With the use of age- and race-specific cause distributions of all male deaths in the United States for comparison, statistically significant excesses occurred for all malignant neoplasms, lung cancer, and nonmalignant respiratory disease among both the whites and blacks. White foundrymen also exhibited a statistically significant excess of respiratory tuberculosis. The lung cancer case-referent study found a statistically significant ($p < 0.05$) odds ratio of 2.36 for workers in iron foundries when compared with workers in steel and nonferrous foundries for those who died before the age of 65. A much smaller odds ratio, 1.19, was found for those who died after the age of 64.

*Key terms:* blacks, foundries, pneumoconiosis, proportional mortality, respiratory.

The foundry industry uses a large and changing inventory of organic and inorganic compounds. The most common of these is the silica sand used to make molds and cores for foundry castings. Organic binders such as dextrine, starch, oils, pitch, asphalt, and synthetic resins are also widely used in molding and coremaking materials (10, 21). Among the compounds identified in foundries are various known or suspect carcinogens such as benzo(a)pyrene, asbestos, talc, benzene, and formaldehyde (18, 21). Furthermore, many foundry processes involve extremely high temperatures which produce chemical reaction by-products, most of which remain unidentified.

It has been known for over 50 a that foundry workers have an excess risk of respiratory illness. As early as 1923, Macklin & Middleton (13) found that sandstone grinders in foundries had an increased prevalence of pulmonary fibrosis and tuberculosis compared with workers in other foundry jobs. Subsequently other studies have shown that foundry workers experience an excess risk of developing nonmalignant respiratory disease (9, 12, 14, 20).

Respiratory problems among foundry workers are not restricted to nonmalignant respiratory disease. In the Registrar General's report of occupational mortality for England and Wales during 1930—1932 (17) "metal moulders and casters" and "iron foundry furnacemen and labourers" occupied fourth and fifth places, respectively, in the list of occupations with a high mortality from lung cancer. In the most recent Registrar General's report for the period 1970—1972 (6), the category "Fur-

[1] National Institute for Occupational Safety and Health (NIOSH), Center for Disease Control, Public Health Service, Cincinnati, Ohio, United States.

[2] Environmental Epidemiology Branch, National Cancer Institute, Bethesda, Maryland, United States.

Reprint requests to: Ms E Egan-Baum, Center for Disease Control, National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati OH 45226, USA.

0355-3140/81/080147-9

nace, forge, foundry and rolling mill workers" occupied first place among all occupations in mortality from lung cancer. An examination of molders and coremakers as a separate group revealed a standardized mortality ratio (SMR) of 155 for cancer of the lung and an SMR of 215 for bronchitis, asthma, and emphysema.

Vital statistics data for the United States in 1950 indicated that men employed in foundries experienced higher lung cancer death rates than the general population (8). Among deaths occurring in California during the period 1959 to 1961 (16), the proportional mortality ratios (PMRs) were elevated for metal molders for lung cancer, tuberculosis, pulmonary emphysema, and silicosis. In Milham's (15) proportional mortality analysis of Washington state deaths between 1951 and 1970, metal molders, again, showed increased mortality from cancer of the bronchus and lung, respiratory tuberculosis, and silicosis.

Recently Egan et al (5) reported a statistically significant excess proportional mortality for lung cancer and nonmalignant respiratory disease among members of the International Molders and Allied Workers Union (IMAW) who were eligible for the Union's death benefits program and who died in the United States between 1971 and 1975. Gibson et al (7) compared lung cancer mortality among 439 steel foundry workers to that among 1,103 nonfoundry workers who were alive and at least 45 a of age in 1967. A foundry worker was found to be under five times greater risk for lung cancer than a nonfoundry worker. An additional comparison of the mortality rates of foundry workers with metropolitan Toronto mortality rates indicated an overall SMR of 250 for lung cancer.

In 1979 Decoufle et al (4) published a study that examined the long-term mortality experience of 2,861 men employed at least one month during 1938 to 1967 in a gray iron foundry. Although no overall excess of lung cancer mortality was seen in the study population, the subgroup of men who achieved five or more years of employment prior to 1938 experienced a twofold increase in respiratory cancer (8 observed vs 4.0 expected deaths).

An excess lung cancer risk among foundry workers has also been reported in several other studies (3, 4, 5, 7, 9, 15, 16, 22). In a comprehensive cohort mortality study of foundry workers conducted in Finland in 1976 (11) the most significant finding was an excess of lung cancer, especially among molders in iron foundries.

Despite the different geographic locations, time periods and methodologies, epidemiologic studies of foundry workers clearly demonstrate a pattern of excess respiratory disease and lung cancer. The present report provides updated results of the mortality patterns among white male foundry workers reported previously by Egan et al (5). Death certificates have now been obtained on 99.2 % of the study population. A sufficient number of blacks has been added to the study population to allow separate analyses of the mortality patterns among male foundry workers by race. In addition, because of the consistent lung cancer excess observed in several studies, a case-referent study was carried out within the data base of the proportional mortality study to identify whether any differential lung cancer risk existed for iron foundrymen compared with other foundrymen. Such an hypothesis has been raised by studies in Finland (11).

## Methods

*Proportional mortality study*

Records maintained by the IMAW as part of its death benefits program were used for the a proportional mortality study. Details of the study design and methods were described in an earlier paper by Egan et al (5). Briefly, the study population consisted of 3,013 male union members who died in the United States between 1971 and 1975 and whose heirs were paid death benefits by the IMAW. To be eligible for death benefits a worker had to have been a union member prior to 1961 and must have paid monthly dues either until death or until receipt of a 45-a life membership card.

For this analysis, death certificates were obtained for 2,990, or 99.2 %, of the deceased foundry workers eligible to be included in the study. For each member of the study group, the underlying cause of death was coded according to the

*Eighth Revision of the International Classification of Disease Adapted* (ICDA) by a qualified nosologist. Cause-specific expected numbers of deaths within 5-a age groups were calculated by the application of the cause-, race- and age-specific proportional mortality of United States males for 1973 to the total number of foundry worker deaths within each 5-a age group. The difference between the observed and expected numbers of deaths was summarized as a PMR. PMRs were not calculated when both the observed and the expected number of deaths within a category were less than five. Statistical significance was determined by a Mantel-Haenszel chi-square test.

*Case-referent study*

So that the case-referent study could be limited to a manageable size, only white male deaths occurring in the 19 union locals with four or more lung cancer deaths were selected from the proportional mortality data base. From this group, 113 cases were identified whose underlying cause of death was cancer of the lung, bronchus, or trachea (ICDA 162). The reference pool consisted of all other deaths from these locals, except those due to other cancers or nonmalignant respiratory disease. These diseases may also be related to a particular type of foundry exposure and could thereby bias the risk estimates.

A variable matching ratio was used in selecting 249 referents for study. The referents were matched within 1 a of birth and death date in all but two instances and were selected from the 19 locals without regard to which local the case had belonged. Questionnaires were sent to the 19 union locals to obtain job titles, foundry types (classified according to type of metal founded, eg, iron, steel, aluminum, copper), and employment dates for the study subjects.

Follow-up phone calls and, in some cases, personal visits by the investigators were made to enhance the exposure ascertainment. In spite of these efforts, inadequate employment information precluded analysis by job or employment dates. Foundry type was determined for only 41 % of the subjects (table 1). It was decided to supplement the exposure ascertainment rate by obtaining company names from employment information on the death certificates and having the IMAW headquarters classify these companies by foundry type. This procedure provided foundry type information on 84 additional subjects and increased the ascertainment rate to 65 %. Questionnaires appeared to be a more useful source for determining foundry type among younger subjects than among retirement age workers (table 2). When employment information was available for a subject from both the questionnaire and from his death certificate, the two were compared. For 84 subjects on whom this comparison could be made, there was exact agreement (ie, the name of the foundry given in both sources was the same) for 80 of them, or 95 %.

Estimates of risk were obtained by the computing of simple odds ratios within each of two age strata. Summary estimates of risk were not derived due to the considerable nonuniformity of the odds ratios across the age strata. Statistical significance for a one-sided test of hypothesis was determined by a Mantel-Haenzel chi with one degree of freedom.

**Table 1.** Employment information obtained from the International Molders and Allied Workers Union (IMAW) locals and death certificates.

| | Potential study population | Employment information | | |
|---|---|---|---|---|
| | | IMAW locals [a] | Death certificates | Combined data |
| Cases | 113 | 43 (38 %) | 48 (42 %) | 68 (60 %) |
| Referents | 249 | 107 (43 %) | 125 (50 %) | 166 (67 %) |
| Total | 362 | 150 (41 %) | 173 (48 %) | 234 (65 %) |

[a] Twelve locals responded out of the 19 selected for study.

**Table 2.** Age-at-death distributions for the potential study population and for those with foundry-type ascertainment.

| Age (a) | Potential study population N = 362 (%) | IMAW data [a] N = 150 (%) | Death certificate data N = 173 (%) | Combined data N = 234 (%) |
|---|---|---|---|---|
| 40—64 | 38 | 49 | 38 | 41 |
| $\geq$ 65 | 62 | 51 | 62 | 59 |
| Total | 100 | 100 | 100 | 100 |

[a] IMAW = International Molders and Allied Workers Union.

**Table 3.** Observed and expected deaths among white and black male foundry workers.

| Cause of death [a] | White males | | | Black males | | |
|---|---|---|---|---|---|---|
| | Observed | Expected | PMR [b] | Observed | Expected | PMR [b] |
| Respiratory tuberculosis (010—012) | 10 | 4.31 | 232 * | 3 | 2.02 | |
| Malignant neoplasms (140—209) | 545 | 497.65 | 110 * | 86 | 69.29 | 124 * |
| Heart disease (393—429) | 1,493 | 1,565.61 | 95 | 152 | 167.75 | 91 |
| Nonmalignant repiratory disease (460—519) | 277 | 200.40 | 138 ** | 30 | 19.81 | 151 * |
| Diseases of digestive system (520—577) | 95 | 98.91 | 96 | 6 | 15.48 | 39 * |
| Diseases of genitourinary system (580—629) | 38 | 36.68 | 104 | 10 | 7.79 | 128 |
| Accidents, poisoning & violent deaths (800—978) | 67 | 87.39 | 77 * | 10 | 18.93 | 53 |
| All other causes | 126 | 158.76 | 79 ** | 42 | 40 | 105 |
| Total deaths | 2,651 | 2,651 | 100 | 339 | 339 | 100 |

[a] According to the International Classification of Disease Adapted, eighth revision.
[b] PMR = proportional mortality ratio.
* $p < 0.05$, ** $p < 0.01$.

**Table 4.** Observed and expected cancer deaths among white and black male foundry workers.

| Cause of death [a] | White males | | | Black males | | |
|---|---|---|---|---|---|---|
| | Observed | Expected | PMR [b] | Observed | Expected | PMR [b] |
| All cancers (140—209) | 545 | 497.65 | 110 * | 86 | 69.29 | 124 * |
| Buccal cavity (140—145) | 11 | 7.62 | 144 | 0 | 1.31 | |
| Pharnyx (146—149) | 5 | 6.36 | 79 | 1 | 1.11 | |
| Esophagus (150) | 11 | 10.71 | 103 | 2 | 4.18 | |
| Stomach (151) | 22 | 23.15 | 93 | 2 | 4.64 | |
| Intestines (152, 153) | 49 | 50.03 | 98 | 4 | 4.34 | |
| Rectum (154) | 15 | 15.38 | 98 | 1 | 1.36 | |
| Pancreas (157) | 22 | 28.03 | 78 | 4 | 3.70 | |
| Trachea, bronchus & lung (162) | 224 | 155.17 | 144 ** | 39 | 22.10 | 176 ** |
| Prostate (185) | 47 | 53.50 | 88 | 10 | 9.06 | 110 |
| Bladder (188) | 39 | 30.26 | 129 | 4 | 2.43 | |
| Lymphatic & hematopoietic (200—209) | 39 | 43.98 | 89 | 4 | 4.51 | |
| All other cancers | 61 | 73.46 | 83 | 15 | 10.55 | 142 |

[a] According to the International Classification of Disease Adapted, eighth revision.
[b] PMR = proportional mortality ratio.
* $p < 0.05$, ** $p < 0.01$.

## Results

*Proportional mortality study*

The proportional mortality experience for 2,651 white and 339 black male foundry workers is presented in table 3 for the major cause of death categories. Among both the white and black foundry workers, there was a statistically significant increase in mortality due to all malignant neoplasms and nonmalignant respiratory disease. Mortality from respiratory tuberculosis was significantly elevated among the white foundry workers. A slight deficit occurred for both the white and black male foundry workers for heart disease, deaths resulting from accidents, poisoning and violent deaths, and deaths due to other causes.

Table 4 presents a more-detailed analysis of cancer mortality among the white and black foundry workers. The excess mortality for all malignant neoplasms resulted mainly from a 44 % excess of deaths from cancer of the lung, trachea, and bronchus among the whites (224 observed vs 155 expected) and a 76 % excess of deaths from this same cause among the blacks (39 observed vs 22 expected). Although not statistically significant, there was a slight excess of bladder cancer among both races, cancer of the buccal cavity among the whites, and "all other cancers" among the blacks.

Statistically significant excesses of emphysema, pneumoconiosis, and "other respiratory disease" were seen among the whites (table 5). A slight excess of mortality from bronchitis was observed, and a statistically significant deficit in mortality influenza and pneumonia was seen among the whites. Except for influenza and pneumonia, similar respiratory disease patterns were seen among the blacks.

Fig 1 shows the PMRs for the white male foundry workers by age at death for the three disease categories that accounted for the majority of the deaths in the study population, ie, heart disease (ICDA 393—429), lung cancer (ICDA 162), and nonmalignant respiratory disease excluding influenza and pneumonia (ICDA 490—519). In each age group, the observed mortality from heart disease was close to that expected. In contrast, lung cancer mortality was elevated in all age groups, peaking at age 60—64, and nonmalignant respiratory disease was elevated only above age 54. The number of deaths among the black foundry workers was too small to be analyzed by similar age categories.

*Case-referent study of lung cancer*

The distribution, based on the combined data sources, of foundry types among the cases of lung cancer and the referents (table 6) indicated that a higher proportion of cases than referents had worked in iron foundries. Only a small proportion had worked in foundries producing both iron and nonferrous castings or in those producing iron and steel castings. It should be noted that two referents who worked in the plastics industry were excluded from this table and from all further analyses. Because the exposure ascertainment rate was low, the matching was

**Table 5.** Observed and expected nonmalignant respiratory deaths among white and black male foundry workers.

| Cause of death [a] | White males | | | Black males | | |
|---|---|---|---|---|---|---|
| | Observed | Expected | PMR [b] | Observed | Expected | PMR [b] |
| Influenza & pneumonia (470—486) | 62 | 84.95 | 73 * | 16 | 11.18 | 143 |
| Bronchitis (466, 490, 491) | 16 | 11.44 | 140 | 1 | 0.62 | |
| Emphysema (492) | 87 | 54.55 | 159 ** | 4 | 2.87 | |
| Pneumoconiosis (515, 516) | 30 | 5.21 | 576 ** | 3 | 0.26 | |
| Other respiratory disease (500—506, 508—514, 517—519) | 82 | 43.09 | 190 ** | 6 | 4.75 | 126 |

[a] According to the International Classification of Disease Adapted, eighth revision.
[b] PMR = proportional mortality ratio.
* $p < 0.05$, ** $p < 0.01$.

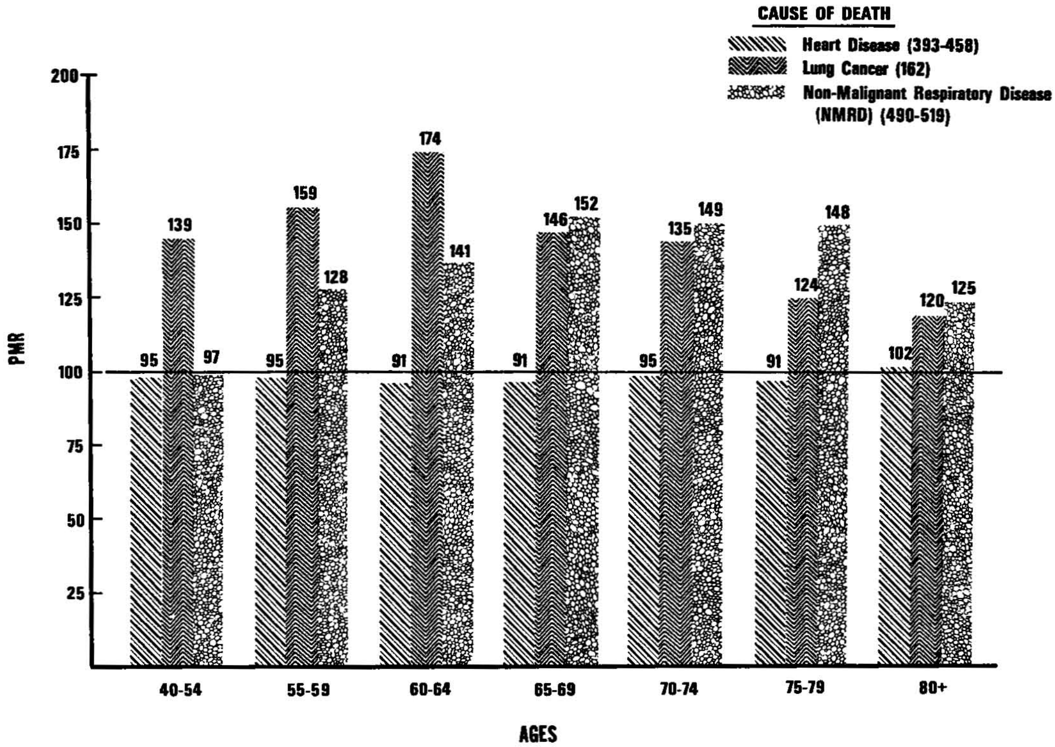


**Fig 1.** Proportional mortality ratios (PMRs) among white male foundry workers.

dropped and an age-stratified analysis was substituted (table 7).

A statistically significant odds ratio of 2.36 for lung cancer was found for iron foundry workers versus steel and nonferrous foundry workers who died before age 65. The odds ratio increased to 2.67 for lung cancer among iron foundry workers when they were compared to nonferrous foundry workers alone who died before age 65. Little association between lung cancer and steel foundry work versus nonferrous foundry work was seen among the study subjects for the same age group (odds ratio = 1.25).

Under the assumption that the prevalence of having worked in the various types of foundries among all IMAW deaths was similar to that of the referents (table 6), the combination of no excess lung cancer risk among the combined nonferrous-steel foundry (NFSF) population and a 2.36-fold risk among the iron foundry (IF) population could explain the PMR of 162 for lung cancer among all white males in the union who died before age 65, as seen in the following formula:

$$\underset{\substack{\text{(prevalence of}\\ \text{NFSF work} \times\\ \text{relative risk of}\\ \text{NFSF workers}\\ \text{aged 40—64)}}}{(0.5 \times 1.00)} + \underset{\substack{\text{(prevalence of}\\ \text{IF work} \times\\ \text{relative risk}\\ \text{of IF workers}\\ \text{aged 40—64)}}}{(0.5 \times 2.36)} = 1.68 \approx 1.62$$

The excess above age 65 could not be similarly attributed to iron foundry work.

## Discussion and conclusion

The results of the PMR study demonstrate excess proportional mortality from nonmalignant respiratory disease and lung cancer among both white and black members of the IMAW death benefits fund. These cause-specific mortality patterns should be interpreted with some caution, since certain deaths among former union members that did not meet the restrictive death benefits plan criteria were not included in the study. In a PMR study over- or underrepresentation of certain cause-specific deaths could lead to biased results. However, this study is only one of many indicating that foundry workers experience excess mortality from nonmalignant respiratory disease and lung cancer.

Among the deaths of workers less than 65 a of age the case-referent study corroborated the Finnish findings of an excess lung cancer risk associated with iron foundry work (11). These results must be interpreted cautiously in light of the 65 % response rate.

The age distribution of the subjects for whom exposure information was missing was not very different from that of the subjects with known foundry exposure (table 2). In addition IMAW information indicated that the two union locals most underrepresented in the respondent population would likely have provided subjects employed in several different types of foundries. Thus there is no obvious reason to believe that the missing subjects differed from the referents with respect to age or type of foundry employment. Furthermore, the distribution of missing cases by foundry type in the under 65 age group would have to be skewed very strongly in a direction opposing the available data in order to eliminate the observed association with work in iron foundries.

Two other studies have found lung cancer excesses in steel foundries (3, 7). Thus it seems the risk of lung cancer may be increased in both iron and steel foundries. It is important to note that the excess lung cancer risk among workers in the younger age groups in this study resembles findings of two other foundry studies. The study conducted in Finland (11) was largely composed of young workers, and a study by Gibson et al (7) reported a significant excess of lung cancer deaths among steel foundry workers aged 64 and

**Table 6.** Distribution of foundry types among lung cancer cases and referents.

| | Foundry type | | | | | Total |
|---|---|---|---|---|---|---|
| | Iron | Steel | Non-ferrous | Iron/nonferrous | Iron/steel | |
| Cases | | | | | | |
| Number | 42 | 11 | 9 | 6 | 0 | 68 |
| Row percentage | 62 | 16 | 13 | 9 | | 100 |
| Referents | | | | | | |
| Number | 82 | 32 | 30 | 18 | 2 | 164 |
| Row percentage | 50 | 20 | 18 | 11 | 1 | 100 |
| Total | 124 | 43 | 39 | 24 | 2 | 232 |

**Table 7.** Lung cancer odds ratios by age and foundry type.

| Foundry type | | Age (a) | Cases | | Referents | | Odds ratio [a] |
|---|---|---|---|---|---|---|---|
| Exposed group | Nonexposed group | | Exposed | Nonexposed | Exposed | Nonexposed | |
| Iron | Steel and nonferrous | 42—64 | 16 | 7 | 30 | 31 | 2.36 * |
| | | ≥ 65 | 26 | 13 | 52 | 31 | 1.19 |
| Iron | Nonferrous | 42—64 | 16 | 3 | 30 | 15 | 2.67 |
| | | ≥ 65 | 26 | 6 | 52 | 15 | 1.25 |
| Steel | Nonferrous | 42—64 | 4 | 3 | 16 | 15 | 1.25 |
| | | ≥ 65 | 7 | 6 | 16 | 15 | 1.09 |

[a] 95 % one-sided confidence limits: 1.01, 5.53.
* $p < 0.05$ (one-sided test).

below. This increased risk of lung cancer among workers in the younger age groups suggests that hazardous exposures in foundries might not be an exclusively historical problem.

Expansion in foundry technology over the last 20—30 a has introduced many new chemicals and substances for mold- and coremaking and a wide range of metals and alloys for casting. Investigators (2, 18) have demonstrated that low concentrations of different compounds such as benzene, toluene, and benzo(a)pyrene are formed when the binders and additives used in molding and coremaking are subjected to elevated temperatures.

In evaluating an increased risk of lung cancer mortality among a particular occupational group such as foundry workers, consideration must be given to the possible role of nonoccupational factors, including smoking habits. The argument could be made that foundry workers smoke more than the general population. Indeed, data collected from the 1970 Household Interview Survey conducted by the National Center for Health Statistics showed that white males who worked as craftsmen, foremen, and kindred workers (the occupational category which included metal molders) had a relatively high percentage of persons who smoked cigarettes (19).

The elevated mortality from emphysema and bladder cancer seen in the proportional mortality study suggests that smoking may have been a factor contributing to the observed excess of lung cancer deaths. Smoking histories were not available for this decedent population; however, in several studies excess lung cancer risk among foundry workers could not be explained by smoking habits (6, 7, 11).

For smoking to have exhibited a confounding effect in the lung cancer case-referent study, the prevalence of smoking would have to be greater among workers in iron foundries (the group at risk) than among workers in steel and nonferrous foundries (the comparison group). Even if this were the case, Axelson has shown that within the range of smoking habits commonly observed in occupational groups, the effect on the risk estimate of differential smoking habits between the group at risk and the comparison group is usually small (1).

Despite the limitations of the PMR methodology, findings from this study concur with those of other investigations showing an increased risk of lung cancer and nonmalignant respiratory disease among foundry workers. The case referent study indicated that the excess lung cancer risk among white males under age 65 might be associated with exposures in iron foundries. However, more complete exposure ascertainment for this and other foundry worker populations is needed to confirm this finding.

In summary, increased risk of lung cancer among workers in the younger age group of the present study indicates that the environmental hazards of foundry work may not have been reduced by modern technology. Incidence studies need to be conducted to evaluate the occurrence of early nonmalignant respiratory disease among foundry workers in the United States today. In addition more epidemiologic studies are needed in iron and steel foundries to delineate those specific job areas associated with the increased disease risks identified in this and other studies. In-depth industrial hygiene surveys are needed to characterize and compare the work environments in iron, steel, and nonferrous foundries. However, given the number of foundry workers worldwide and the body of positive epidemiologic data at hand, efforts to control exposures in foundries should not be delayed until future research is carried out.

## Acknowledgments

Dr J Sherman helped initiate this study. Mr J Wolfe and Ms J Brown of the IMAW were helpful in making union records available and encouraging local union participation in the study.

## References

1. Axelson O. Aspects on confounding in occupational health epidemiology. Scand j work environ health 4 (1978) 85—89.
2. Bates CE, Scheel LD. Processing emissions and occupational health in the ferrous foundry industry. Am ind hyg assoc j August (1974) 452—462.

3. Breslin P. Mortality among foundrymen in steel mills. In: Lemen RA, Dement JM, ed. Dusts and diseases. Pathotox Publishers, Park Forest, IL 1979, pp 439—447.
4. DeCoufle P, Wood DJ. Mortality patterns among workers in a gray area foundry. Am j epidemiol 109 (1979) 667—675.
5. Egan B, Waxweiler RJ, Blade L, Wolfe J, Wagoner, JK. A preliminary report of mortality patterns among foundry workers. In: Lemen RA, Dement JM, ed. Dusts and diseases. Pathotox, Park Forest, IL 1979, pp 417—428.
6. Fox J. Occupational mortality 1970—72: Part II. British Registrar General's Report, England and Wales. Her Majesty's Stationery Office, London 1977.
7. Gibson ES, Lockington JN, Martin RH. Lung cancer mortality in a steel foundry. J occup med 19 (1977) 806—812.
8. Guralnick L. Mortality by occupation and cause of death among men 20 to 64 years of age: United States, 1950. Vital stat spec rep 53 (1963): 3.
9. Hernberg S. The Finnish foundry project: Background and general methodology. Scand j work environ health 2 (1976): suppl 1, 8—12.
10. International Labour Office. Encyclopedia of occupational health and safety, McGraw-Hill, New York NY 1971, pp 576—581.
11. Koskela R-S, Hernberg S, Kärävä R, Järvinen E, Nurminen M. A mortality study of foundry workers. Scand j work environ health 2 (1976): suppl 1, 73—89.
12. Lloyd-Davies TA. Respiratory disease in foundrymen — Report of a survey. Department of Employment, Her Majesty's Stationery Office, London 1971.
13. Macklin EL, Middleton. Report on grinding of metals and cleaning of castings. Her Majesty's Stationery Office, London 1923.
14. McLaughlin AIG, Harding HE. Pneumoconiosis and other causes of death in iron and steel foundry workers. Arch ind health 14 (1956) 350—378.
15. Milham S. Cancer mortality patterns associated with exposure to metals. Ann ny acad sci 271 (1976) 243—249.
16. Petersen GR, Milham S. Occupational mortality in the state of California, 1959—1961. National Institute for Occupational Safety and Health, Cincinnati, OH 1980 (NIOSH research report, US DHEW 1980).
17. Registrar General, Great Britain. Occupational mortality 1930—32: Part II. Decennial supplement, England and Wales, Her Majesty's Stationery Office, London 1939.
18. Scott WD, Bates CE, James RH. Chemical emissions from foundry molds. Am foundrymen's soc transact 85 (1977) 203—208.
19. Sterling TD, Weinkam JJ. Smoking characteristics by type of employment. J occup med 18 (1976) 743—754.
20. Trasko VM. Some facts on the prevalence of silicosis in the United States. Arch ind health June (1956) 380—386.
21. Tubich GE. New materials and processes create new liabilities for the foundry. Ind med surg (1964) 79—85.
22. Turner HM, Grace HG. An investigation into cancer mortality among males in certain Sheffield trades. J hyg 38 (1938) 90—103.