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Mortality Among Rubber Workers: VII. Aerospace Workers

Elizabeth Delzell, SD, and Richard R. Monson, MD

This study evaluated cause-specific mortality among 3,161 men who were employed in the aerospace division of a rubber manufacturing company. Compared to other production workers at the plant, aerospace workers in deicer and fuel cell manufacturing jobs experienced a 60% excess of deaths from lung cancer. Deicer and fuel cell workers who were under 65 years of age had lung cancer rates that were approximately twice those of other rubber workers of comparable age. Aerospace division employees also had elevated rates of bladder cancer, leukemia, lymphoma, and multiple myeloma. However, detailed analyses suggested that, with the exception of lung cancer, these cancer excesses were not likely to be attributable to employment in the aerospace division.

Key words: rubber workers, mortality, cancer, lung cancer

INTRODUCTION

In 1978, Monson and Fine reported an excess of lung cancer among men employed in fuel cell and deicer manufacturing in the aerospace division of a large rubber company [Monson and Fine, 1978]. A study of another group of rubber workers also found an increased risk of lung cancer among men employed in the special-products division, where fuel cells were manufactured [Delzell et al, 1982].

The report by Monson and Fine [1978] evaluated morbidity and mortality from cancer among men employed by the company for at least 5 years. The potential period of observation was January 1, 1940, through June 30, 1976. The present study describes the detailed mortality experience of the aerospace division workers. Follow-up has been updated through June 30, 1978, and the experience of men employed by the company for 2 through 4 years has been added.

METHODS

The methods used to enumerate the total cohort of rubber workers and to obtain information on their mortality experience have been described in detail previously

Department of Epidemiology, Harvard School of Public Health, Boston (R.R.M.).
Department of Community and Family Medicine, Duke University Comprehensive Cancer Center, Durham, North Carolina (E.D.).
Address reprint requests to Dr. Elizabeth Delzell, Department of Epidemiology, School of Public Health, University of Alabama in Birmingham, University Station, Birmingham AL 35294.
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[Monson and Nakano, 1976; Delzell and Monson, 1981]. The cohort comprised 15,643 white men who were actively employed as production workers for some time between January 1, 1940, and July 1, 1971, and who worked at the company under study for at least 2 years before July 1, 1971. All men had also been members of the United Rubber, Cork, Linoleum and Plastic Workers of America Union.

Among these workers, 3,161 men had been employed in the aerospace division of the company. The aerospace division was formally organized in the late 1940s, but it included a number of departments and operations that had been established much earlier. In the present report, men who worked in these older departments have been considered as aerospace workers, and the aerospace division has been divided into three major sections: deicer manufacturing, fuel cell manufacturing, and other aerospace products manufacturing. Deicer manufacturing consisted of making pneumatic deicers. This involved cementing strips of rubber to metal and cementing together sections of rubber. Various cements and acetylene black were used in this section. Fuel cell manufacturing involved the production of rubber-lined gas tanks for aircraft and entailed a similar process of cementing strips of rubber to metal. Chlorinated organic solvents, including ethylene dichloride, were used in both sections. These processes were discontinued at the plant in the early 1970s. Therefore, we have no measures of environmental exposures in the aerospace division.

Of the 3,161 aerospace division workers, the number employed in each section was 1,214 in deicers, 1,390 in fuel cells, and 938 in other aerospace divisions. The proportion employed exclusively in one section of the aerospace division was 81% for deicers, 79% for fuel cells, and 78% for other aerospace. The 12,482 white male production workers at the company who had never been employed in the aerospace division are referred to as "nonaerospace workers" in this report. Details of the employment histories of both groups of rubber workers were obtained from company and union records and included dates of starting and terminating employment with the company and, since the mid-1930s, sequential department changes and the approximate date of each change.

The aerospace and nonaerospace workers were traced using company records of active and pensioned employees and Social Security Administration records of death claims. The period of follow-up was January 1, 1940, to July 1, 1978. Men whose vital status was unknown at the end of this interval were assumed to be alive at the close of follow-up. There were 950 deaths among aerospace workers and 5,847 deaths among nonaerospace workers during the observation period. Death certificates were obtained from state departments of health for 919 (97%) and 5,604 (96%) of the reported deaths among aerospace and nonaerospace workers, respectively. Underlying cause of death was coded according to the Seventh Revision of the International Classification of Diseases without reference to the decedent's classification as an aerospace or nonaerospace worker.

The observed numbers of overall and cause-specific deaths among aerospace workers were compared with numbers expected, based on the death rates of either U.S. white males or nonaerospace workers. Expected numbers were calculated by multiplying the 5-year age- and calendar time-specific person-years of observation of aerospace workers by the corresponding rates of U.S. white males or nonaerospace workers [Monson, 1974]. Accumulation of person-years started for aerospace workers on January 1, 1940, or the midyear of beginning work in the aerospace division, whichever was later, and for nonaerospace workers on January 1, 1940, or the second year after starting work at the company, whichever was later. For these comparisons, rate ratios were estimated as the observed divided by the expected numbers of deaths (O/E). Confidence intervals of the O/E and p-values were estimated assuming a Poisson distribution of the observed number of deaths.

For selected causes of deaths, O/E were also estimated separately for men employed in each section of the aerospace division compared to nonaerospace workers. Because cause- and section-specific rates were unstable, they were not directly standardized. However, the distributions of person-years were quite similar for the three sections. Therefore, it is not misleading to compare the section-specific O/E.

RESULTS

Aerospace workers started working at the company an average of 4 years later than nonaerospace workers (Table I). In addition, approximately 91% of the person-years of observation among aerospace workers was contributed by men under 65 years of age, compared to 83% among nonaerospace workers. Thus, men employed in the aerospace division tended to be younger as a group than other production workers at the company.

Table II shows observed numbers of deaths among aerospace workers and expected numbers based on the mortality rates of U.S. white males. There were substantial deficits of deaths from all causes combined and from most other causes except for malignant neoplasms and diseases of the nervous system. There were excesses of deaths from digestive, lung, and bladder cancers and from leukemia and other lymphomas and multiple myeloma. The 95% confidence intervals for all of the excesses included the null value of 1.0.

Comparisons between the age- and calendar period-adjusted mortality rates of aerospace and nonaerospace workers indicated that they had similar rates for most of the causes for which deficits were seen in Table II. The rates (times 1,000 person-years) for aerospace workers and other rubber workers were as follows: 10.6 and 11.5 for all causes; 4.5 and 5.1 for diseases of the circulatory system; 0.56 and 0.53 for diseases of the respiratory system; 0.49 and 0.51 for diseases of the digestive system; and 0.10 and 0.13 for diseases of the genitourinary system. However, for

TABLE I. Selected Characteristics of Aerospace and Nonaerospace Workers

Characteristics	Aerospace	Nonaerospace
No. of employees	3,161	12,482[a]
Person-years of observation	90,027	354,468
Average year started at the company	1940	1936
No. started at the company after 1929 (%)	2,663 (84.2%)	8,179 (65.5%)
Average years worked at the company	23	21
Average year started in aerospace	1946	—
Average years worked in aerospace	6.3	—

[a]Men never employed in the aerospace division.

TABLE II. Observed and Expected[a] Numbers of Deaths Among Aerospace Workers According to Cause

Cause (ICD No.)[b]	Observed	Expected	O/E[c]	95% CI[d]
All causes	950	1,175.3	0.8	0.8–0.9
Malignant neoplasms (140–205)	228	225.7	1.0	0.9–1.1
Digestive organs and peritoneum (150–159)	67	66.4	1.0	0.8–1.3
Lung (162, 163)	79	69.8	1.1	0.9–1.4
Prostate (177)	14	14.5	0.9	0.5–1.6
Bladder (181)	9	7.1	1.3	0.6–2.4
Lymphatic and hematopoietic tissue (200–205)	26	21.8	1.2	0.8–1.7
Leukemia (204)	12	9.0	1.3	0.7–2.3
Other lymphoma and multiple myeloma (202, 203)[e]	9	4.9	1.9	0.8–3.5
Diabetes (260)	15	16.7	0.9	0.5–1.5
Diseases of the nervous system (330–398)	90	91.9	1.0	0.8–1.2
Diseases of the circulatory system (400–468)	406	536.8	0.8	0.7–0.8
Diseases of the respiratory system (470–527)	50	66.1	0.8	0.6–1.0
Diseases of the digestive system (530–587)	44	58.2	0.8	0.5–1.0
Diseases of the genitourinary system (590–637)	9	18.4	0.5	0.2–0.9
External causes (800–998)	46	104.8	0.4	0.3–0.6
Other known causes	31	52.6	—	—
Deaths without certificates	31	—	—	—

[a]Expected numbers are based on calendar time- and age-specific mortality rates of U.S. white males.
[b]International Classification of Diseases, 7th Revision.
[c]Observed/expected number of deaths.
[d]CI refers to confidence interval of the O/E.
[e]Includes seven deaths from multiple myeloma and two deaths from other lymphoma that occurred after 1949.

external causes, the rates (times 1,000 person-years) were 0.51 and 0.77 for aerospace and other workers, respectively.

Table III shows section-specific observed and expected numbers of deaths from malignancies for which there was an excess among all aerospace workers. In this table, expected numbers were based on the mortality rates of nonaerospace workers, and the aerospace sections were not mutually exclusive. Most of the lung cancer deaths among aerospace workers occurred among men employed in deicers and fuel cells, and the excess risk appeared to concentrate among these men. When men who had been employed in deicers or fuel cells were excluded from analyses of other aerospace workers, the O/E was 0.9 (11 observed/12.0 expected), suggesting that there was no excess risk associated independently with other aerospace.

Elevated rates of lung cancer have been noted in other groups of employees at the company, including curing and tire-molds workers [Monson and Fine, 1978]. To determine whether lung cancer was independently associated with employment in deicers and fuel cells, we examined the experience of men who had never been employed in curing or tire molds. The lung cancer excess persisted in this residual group of deicers and fuel cell workers (58 observed/37.6 expected).

The excess of bladder cancer in aerospace workers was confined to men employed in fuel cells. All of the deaths among workers in this section occurred during 1970–78 (5 observed/1.5 expected), and none of the decedents had worked in other sections of the aerospace division. One man had worked for 5 years in the

TABLE III. Mortality From Selected Cancers According to Section of the Aerospace Division

	Number of deaths	O/E[a]	p-value[b]
Lung cancer			
Deicers	33	1.5	0.03
Fuel cells	37	1.6	0.003
Other aerospace	18	1.2	0.47
Nonaerospace	263	—[c]	—
Bladder cancer			
Deicers	3	1.0	0.95
Fuel cells	5	1.5	0.33
Other aerospace	1	(2.2)[d]	—
Nonaerospace	51	—	—
Leukemia			
Deicers	7	1.8	0.13
Fuel cells	2	(4.4)	—
Other aerospace	4	1.5	0.42
Nonaerospace	56	—	—
Multiple myeloma			
Deicers	1	(1.3)	—
Fuel cells	3	2.2	0.17
Other aerospace	4	4.5	0.001
Nonaerospace	16	—	—

[a]Expected numbers are based on the age- and calendar time-specific mortality rates of nonaerospace workers.
[b]Two-sided p; not given when the observed number is less than 3.
[c]Referent category.
[d]Expected numbers instead of O/E are given in parentheses when the observed number is less than 3.

chemical division, for which an increased occurrence of bladder cancer has also been reported [Monson and Fine, 1978].

There was an excess of leukemia in both deicers and other aerospace. An analysis of leukemia mortality using mutually exclusive sectional categories confirmed the excess among men employed only in deicers (7 observed/3.3 expected). However, there was essentially no increased risk for men employed exclusively in other aerospace (3 observed/2.0 expected). High rates of leukemia have been found in several areas of the company besides aerospace, including tire curing and other departments in the tire division, the elevator department, and the back processing section of the processing division [Monson and Fine, 1978; Delzell and Monson, 1982]. There was only one leukemia death among deicer workers who had not been employed in one or more of these other high risk areas.

The excess of deaths from multiple myeloma was present in both fuel cells and other aerospace. The interpretation of this finding is not clear because of the small number of deaths in each section and because four of the seven decedents employed in these sections had also worked in industrial products or reclaim, where elevated rates of multiple myeloma have been found [Delzell and Monson, 1981].

Because men who worked in deicers and fuel cells had similar patterns of lung cancer mortality, their experience was combined for more detailed analyses. Tables IV and V further describe the lung cancer experience of these men compared to nonaerospace workers. The lung cancer excess appeared to be largest among deicers

TABLE IV. Observed/Expected[a] Numbers of Lung Cancer Deaths Among Deicers and Fuel Cell Workers by Age and Year of Starting Work in the Aerospace Division

Age started work (yrs)	Year started work < 1940	1940–49	⩾ 1950	All years
<30	2/1.7	16/8.2	2/0.1	20/10.0
⩾30	1/2.4	39/25.7	8/4.2	48/32.3
All ages	3/4.1	55/33.9	10/4.3	68/42.3

[a]Expected numbers are based on age- and calendar time-specific lung cancer death rates of nonaerospace workers.

TABLE V. Observed/Expected[a] Numbers of Lung Cancer Deaths Among Deicers and Fuel Cell Workers by Duration of Employment and Years Since Starting Work in the Aerospace Division

Duration of employment (yrs)	Years since starting work 0–4	5–19	⩾20	All years
<5	3/0.9	13/4.3	17/13.3	33/18.5
5–19		14/6.0	17/13.7	31/19.7
⩾20			4/4.1	4/4.1
All durations	3/0.9	27/10.3	38/31.1	68/42.3

[a]Expected numbers are based on the calendar time- and age-specific lung cancer rates of nonaerospace workers.

and fuel cells workers who started in aerospace before age 30 and after 1939 (18 observed/8.3 expected) (Table IV). There was an increased risk both for men who were first employed in aerospace during 1940–49 and for those who started after 1949, although the latter excess was based on only ten observed deaths. Overall, the data in Table V on duration of employment do not suggest that there is a trend of rising lung cancer risk with increasing length of work in the aerospace division. Lung cancer was elevated only among men who spent less than 20 years in the aerospace division. However, information on men employed for 20 or more years was sparse and therefore not conclusive. Although there was an increased risk of lung cancer in each category of years since starting work in the aerospace division, the risk appeared to be greatest among men 0–19 years after starting work.

Lung cancer mortality was also examined by age and calendar period of death. O/E were 1.8 for 1940–59 (10 observed deaths), 2.1 for 1960–69 (28 observed deaths), and 1.3 for 1970–78 (30 observed deaths). The lung cancer excess was confined to men who were under 65 years of age (O/E = 2.1; 48 observed deaths).

DISCUSSION

In this study, we evaluated the mortality experience of workers employed in the aerospace division of a large rubber manufacturing company. Compared to other production workers at the plant, men in the aerospace division had excesses of deaths from several cancers, including lung and bladder cancer, leukemia, and other lymphoma and multiple myeloma. However, many of the aerospace workers had been employed in nonaerospace production areas previously found to be associated with an elevated rate of these cancers. Therefore, we performed analyses that excluded all workers employed in high-risk nonaerospace work areas. Results of these analyses suggested that, with the exception of lung cancer, there was no residual excess risk of these cancers associated with employment in the aerospace division.

The excess of deaths from lung cancer occurred only among men employed in deicer and fuel cell manufacturing. The excess was based on relatively large numbers of observed and expected deaths and was statistically stable. It was also present among deicers and fuel cells workers who had not been employed in other high-risk areas. There was no pattern of increasing risk of lung cancer with longer duration of employment in the aerospace division, as might be expected if the observed association results from occupational exposures in this division. However, it seems unlikely that the entire excess results from a greater use of cigarettes among deicers and fuel cell workers than among other men at the plant, because observed numbers of deaths from other diseases associated with smoking, such as chronic nonmalignant respiratory diseases, were not elevated among aerospace workers.

The observed excess of lung cancer in deicers and fuel cell workers is consistent with the finding of a case-control study of lung cancer among workers at another rubber company [Delzell et al, 1982]. The latter investigation found a 70% increase in the risk of lung cancer among workers in fuel cell manufacturing compared to other employees. Workplace exposures that may have been responsible for the increased risk of lung cancer among these men and among the deicers and fuel cell workers in our study are unknown. Monson and Fine [1978] have suggested that exposure to chlorinated organic solvents or to acetylene black, which were used extensively in parts of the production process, may have contributed to the lung cancer excesses. We have no further information on this possible explanation.

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