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Mortality and Cancer Morbidity Among Workers in the Rubber Tire Industry

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A retrospective follow-up study was conducted to evaluate mortality and cancer incidence between 1954 and 1976 among 1,792 white male production workers employed for at least 2 years at a tire manufacturing plant. There were no marked excesses in overall or site-specific cancer deaths or incident cases. Compared to U.S. white males, men employed for at least 10 years experienced small increases in deaths from cancers of the large intestine, pancreas, and lung. Results obtained by comparing observed incident cancer cases to the numbers expected based on age- and calendar time-specific incidence rates of Connecticut males also suggested excesses of these three malignancies. These findings were based on small numbers and therefore do not necessarily indicate causal associations between cancer excesses and employment in the rubber tire industry. However, because the workers studied comprised a relatively young population that may not have experienced the full impact of carcinogenic occupational exposures, further follow-up is warranted.

Key words: rubber workers, mortality, morbidity, cancer

INTRODUCTION

Recent studies of mortality among four large groups of rubber workers in the United States and Great Britain found no evidence of excessive overall mortality among rubber workers, compared to general national populations [Andjelkovich et al, 1976; Fox et al, 1974; Fox and Collier, 1976; McMichael et al, 1974; Monson and Nakano, 1976a]. However, these studies reported increased mortality from several malignant diseases, including cancers of the bladder, lung, stomach, and hematopoietic system, and subsequent investigation linked some of the observed cancer excesses to specific jobs, work areas, or substances to which workers were exposed [Andjelkovich et al, 1977; Mancuso, 1975; McMichael et al 1975, 1976a,b; Monson and Nakano, 1976b; Monson and Fine, 1978].

The rubber industry encompasses a variety of industrial activities, ranging from the synthesis of chemicals required for subsequent production steps, to the mixing and milling of raw rubber stocks, and to the assembly, curing, and finishing of rubber goods, includ-

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ing tires and many other rubber products. The studies mentioned above examined mortality patterns among workers at large rubber manufacturing facilities engaged in the full range of rubber industry activities. In contrast, the present retrospective follow-up study evaluates mortality and cancer incidence among employees of a smaller rubber plant whose single major product has been automobile tires.

MATERIALS AND METHODS

The plant under study started operating in 1922. It is located in southwestern Connecticut. Plant personnel files were reviewed to obtain demographic information, employment histories, and records of deaths for all workers actively employed after 1947. Records of employees who left the plant before 1948 were not available. Also, because few deaths were noted in the files between 1948 and 1954, it seemed likely that records had been lost for some of the employees who died during that interval. Therefore, only workers who were actively employed after 1947 and who were still alive on January 1, 1954, were included in the study. The study group was further restricted to white male production workers who had worked for at least 2 years before January 1, 1977. For the 1,792 men meeting these criteria, follow-up started on January 1, 1954, or the second anniversary after starting work (whichever was later) and continued through December 31, 1976, or December 31, 1977, for ascertainment of mortality and cancer incidence, respectively.

Company records of deaths among retired and active workers and a Social Security Administration (SSA) search for death claims were used to identify 249 deaths during the follow-up period and to determine date and place of death. Death certificates were obtained for 208 of the reported decedents. The 41 remaining death certificates could not be located. The proportion of certificates not found was greater for deaths among men employed for 2–9 years (21 or 29% of 73 deaths) than for deaths among those employed for at least 10 years (20 or 11% of 176 deaths). Subjects with a death claim reported by the SSA but without death certificate confirmation were assumed to have died on the date reported. Underlying cause of death was coded from the available death certificates according to the International Classification of Diseases, 7th Revision. If cancer appeared on the death certificate as other than an underlying cause, it was included in cancer incidence but not in mortality tabulations.

Incident cancer cases were identified by searching for study subjects' names in the Connecticut Tumor Registry, a population-based registry that has recorded new cancer cases for the entire state of Connecticut since 1935 [Cancer in Connecticut, 1967]. Registry reports were located for 84 employees and were used to obtain information on tumor site and date of diagnosis. In addition, there were six workers who died from cancer but who did not have a record in the Connecticut Tumor Registry. These deaths were included in calculations of cancer incidence with the date of diagnosis assumed to be the date of death.

Observed numbers of deaths were compared to numbers expected based on age- and calendar time-specific mortality rates of U.S. white males. To derive expected numbers, person-years of follow-up were accumulated through December 31, 1976, and were grouped into 5-year age and time categories and multiplied by the corresponding cause-, age- and time-specific U.S. mortality rates [Monson, 1974]. Observed numbers of incident cancer cases were compared to the numbers of cases expected based on cancer incidence rates of Connecticut white males. To derive expected numbers of incident cases for each site, person-years of follow-up were accumulated through December 31, 1977,

grouped as described for computation of expected deaths and multiplied by time-, age-, and site-specific Connecticut incidence rates. Measures of association used in this study are the ratio of observed to expected numbers of deaths (or cancer cases) (O/E), which may be interpreted as a mortality (or cancer incidence) rate ratio for rubber workers compared to U.S. white males (or Connecticut males), and the standardized mortality ratio (SMR). Confidence intervals for SMRs were computed assuming that observed numbers of deaths followed a Poisson distribution [Rothman and Boice, 1979].

Employment histories consisted of year of first hire at the plant, year of termination of employment, and for each department, year first worked and cumulative number of years spent in the department. Approximately 70 production departments operated during the study period. Departments were grouped into eight divisions for analysis of cancer incidence: 1) *processing*—departments at the beginning of the production line, where mixing of raw materials, milling of rubber stocks, and extrusion take place; 2) *tire building*—departments where structural components of tires are produced and assembled; 3) *curing and final finish*—departments where green tires are prepared for curing and are cured and buffed; 4) *tubes*—departments where tubes are prepared from extruded rubber, cured, and buffed (this process no longer exists at the plant); 5) *warehousing*—departments comprising receiving and shipping activities; 6) *factory services*—departments comprising janitorial jobs; 7) *maintenance*—machine and instrument shops, electrical and pipefitting departments; 8) *quality control*—quality control and stock testing departments.

Cancer incidence rates, directly adjusted to the 5-year age by calendar year person-years distribution of all employees, were computed for each division and compared to similarly adjusted rates for men in all other divisions combined. Person-years for each division were accumulated starting from the year of first employment in the division or January 1, 1954, whichever was later.

RESULTS

There were 26,839 person-years of follow-up accumulated by the 1,792 production workers. The study group was young, with 93% of the total person-years contributed below 65 years of age and 81% below age 55.

Major causes of death for the 249 decedents are shown in Table I. The SMR for all causes was 89, indicating an 11% deficit in overall mortality for the production workers compared to U.S. white males. There were large deficits in deaths from external causes (SMR = 43) and vascular lesions of the central nervous system (SMR = 29). It is possible that the low SMRs for these two causes reflect relatively less complete location of death certificates for acute conditions, which may be more likely to occur outside the state of residence.

Table II presents observed and expected numbers of cancer deaths and incident cancer cases by tumor site. There were excesses in both deaths and incident cases for four sites: buccal cavity and pharynx, large intestine, pancreas, and kidney. In addition, there were excesses in deaths from cancers of the digestive organs and peritoneum and in incident cases of cancer of the bronchus and lung.

With the exception of kidney cancer, these excesses occurred only among men who had worked at the plant for at least 10 years. Among men employed for 10 or more years, overall cancer mortality was approximately 19% higher than expected (42 observed deaths/35.3 expected), while cancer incidence for all sites combined was similar to that of Connecticut white males (66 observed cases/67.3 expected).

TABLE I. Observed and Expected Numbers of Deaths (1954–1976) Among White Male Production Workers According to Cause

Cause (ICD No., 7th Revision)	Observed	Expected[a]	SMR[b]	95% CI[c]
All causes	249	280.3	89	78–101
Malignant neoplasms (140–205)	49	51.2	96	71–127
Diabetes mellitus (260)	7	3.9	180	71–366
Vascular lesions of the central nervous system (330–334)	6	21.0	29	10– 62
Diseases of the circulatory system (400–468)	101	127.0	80	65– 97
Diseases of the respiratory system (470–527)	14	14.9	94	51–157
Accidents, poisoning, violence (800–998)	13	30.3	43	23– 73
All other known causes	18	22.8	79	
Unknown causes of death	41			

[a]Expected numbers are based on 5-year age- and calendar time-specific death rates of U.S. white males.
[b]Standardized mortality ratio: (observed No. of deaths ÷ expected No. of deaths) × 100.
[c]CI refers to confidence interval.

TABLE II. Observed and Expected Cancer Deaths (1954–1976) and Incident Cancer Cases (1954–1977) Among White Male Production Workers

	Cancer deaths		Cancer incidence	
Site (ICD No.)	Observed	Expected[a]	Observed	Expected[b]
All sites (140–205)	49	51.2	90	97.6
Buccal cavity and pharynx (140–149)	4	1.7	8	6.2
Digestive organs & peritoneum (150–159)	18	14.7	26	29.1
Stomach (151)	3	3.0	3	5.1
Large intestine (153)	9	4.6	12	9.9
Rectum (154)	0	1.8	4	5.9
Pancreas (157)	6	2.8	6	3.2
Respiratory system (160–165)	15	16.2	25	22.6
Bronchus and lung (162, 163)	15	15.2	24	19.0
Prostate (177)	2	3.5	9	10.2
Kidney (180)	4	1.3	5	3.0
Bladder (181)	1	1.6	3	7.4
Skin (melanoma) (190)	1	1.1	2	2.0
Brain (193)	0	1.7	2	2.0
Leukemia (204)	1	2.2	3	3.0
All other sites and unknown sites	3		11	

[a]Expected numbers of deaths are based on age- and calendar time-specific death rates of U.S. white males.
[b]Expected numbers of cases are based on age- and calendar time-specific cancer incidence rates of Connecticut males.

All-cause mortality, cancer mortality, and cancer incidence were examined by age, calendar time, and employment characteristics. The data in Table III show excesses in cancer deaths (22 observed/15.4 expected) and in incident cases (40 observed/29.7 expected) among men aged 55–64. There were also excesses in cancer deaths among men who died before 1965 (21 observed/15.6 expected) or after 1975 (10 observed/7.7 expected).

TABLE III. Ratios of Observed to Expected Deaths From All Causes, Cancer Deaths, and Incident Cancer Cases Among White Male Production Workers According to Selected Characteristics

Characteristic	All causes of death		Cancer deaths		Cancer incidence	
	Obs[a]	O/E[b]	Obs	O/E	Obs[c]	O/E[d]
Age at death or diagnosis (yrs)						
20-54	70	0.7	9	0.6	25	0.8
55-64	73	0.8	22	1.4	40	1.3
≥65	106	0.9	18	0.9	25	0.7
Year of death or diagnosis						
1955-64	90	1.0	21	1.3	31	1.1
1965-74	132	0.9	18	0.6	41	0.8
≥1975	27	0.7	10	1.3	18	0.9
Year started work						
<1945	88	0.9	18	1.0	26	0.8
1945-49	81	1.0	16	1.0	33	1.2
≥1950	80	0.8	15	0.8	31	0.8
Duration of employment (yrs)						
2-9	73	0.7	7	0.4	24	0.7
10-24	131	1.0	32	1.4	52	1.2
≥25	45	0.9	10	1.0	14	0.7
Years since starting work						
2-9	26	0.5	1	0.1	8	0.5
10-24	148	1.0	36	1.3	56	1.1
≥25	75	0.9	12	0.8	26	0.8

[a]Observed number of deaths.
[b]Observed/expected deaths, with expected number of deaths based on age- and calendar time-specific rates of U.S. white males.
[c]Observed number of cases.
[d]Observed/expected cases, with expected number of cases based on age- and calendar time-specific cancer incidence rates of Connecticut males.

Age, time, and employment patterns of digestive cancer incidence are shown in Table IV. There were excess cases of all digestive cancer among men who started working in 1945–49, accounted for by cancers of the large intestine and pancreas. Excess incidence of large intestine cancer occurred among men who 1) were at least 65 years of age at diagnosis, 2) were diagnosed before 1970, 3) had started working before 1950, 4) had worked 10–24 years, and 5) were diagnosed 10–24 years after date of first hire. Pancreas cancer incidence followed a similar pattern, except that the observed excess was confined to men 20–64 years of age at diagnosis.

Respiratory cancer incidence, described in Table V, was elevated among men who were younger than 65 at diagnosis, were diagnosed before 1970, and were first employed before 1945 or after 1954. As for large intestine and pancreas cancers, excess respiratory cancer incidence was restricted to men who had worked 10–24 years and had started working 10–24 years before diagnosis.

Table VI gives cancer incidence rates by division. Cancer incidence rates were slightly elevated among men who had worked in tubes and in factory services. Because numbers of cancers in each division were small, detailed analyses of site-specific cancer

TABLE IV. Large Intestine and Pancreas Cancer Incidence Among White Male Production Workers According to Selected Characteristics

Characteristic	Large intestine cancer			Pancreas cancer		
	O[a]	E[b]	O/E	O	E	O/E
Age at diagnosis (yrs)						
20–64	6	5.4	1.1	5	1.9	2.6
≥65	6	4.5	1.3	1	1.3	0.8
Year of diagnosis						
1954–69	9	4.8	1.9	5	1.6	3.1
≥1970	3	5.1	0.6	1	1.5	0.6
Year started work						
<1945	5	3.7	1.3	1	1.1	0.9
1945–49	5	2.9	1.7	4	0.9	4.3
≥1950	2	3.2	0.6	1	1.1	0.9
Duration of employment (yrs)						
2–9	2	3.1	0.6	0	1.0	0.0
10–24	6	4.5	1.3	5	1.4	3.5
≥25	4	2.3	1.8	1	0.7	1.5
Years since starting work						
2–9	0	1.4	0.0	0	0.5	0.0
10–24	8	5.0	1.6	5	1.7	3.0
≥25	4	3.5	1.1	1	1.0	1.0

[a]Observed number of cases.
[b]Expected number of cases based on age- and calendar time-specific cancer incidence rates of Connecticut white males.

TABLE V. Observed and Expected Respiratory Cancer Cases Among White Male Production Workers According to Selected Characteristics

Characteristic	Observed	Expected[a]	O/E[b]
Age at diagnosis (yrs)			
20–64	19	15.6	1.2
≥65	6	7.0	0.9
Year of diagnosis			
1954–69	15	10.2	1.5
≥1970	10	12.4	0.8
Year started work			
<1945	9	7.0	1.3
1945–54	9	10.2	0.9
≥1955	7	5.4	1.3
Duration of employment (yrs)			
2–9	6	7.6	0.8
10–24	15	10.2	1.5
≥25	4	4.8	0.8
Years since starting work			
2–9	2	3.5	0.6
10–24	18	12.1	1.5
≥25	5	7.0	0.7

[a]Expected numbers are based on age- and calendar time-specific respiratory cancer incidence rates of Connecticut white males.
[b]Observed/expected cases.

TABLE VI. Cancer Incidence Among White Male Production Workers According to Division

Division	No. of cancers	Rate[a] in division employees[b]		Rate ratio[c]
Processing	13	3.1	(0.9)	0.9
Tire building	25	3.4	(0.7)	1.0
Curing and final finish	19	2.7	(0.6)	0.8
Tubes	5	6.3	(1.4)	1.9
Warehousing	15	3.6	(0.9)	1.1
Factory services	17	4.2	(1.3)	1.3
Maintenance	15	2.7	(0.7)	0.8
Quality control	5	4.3	(1.9)	1.3

[a]Cancer incidence rate (× 1,000 person-years), directly standardized to the age by time person-years distribution of all white male production workers. Numbers in parentheses are standard errors (× 1,000 person-years).
[b]Workers ever employed in the division.
[c]Standardized rate in division employees ÷ rate among men never employed in the division, directly standardized to the age by time person-years distribution of all white male production workers.

incidence by division are not presented. Cancer of the large intestine was responsible for the overall cancer excess in tubes (two cases) and in factory services (five cases). Kidney and pancreas cancers did not appear to be associated with any particular division. Each of the five kidney cancer cases worked in a different division (tire building, warehousing, final finish and tubes, maintenance, and processing). Of the six pancreas cancer cases, two worked in both tire building and curing and final finish, two in warehousing, one in maintenance, and one in tubes.

DISCUSSION

Present findings indicate that overall mortality was lower among this group of rubber workers than among U.S. white males, and cancer incidence for all sites combined among rubber workers was similar to that in Connecticut males. However, there were excesses in mortality and morbidity from cancers of the large intestine, pancreas, and lung. In contrast to studies of other groups of rubber workers, there was no evidence of an increased occurrence of stomach or bladder cancer or of leukemia. In interpreting these results, it is important to consider several limitations of the data available for the study.

First, most measures of association were based on small numbers of events and were statistically unstable. Therefore, sampling variability cannot be easily discounted as an explanation for some of the observed excesses and deficits.

Second, caution must be exercised in assessing the contribution of occupation to observed cancer excesses. Our findings of elevated mortality from incidence of large intestine and respiratory cancers are consistent with reports from other studies [Fox et al, 1974; Fox and Collier, 1976; Monson and Nakano, 1976a]. Also, a slight excess in pancreas cancer mortality has been noted in another group or rubber workers [Andjelkovich et al, 1976]. Although not attributable to age, time, gender, or race differences between study and referent groups, these associations may reflect lack of comparability with respect to other nonoccupational disease determinants such as cigarette smoking and diet.

Third, measures of association involving comparisons of employee mortality or cancer morbidity with U.S. mortality or Connecticut cancer incidence were probably underestimated because of incomplete ascertainment of deaths and cancer cases. The

study identified only those deaths reported either to the SSA or the company. If there were other unknown deaths among study subjects during the follow-up period, observed overall and cause-specific SMRs would be lower than true SMRs. In addition, death certificates and hence cause of death were unavailable for a substantial proportion (16%) of the total deaths, producing further underestimation of SMRs for specific disease categories. Ascertainment of cancer incidence was also incomplete for workers who were diagnosed in states other than Connecticut. These cancer cases would have come to our attention only if they died during the follow-up period and if their death certificates were located and mentioned cancer.

The workers investigated were relatively young and may not have experienced the full impact of any carcinogenic occupational exposures. For this reason and because estimates of cancer excesses were undoubtedly conservative in the present study, it would be prudent to continue to monitor cancer mortality and morbidity in this group of rubber workers.

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