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A Proportional Mortality Ratio Study of Workers in a Construction Equipment and Diesel Engine Manufacturing Plant

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The mortality of 461 workers who were employed 10 or more years in a Midwest engine and construction equipment plant was examined, using the method of proportional mortality ratios. Both state and national deaths were used as the standard population. Major exposures in this plant included solvents, cutting oils, and metal fumes and dusts. However, precise exposure data were not available. Among white males, no significant deviations from expected deaths were found. Among black males, significant excess deaths were found for all malignant neoplasms combined, for cancer of the pancreas, and for non-Hodgkin's lymphomas. Proportional cancer mortality ratios produced similar results, although the excess of pancreatic cancer in blacks was only significant among those with 20 or more years of service. Although complete occupational histories were not available, these results may provide hypotheses for future studies of workers in heavy machinery production.

Key words: proportional mortality ratio, malignancies, cutting oils, solvents, pancreatic cancer, non-Hodgkin's lymphomas, cancer in blacks

INTRODUCTION

Workers involved in heavy machinery production are often exposed to a variety of potentially hazardous materials, including cutting oils, solvents, and metal fumes and dusts, but little is known about the mortality experience of these cohorts. Although the evidence is inconclusive, exposure to solvents, particularly chlorinated hydrocarbons, has been linked to liver tumors in experiments [Lemen et al, 1976], and to lymphatic and hematopoietic cancers in epidemiologic studies [Hardell et al, 1981; Capurro and Eldridge, 1978; Infante et al; 1977; McMichael et al, 1976]. Cutting oils, which are widely used in machining processes as coolants and lubricants, have been associated with gastrointestinal cancers in recent epidemiological studies [Decouflé, 1978; Jarvholm et al, 1981]. Of particular interest are the polycylic aromatic hydrocarbons (PAHs) which have been isolated from some mineral oils

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[Kipling and Waldron, 1976; Bingham et al, 1980]. Metal fumes and dusts have been associated with excess lung cancer in welders [Beaumont and Weiss, 1981], and cadmium in particular has been linked to cancer of the prostate in epidemiologic studies [McMichael et al, 1976; Lemen et al, 1976].

An opportunity arose to examine the mortality of workers at a large plant in Illinois which manufactures construction equipment and diesel engines. The local union approached local health policy organizations to request their assistance in evaluating the cancer mortality experience of its members. In cooperation with the University of Illinois School of Public Health, this preliminary study was undertaken to determine if further research was warranted.

The study plant, which began operating in 1946, contains 2.3 million square feet, and employed an average work force of 3000 during the 1970s, with minimal turnover. Production and maintenance workers at the plant have been represented by their own local of United Auto Workers (U.A.W.) since 1946. The local has maintained a rather complete death card file of its active and pensioned members. However, the entire at-risk group could not be identified, so it was not possible to undertake a retrospective cohort study. Instead, an investigation focusing on proportional mortality ratios (PMR) and proportional cancer mortality ratios (PCMR) was undertaken. Although specific etiologic agents could not be identified at the plant, previous use of suspected carcinogens such as benzene, carbon tetrachloride, and petroleum-based cutting fluids were of particular concern to the union.

Some of the major industrial processes at the plant included machining, solvent and caustic cleaning, welding, heat treating, assembly, painting, and engine testing. Major exposures included organic solvents, used in degreasing operations, metal cleaning, and painting; coolants and cutting oils used in machining operations; and metal dust and fumes, by-products of machining, cutting, and welding. The processes included in the two sides of the study plant are outlined in Figures 1 and 2.

MATERIALS AND METHODS

Death cards for each active and retired worker were obtained from the union local, which received notification from company headquarters whenever an active or pensioned worker had died. A computerized list of all pensioned members who died in the study period was also obtained from the company and used to supplement the union records. Deaths of active workers could only be identified from union records, since company termination records could not identify those who died while in service. Few deaths of pensioned workers would be missed in this study, due to the financial records kept for this group. However, the union records for active workers were more likely to be complete for workers who died after 1969 and had at least 10 years of service, since 10 years of service is required to be vested. Hence, deaths eligible for this study are those that occurred between January 1, 1970, and March 31, 1982, to any active or pensioned worker with at least 10 years of service at the study plant. Since cancer mortality is the major interest of this study, the exclusion of deaths of workers with less than 10 years of service will not severely bias the study results, due to the duration of exposure and latency period required for most occupationally related cancers.

A total of 625 cases were found to have died in the study period. Of these, 132 were excluded, including four women and 128 males with less than 10 years of

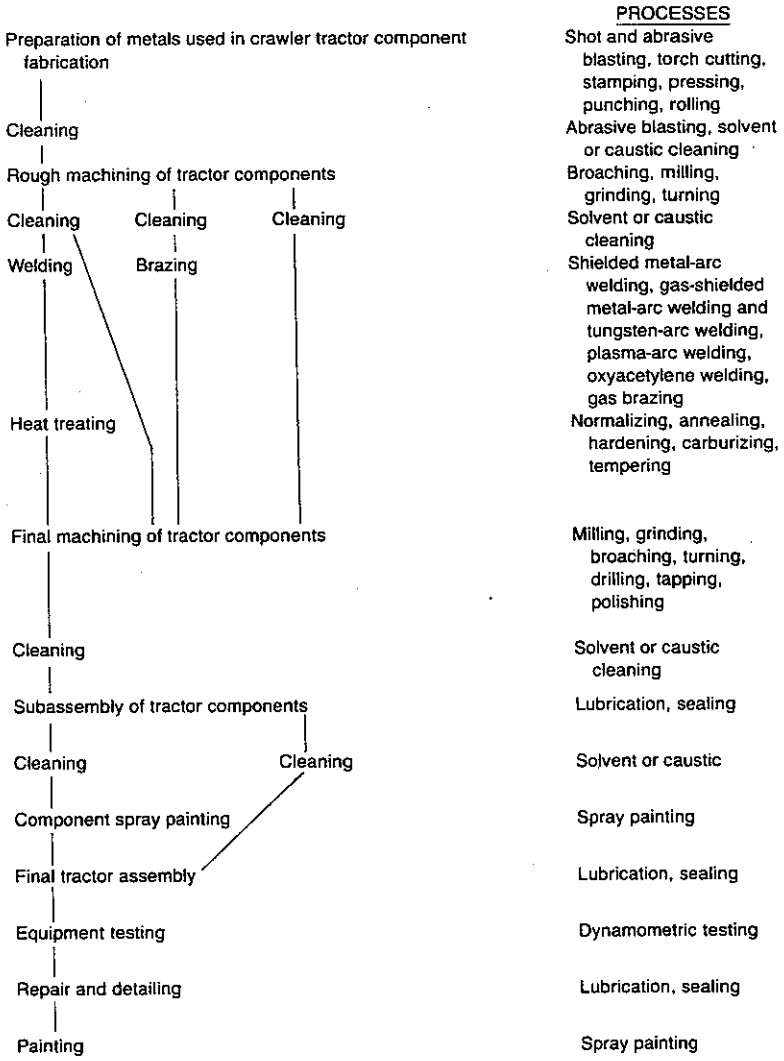

Fig. 1. Flow chart of processes used in the construction side of the study plant.

service, resulting in 493 eligible deaths—376 among pensioned workers and 117 among active workers. Death certificates were requested for these 493 eligibles from vital records offices in Illinois, and from other states for which an address was known for retired workers. A total of 461 death certificates were eventually located, or 93.5% of those eligible. Of the 32 not found, two were of workers who died in another country, one other was of a worker who died in a state which requires family consent to obtain death certificates, and 29 could not be located in any state for which an address was known.

In order to ascertain if the missing deaths differed in any known way from those located, year of death, year first employed, pension status, year pensioned, and number of years worked in the study plant were compared for the two groups. No

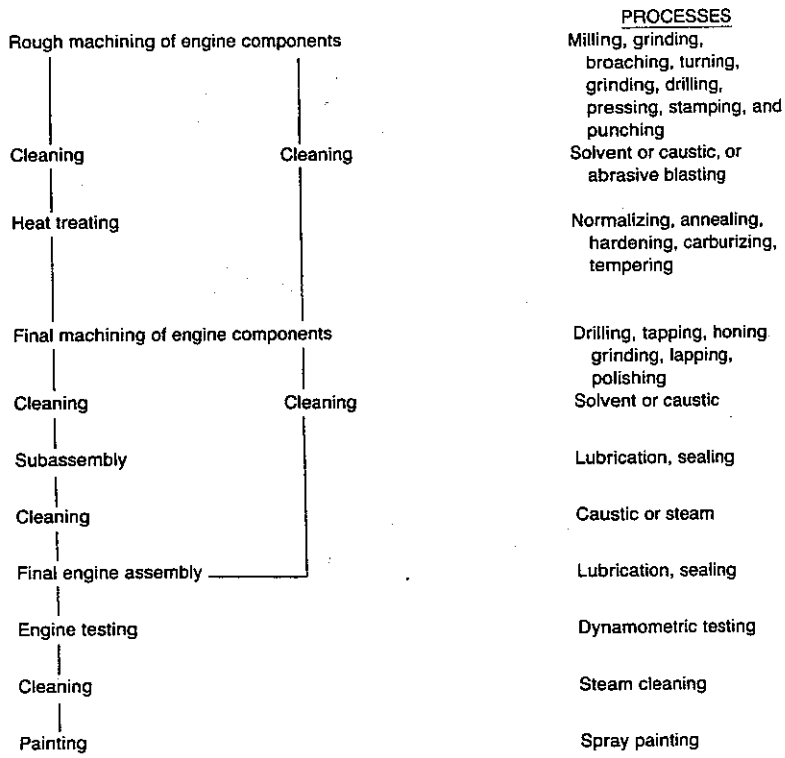

Fig. 2. Flow chart of processes used in the component side of the study plant.

statistically significant differences were found between the two groups for these variables, using a .05 significance level, two tailed (Table I).

Underlying cause of death codes were abstracted from the 461 death certificates located, using the Eighth Revision of the International Classification of Diseases (Adapted) coding scheme [National Center for Health Statistics, 1975]. If ICDA codes were missing, a University of Illinois nosologist provided the appropriate code. In addition, age, race, year of death, country of birth, usual occupation, and industry were abstracted from death certificates onto coding sheets.

Complete employment histories were not available for most workers. However, death records from the union local included codes for the most recent departments worked in; usually two or more departments were listed. No information was available regarding exposures or years of service in each department; hence, workers could only be classified according to these department codes.

Total years of service and year first employed at the plant were also obtained from plant records and from company pension and discharge lists. For workers who transferred to the study plant from other company plants, estimates of years of service at the study plant were obtained by subtracting the year started at the company from the year started at the study plant.

Standard Population

Since state and county mortality rates for several cancer sites were higher than U.S. mortality rates, state and county deaths were used to generate expected number

TABLE I. Percentage Distribution and Mean Values of Selected Variables for Available vs Missing Death Certificates

	Percent		
	Available	Missing	Chi square[a]
Year of death	(n = 461)	(n = 32)	
1970–1975	44.2	37.5	
1976–1982	55.8	62.5	0.55
Status at death	(n = 461)	(n = 32)	
Active	24.1	18.8	
Pensioned	75.9	81.2	0.47
Year pensioned (pensioners only)	(n = 350)	(n = 26)	
1951–1960	6.3	7.7	
1961–1970	52.9	53.9	
1971–1982	40.9	38.5	0.11
Year first employed	(n = 460)	(n = 32)	
1941–1950	80.4	81.2	
1951–1971	19.6	18.8	0.01
	Mean years		Student's t[a]
Total number of years employed	(n = 461) 20.8	(n = 32) 18.6	1.87

[a]p-values all greater than .05.

of deaths and PMRs and PCMRs. The years 1971 and 1974 were used as the standard for the 1970–1975 study deaths, and the years 1977 and 1980 were used for the 1976–1982 study deaths. Age- and calendar-year-adjusted expected deaths were calculated for blacks and whites separately, using the distribution of deaths in the state and local counties as the standard. Since the study plant bordered on the two counties where most plant workers lived, deaths from the two adjacent counties were combined for the standard population. Using a matrix procedure of the Statistical Analysis System software package [SAS, 1982], age-, race-, and calendar-year-specific proportions were applied to the study population distribution to generate expected deaths. In addition, PMRs were calculated based on the United States standard population, using the computer program developed by Monson [1974], which was modified and updated by the (U.A.W.) International Union [1984].

Statistical Methods

Since PMRs for malignant causes of death may be artificially inflated due to deficits in other causes of deaths, such as deficits due to the effect of the "healthy worker," PCMRs were also calculated to reduce this bias. Since cancer mortality is not generally affected by the "healthy worker" phenomenon, this source of bias is reduced when only cancer deaths are used to generate expected deaths for specific cancer sites.

The ratio of observed to expected deaths multiplied times 100 forms the PMRs and PCMRs. Their significance is assessed using the Mantel-Haenszel [1959] summary chi square, except when the number of expected deaths is less than five for any site, in which case a confidence interval table based on the Poisson distribution is used [Bailar and Ederer, 1964]. Since this is primarily a hypothesis-generating study, a two-tailed test using a .05 significance level is used throughout the analysis.

RESULTS—DESCRIPTIVE

Most of the 461 deaths occurred in Illinois (85.5%); 91.4% of these occurred in the two local counties. There were 351 deaths of whites and 110 of blacks. The mean age at death was 66.3; 67.8 for whites and 61.5 for blacks.

Most deaths occurred to retired workers; 80.6% of whites and 60.9% of blacks were retirees. The mean number of years worked at the study plant was 22.1 for blacks and 20.4 for whites. In fact, 70% of blacks were employed 20 or more years compared to 54% of whites. However, whites were more frequently employed at earlier starting dates than blacks: 76% of whites were first employed between 1946 and 1949, compared to 63% of blacks.

Since cancer mortality has been shown to vary with country of origin, place of birth was abstracted from death certificates. Of the 62 foreign-born whites, 38.7% were born in Northern or Western Europe; 19.4% in Poland; 22.6% in other Eastern and Central European countries; 14.5% in Italy; and the remainder in various other countries. This distribution is similar to that of the two local counties.

MORTALITY RESULTS

Since results using the U.S. and local counties' distribution of deaths were similar to results based on the state's distribution of deaths, only the latter results are reported. PMRs for major causes of death are presented for whites and blacks in Table II.

In general, the results for whites show no significant departures from expected deaths for most causes. The PMR for all malignant neoplasms is slightly above expectation but is not significant. A small nonsignificant deficit of deaths from nonmalignant digestive diseases and from accidents of all kinds was also found. A significant excess of deaths from mental disorders was found, but the four observed deaths had no common underlying cause.

Observed deaths of blacks were also near expectation for most causes, except for the significant excess found for all malignant neoplasms. A slight deficit of deaths from digestive diseases was also found for blacks, but the PMR was not significant.

Cancer Mortality in Whites

PMRs and PCMRs for specific cancer sites among white males are presented in Table III. No statistically significant PMRs or PCMRs were found, although some were elevated. The small excess of deaths from digestive cancers was due primarily to the nonsignificant excess of deaths due to stomach cancer. The 10 observed deaths from cancer of the prostate were also elevated but were not significant. The eight observed deaths from all lymphatic and hematopoietic causes were near expectation, but among these eight deaths, three were from multiple myeloma, compared to the 1.04 and 1.21 expected, based on all deaths and on cancer deaths only.

Cancer Mortality in Blacks

The corresponding PMRs and PCMRs for blacks are presented in Table IV. A significant excess of deaths from cancer of the pancreas was found, with five observed and 1.40 expected in the PMR analysis. The PCMR was also elevated but not significant. No other digestive cancer deaths deviated from expectation.

TABLE II. Observed Deaths (1970–1982) and PMRS Among White and Black Males, Based on the State Distribution of Deaths

	Whites		Blacks	
Cause of death (ICDA-8)	Observed	PMR[a]	Observed	PMR[a]
Infectious (000–136)	4	209	0	—
Malignant neoplasms (140–209)	92	116	36	136[b]
Endocrine (240–279)	3	49	2	92
Blood, blood-forming organs (280–289)	1	—	0	—
Mental disorders (290–315)	4[c]	372[b]	1	—
Nervous system (320–389)	5	213		
Circulatory system (390–458)	198	98	50	91
Respiratory system (460–519)	15	68	6	93
Digestive system (520–577)	10	69	4	71
Genitourinary system (580–629)	3	76	1	—
Symptoms, ill-defined conditions (780–796)	4	477[b]	2	261
Accidents, poisoning, violence (800–999)	10	70	7	82
All other	2		1	
Total deaths	351		110	

[a]PMRs were not calculated if observed and expected deaths numbered less than two for any cause.
[b]$p \leq .05$.
[c]Includes two deaths due to chronic alcoholism, and one each from senile psychosis and chronic brain syndrome.

There were six deaths from prostate cancer, compared to less than three expected, but neither the PMR or PCMR were significant. The six deaths from all cancers of the lymphatic system were significantly above expectation in the PMR analysis, primarily due to an excess of non-Hodgkin's lymphomas (NHL), which was significant in both the PMR and PCMR analyses. The two deaths from multiple myeloma also exceeded the .50 and .65 expected in the PMR and PCMR analyses, but no conclusions can be based on such small numbers.

Cancer Mortality in Whites, Blacks Combined

There were only two sites—prostate and multiple myeloma—for which excess mortality was found in both blacks and whites, although neither excess was statistically significant. When observed and expected deaths were combined for the two groups, the 16 observed prostate cancer deaths produced a PMR of 172 and a PCMR of 139; only the PMR result was significant, however. Similarly, the five deaths from multiple myeloma resulted in a PMR of 324 and a PMCR of 269, with only the PMR reaching statistical significance. Hence, results for these two sites are inconclusive.

Cancer Mortality by Years of Service

Analyses were also performed stratified by years of service groups. Due to the small number of deaths, only two groups were compared: those with 10 to 19 years service and those with 20 or more years of service. Since among blacks, there were

TABLE III. Observed Deaths (1970–1982), PMRS, and PCMRS Among White Males, for Selected Cancer Sites, Based on the State Distribution of Deaths

Cause of death (ICDA-8)	Observed	PMR[a,b]	PCMR[a,b]
All malignant neoplasms (140–209)	92	116	
Buccal cavity, pharynx (140–149)	2	79	69
Digestive organs peritoneum (150–159)	28	124	126
Esophagus (150)	2	101	88
Stomach (151)	6	185	158
Large intestine (153)	10	117	99
Rectum (154)	2	80	68
Pancreas (157)	5	119	103
All other gastrointestinal (152, 155, 156, 158, 159)	3	147	126
Larynx (161)	2	176	155
Trachea, bronchus lung (162)	34	127	110
Prostate (185)	10	153	124
Bladder (188)	2	78	66
Kidney (189)	1	—	45
Brain, nervous system (191, 192)	1	—	—
Unspecified (199)	4	154	131
All lymphatic, hematopoietic (200–209)	8	119	103
Non-Hodgkin's lymphoma (200, 202)	3	136	118
Hodgkin's disease (201)	0	—	—
Multiple myeloma (203)	3	289	248
Leukemias (204–207)	1	38	33
Other lymphatic, hematopoietic (208–209)	1	—	—
All other malignancies	0		

[a]PMRs and PCMRs were not calculated if observed and expected deaths numbered less than two for any cause.

[b]No PMRs or PCMRs were statistically significant at the .05 level.

only 11 cancer deaths to workers with 10 to 19 years service, the PCMR analysis was only done for the 20 or more years of service group.

Among white males, there were no significant PMRs in either subgroup except for a significant excess of all malignant deaths in the 10 to 19-years service group (Table V). Other causes exhibit trends similar to the previous analysis. Although some PMRs for the 10 to 19-years service group exceed those for the 20-or-more-years group, the PMRs are not significantly different from 100 for any site. Hence, the differences between the two groups are not significant. The PCMR results for whites (not shown) are similar to the PMR results, but are less elevated than the corresponding PMRs, and none are statistically significant.

Among blacks, all of the pancreatic cancer deaths and lymphatic and hematopoietic deaths occurred to workers with 20 or more years of service and significantly exceed expectation in both the PMR and PCMR analysis for this group (Table VI). Prostate cancer deaths were also elevated in both years-of-service groups, but the PMRs and PCMRs were not significant. Multiple myeloma deaths, which only

TABLE IV. Observed Deaths (1970–1982), PMRS, and PCMRS Among Black Males for Selected Cancer Sites, Based on the State Distribution of Deaths

Cause of death (ICDA-8)	Observed	PMR[a]	PCMR[a]
All malignant neoplasms (149–209)	36	136[b]	
Buccal cavity and pharynx (140–149)	1	—	—
Digestive organs and peritoneum (150–159)	8	99	73
Stomach (151)	1	—	—
Large intestine (153)	2	104	77
Pancreas (157)	5	357[b]	267
Nose, larynx (160–161)	0	—	—
Trachea, bronchus, lung (162)	12	129	93
Genito-urinary organs (180–189)	6	163	130
Prostate (185)	6	219	175
Unspecified (190–199)	3	167	123
All lymphatic, hematopoietic (200–209)	6	354[c]	261
Non-Hodgkin's lymphoma (200, 202)	3	687[b]	489[b]
Hodgkin's (201)	0	—	—
Multiple myeloma (203)	2	396	310
Leukemias (204–207)	1	—	—

[a]PMRs and PCMRs were not calculated if observed and expected deaths were less than two for any cause.
[b]$p \leqslant .05$.
[c]$p \leqslant .01$.

occurred in the 20-or-more-years of service group, are also above expectation in the PMR and PCMR analyses but are not significant.

Cancer Mortality by Latency

Analysis of PMRs and PCMRs by latency (year of death minus year first employed) produce findings similar to those found for years of service, and so are not presented. Since only two latency periods were examined (less than 25 years vs 25 or more years latency) due to the limited number of deaths, there was considerable overlap between years of service and latency. A larger cohort would be required to determine if latency and years of service were independently associated with specific causes of death.

DISCUSSION

The proportional distribution of nonmalignant causes of death did not deviate significantly from expectation for black or white workers in this plant. The fact that no significant deficits were found may be due in part to the fact that over three fourths of the deaths occurred in retirees, since the "healthy worker effect" declines with age and the number of retirees included in the study population [Fox and Collier, 1976;

TABLE V. Observed Deaths and PMRS Among White Males, by Years of Service, for Selected Cancer Sites, Based on the State Distribution of Deaths

	Years of service			
	10 to 19		20 or more	
Cause of death (ICDA-8)	Observed	PMR[a]	Observed	PMR[a]
All malignant neoplasms (140–209)	42	130[b]	50	107
Buccal cavity pharynx (140–149)	0	—	2	124
Digestive organs, peritoneum (150–159)	13	137	15	115
Stomach (151)	3	207	3	167
Pancreas (157)	2	117	3	121
Trachea, bronchus, lung (162)	15	151	19	112
Prostate (185)	6	172	4	131
Non-Hodgkin's lymphoma (200, 202)	2	234	1	—
Multiple myeloma (203)	2	489	1	—
Total deaths	160		191	

[a]PMRs were not calculated if observed and expected deaths were less than two for any cause.
[b]$p \leqslant .05$.

TABLE VI. Observed Deaths Among Black Males, PMRS, PCMRS, by Years of Service, for Selected Cancer Sites, Based on the State Distribution of Deaths

	Years of Service				
	10 to 19		20 or more		
Cause of death (ICDA-8)	Observed	PMR[a]	Observed	PMR[a]	PCMR[a]
All malignant neoplasms (140–209)	11	157	25	128	
Buccal cavity, pharynx (140–149)	1	—	0	—	0
Digestive organs, peritoneum (150–159)	1	—	7	117	91
Pancreas (157)	0	—	5	479[b]	380[c]
Trachea, bronchus, lung (162)	5	231	7	98	74
Prostate (185)	3	295	3	174	166
Symptoms, ill-defined (190–199)	1	—	2	153	118
Lymphatic, hematopoietic system (200–209)	0	—	6	478[b]	384[c]
Non-Hodgkin's lymphoma (200, 202)	0	—	3	915[b]	712[c]
Multiple myeloma (203)	0	—	2	526	446
Leukemias (204–207)	0	—	1	—	—
Total deaths	33		77		

[a]PMRs and PCMRs were not calculated if observed and expected deaths were less than two for any cause.
[b]$p \leqslant .01$.
[c]$p \leqslant .05$.

McMichael, 1976]. The exclusion of workers with less than 10 years of service would have increased the percentage of pensioners, and reduced the bias from the "healthy worker effect." The fact that the PMR and PCMR analyses produced similar findings for malignant causes of death suggests that this source of bias has been minimized in this study.

The overall excess of malignant causes of death found for blacks is interesting, given recent trends in cancer incidence among blacks which suggest changes in environmental exposures. The increase in cancer incidence and mortality among black males in the last 40 years is greater than the increase for white males and has occurred in both smoking- and nonsmoking-related sites, including lung, esophagus, pancreas, prostate, and lymphomas [Young et al, 1975]. Although much of the increase may be artifactual, due to improved access to medical care and better diagnostic practices, the influence of environmental factors, including smoking, diet, and occupation, cannot be ruled out.

Although occupational histories in this plant are incomplete, the information on recently held jobs that is listed on union cards suggests that black and white workers may not have been similarly distributed among job categories. For example, 28% of white workers held skilled trade occupations (e.g., tool and die makers, millwrights, pipe and steam fitters, tool grinders, machine repairmen, and electricians), whereas no blacks had these occupations listed in their records ($X^2 = 29.41$, $p \leqslant .001$). Unfortunately, not enough information is available to classify whites and blacks according to major occupational exposures. Additional documentation of exposure and work histories is needed to clarify the nature of the relationship between job distribution and cancer mortality among blacks and whites in this plant.

Site-specific Cancer Mortality

The nonsignificant excess of stomach cancer found for whites is suggestive, but the lack of complete employment histories precludes a more definitive analysis. Although diet has been implicated as a major risk factor for stomach cancer [Nomura, 1982; Weisburger and Raineri, 1975], excess risks have been found in occupations with exposures to metals [Houten et al, 1977], and among machinists with probable cutting oil exposures [Decouflé, 1978; Jarvholm et al, 1981; Dubrow and Wegman, 1984]. The recent employment histories for these workers, however, reveal no common job histories among the six deaths.

The significant excess of pancreatic cancer found among blacks is interesting, in that all of these deaths occurred to workers with 20 or more years of service. No recent occupations were held in common for these five cases, although four had machining experience (Table VII).

Although the etiology of pancreatic cancer in not clear, U.S. nonwhites have one of the highest mortality rates in the world [Fontam, 1982]. The increase in pancreatic cancer in U.S. blacks in the last 40 to 50 years may be due to better diagnostic practices but may also be due to changes in personal and environmental exposures. Smoking has been implicated as a moderate risk factor for this site [Fontham, 1982] and must be considered as a potential confounder in this study.

Excess pancreatic cancer risks have also been found in several occupational groups, including metal workers [Dorken, 1964; Maruchi et al, 1979], chemists [Li et al, 1969], workers exposed to beta napthylamine and benzidene [Mancuso and El-Attar, 1967], and workers exposed to gasoline and dry cleaning solvents [Lin and

TABLE VII. Known Occupational History, Age, Total Years of Service, and Year First Employed for Black Males Who Died of Cancer of the Pancreas

Occupations listed in union records	Age at death	Total years of service	Year first employed
Torch cutting, welding	57	21	1955
Machining[a]	66	24	1947
Machining, assembly	59	25	1946
Machining, welding, power trucking, shipping	55	28	1952
Machining	57	30	1948

[a]No union information listed; based on death certificate occupation only.

Kessler, 1981]. Although many of these studies were based on small numbers and used broad occupational categories, the nature of the risk among solvent-exposed workers is one that bears further scrutiny in this and other machining industries.

The moderate excess of prostate cancer found in whites and blacks is suggestive but could have been a chance finding, since only the PMR results were significant, and then only for whites and blacks combined. Twelve of the 16 cases were first employed before 1950, and 14 had been employed at least 15 years. No recent job categories were held in common for all 16 cases, although 12 had machining or machine repair experience.

Several different occupational groups have been found to have excess prostate cancer risks, including chemists [Olin, 1978] and rubber workers [McMichael et al, 1976; Goldsmith et al, 1980; Monson and Fine, 1978]. Epidemiological studies have shown cadmium to be a risk factor for prostate cancer [McMichael et al, 1976; Lemen et al, 1976], but it was not known if the study population was exposed to this metal.

The six blacks who died from lymphatic–hematopoietic system cancers all had 20 or more years of service at the study plant. Significant excesses were found for these six deaths and for the subgroup of three non-Hodgkin's lymphoma deaths. The three non-Hodgkin's lymphoma deaths included one lymphosarcoma and two malignant lymphomas. No recent occupations were found in common among the six lymphatic-hematopoietic deaths (Table VIII).

Excess risks for NHL have been found in chemists [Li et al, 1969; Olin, 1978; Searle et al, 1978]; in rubber workers exposed to organic solvents, mixed rubber, and cements [Monson and Nakano, 1976]; in workers with high exposure to organic solvents that included benzene, trichloroethylene, perchloroethylene, and styrene [Hardell et al, 1981]; and in members of a small community near a chemical recycling plant where several solvents were detected in the atmosphere, including aromatic hydrocarbons, chlorinated hydrocarbons, and nitrocompounds [Capurro and Eldridge, 1978]. A survey of New York state death certificates (exclusive of New York City) found reticulum cell sarcoma, lymphosarcoma, and Hodgkin's disease in 14 occupations with probable exposure to benzene, including machinists, whose mortality rate was 8.37 per 100,000 as compared to a rate of 3.54 for New York state [Vianna and Polan, 1979]. Although the number of NHL deaths in this study is small, previous research suggests that occupational exposures to solvents may be associated

TABLE VIII. Known Occupational History, Age, Total Years of Service, and Year First Employed for Black Males Who Died From Cancers of the Lymphatic-Hematopoietic System

Cancer Site	Occupations listed in union records	Age at death	Total years of service	Year first employed
Leukemic lymphosarcoma	Machining	69	21	1947
Malignant lymphoma	Assembly	50	25	1948
Malignant lymphoma	Torch cutting, heat treating	57	29	1948
Multiple myeloma	Welding	68	27	1949
Multiple myeloma	Power trucking	73	26	1946
Acute myeloblastic leukemia	Machining	59	31	1949

with this cause of death. In the study plant, past use of benzene was suspected but not confirmed.

The excess deaths from multiple myeloma among whites and blacks merit some attention despite the small numbers and inconclusive results, because of the increase in this cause of death that has occurred since 1950, particularly among nonwhites [Blattner, 1980]. However, it is not clear how much of the increase is due to better case ascertainment.

Occupational associations with multiple myeloma are primarily suggestive. Case control series have found excess risks for workers in the metal industry [Dorken and Vollmer, 1968], and among tool and die workers [Decouflé et al, 1977]. Proportional mortality ratio studies have found excess risks among composing room employees with exposure to inorganic lead [Greene et al, 1979], in petrochemical workers with 20 or more years of employment in refining and petrochemical plants [Thomas et al, 1980], and among paper and pulp mill workers [Milham, 1976]. Of the five multiple myeloma cases in this study, three had 20 or more years of service, and two had 11 years of service with no recent occupations found in common.

CONCLUSION

This preliminary study found a significant excess of pancreatic cancer and non-Hodgkin's lymphomas in blacks, which was confined to workers with 20 or more years of service. Excesses were also found for prostate cancer and multiple myeloma deaths in blacks and whites, but these results were inconclusive, since PCMRs were not statistically significant.

The small number of deaths, the lack of complete employment histories, and the limitations of PMR studies prevent us from making any definitive conclusions based on these results. A follow-up study should include additional deaths among workers in this cohort and attempt to reconstruct occupational and exposure histories based on company and union records. Despite the limitations of this study, these results should provide new leads for future studies of workers in heavy machinery and related industries, and suggest new hypotheses regarding the increase in cancer mortality in black males that has occurred in the last 40 years.

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