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TEXACO MORTALITY STUDY

TEXACO INC.
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I. MORTALITY AMONG WHITE MALE REFINERY, PETROCHEMICAL, AND RESEARCH WORKERS

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ABSTRACT

The Texaco Mortality Study is a cohor: mortality study of all persons who were employed at least five years in a refining, petrochemical. or research facility and who worked sometime between January 1, 1947, and December 31, 1977. Basic demographic data and complete work history information were collected and coded for all eligible employes. This is a report on the study methodology and on the overall mortality results for white males. There were 19,077 white males in the cohort with 14,609 alive, 4,024 dead, and 444 with vital status unknown. There were 5.559 expected deaths giving an all causes standardized mortality ratio (SMR) of 72. Large statistically significant deficits were seen for all the major causes of death including all malignant neoplasms (SMR = 73). cancer of the lung (SMR = 58), stroke (SMR = 75), arteriosclerotic heart disease (SMR = 77), respiratory disease (SMR = 50), and accidents (SMR = 51). There were six causes of death where the SMR was greater than 100: however, none of these increases was statistically significant! and each was based on only a few deaths. The elevated SMRs were seen for cancer of the pancreas (SMR = 104), cancer of the brain (SMR = 108), Hodgkin's Disease (SMR = 106), leukemia (SMR = 113), cancer of other lymphatic tissue (SMR = 111). and benign neoplasms (SMR = 144).

INTRODUCTION

Numerous recent studies have examined patterns of mortality in petroleum workers. While most have shown overall mortality rates to be substantially less than those for the general population, deaths from a number of causes have been elevated. These causes include cancer of the lung,[1, 2, 3] cancer of the skin,[1, 2, 4] cancer of the nasal cavity and sinuses,[1, 4] cancer of the digestive system,[2, 3, 4, 5] cancer of the brain,[2, 4, 6] cancer of the pancreas,[1] cancer of the kidney,[7] lymphoma,[6, 8] and leukemia.[2, 6] It can be noted, however, that the same malignancies have not been elevated in all the studies, and many of the studies suffered from methodological drawbacks.

This report details a cohort mortality study of workers who were employed five years or more at Texaco refineries, research laboratories, or chemical plants and who worked between January 1, 1947, and December 31, 1977. The major objective of the study was to determine the patterns of mortality in these workers and, in particular, to determine if any of the elevated causes of death found previously also occurred in the Texaco population. The study was designed to provide detailed information on a large number of long-term Texaco employes in the above mentioned types of facilities, in order to avoid most of the limitations of previous refinery worker studies.

METHODS

Definition of Cohort

The study cohort consists of all employes of Texaco Inc. who worked at selected refinery, petrochemical, and research facilities at least one day between January 1, 1947 and December 31,1977, who were employed at these facilities for a cumulative total of at least five years, and who were employed by the facility on either their last day of employment or the common closing date (December 31,1977). The participating facilities were all those in operation when the study was designed and are listed in Table 1.
Two groups of employes were excluded from the cohort:.

- Employes of the Administrative, Engineering, and Medical Services Departments who could not be identified from the personnel rosters (see below).
- Employes of the former Jefferson Chemical Company (see Table 1) locations who terminated before 1955 and whose work records were not retained.

TABLE 1

PARTICIPATING FACILITIES

Type of Facility	Location	Date Founded
Refining ·	Amarillo, Texas	1920
	Anacortes, Washington (Puget Sound)	1958
	Casper, Wyoming	1923
	Convent, Louisiana	1967
	Eagle Point, New Jersey	1949
	El Paso, Texas	1929
	Houston, Texas (Headquarters Office)	1963
	Lawrenceville, Illinois	1931
	Lockport, Illinois	1911
	Los Angeles, California	1928
	Port Arthur, Texas (includes Port Arthur Terminal)	1903
	Port Neches, Texas	1906
	West Tulsa, Oklahoma	1910
Packaging ·	Bayonne, New Jersey	1909
	Port Arthur, Texas	1903
Chemical ·	Austin, Texas'	1949
	Conroe, Texas*	1961
	Eagle Point, New Jersey	1961
	Port Arthur, Texas	1957
	Port Neches, Texas'	1948
Research ·	Beacon, New York	1931
	Montebello, California	1946
	Port Arthur, Texas	1954

* Formerly Jefferson Chemical Company

All employes who met the eligibility requirements were identified from personnel system separation rosters listings all employes who separated from the company between 1947 and 1978, and from personnel listing of employes active in 1978.

Numerous other cohort mortality studies have required a minimal length of employment much shorter than the five year requirement used in this study (e.g. one year, six months, one day). The argument against a short employment requirement is that the resulting cohort may include an undue proportion of people who spent the largest part of their working lifetime at other companies in jobs with unknown exposures. On the other hand, the argument for a short employment requirement is that it is unknown whether a short exposure, especially early in life. may have adverse health effects. In order to test whether the five-year requirement affected the pattern of results (particularly whether it made some of the cancer SMRs too low), persons who worked one to five years at the Port Arthur facilities (excluding the Package Division) were also studied. Comparison of mortality patterns for the two groups were made.

Data Collection and Coding

Data collected on each employe included name, social security number, race, sex. date of birth, and a complete work history, if available. Vital status information for former employes was obtained from Texaco where available or the Social Security Administration (SSA). Copies of death certificates were obtained either from Texaco at the time of data collection, or from the states where the deaths occurred.* Each death certificate was coded for the underlying cause of death by a nosologist. Deaths occurring through 1967 were coded according to the 7th Revision of the International Classification of Diseases and deaths after 1967 according to the 8th Revision.

Cohort Verification

In order to verify the accuracy and completeness of cohort ascertainment, data were collected at two locations without reference to the personnel system lists of eligible persons. The names found were compared with the roster of eligible workers. The vast majority of persons missing from the personnel system lists were employed by ineligible departments (e.g. accounting, medical) or had transferred to a nonparticipating location before the study end date and, therefore, were appropriately excluded from the study. A number of persons were on the personnel rosters but had been missed in the process of screening these rosters for eligible employes. These persons were added to the study cohort. Although a small number of eligible persons are likely to be missing for other participating locations as well, this should not bias the patterns observed since a person's inclusion in the study should not have been related to his mortality experience. A very small number of persons (less than 1.5%) appeared to be eligible according to their work histories but were not on the personnel roster. No reason for this could be determined.

RESULTS

The Studv Population

There were 21,314 persons eligible for inclusion in the study cohort. Table 2 shows the number of subjects according to sex, race, and vital status as of the study end date, December 31, 1977. Those persons with race and sex unknown were assumed to be white males. (There were 28 persons with sex unknown and 344 with race unknown.) White males made up 89.5% of the total cohort and 94.1% of the deaths. All analyses were done on the subcohort of white males. Further reports will examine mortality in nonwhites and females.

Table 3 shows the breakdown of the cohort by plant and vital status *as* well as the person years of observation at the larger locations. Of the 19,077 total white male cohort, 14,609 (76.6%) are still alive, 4,024 (21.1%) are deceased, and 444 (2.3%) have vital status unknown. Approximately 75% of the cohort is concentrated in six of the 20 locations with over 43% at the Port Arthur facilities (Port Arthur Refinery, Chemical Plant, Terminal, and Package Division). Table 4 shows the cohort employment status at the end of the study. Almost half were still active employes. and over a quarter were retired employes.

* We would like to acknowledge the cooperation of the various state health departments, including the state of New Jersey, in providing copies of death certificates for deceased members of the cohort

Table 5 shows the distribution of the cohort and of the deaths by year of birth; the births appear to be evenly distributed throughout for the total cohort while almost half of the decedents were born before 1900 and over three-quarters before 1910. Table 6 shows the distribution of the cohort and the deaths by year first employed. Well over half of the cohort was employed before 1950 and about one third of the cohort was employed before 1940. Almost three-quarters of the decedents, however, were first employed before 1940. Most of the cohort (56.3%) were first employed before age 25 and very few (9.7%) after age 35. Table 7 shows the distribution of the cohort and the deaths by length of employment. Over one third of the cohort and one half of the deaths were employed 30 years or more. These findings substantiate the claim that employment in the petroleum industry tends to be long-term and stable. Table 8 shows the breakdown of the decedents by year of death and Table 9 by age at death. Most of the cohort died in the latter half of the study period, and most were age 55 to 79 at the time of death.

TABLE 2

COHORT VITAL STATUS BY RACE AND SEX

	Vital Status			
	Alive	**Dead**	**Unknown**	**Total**
White Males	14,609	4,024	444	19,077
Nonwhite Males	868	176	16	1,060
White Females	771	72	262	1,105
Nonwhite Females	56	5	3	64
Total	16,304	4,277	725	21,306

TABLE 3

WHITE MALES BY PLANT AND VITAL STATUS

Type of Facility/ Plant Location	Vital Status Alive	Dead	Unknown	Total	Person Years
Refining:					
Amarillo Plant	239	53	2	294	6.727
Casper Plant	292	59	22	383	9.685
Eagle Point Plant	859	94	9	972	15.962
El Paso Plant	238	23	19	280	6,150
Houston Office	99	33	6	138	—
Lawrenceviiie Plant	713	305	77	1,095	24,065
Lockport Plant	992	473	13	1,478	34.923
Los Angeles Plant	953	266	64	1,283	24,068
Louisiana Plant	241	6	1	248	—
Port Arthur Plant	6,194	1,906	142	8.242	170.834
Port Neches Plant	337	202	6	545	17,392
Puget Sound Plant	331	27	2	360	4.871
West Tulsa Plant	475	180	12	667	14.985
Packaging:					
Bayonne Terminal	266	102	0	368	9,217
Petrochemicals:					
Austin Research Lab	199	10	4	213	2,875
Conroe Chemical Plant	105	3	3	110	1,073
Neches Chemical Plant	697	43	11	751	11,177
Research:					
Beacon Research Lab	978	189	30	1,197	24,846
Montebello Research Lab	54	4	15	83	1,496
Port Arthur Research Lab	327	37	3	367	6.564
Unknown	0	3	3	3	—
Total	14.609	4,024	444	19,077	365.510

TABLE 4

WHITE MALES BY EMPLOYMENT STATUS

AS OF DECEMBER 31,1977

	Number	Percent
Active	8.998	47.2
Retired	5.281	27.7
Resigned	1,962	10.3
Died	1,405	7.4
Dismissed	277	1.5
Disability Retirement	994	5.2
Left Texaco, Reason Unknown*	160	0.8
Total	19,077	100.0

* Work history not found

TABLE 5

WHITE MALES BY YEAR OF BIRTH

	Total Cohort No. (%)	Deaths No. (%)
Before 1890	607 (3.2)	514 (12.8)
1890 - 1899	1,954 (10.2)	1,352 (33.6)
1900 - 1909	3,119 (16.3)	1,202 (29.9)
1910 - 1919	3,596 (18.8)	640 (15.9)
1920 - 1929	3,984 (20.9)	
1930 - 1939	2,547 (13.4)	316 (7.9)
1940 & After	3.268 (17.1)	
Unknown	2	
Total	19,077	4,024

TABLE 6

WHITE MALES BY YEAR FIRST EMPLOYED

	Total Cohort No. (%)	Deaths No.(%)
Before 1940	6,411 (33.6)	3,000 (74.6)
1940 - 1949	4,923 (25.8)	829 (20.6)
1950 - 1959	3.406 (17.9)	
1960 - 1969	2.692 (14.1)	195 (4.8)
1970 & After	1,645 (8.6)	
Total	19.077	4,024

TABLE 7

WHITE MALES BY LENGTH OF EMPLOYMENT

	Total Cohort No.(%)	Deaths No.(%)
5 - 9 Yrs	4,201 (22.0)	205 **(5.1)**
10 - 19 Yrs	3,002 (15.7)	641 (15.9)
20 - 29 Yrs	5,081 (26.6)	1,156 (28.7)
30+ Yrs	6,793 (35.6)	2.022 (50.2)
Total	19.077	4.024

TABLE 8

WHITE MALE DEATHS BY YEAR OF DEATH

	Number	Percent
1947-1949	108	2.7
1950-1959	726	18.0
1960-1969	1,507	37.5
1970-1977	1,679	41.7
Unknown	4	0.1
Total	4,024	100.0

TABLE 9

WHITE MALE DEATHS BY AGE AT DEATH

	Number	Percent
Under 40	105	2.6
40-49	403	10.0
50-59	858	21.3
60-69	1,240	30.8
70-79	1,065	26.5
80 & Over	349	8.7
Unknown	4	0.1
Total	4,024	100.0

The 444 persons for whom vital status was unknown were assumed to be alive in the analysis of mortality Because the percentage is so small (2.3%) and because they are distributed throughout the cohort. it is not expected that this assumption will affect the results. Death certificates were obtained for alt except 152, or 3.8% of the 4,024 decedent white males.

Patterns of Mortality

Analysis of mortality was performed using Monson's computer program [9] to compare the observed and expected number of deaths using the U.S. white male population as the comparison group. For the 4,024 deaths observed 5.558.9 were expected giving a standardized mortality ratio (SMR) of 72.' Table 10 shows the observed and expected number of deaths for the major causes of death plus the SMRs and their lower and upper 95% confidence limits. The most striking result is the large deficit seen for almost every major cause of death category including all malignant neoplasms (SMR = 73), cancer of the digestive organs (SMR = 67), cancer of the lung (SMR = 58), metabolic diseases (SMR = 75), diabetes (SMR = 77), diseases of the nervous system (SMR = 76), vascular lesions of the central nervous system (CNS) (SMR = 75), arteriosclerotic heart disease (SMR = 77), all respiratory diseases (SMR = 50), all diseases of the digestive system (SMR = 54), and all external causes of death (SMR = 52). For none of these categories does the 95% confidence interval include 100.

There are a few causes of death for which the SMR is greater than 100; however, for none of these does the lower confidence limit exceed 100. The highest SMR (144) is for benign neoplasms with 20 deaths observed and 13.9 expected. Of these. 12 were brain tumors; 9.3 were expected, giving an SMR of 130. The SMR for cancer of the brain and CNS was slightly elevated at 108. Other causes of death for which the SMR was greater than 100 are cancer of the pancreas (SMR = 104), Hodgkin's Disease (SMR = 106), leukemia (SMR = 113), and cancer of other lymphopoietic tissue (SMR = 111).

' It should be noted that if those with vital status unknown are assumed lost on the date last employed, the overall SMR is 75 Even under the extremely unlikely assumption that they are all deceased midway between the date last employed and the study end date, the overall SMR is 83

TABLE 10

SMRs FOR SELECTED CAUSES OF DEATH

WHITE MALES, 1947-1977

Cause	Observed	Expected	SMR	LCL	UCL
All Causes of Death	4,024	5,558.9	72	70	75
All Infective & Parasitic Diseases	22	82.4	27	17	40
All Malignant Neoplasms	767	1,056.4	73	68	78
Cancer of the Digestive Organs	215	318.6	67	59	77
Cancer of the Stomach	45	66.4	68	49	91
Cancer of the Large Intestine	64	98.2	65	50	83
Cancer of the Pancreas	62	59.8	104	80	133
Cancer of the Lung	182	315.1	58	50	67
Cancer of the Prostate	62	77.9	80	61	102
Cancer of the Kidney	24	25.9	93	59	138
Cancer of the Bladder	19	35.5	54	32	84
Cancer of the Skin	14	17.3	81	44	136
Cancer of the Brain	31	28.7	108	73	154
Lymphosarcoma & Reticulosarcoma	20	22.9	87	53	135
Hodgkin's Disease	13	12.3	106	56	181
Leukemia	48	42.3	113	84	150,
Cancer of Other Lymphatic Tissue	25	22.6	111	72	164
Benign Neoplasms	20	13.9	144	88	222
Endocrine, Metabolic Diseases	78	103.8	75	59	94
All Diseases of the Nervous System	360	473.8	76	68	84
All Vascular Lesions of CNS	322	431.7	75	67	83
All Diseases of the Circulatory System	1,975	2,609.4	76	72	79
Arteriosclerotic Heart Disease	1,623	2,101.1	77	74	81
All Respiratory Diseases	159	319.1	50	42	58
Emphysema	52	89.7	58	43	76
All Diseases of the Digestive System	141	260.2	54	46	64
Cirrhosis of Liver	56	122.9	46	34	59
All Diseases of G-U System	43	85.1	51	37	68
All External Causes of Death	227	434.8	52	46	59
All Accidents	152	297.0	51	43	60
Unknown	152				

Similar analyses of the patterns *of* mortality were carried out for each of the plants in the study excluding those with fewer than 20 deaths and those opened since 1958. **A** person was counted at each plant where he was ever employed and. therefore, could be included more than once. Essentially, the patterns of mortality seen at each facility were similar to those for the overall cohort. Deficits were seen for almost all of the major causes of death at every location.

The Port Arthur complex (Refinery, Terminal, Package Division, and Chemical Plant) includes almost half of the total cohort and almost half of the deaths. Table **12** shows the **SMRs** for selected causes of death for all white males employed five years or more, and who were ever employed at the Port Arthur complex. The mortality patterns are the same as those for the entire cohort. The SMR for benign neoplasms is higher for the Port Arthur facilities than for the total cohort and is statistically significant. It should be noted that while the distribution of lymphatic and hematopoietic cancers differs between the total cohort and Port Arthur, the overall SMRs are the same. The differences may be due to diagnostic preferences.

Table **12** shows SMRs for selected causes of death for the expanded cohort of white males employed one year or more at the Port Arthur complex (excluding the Package Division). There were **1,614** additional persons in the cohort and **72** additional deaths. **A** comparison with Table **11** shows the same pattern of mortality with many of the SMRs slightly lower for the latter group. The lower **SMRs** can be seen particularly for the major causes of death. For example, in looking at the one to five year group alone, the all causes of death SMR is only **64** compared with **73** for the five years or more group, that for malignant neoplasms is only **44** compared with **76,** and that for arteriosclerotic heart disease *is* 65 compared with 75. Lower **SMRs** are seen for the one to five year group for every cause *of* death category with more than four deaths. It *is,* therefore, concluded that restricting the study to those employed at least five years or more has not obscured any patterns of death.

TABLE 11

SMRs FOR SELECTED CAUSES OF DEATH
WHITE MALES, PORT ARTHUR COMPLEX
EMPLOYED FIVE YEARS OR MORE

Cause"	Observed	Expected	SMR	LCL	UCL
All Causes of Death	1.958	2,667.7	73	70	77
All Infective & Parasitic Diseases	8	40.8	20	8	39
All Malignant Neoplasms	393	509.2	77	70	85
Cancer of the Digestive Organs	120	154.4	78	64	93
Cancer of the Stomach	27	32.3	84	55	122
Cancer of the Large Intestine	36	47.5	76	53	105
Cancer of the Pancreas	33	28.9	114	79	160
Cancer of the Lung	88	151.6	58	47	72
Cancer of the Prostate	37	37.9	98	69	135
Cancer of the Kidney	12	12.4	97	50	169
Cancer of the Bladder	11	17.3	64	32	114
Cancer of the Skin	7	8.1	86	35	178
Cancer of the Brain	15	13.5	111	62	183
Lymphosarcoma & Reticulosarcoma	12	10.9	110	57	192
Hodgkin's Disease	6	5.9	103	37	223
Leukemia	19	20.3	93	56	146
Cancer of Other Lymphatic Tissue	14	10.8	129	71	217
Benign Neoplasms	13	6.7	195	104	333
Endocrine, Metabolic Diseases	42	49.9	84	61	114
All Diseases of the Nervous System	193	227.7	85	73	98
All Vascular Lesions of CNS	172	207.5	83	71	96
All Diseases of the Circulatory System	919	1,253.7	73	69	78
Arteriosclerotic Heart Disease	754	1,008.6	75	70	80
All Respiratory Diseases	77	154.1	50	39	62
Emphysema	26	44.0	59	39	87
All Diseases of the Digestive System	69	123.5	56	43	71
Cirrhosis of Liver	23	57.4	40	25	60
All Diseases of G-U System	20	41.1	49	30	75
All External Causes of Death	116	204.3	57	47	68
All Accidents	74	140.2	53	41	66
Unknown	59				

TABLE 12

SMRs FOR SELECTED CAUSES OF DEATH
WHITE MALES, PORT ARTHUR COMPLEX
EMPLOYED ONE YEAR OR MORE

Cause	Observed	Expected	SMR	LCL	UCL
All Causes of Death	2,030	2,780.7	73	70	76
All Infective & Parasitic Diseases	9	43.8	21	9	39
All Malignant Neoplasms	400	525.2	76	69	84
Cancer of the Digestive Organs	120	158.0	76	63	91
Cancer of the Stomach	27	33.0	82	54	119
Cancer of the Large Intestine	36	48.7	74	52	102
Cancer of the Pancreas	33	29.6	112	77	157
Cancer of the Lung	91	155.8	58	47	72
Cancer of the Prostate	37	38.2	97	68	133
Cancer of the Kidney	12	12.8	94	48	164
Cancer of the Bladder	11	17.6	63	31	112
Cancer of the Skin	7	8.7	81	32	166
Cancer of the Brain	16	14.5	110	63	179
Lymphosarcoma & Reticulosarcoma	13	11.5	113	60	194
Hodgkin's Disease	6	6.7	90	33	196
Leukemia	19	21.5	88	53	138
Cancer of Other Lymphatic Tissue	14	11.2	125	69	210
Benign Neoplasms	13	7.1	183	97	313
Endocrine, Metabolic Diseases	42	51.6	81	59	110
All Diseases of the Nervous System	197	233.2	84	73	97
All Vascular Lesions of CNS	176	211.3	83	71	97
All Diseases of the Circulatory System	939	1,283.8	73	69	78
Arteriosclerotic Heart Disease	769	1,031.8	75	69	80
All Respiratory Diseases	78	158.1	49	39	62
Emphysema	26	44.6	58	38	85
All Diseases of the Digestive System	71	129.2	55	43	69
Cirrhosis of Liver	25	60.5	41	27	61
All Diseases of G-U System	21	43.0	49	30	75
All External Causes of Death	138	245.0	56	47	67
All Accidents	88	170.6	52	41	64
Unknown	73				

DISCUSSION

The most outstanding result of this study is the large deficit of deaths seen for all the leading causes of death. Although an overall SMR less than 100 is expected because of the 'healthy worker effect', the all causes SMR of 72 is lower than is usually seen in studies of this size ana length of follow-up. Except for that in the refinery worker study by Gaffey et al.[5] which had only 10 years of follow-up, this SMR is lower than those reported in all other mortality studies of petroleum workers.[4,5,7,10]

Several factors may have favorably influenced the overall SMR. One is that new Texaco employes are required to pass a preemployment physical examination; however, any selection effect should not extend beyond the first few years of employment. Because of wage and health care benefits provided to Texaco employes, persons who remain with Texaco have access to a comfortable standard of living and quality medical care. It was anticipated that excluding those employed less than five years might have lowered some SMRs or obscured some excess cause of death, but this is not the case. The SMRs are consistently lower for those employed one year or more. and the pattern of deaths is the same as for those employed five years or more.

There are a few causes of death for which the SMR is greater than 100. These are cancer of the pancreas. cancer of the brain, leukemia, cancer of other lymphatic tissue, and benign neoplasms. Mortality from these causes has also been elevated in other studies of petroleum workers. Cancer of the pancreas and cancer of the brain in particular have been associated with refinery employment.[2,5,7] However, in this study the SMR's for each of these two causes are increased less than 10%, much less than the increases seen in other studies. The largest SMR observed is 144, each is based on an excess of seven or fewer deaths, and none is statistically significant. These excesses seem small and insignificant when compared with the number and size of the deficits.

It should be noted that many of the causes of death with large deficits are causes for which mortality rates have declined dramatically over the past 50 years and/or are diseases where medical technology and preventive medicine have had an impact. This can be seen particularly in the SMR of 27 for parasitic and infective diseases. This is a category of diseases where a good standard of living and access to medical care would be expected to have a substantial effect in reducing mortality. This same effect would be expected to a lesser extent and is seen for causes such as cancer of the large intestine, stroke, and heart disease.

In contrast, those causes of deaths mentioned above as having elevated SMRs are causes for which no means of prevention are known and for which survival is generally very short after diagnosis. Therefore, the 'healthy worker effect' and access to medical care would not be expected to have any impact on these causes of death. It is, therefore, expected that mortality from these causes would not be significantly different from the general U.S. population.

Plant specific mortality patterns were also examined and in general resembled those for the total cohort. However, the SMRs which were elevated for the total cohort were not consistently elevated at all locations. Except for the largest refineries which have process units not found at the smaller refineries, all the refineries have similar process units and, therefore, similar on-the-job exposures. If mortality is, in fact, associated with employment, the same patterns should be seen at all refineries large enough to provide a stable estimate of the SMR. The fact that the elevated SMRs were not seen at all refineries argues against an association with refinery employment.

Other studies of petroleum workers have shown excesses for cancers of the digestive system,[3,4,5] cancer of the stomach,* cancer of the lung,[1,2,3,11] and cancer of the skin.[1,4] Elevations for these causes were not seen in the Texaco cohort. In fact. for cancer of the digestive organs, cancer of the stomach, and cancer of the lung, a statistically significant deficit is seen. Recent toxicology studies in animals have associated exposure to gasoline with an increased risk *of* kidney cancer', and at least one other refinery worker cohort study has shown an elevated SMR for kidney cancer.' No indication of an excess risk of kidney cancer was seen for the TMS cohort. The lower SMR for cancer of the lung (SMR = 58) is particularly interesting and is probably due to the nonsmoking rules in effect throughout the plants.

The possibility remains that by looking at mortality in the cohort as a whole. excess risks of death associated with employment in a specific job or at a specific unit have been obscured. Further studies of this cohort will include an analysis of mortality by specific jobs ana case-control studies of those causes of death which were elevated in th[illegible]r other studies of refine[illegible]

* Personal communication with the American Petroleum Institute.

REFERENCES

1. Blot WJ, Brinton LA. Fraumeni JF et al.: Cancer mortality in **U.S.** counties with petroleum industries. Science 198:51-53, 1977.

2. Thomas TL, Decoufle P, Moure-Eraso R: Mortality among workers employed in petroleum refining and petrochemical plants. JOM 22:97-103, 1980.

3. Hanis NM, Stavraky KM, Fowler JL: Cancer mortality in oil refinery workers. JOM 21:167-174, 1979.

4. Rushton L, Alderson MR: An epidemiological survey of eight oil refineries in Britain. Br J Ind Med 38:225-234, 1981.

5. Theriault G, Goulet I: A mortality study of oil refinery workers. JOM 21:367-370, 1979.

6. Thomas TL, Waxweiler RJ, Moure-Eraso R, et al.: Mortality patterns among workers in three Texas oil refineries. JOM 24:135-141, 1982.

7. Hanis NM, Holmes TM, Shallenberger LG et al.: Epidemiologic study of refinery and chemical plant workers. JOM 24:203-212, 1982.

8. Gaffey W, Weaver NK, Tabershaw IPA: Mortality Study of Petroleum Refinery Workers. Washington, D.C.: The American Petroleum Institute, 1974.

9. Monson RR: Analysis of relative survival and proportional mortality. Comput Biomed Res 7:325-332, 1972.

10. Wen CP, Tsai SP, Weiss NS, et al.: A population- based cohort study of brain tumor mortality among oil refinery workers with a discussion of methodological issues of **SMR** and PMR, in Banbury Report 9: Quantification of Occupational Cancer, Peto R, Schneiderman M, ed. Cold Spring Harbor Laboratory, 1981, pp 413-432.

11. Gottlieb MS: Lung cancer and the petroleum industry in Louisiana. JOM 22:384-388, 1980.

II. PATTERNS OF MORTALITY AMONG NONWHITE MALES AND AMONG FEMALES

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ABSTRACT

An earlier report on the Texaco Mortality Study discussed overall patterns of mortality in white male refinery. petrochemical, and research workers who were employed at least five years at a participating location and who worked sometime between January 1, 1947, and December 31, 1977. The standardized mortality ratio (SMR) for all causes of death was 72, and large deficits were seen for all the major causes of death. For a few causes of death the SMR was greater than 100; however, none was statistically significant, and all were based on a few deaths. This is a similar analysis of mortality for the nonwhite males and the females in the cohort. The all causes SMR for nonwhite males is 69, and again, large deficits are seen for all the major causes of death. Elevated SMRs are seen for a few causes of death, but each is based on three or fewer deaths, and none is statistically significant, The all causes SMR was also low for females; however, the percentage of females lost to follow-up is extremely high (24%), and the results should be interpreted with caution.

INTRODUCTION

The previous paper on the Texaco Mortality Study (TMS) was concerned with patterns of mortality among the white males in the study cohort.[1] This study showed a large deficit for all the major causes of death. There were a few causes of death for which the standardized mortality ratio (SMR) was greater than 100. However, for none of these causes of death was the increase statistically significant, and both the increased risk and the increased number of deaths are very small. This paper is a similar description of the patterns of mortality among the nonwhite males and the females in the TMS cohort.

METHODS

The cohort eligibility requirements and the data collection methods are the same as described in the paper on white males.

RESULTS

There were 1,061 nonwhite males, 1,105 white females, and 64 nonwhite females eligible for inclusion in the TMS cohort. Table 1 shows the vital status breakdown of the cohort as of the study end date of December 31, 1977. For nonwhite males, the percentage with vital status unknown is only 1.6; however, for white females 23.7% have vital status unknown. Sixteen percent of the nonwhite males and 6.5% of the white females are deceased. Because of the small number of nonwhite females, they are combined with the white females in the remainder of the paper.

Table 2 shows each group by year of birth as well as the breakdown for the deaths. For nonwhite males, over one-third were born after 1940. For females, over one-half of the group was born in the 1920s and 1930s. The distribution by year of birth for white males was more evenly distributed throughout.[1] In contrast, about one-half of the deaths in each group were born before 1910. Table 3 shows the distribution of each group and the deaths by year first employed. In contrast to the white males where over one-third were employed before 1940,[1] more than 90% of the total group was first employed in the 1940s and later. While the percentages are not as large, a substantial proportion of the deaths were also first employed after 1940; over three-quarters of the white male deaths were first employed before 1940.[1]

More than 70% of the nonwhites were either still employed at the end of the study or left in the last three years. In comparison, white females left regularly throughout the study time period, and only 28.1% were actively employed at the closing date of the study. Few in any group were retired, and almost half of the white females had resigned. In contrast, almost half of the white males were still employed at the study end date and over one quarter had retired.[1]

Table 4 shows the distribution of the groups by length of employment. For each total group, the largest percentage is in the five to nine years of employment category, and for the deaths, the largest percentage is in the 10 to 19 years of employment category. This is in contrast to the white males where over 60% of the total and over 75% of the deaths were employed 20 years or more. More than half of each group was employed less than 20 years whereas for white males over half were employed 30 years or more.[1]

Table 5 shows the breakdown of deaths by year of death. Approximately half of each group died between 1970-1977. Table 6 shows the distribution of the deaths by age at death. For nonwhite males and females. the distributions are similar; however, higher percentages died at earlier ages and lower percentages in the older age groups than the white males.'

Patterns of Mortality

Persons for whom vital status was unknown were assumed to be alive in the analysis of mortality. For nonwhites, the percentage is so small that ?he assumption is unlikely to have affected the results. For white females. the percent lost to follow-up is so large that the results should be interpreted with caution.

Analysis of mortality was performed using the Monson program' to compare the observed and expected number of deaths. For nonwhite males, the U.S. nonwhite male population was used as the comparison group, and for females the U.S. white female population was used.

Table 7 shows the observed and expected number of deaths for the major causes of death, the SMRs, and their upper and lower confidence limits (95%) for nonwhite males. SMRs are not calculated when the number of observed deaths is less than five. There were 253.4 expected deaths and 176 observed, giving an all causes SMR of 69. All of the major causes of death show substantial deficits. There are a few causes of death for which the observed number of deaths is greater than the expected number (cancer of the pancreas, cancer of the brain, cancer of the skin, cancer of other lymphatic tissue, benign neoplasms, and emphysema). However, each is based on three or fewer deaths, and the confidence limits are very wide and include 100 in every case.

Table 8 is a similar table for females. There were 104.8 expected deaths and 77 observed for an all causes SMR of 73. Again, most of the major causes of death show large deficits. However, in contrast to both male cohorts, cancer of the lung shows an elevated SMR of 174 although the confidence limits include 100. In several other instances, the observed number of deaths is greater than expected (cancer of the bladder, cancer of the brain, leukemia, cancer of other lymphatic tissue, and all diseases of the genito-urinary system); however, again all are based on three or fewer deaths, and the confidence limits are very wide and include 100.

DISCUSSION

As in the study of mortality among white males, the most striking result of this study is the large deficit of deaths seen for all the leading causes of death. The patterns of mortality seen for nonwhite males are very similar to those reported earlier for white males.' Although the actual number of deaths is very small for each cause, more than expected numbers of deaths for the nonwhite cohort are observed for the same causes of death as for white males, namely cancer of the pancreas, cancer of the brain, cancer of other lymphatic tissue, and benign neoplasms. Subsequent case-control studies of these causes of death in white males will attempt to determine if these elevations are associated with job-specific employment in the petroleum industry.

While the results for females must be interpreted with caution because of the high percentage with vital status unknown, it is interesting that the size *of* the deficit in mortality is similar to that for males. It is also interesting that while a deficit is seen for cancer of the lung in males, an excess is seen for females. However, since the largest portion of the females would have worked in office areas where there are no restrictions on smoking, this is not totally surprising. Because the females traditionally worked in jobs with little or no chemical exposures, it seems highly unlikely that the excess is associated with employment in the petroleum industry.

Nonwhite males and females show a number of differences in the breakdown by demographic characteristics when compared with the white males. In particular, the nonwhite males and females tend to be younger and to have worked for shorter time periods. For both these groups, this is due to the fact that substantial numbers were not hired until the 1960s and later. In addition, for females this reflects their tendency to work for a few years and then resign because of marriage or pregnancy, which also may explain the high percentage lost-to-follow-up.

Because both of these groups are young and have more recent employment, it will be many more years before the number of deaths is large enough to provide more definitive answers about the relationship of employment in the petroleum industry and mortality in nonwhites and females.

REFERENCES

1. Divine BJ. Barron V, and Kaplan SD: The Texaco Mortality Study. I. Patterns of mortality among white male refinery, petrochemical, and research workers. (Submitted for publication.)

2. Monson RR: Analysis of relative survival and proportional mortality. *Comput Biomed Res* 7:325-332, 1974.

TABLE 1

VITAL STATUS FOR NONWHITE MALES, FEMALES

AS OF DECEMBER 31, 1977

	Vital Status			
	Alive	Dead	Unknown	Total
Nonwhite Males	868	176	17	1,061
White Females	771	72	262	1,105
Nonwhite Females	56	5	3	64

TABLE 2

NONWHITE MALES, FEMALES

BY YEAR OF BIRTH

	Total Cohort				Deaths			
	Nonwhite Males Number	(%)	Females Number	(%)	Nonwhite Males Number	(%)	Females Number	(%)
Before 1900	56	(5.3)	37	(3.2)	45	(25.6)	20	(26.0)
1900-1909	98	(9.2)	91	(7.8)	43	(24.4)	17	(22.1)
1910-1919	201	(18.9)	198	(16.9)	50	(28.4)	20	(26.0)
1920-1929	243	(22.9)	402	(34.4)				
1930-1939	104	(9.8)	238	(20.4)	38	(21.6)	20	(26.0)
1940 & After	359	(33.8)	203	(17.4)				
Total	1.061		1.169		176		77	

TABLE 3

NONWHITE MALES, FEMALES

BY YEAR FIRST EMPLOYED

	Total Cohort		Deaths	
	Nonwhite Males Number(%)	Females Number(%)	Nonwhite Males Number(%)	Females Number(%)
Before 1940	17 (1.6)	97 (8.3)	11 (6.3)	25 (32.5)
1940-1949	429 (40.4)	528 (45.2)	141 (80.1)	43 (55.8)
1950-1959	169 (15.9)	274 (23.4)		
1960-1969	216 (20.4)	175 (15.0)	24 (13.6)	9 (11.7)
1970 & After	230 (21.7)	97 (8.3)		
Total	1,061	1,169	176	77

TABLE 4

NONWHITE MALES, FEMALES

BY LENGTH OF EMPLOYMENT

	Total Cohort		Deaths	
	Nonwhite Males Number(%)	Females Number(%)	Nonwhite Males Number(%)	Females Number(%)
5— 9 Years	441 (41.6)	599 (51.2)	23 (13.1)	18 (23.4)
10—19 Years	171 (16.1)	250 (21.4)	77 (43.8)	27 (35.1)
20—29 Years	258 (24.3)	187 (16.0)	59 (33.5)	22 (28.6)
30+ Years	191 (18.0)	133 (11.4)	17 (9.7)	10 (13.0)
Total	1,061	1,169	176	77

TABLE 5

NONWHITE MALES, FEMALES

DEATHS BY YEAR OF DEATH

	NWM Number(%)		Females Number(%)	
1947-1949	1	(0.6)	0	
1950-1959	27	(15.3)	11	(14.3)
1960-1969	57	(32.4)	27	(35.1)
1970-1977	91	(51.7)	38	(49.4)
Unknown			1	(1.3)
Total	176		77	

TABLE 6

NONWHITE MALES, FEMALES

DEATHS BY AGE AT DEATH

	NWM Number(%)		Females Number(%)	
Under 40	14	(8.0)	8	(10.4)
40-49	29	(16.5)	15	(19.5)
50-59	47	(26.7)	16	(20.8)
60-69	47	(26.7)	20	(26.0)
70-79	35	(19.9)	12	(15.6)
80 & Over	4	(2.3)	5	(6.5)
Unknown			1	(1.3)
Total	176		77	

TABLE 7

SMRs FOR SELECTED CAUSES OF DEATH

NONWHITE MALES, 1947-1977

Cause	Observed	Expected	SMR	LCL	UCL
All Causes of Death	176	253.4	69	60	81
All Infective & Parasitic Diseases	2	8.4	—	3	86
All Malignant Neoplasms	30	43.5	69	47	99
Cancer of the Digestive Organs	11	14.4	76	38	137
Cancer of the Stomach	3	4.0	—	15	221
Cancer of the Large Intestine	1	2.7	—	0	207
Cancer of the Pancreas	3	2.4	—	25	362
Cancer of the Lung	9	12.7	71	32	135
Cancer of the Prostate	0	4.2	—	0	87
Cancer of the Kidney	0	0.7	—	0	537
Cancer of the Bladder	0	1.0	—	0	382
Cancer of the Skin	1	0.3	—	5	2,229
Cancer of the Brain	2	0.6	—	38	1,216
Lymphosarcoma & Reticulosarcoma	0	0.6	—	0	666
Hodgkin's Disease	0	0.4	—	0	997
Leukemia	0	1.1	—	0	332
Cancer of Other Lymphatic Tissue	2	1.1	—	21	677
Benign Neoplasms	2	0.6	—	36	1,148
Endocrine, Metabolic Diseases	5	5.4	92	30	215
All Diseases of the Nervous System	21	27.9	75	47	115
All Vascular Lesions of CNS	17	25.6	67	39	106
All Diseases of the Circulatory System	66	89.7	74	57	94
Arteriosclerotic Heart Disease	48	56.9	84	62	112
All Respiratory Diseases	6	13.8	43	16	94
Emphysema	3	1.6	—	37	539
All Diseases of the Digestive System	1	12.6	—	0	44
Cirrhosis of Liver	0	6.5	—	0	56
All Diseases of G-U System	6	7.2	84	31	182
All External Causes of Death	27	31.9	85	56	123
All Accidents	15	18.3	82	46	135
Unknown	4				

TABLE 8

SMRs FOR SELECTED CAUSES OF DEATH

ALL FEMALES, 1947-1977

Cause	Observed	Expected	SMR	LCL	UCL
All Causes of Death	77	104.9	73	58	92
All Infective & Parasitic Diseases	1	1.5	—	1	375
All Malignant Neoplasms	24	31.5	76	49	114
Cancer of the Digestive Organs	1	7.3	—	0	77
Cancer of the Stomach	1	1.0	—	1	547
Cancer of the Large Intestine	0	3.1	—	0	117
Cancer of the Pancreas	0	1.2	—	0	305
Cancer of the Lung	5	2.9	174	56	406
Cancer of the Breast	4	7.7	—	14	134
Cancer of the Kidney	0	0.4	—	0	825
Cancer of the Bladder	1	0.3	—	4	1,801
Cancer of the Skin	0	0.5	—	0	741
Cancer of the Brain	1	0.9	—	1	599
Lymphosarcoma & Reticulosarcoma	0	0.6	—	0	577
Hodgkin's Disease	0	0.4	—	0	990
Leukemia	2	1.1	—	21	676
Cancer of Other Lymphatic Tissue	1	0.6	—	2	925
Benign Neoplasms	0	0.6	—	0	600
Endocrine, Metabolic Diseases	0	3.5	—	0	105
All Diseases of the Nervous System	9	10.8	83	38	158
All Vascular Lesions of CNS	9	9.5	95	43	180
All Diseases of the Circulatory System	22	33.7	65	41	99
Arteriosclerotic Heart Disease	16	23.7	67	39	110
All Respiratory Diseases	3	3.9	—	15	223
Emphysema	0	0.6	—	0	666
All, Diseases of the Digestive System	3	5.5	—	11	159
Cirrhosis of Liver	0	2.9	—	0	127
All Diseases of G-U System	3	1.9	—	32	460
All External Causes of Death	7	8.1	86	34	177
All Accidents	4	5.1	—	21	202
Unknown	4				

III. ANALYSIS OF MORTALITY BY JOB AND CASE-CONTROL STUDIES OF SPECIFIC CAUSES OF DEATH

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INTRODUCTION

The introductory paper on the Texaco Mortality Study (TMS) cohort was concerned with overall patterns of mortality among white male employes. The major result of the study was a large deficit for all the major causes of death. There were a few causes of death where the standardized mortality ratio (SMR) was greater than 100. However. the increases were small. and none were statistically significant. The question still remained whether an increased risk of mortality in a small sub-group of workers was obscured in the analysis of the cohort as a whole. In addition. a further examination of those causes of death with elevated SMRs was desired in order to determine if there were work areas where the decedents had clustered and which were not common to the whole cohort.

This paper is an analvsis of the mortality patterns for white males employed in specific jobs in order to determine if any workplace characteristics are associated with an increased risk of mortality. Two different types of studies are used: the first is an analysis of the overall patterns of death for sub-groups employed in specific jobs. and the second is a series of case-control studies of those causes with elevated SMR's. In addition, two other causes of death which have Seen suggested as being associated with employment in the refining industry are included in the case-control studies.

METHODS

The cohort eligibility requirements and the data collection methods were those described in the previous papers. In addition to the demographic data. available work history data were also used. All persons without work history records had to be excluded from this analysis.

Each job held by an employe consisted of a unit (e.g. crude still, maintenance), a task (e.g. operator, pipefitter), and the dates that position was held. Each combination of task and unit title was coded into one of approximately 1.200 exposure categories, based on the American Petroleum Institute (API) Job Code Classification System of Petroleum Refineries and Seiected Petrochemical Operations (1979).

Job history coding accounted for all periods of time between the cohort member's initial hire date and final termination date, or the common closing date. Periods of not working for one month or longer were coded.

Because of numerous job changes over relatively short periods of time, a method was developed for selecting jobs to be coded on each work history. An employe's initial job was coded. Subsequent jobs to be coded were identified by scanning the work history for the next job that began at least six months later and had a different task or unit code. This process continued until the employe transferred, terminated. or died, or until the study end date was reached. When one or more jobs were held concurrently, they were all coded. If any of three conditions existed, however, a job change was coded, regardless of this 'six-month sample' method. These conditions were:

- Transfer to another facility.
- Employment in a task or unit defined in advance.
- Periods of nonwork due to personal, military, or medical leaves of absence of one month or longer.

To obtain estimates of intra-coder reliability and inter-coder validity for the job history coding, a systemaiic sample of employe work histories was selected for duplicate coding by the original coder and for recoding by a randomly selected alternate coder. As noted below, no significant differences between the original coding and the duplicate coding were found.

The 28 process units and 40 job tasks were condensed to 18 process groups. based on similar process feed stocks, raw materials, or produced products. and 12 job task groups, according to similar craft and maintenance activities (see Appendix I for a listing of each grouping). These groupings were developed after consultation with industrial hygiene and plant personnel.

For the case-control portion of the study, the six case groups consist of all white males with a work history record whose underlying cause of death was: 1) cancer of the pancreas (n = 62); 2) neoplasm of the brain benign or unspecified (n = 12) and malignant (n = 31); 3) leukemia (n = 48); 4) other cancers of the lymphatic and hematopoietic tissues including Hodgkin's Disease (n = 13), lymphosarcoma and reticulosarcoma (n = 20) and unspecified (n = 24): 5) cancer of the stomach (n = **44);** and 6) cancer of the kidney (n = 24). One lymphatic cancer case and one stomach cancer case were excluded because their work histories could not be located Each case group was analyzed separately using the same control group for all analyses.

The control group was randomly selected from the cohort of noncase white males who had a work history record and who had died after the age of 30. The demographic characteristics of the control group were compared with those for the cohort of all white male decedents, and no significant differences were observed.

1. Demographic Characteristics: type of facility, year of hire, year of death, age at death; and

RESULTS

Coding Reliability and Validity

It was found that 97.1% of the duplicate coding matched on length of employment and 96.8% of the randomly selected alternate coder records agreed with the original. In only one of the 644 records that were recoded by the same coder was a different decision made as to eligibility for the total cohort. There was no disagreement on eligibility in the 636 records that were recoded by a different coder.

Each job was matched on the date started, and agreement on unit code, job code, and plant code was checked. It was found that 8.5% of the job codes on the reliability check and 12.6% on the validity check did not have a corresponding job starting on that date. Because of the complex coding rules regarding multiple jobs, this rate of disagreement is generally satisfactory. The error rates for the plant code are approximately 1.7% for the reliability check and 0.8% for the validity check.

Patterns of Mortality

There were 18.798 white males who were eligible for inclusion in the cohort and for whom work histories were located. Two hundred eighty-six white males had only demographic data available and, therefore. had to be excluded from this analysis.

There were 70.163 task-unit combinations recorded for the total cohort. The average length of time a job was held was 6.2 years giving 434.668 person years of employment. The job with the greatest number of person years was pipefitter in maintenance. The job held the most number of times was yard laborer in maintenance. although the average length of time spent in the job was short (two years).

Table 1 shows the number of white males employed five years or more in specific jobs, the observed and expected numbers of deaths. and the SMRs associated with each. It should be noted that all of the overall SMRs are less than 100. and most of these deficits are statistically significant.

Table 2 shows the number of observed and expected deaths and the SMRs for the four leading causes of death. all malignant neoplasms. vascular lesions of the central nervous system (CNS), arteriosclerotic heart disease. and accidents. SMRs are not calculated when there are fewer than five deaths. For malignant neoplasms, there are two job categories where the SMR is greater than 100, cleaners in maintenance and yard laborers in maintenance. For accidents. the SMR is elevated for one job category, boilermakers in maintenance. For vascular lesions of the CNS. there are four job categories where the SMR is greater than 100, the delayed coking unit. lube oil refining, equipment operators, and electricians. For heart disease, there are five categories where the SMR is greater than 100. lube oil refining, the solvent dewaxing unit, the asphalt plant. the delayed coking unit, and the treating unit. In every instance, however, the increased number of deaths is less than eight, and none are statistically significant. Therefore, it is most likely that these elevated SMRs are due to chance and are not due to the workplace environment.

Those causes of death which are elevated for the total cohort are also elevated for some of the job-specific groups. However, it is felt that the case-control analyses provide more information in terms of whether the association is meaningful. Further discussions will. therefore, be limited to the results of the case-control studies. It should be noted in interpreting the results of the case-control studies that several of the following criteria should hold for an association to be considered further; i.e., that it is compatible with a causal association. The results should be statistically significant, i.e. both confidence limits are above one; the results should be consistent for both the ever worked and the longest job held categories; the length of employment in that job category should be longer for the cases than for the controls; and it should make sense from a biological point of view. Furthermore, because of the laws of probability, when using the 95% confidence limits, one out of every twenty tests may be expected to show a statistically significant result due to chance alone. Because of the large number of tests done as part of these studies, many of the elevated rate ratios (RR) are likely to be due to chance.

Pancreas Cancer

Table 3 shows the rate ratios for the pancreas cancer cases and controls. The cases who ever worked in the asphalt plants have a RR of 2.9. The RR is 4.4 if this position was the longest job held. However, the adjusted average job duration for the cases is two years shorter than the controls for those ever employed in asphalt plants, and 9 years shorter for the cases whose longest job was on this process unit. The cases who ever worked in packaging and shipping (P&S) departments were there for an average of five years longer, but the RR is 1.1. For those cases and controls whose longest employment was in P&S. the RR is 2.7, but the standardized job duration is roughly the same.

None of the specific job tasks have rate ratios statistically different from 1.0 except for the manager category with RR = 1.8. but the average job duration is shorter for the pancreas cases. Any exposure relating to disease might have occurred in jobs held previous to this job. but is unlikely since no consistent patterns for other jobs ever held are seen. Regardless of whether an employe was ever employed or held his longest job as manager in the maintenance department. the RR is elevated, 2.2 and 2.9. respectively. with roughly equivalent durations of employment between ?he pancreas cases and the controls. These managers probably worked in maintenance activities for most of their employment: however. the RR for all jobs in maintenance is only 1.2.

The RR for controlman as the longest job held in the P&S departments is 3.2, and the cases worked an average of four years longer. No other rate ratios are significant at the 5% level, and no job duration patterns are observed. It appears most likely that any elevaiions in pancreas cancer are due to some unknown lifestyle factors and not to the workplace. Other factors which have been associated with pancreas cancer include coffee drinking, alcohol use. and smoking.

Brain Neoplasms- Malignant, Benign, and Unspecified

Some important demographic differences between the cases and the controls are seen due to the short survival time and the younger ages which are generally affected by these types of tumors. The cases are more likely to have begun employment after the 1940s (51% vs 23%), and to have died before age 65 (80% vs 46%).

Because of the early age at onset and the short survival time for brain tumors, most persons who were employed very early. i.e. before 1940, and developed brain tumors probably did not survive long enough to be included in the study. Although the time employed may have overlapped with many others in the cohort, anyone dying or terminated before January 1, 1947, was not eligible for the study. This cohort will be followed further in order to determine if this difference in time first employed diminishes in later years.

Table 4 shows the rate ratios associated with the various job categories. For those ever having been employed in the quality control laboratories, or for whom this was the longest job held, the RR is elevated, 3.0 and 4.1, respectively. The adjusted average job duration is five years longer for the cases than the controls ever employed in these laboratories, but the same for the longest job held. If employment in the research laboratories is also included. the RR remains elevated at 3.4 and 3.9 for ever worked and longest job held, respectively. However, the difference in the average duration is much less. While no specific job task in the laboratory shows significant excess risk, the RRs for all laboratory job tasks are 2.9 for the ever employed category and 2.7 for the longest job held. The adjusted job duration is slightly less for the cases than the controls.

The RR for ever being employed in the paraffin, refrigeration, and ammonia plant process is 3.4, with a two-year average job duration for the cases and over six years for the controls. None of the cases held this job as their longest job. When employment at the filter plant, paraffin, lube oil extraction, and solvent dewaxing units are combined into lube oil refining processes, the RR is 3.6 for ever working on these units and 4.1 for the longest employment. The adjusted average job duration is shorter for the cases than the controls. the difference being approximately a year for those ever employed in these process units to over seven years for the longest employment. Therefore, none of these results are likely to be meaningful.

The RR for longest job in the filter plant is 7.3. However, only two cases and three controls were so employed on this unit with the cases working an average of 16 years longer than the controls. The confidence limits are extremely wide, and this result is most likely due to chance. While the welder job task has a RR of 2.6 for ever employed and 3.7 for longest job held, no clear job duration trend exists.

The RR for ever being employed in general maintenance tasks is 1.1 with an average duration of five years for the cases and three years for the controls: however, if these tasks were the longest job held, the RR is *3.2.* Here, the cases have a shorter average job duration than the controls.

The only association with brain tumors which meets the criteria outlined above is the association with employment in the quality control laboratories and to a lesser extent with employment in both quality control and research laboratories. If there is a meaningful association, however, there is still no indication of what specific chemicals might be involved. Furthermore, most of these decedents were first employed *30* or more years ago. Laboratory work practices have changed dramatically over the past 20 years through automation of test procedures and advances in the design of laboratory ventilation. Future studies of this group will be carried out to determine if the association disappears over time as anticipated.

Leukemia

Table 5 shows the rate ratios for the leukemia cases and controls. The only process units which show RRs significantly different from 1.0 are utilities and lube oil refining. Light ends processes have a RR of

2.3 for ever employed. but the 95% confidence intervals are 0.8 to 6.1, and no job duration trend is indicated. The RR for the asphalt plant is 2.6 and is on the borderline of being statistically significant. However, the controls were employed six years longer than the cases, and for no cases was this the longest job held. All other process units have RRs near or below 1.0.

The controlmen in utilities show a RR of 2.8 for ever worked and 5.1 for longest job held, but the average job duration for the longest job held is seven years shorter for the cases than the controls and roughly equivalent for ever employed. The asphalt plant has a RR of 2.6, but the cases worked only half the time of the controls on this unit. No cases worked their longest job in the asphalt plant. Ever working in lube oil refining processes shows a RR of 3.2. but for only one case was the longest employment on this unit. Again. the cases worked a much shorter average time on this unit than the controls.

The only job task with a significantly elevated RR is longest job as a pipefitter in maintenance and yard activities (RR = 2.8), but the standardized average employment duration is nearly the same.

Thus, it is unlikely that employment in any of the jobs is associated with leukemia. Although other studies have associated benzene exposure with an excess risk of leukemia, it is striking that no excess risk is found in those job categories where there may be potential exposure to benzene (product handling, catalytic reforming units, petrochemicals, laboratories, and maintenance).

Lymphatic Cancer, Excluding Leukemia

Significant differences are observed for several demographic characteristics. Even with small numbers. a higher proportion of the cases than the controls were last employed in petrochemical facilities (5% vs 1%). The cases were more likely to have begun employment after 1940 (39% vs 23%) and they died, on the average, five years younger. By adjusting the average duration, using the controls as a standard, some of these factors have been taken into account.

Table 6 shows the rate ratios for the lymphatic cancer cases and controls. Most of the process units show no association except for those ever employed in the fluid catalytic cracking unit (FCCU). While the RR is 3.1, the adjusted duration for the cases is equivalent to the controls, showing no length of employment effect. For those whose longest employment was on the FCCU, the RR is 1.8 (0.6-5.5) with the adjusted duration for the cases being four years longer than the controls. Controlmen who ever worked on the FCCU have a RR of 3.0, and controlmen whose longest job was in the Receipt. Storage, and Movement department have a RR *of* 2.5, but the average job durations are roughly equivalent. When looking at the longest job as controlman on the FCCU or ever employed as controlman in RS&M, the RR is not statistically significant, but the cases worked an average of four years longer than the controls. Again, these associations are not consistent with a causal association.

Stomach Cancer

Even though the SMR for stomach cancer in the white male cohort is significantly low, some workplace associations are statistically significant (see Table 7). The stomach cancer cases are more likely than the controls to have ever worked in maintenance and yard activities, specifically yard laborer and cleaner job tasks, but the average duration in those jobs for cases and controls is nearly the same. When considering the longest employment in these units and tasks, the RR is not statistically different from one, but the number of cases is small.

The lube oil refining process units have a RR *of* 5.1 for those ever employed, but the average job duration is only half as long for the cases as the controls. The RR for longest employment on these units is 1.3 (0.2-10.5), based on only one case. Longest employment in the gas plant has a RR of 5.1, but this is based on two cases and four controls. The other job task ever held with an elevated RR is metal working. but the cases again have a shorter job duration than the controls. Only two cases were employed in this task the longest. and the RR is 1.0 (0.2-4.3). Examination of the structural steel task group shows a RR of 1.6 (0.9-2.9) for those ever employed in these jobs an3 1.9 for the longest job held. The average job durations between the cases and controls are not substantially different.

Because of the lack of any apparent timetrend, i.e. jobs where the RR is high and the cases employed longer than the controls. these associations are not likely to be important.

Kidnev Cancer

All of the RRs calculated for process units and job tasks are below or near 1.0 (see Table 8) with the exception of ever being employed as manager in the maintenance department (2.5) with an adjusted average duration of nearly 15 years for the cases and 10 years for the controls. The rate ratio is 5.4 for this category when examining the longest job held. but the average years worked are roughly equivalent. Kidney cancer cases whose longest job was yard laborer in maintenance have a RR of 5.1, but worked an average of six years less than the comparisons.

Although toxicology studies in animals have associated an excess risk of kidney cancer with exposure to gasoline and other middle distillates, such an association was not seen here, i.e. no associations were found with those jcb categories where there may be potential exposures to gasoline and middle distillates (product handling, catalytic reforming, thermal cracking, light ends, catalytic cracking, treating, and laboratories).

TABLE 1

NUMBER EMPLOYED FIVE YEARS OR MORE IN SPECIFIC JOBS, DEATHS FROM ALL CAUSES AND STANDARDIZED MORTALITY RATIOS, 1947-1977

	Number	Observed Deaths	Expected Deaths	SMR
Total Cohort	18,798	3,984	5,307.1	75•
Managers, Office Personnel	4.923	1,146	1,672.0	69•
All Operating Personnel	7,745	1,875	2,454.6	76•
Product Handling	1.209	294	388.0	76•
Crude Stills	1,109	431	562.7	77*
Catalytic Cracking	1,040	252	321.3	78*
Lube Oil Refining	271	78	96.9	80
Solvent Dewaxing	106	26	40.5	64•
Treating	402	131	165.9	79*
Light Ends	480	104	150.6	69*
Asphalt Plant	314	121	136.9	88
Delayed Coking	285	102	107.5	95
Research, Quality Control Lab	2.200	297	478.5	62*
Quality Control Lab	930	161	240.6	67•
Laboratory Staff	1,883	255	418.7	61•
All Maintenance Personnel	8,075	1,917	2,477.6	77*
Cleaners	190	71	94.3	75•
Electricians	816	121	169.7	71•
Insulators	255	57	88.2	65•
Yard Laborers	1,074	299	400.6	75•
Equipment Operators	521	157	203.5	77•
Pipefitters	1,325	320	414.7	77•
Boilermakers	341	128	1510	85
Structural Steel	2.931	705	920.1	77•

• p ± 0.05

TABLE 2
OBSERVED AND EXPECTED DEATHS
AND STANDARDIZED MORTALITY RATIOS
FOR SELECTED CAUSES,
1947-1977

WHITE MALES EMPLOYED FIVE YEARS OR MORE
IN SPECIFIC JOBS

JOB	Malignant Neoplasms Obsvd. Deaths	Malignant Neoplasms Expctd. Deaths	Malignant Neoplasms SMR	Vascular Lesions of CNS Obsvd. Deaths	Vascular Lesions of CNS Expctd. Deaths	Vascular Lesions of CNS SMR
Total Cohort	762	1,015.7	75*	321	403.0	80*
Managers, Office Staff	211	321.7	66*	92	133.5	69*
Operating Personnel	348	471.0	74*	152	187.9	81*
Product Handling	57	74.8	76*	20	29.3	68
Crude Stills	64	107.3	60*	37	47.8	77
Catalytic Cracking	44	63.5	69*	19	23.1	82
Lube Oil Refining	18	19.1	94	7	6.8	103
Solvent Dewaxing	4	8.0	—	2	2.8	—
Treating	20	32.4	62*	11	12.7	86
Light Ends	16	30.3	53*	5	10.4	48
Asphalt Plant	16	26.2	61*	7	10.9	64
Delayed Coking	16	20.6	78	14	8.6	163
Research, Quality Control Lab	58	94.5	61*	22	29.6	74
Quality Control Lab	39	47.7	82	14	15.5	91
Laboratory Staff	52	82.8	63*	19	25.8	74
Maintenance Personnel	404	474.2	85'	169	190.1	89
Cleaners	21	18.0	117	6	8.1	74
Electricians	25	33.7	74	11	10.9	101
Insulators	11	16.9	65	6	6.8	89
Yard Laborers	80	75.8	105	29	32.9	88
Equipment Operators	31	38.6	80	19	16.9	113
Pipefitters	70	79.7	88	23	31.8	72
Boilermakers	21	28.5	74	10	13.0	77
Structural Steel	155	176.7	88	51	70.2	73*

* $p \pm 0.05$

TABLE 2—continued

OBSERVED AND EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS FOR SELECTED CAUSES, 1947-1977

WHITE MALES EMPLOYED FIVE YEARS OR MORE IN SPECIFIC JOBS

JOB	Heart Disease Obsvd. Deaths	Heart Disease Expctd. Deaths	Heart Disease SMR	Accidents Obsvd. Deaths	Accidents Expctd. Deaths	Accidents SMR
Total Cohort	1,608	2,001.7	80*	151	288.7	52*
Managers, Office Staff	474	642.3	74*	43	77.1	56*
Operating Personnel	768	930.4	83*	67	128.4	52*
Product Handling	131	147.3	89	10	20.6	49*
Crude Stills	196	218.7	90	13	22.2	58
Catalytic Cracking	104	122.8	85	15	16.7	90
Lube Oil Refining	37	36.8	101	1	5.1	—
Solvent Dewaxing	17	15.4	110	0	2.2	—
Treating	71	63.8	111	5	7.7	65
Light Ends	38	57.9	66'	6	7.7	78
Asphalt Plant	54	52.3	103	5	6.4	78
Delayed Coking	45	41.2	109	4	5.0	—
Research, Quality Control Lab	117	177.0	66*	21	32.7	64*
Quality Control Lab	58	90.1	64*	9	15.0	60
Laboratory Staff	100	155.0	65*	18	28.5	63*
Maintenance Personnel	772	936.2	82*	63	132.2	48*
Cleaners	21	36.5	58*	2	3.8	—
Electricians	52	63.3	82	6	10.9	55
Insulators	17	33.5	51*	2	4.6	—
Yard Laborers	97	152.3	64*	4	19.3	—
Equipment Operators	67	77.7	86	3	9.5	—
Pipefitters	133	157.5	84	11	21.7	51*
Boilermakers	56	57.9	97	7	6.4	110
Structural Steel	308	348.7	88*	17	48.6	35*

* $p \pm 0.05$

TABLE 3

PANCREAS CANCER CASE-CONTROL ANALYSIS RESULTS

PROCESS UNIT	Never So Employed Cases	Never So Employed Controls	Ever So Employed Cases	Ever So Employed Controls	Ever So Employed RR(95%CI)	Ever So Employed Av.Duration**	Longest Job Held Cases	Longest Job Held Controls	Longest Job Held RR(95%CI)	Longest Job Held Av.Duration**
Maintenance & Yard (M&Y)	10	84	52	366	1.2 (0.6, 2.4)	15.2, 13.8	29	187	1.2 (0.7, 2.1)	24.5, 23.7
Packaging & Shipping (P&S)	49	365	13	85	1.1 (0.6, 2.2)	14.2, 8.7	6	17	2.7 (1.1, 7.0)	27.7, 28.8
Crude, Vacuum Pipe Still (CVPS)	52	342	10	108	0.6 (0.3, 1.2)	14.7, 11.4	5	43	0.8 (0.3, 2.2)	24.0, 22.9
Receipt, Storage & Movement (RS&M)	56	380	6	70	0.5 (0.2, 1.4)	17.4, 10.3	3	25	0.9 (0.3, 3.0)	27.8, 24.8
Fluid Catalytic Cracking (FCC)	54	414	8	36	1.7 (0.8, 3.8)	9.5, 11.2	1	18	0.4 (0.1, 2.8)	10.4, 15.4
Delayed Coking, Pressure Coking (DC)	57	397	5	53	0.7 (0.3, 1.7)	1.0, 2.9	0	4	--	-- , 16.0
Multi-Processes*	55	422	7	28	1.9 (0.8, 4.5)	6.8, 6.6	0	3	--	-- , 23.4
Office - General*	51	341	11	109	0.7 (0.3, 1.3)	12.2, 12.7	6	50	0.8 (0.3, 2.0)	19.6, 24.2
Research & Quality Control Labs.*	55	409	7	41	1.3 (0.5, 3.0)	13.5, 15.5	3	25	0.9 (0.3, 3.0)	28.9, 23.6
Asphalt Plant Facilities*	55	431	7	19	2.9 (1.2, 6.9)	8.5, 10.5	4	7	4.4 (1.4, 13.9)	13.6, 22.7
JOB TASKS										
Controlman	22	160	40	290	1.0 (0.6, 1.7)	16.8, 15.9	25	170	1.1 (0.7, 1.9)	24.7, 23.6
Manager	32	294	30	156	1.8 (1.0, 3.0)	14.3, 16.2	13	81	1.2 (0.6, 2.3)	24.3, 25.5
Machinist	53	394	9	56	1.2 (0.6, 2.6)	12.6, 12.8	5	28	1.3 (0.5, 3.6)	20.2, 21.3
Pipefitter	46	331	16	119	1.0 (0.5, 1.8)	6.4, 7.1	4	36	0.8 (0.3, 2.3)	17.5, 19.5
Yard Work	31	209	31	241	0.9 (0.5, 1.5)	2.7, 2.8	2	16	0.9 (0.2, 4.0)	14.1, 16.7
Equipment Operator	55	398	7	52	1.0 (0.4, 2.3)	5.4, 6.4	1	7	1.0 (0.1, 8.6)	10.9, 22.1
Cleaner	54	378	8	72	0.8 (0.4, 1.7)	1.6, 1.8	0	4	--	-- , 13.1
Painter	60	419	2	31	0.5 (0.1, 1.9)	1.1, 7.6	0	10	--	-- , 20.3
Structural Steel*	35	265	27	185	1.1 (0.7, 1.9)	9.9, 10.0	11	74	1.1 (0.6, 2.2)	19.3, 20.9
Carpenter, Insulator, Mason*	59	377	3	73	0.3 (0.1, 0.8)	28.8, 6.7	3	19	1.1 (0.3, 3.9)	28.8, 22.5
Electrical*	57	429	5	21	1.8 (0.7, 4.9)	14.4, 12.8	3	11	2.0 (0.6, 7.3)	13.7, 17.9
Laboratory Work - General*	56	412	6	38	1.2 (0.5, 2.9)	8.8, 13.3	1	21	0.3 (0.1, 2.3)	26.7, 20.3
Metal Work*	57	405	5	45	0.8 (0.3, 2.1)	5.5, 12.2	0	21	--	-- , 22.2
Craft & Maintenance*	10	85	52	365	1.2 (0.6, 2.5)	13.1, 12.9	21	177	0.8 (0.5, 1.4)	22.3, 23.0
SPECIFIC PROCESS UNIT - JOB TASK										
M&Y - Manager	48	397	14	53	2.2 (1.1, 4.2)	12.1, 10.3	6	16	2.9 (1.1, 7.4)	21.5, 21.1
P&S - Controlman	50	372	12	78	1.1 (0.6, 2.3)	13.0, 7.1	5	12	3.2 (1.2, 8.9)	30.0, 26.4
CVPS - Controlman	52	348	10	102	0.7 (0.3, 1.3)	14.0, 11.3	5	42	0.9 (0.3, 2.2)	23.6, 21.8
M&Y - Pipefitter	46	332	16	118	1.0 (0.5, 1.8)	6.4, 6.9	4	34	0.8 (0.3, 2.5)	17.6, 19.7
RS&M - Controlman	56	384	6	66	0.6 (0.3, 1.5)	14.3, 8.3	3	20	1.1 (0.3, 3.8)	23.9, 21.0
M&Y - Machinist	53	394	5	56	1.2 (0.6, 2.6)	11.4, 12.6	4	29	1.0 (0.3, 3.0)	22.1, 20.9
M&Y - Yard Work	31	210	31	240	0.9 (0.5, 1.5)	2.7, 2.8	2	17	0.8 (0.2, 3.8)	14.1, 15.9
Office - Manager	58	402	4	48	0.6 (0.2, 1.6)	8.8, 16.7	3	30	0.7 (0.2, 2.4)	25.9, 24.5

* grouped category

** In years; first number is for cases [illegible] for controls. Cases [illegible] adjusted as described in text

TABLE 4

BRAIN TUMOR CASE-CONTROL ANALYSIS RESULTS

	Never So Employed		Ever So Employed				Longest Job Held			
	Cases	Controls	Cases	Controls	RR(95%CI)	Av.Duration**	Cases	Controls	RR(95%CI)	Av.Duration**
PROCESS UNIT										
Maintenance & Yard (M&Y)	9	84	34	366	0.9 (0.4, 1.9)	11.8, 13.8	19	187	1.1 (0.6, 2.1)	19.2, 23.7
Quality Control Laboratories (QCL)	36	423	7	27	3.0 (1.3, 7.2)	19.6, 14.2	5	14	4.1 (1.5,11.1)	25.5, 25.3
Receipt, Storage & Movement (RS&M)	35	380	8	70	1.2 (0.6, 2.8)	9.3, 10.3	2	25	0.8 (0.2, 3.6)	32.8, 24.8
Filter	41	436	2	14	1.5 (0.3, 6.9)	37.2, 6.3	2	3	7.3 (1.5,34.7)	37.2, 21.3
Packaging & Shipping (P&S)	36	365	7	85	0.8 (0.4, 1.9)	8.8, 8.7	3	17	1.9 (0.6, 6.7)	19.2, 28.8
Paraffin, Refrig.& Ammonia (PR&A)	38	433	5	17	3.4 (1.2, 9.1)	2.3, 6.7	0	3	--	-- , 26.7
Office - General*	37	341	6	109	0.5 (0.2, 1.2)	8.0, 12.7	2	50	0.4 (0.1, 1.6)	18.5, 24.2
Research & Quality Control Labs.*	32	409	11	41	3.4 (1.7, 7.0)	16.4, 15.5	8	25	3.9 (1.7, 8.8)	20.4, 23.6
	38	434	5	16	3.6 (1.3, 9.7)	10.9, 12.3	3	8	4.1 (1.2,14.7)	14.1, 21.6
JOB TASKS										
Controlman	16	160	27	290	0.9 (0.5, 1.8)	12.8, 15.9	13	170	0.7 (0.4, 1.4)	22.8, 23.6
Technical Laboratory Work	37	421	6	29	2.4 (0.9, 5.9)	12.5, 12.6	3	16	2.0 (0.6, 7.1)	22.5, 19.4
Welder	39	433	4	17	2.6 (0.9, 7.8)	17.7, 15.1	3	9	3.7 (1.0,13.0)	22.0, 22.5
Manager	36	294	7	156	0.4 (0.2, 0.8)	13.0, 16.2	4	81	0.5 (0.2, 1.3)	20.3, 25.5
Yard Worker	22	209	21	241	0.8 (0.4, 1.6)	3.6, 2.8	3	16	2.0 (0.6, 7.1)	16.0, 16.7
Pipefitter	31	331	12	119	1.1 (0.5, 2.2)	4.5, 7.1	3	36	0.9 (0.3, 2.9)	14.2, 19.5
Cleaner	37	378	6	72	0.9 (0.4, 2.1)	1.9, 1.8	0	4	--	-- , 13.1
Painter	38	419	5	31	1.8 (0.7, 4.8)	7.3, 7.6	1	10	1.0 (0.1, 8.4)	4.4, 20.3
Equipment Operator	40	398	3	52	0.6 (0.2, 1.9)	13.4, 6.4	2	7	3.1 (0.7,14.2)	12.8, 22.1
Structural Steel*	27	265	16	185	0.8 (0.5, 1.6)	4.8, 10.0	5	74	0.7 (0.3, 1.8)	12.3, 20.9
General Maintenance Tasks*	18	195	25	255	1.1 (0.6, 2.0)	5.1, 3.4	6	22	3.2 (1.3, 7.9)	15.6, 17.4
Carpenter, Insulator, Mason*	39	[illegible]	4	73	0.5 (0.2, 1.5)	7.7, 6.7	1	19	0.5 (0.1, 4.0)	28.8, 22.5
Electrical*	39	429	4	21	2.1 (0.7, 6.3)	8.9, 12.8	2	11	1.9 (0.4, 8.9)	17.1, 17.9
Laboratory Work - General*	34	412	9	38	2.9 (1.3, 6.2)	11.7, 13.3	5	21	2.7 (1.0, 7.3)	16.1, 20.3
[illegible] Work*	37	405	6	45	1.5 (0.6, 3.6)	17.1, 12.2	4	21	2.1 (0.7, 6.3)	24.0, 22.2
Craft & Maintenance*	8	85	35	365	1.0 (0.5, 2.3)	12.3, 12.9	21	177	1.5 (0.8, 2.8)	18.9, 23.0
SPECIFIC PROCESS UNIT - JOB TASK										
QLC - Technical	39	431	4	19	2.3 (0.8, 7.0)	16.5, 12.2	2	8	2.7 (0.6,12.4)	31.4, 23.6
RS&M - Controlman	35	384	8	66	1.3 (0.6, 3.0)	7.8, 8.3	2	20	1.0 (0.2, 4.7)	27.0, 21.0
Filter - Controlman	41	436	2	14	1.5 (0.3, 6.9)	37.2, 6.3	2	3	7.3 (1.5,34.7)	37.2, 21.3
M&Y - Yard Work	22	210	21	240	0.8 (0.5, 1.6)	3.6, 2.8	4	17	2.6 (0.9, 7.8)	13.9, 15.9
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.4, 7.1	3	12	2.7 (0.8, 9.6)	15.4, 26.4
M&Y - Welder	[illegible]	[illegible]					0	4	--	-- , 12.7
M&Y - Cleaner	37	382	6	68	0.9 (0.4, 2.2)	1.9, 1.8	2	8	2.7 (0.6,12.4)	12.8, 20.3
M&Y - Equipment Operator	40	401	3	49	0.6 (0.2, 2.0)	13.4, 6.5				

* g o ped c t g ry

** In y a s; first umber is f r a es sec n f r c nt ols Ca y rs adjus d as describ d in text

TABLE 5

LEUKEMIA CASE-CONTROL ANALYSIS RESULTS

	Never So Employed		Ever So Employed				Longest Job Held			
	Cases	Controls	Cases	Controls	RR(95%CI)	Av.Duration**	Cases	Controls	RR(95%CI)	Av.Duration**
PROCESS UNIT										
Maintenance & Yard (M&Y)	8	84	40	366	1.1 (0.5, 2.5)	14.6, 13.8	23	187	1.3 (0.7, 2.4)	23.7, 23.7
Office	45	402	3	48	0.6 (0.2, 1.8)	20.6, 16.7	2	30	0.6 (0.1, 2.6)	29.9, 24.5
Warehouse	42	411	6	39	1.5 (0.6, 3.8)	10.4, 11.2	1	11	0.8 (0.1, 6.7)	32.4, 17.8
Utilities	41	422	7	28	2.6 (1.1, 6.1)	8.7, 10.1	5	11	4.6 (1.7, 12.8)	10.8, 21.4
Receipt, Storage & Movement (RS&M)	41	380	7	70	0.9 (0.4, 2.2)	4.9, 10.3	1	25	0.4 (0.1, 2.5)	32.8, 24.8
Crude, Vacuum Pipe Still (CVPS)	40	342	8	108	0.6 (0.3, 1.4)	4.9, 11.4	1	43	0.2 (0.1, 1.2)	12.9, 22.9
Delayed Coking, Pressure Coking (DC)	43	397	5	53	0.9 (0.3, 2.3)	7.5, 2.9	1	4	2.4 (0.3, 20.3)	28.1, 16.0
Packaging*	35	335	13	115	1.1 (0.6, 2.1)	8.9, 10.2	0	28	--	-- , 29.4
Research & Quality Control Labs*	44	409	4	41	0.9 (0.3, 2.7)	22.2, 15.5	1	25	0.4 (0.1, 2.5)	17.2, 23.6
Asphalt Plant Facilities*	43	431	5	19	2.6 (1.0, 7.2)	4.7, 10.5	-	7	--	-- , 22.7
Catalytic Cracking*	44	414	4	36	1.0 (0.4, 3.1)	12.0, 11.2	1	18	0.5 (0.1, 3.8)	10.4, 15.4
Light Ends*	43	428	5	22	2.3 (0.8, 6.1)	8.7, 11.9	1	9	1.0 (0.1, 8.4)	28.9, 23.0
Lube Oil Refining*	43	434	5	16	3.2 (1.2, 8.6)	4.3, 12.3	1	8	1.2 (0.1, 9.6)	6.3, 21.6
JOB TASKS										
Controlman	12	160	36	290	1.7 (0.8, 3.3)	12.6, 15.9	17	170	0.9 (0.5, 1.7)	21.8, 23.6
Manager	32	294	16	156	0.9 (0.5, 1.8)	14.5, 16.2	8	81	0.9 (0.4, 2.0)	23.4, 25.5
Pipefitter	32	331	16	119	1.4 (0.7, 2.6)	11.5, 7.1	9	36	2.7 (1.2, 5.8)	18.9, 19.5
Yard Work	20	209	28	241	1.2 (0.7, 2.2)	3.0, 2.8	3	16	1.8 (0.5, 6.3)	16.9, 16.7
Cleaner	39	378	9	72	1.2 (0.6, 2.6)	0.8, 1.8	0	4	--	-- , 13.1
Equipment Operator	41	398	7	52	1.3 (0.6, 3.1)	7.4, 6.4	2	7	2.8 (0.6, 12.8)	12.8, 22.1
Painter	46	419	2	31	0.6 (0.1, 2.5)	1.1, 7.6	0	10	--	-- , 20.3
Machinist	44	394	4	56	0.6 (0.2, 1.8)	19.4, 12.8	3	28	1.0 (0.3, 3.4)	25.3, 21.3
Carpenter	45	418	3	32	0.9 (0.3, 3.0)	17.2, 10.5	2	13	1.5 (0.3, 6.6)	22.1, 22.7
Structural Steel*	29	265	19	185	0.9 (0.5, 1.7)	14.5, 10.0	12	74	1.7 (0.9, 2.4)	21.3, 20.9
Carpenter, Insulator, Mason*	40	377	8	73	1.0 (0.5, 2.3)	10.6, 6.7	3	19	1.5 (0.4, 5.2)	24.8, 22.5
Laboratory Work - General*	44	412	4	38	1.0 (0.3, 2.9)	1.7, 13.3	1	21	0.4 (0.3, 3.1)	17.2, 20.3
Metal Work*	42	405	6	45	1.3 (0.5, 3.2)	8.5, 12.2	1	21	0.4 (0.1, 3.1)	27.4, 22.2
Craft & Maintenance*	28	85	20	365	1.2 (0.5, 2.6)	14.2, 12.9	23	177	1.4 (0.8, 2.6)	23.3, 23.0
SPECIFIC PROCESS UNIT - JOB TASK										
M&Y - Pipefitter	32	332	16	118	1.4 (0.8, 2.7)	11.2, 6.9	9	34	2.8 (1.3, 6.1)	19.0, 19.7
Office - Manager	45	402	3	48	0.6 (0.2, 1.8)	20.6, 16.7	2	30	0.6 (0.1, 2.6)	29.9, 24.5
M&Y - Yard Work	20	210	28	240	1.2 (0.7, 2.2)	3.0, 2.8	3	17	1.7 (0.5, 5.9)	16.9, 15.9
P&S - Controlman	40	372	8	78	1.0 (0.4, 2.1)	3.0, 7.1	0	12	--	-- , 26.4
M&Y - Cleaner	40	382	8	68	1.1 (0.5, 2.5)	0.8, 1.8	0	4	--	-- , 12.7
Utilities - Controlman	41	424	7	26	2.8 (1.2, 6.6)	8.5, 8.5	5	10	5.1 (1.9, 14.1)	10.8, 16.2
M&Y - Machinist	44	394	4	56	0.6 (0.2, 1.8)	19.4, 12.8	3	29	1.0 (0.3, 3.3)	25.3, 20.9
M&Y - Carpenter	45	419	3	31	0.9 (0.3, 3.1)	16.9, 10.2	2	12	1.6 (0.4, 7.2)	21.9, 23.2

* Grouped category

** In years; first number is for cases, second for controls. Case years adjusted as described in text.

TABLE 6

LYMPHATIC CANCER (EXCEPT LEUKEMIA) CASE-CONTROL ANALYSIS RESULTS

	Never So Employed		Ever So Employed				Longest Job Held			
	Cases	Controls	Cases	Controls	RR(95%CI)	Av.Duration**	Cases	Controls	RR(95%CI)	Av.Duration**
PROCESS UNIT										
Maintenance & Yard (M&Y)	13	84	45	366	0.9 (0.4, 1.7)	14.1, 13.8	23	187	1.0 (0.5, 1.7)	25.1, 23.7
Fluid Catalytic Cracking (FCC)	46	414	12	36	3.1 (1.5, 6.1)	11.2, 11.2	4	18	1.8 (0.6, 5.5)	19.7, 15.4
Receipt, Storage & Movement (RS&M)	48	380	10	70	1.2 (0.6, 2.4)	14.1, 10.3	6	25	2.0 (0.8, 5.0)	22.8, 24.8
Packaging & Shipping (P&S)	46	365	12	85	1.1 (0.6, 2.3)	9.2, 8.7	4	17	1.9 (0.6, 5.8)	20.7, 28.8
Crude, Vacuum Pipe Still (CVPS)	44	342	14	108	1.0 (0.5, 2.0)	8.3, 11.4	5	43	0.9 (0.4, 2.4)	16.5, 22.9
Warehouse	50	411	8	39	1.7 (0.8, 3.9)	6.0, 11.2	2	11	1.4 (0.3, 6.6)	9.5, 17.8
Delayed Coking, Pressure Coking (DC)	48	397	10	53	1.6 (0.8, 3.3)	1.0, 2.9	0	4	--	-- , 16.0
Office - General*	44	341	14	109	1.0 (0.5, 1.9)	6.8, 12.7	3	50	0.4 (0.1, 1.4)	24.3, 24.2
JOB TASKS										
Controlman	17	160	41	290	1.4 (0.8, 2.6)	15.2, 15.9	24	170	1.2 (0.7, 2.1)	22.0, 23.6
Manager	45	294	13	156	0.6 (0.3, 1.1)	15.5, 16.2	9	81	0.9 (0.4, 1.8)	21.0, 25.5
Yard Work	33	209	25	241	0.7 (0.4, 1.2)	5.9, 2.8	3	16	1.5 (0.4, 5.3)	26.1, 16.7
Pipefitter	42	331	16	119	1.1 (0.6, 2.0)	8.2, 7.1	5	36	1.1 (0.4, 3.0)	23.5, 19.5
Cleaner	45	378	13	72	1.6 (0.8, 3.0)	2.9, 1.8	2	4	4.0 (0.8,19.7)	20.7, 13.1
Equipment Operator	51	398	7	52	1.1 (0.5, 2.5)	8.8, 6.4	2	7	2.3 (0.5,10.7)	21.5, 22.1
Structural Steel*	34	265	24	185	1.0 (0.6, 1.8)	9.0, 10.0	8	74	0.8 (0.4, 1.8)	23.5, 20.9
Carpenter, Insulator, Mason*	47	377	11	73	1.2 (0.6, 2.5)	8.5, 6.7	4	19	1.7 (0.6, 5.1)	22.2, 22.5
Electrical*	56	429	2	21	0.7 (0.2, 3.2)	0.8, 12.8	0	11	--	-- , 17.9
Laboratory Work - General*	54	412	4	38	0.8 (0.3, 2.4)	6.3, 13.3	1	21	0.4 (0.1, 2.5)	10.5, 20.3
Metal Work*	52	405	6	45	1.1 (0.4, 2.6)	7.8, 12.2	2	21	0.7 (0.2, 3.2)	20.7, 22.2
Craft & Maintenance*	11	85	47	365	1.1 (0.5, 2.3)	13.3, 12.9	24	177	1.1 (0.6, 2.0)	23.8, 23.0
SPECIFIC PROCESS UNIT - JOB TASK										
M&Y - Yard Work	33	210	25	240	0.7 (0.4, 1.2)	5.9, 2.8	3	17	1.4 (0.4, 5.0)	26.1, 15.9
RS&M - Controlman	48	384	10	66	1.2 (0.6, 2.6)	12.3, 8.3	6	20	2.5 (1.0, 6.4)	19.7, 21.0
FCC - Controlman	47	417	11	33	3.0 (1.5, 6.2)	10.7, 11.8	3	18	1.3 (0.4, 4.7)	20.5, 15.4
CVPS - Controlman	45	348	13	102	1.0 (0.5, 2.0)	8.4, 11.3	4	42	0.7 (0.3, 2.1)	18.0, 21.8
M&Y - Pipefitter	42	332	16	118	1.1 (0.6, 2.0)	6.9, 6.9	4	34	0.9 (0.3, 2.7)	22.7, 19.7
P&S - Controlman	46	372	12	78	1.3 (0.6, 2.5)	4.8, 7.1	2	12	1.3 (0.3, 6.0)	8.1, 26.4
M&Y - Cleaner	47	382	11	68	1.3 (0.7, 2.7)	3.3, 1.8	2	4	4.0 (0.8,19.7)	8.3, 12.7

* Grouped category

** In years; first number is for cases, second for controls. Case years adjusted as described in text

TABLE 7

STOMACH CANCER CASE-CONTROL ANALYSIS RESULTS

	Never So Employed		Ever So Employed				Longest Job Held			
PROCESS UNIT	Cases	Controls	Cases	Controls	RR(95%CI)	Av.Duration**	Cases	Controls	RR(95%CI)	Av.Duration**
Maintenance & Yard (M&Y)	3	84	41	366	3.1 (1.0, 9.8)	14.2, 13.8	21	187	1.3 (0.7, 2.4)	24.9, 23.7
Receipt, Storage & Movement (RS&M)	40	380	4	70	0.5 (0.2, 1.5)	21.2, 10.3	3	25	1.2 (0.4, 4.3)	27.8, 22.9
Crude, Vacuum Pipe Still (CVPS)	33	342	11	108	1.1 (0.5, 2.2)	6.3, 11.4	1	43	0.2 (0.1, 1.4)	27.5, 22.9
Research Laboratories	42	436	2	14	1.5 (0.3, 6.7)	26.5, 18.0	2	11	1.9 (0.4, 8.7)	26.5, 21.4
Packaging & Shipping (P&S)	35	365	9	85	1.1 (0.5, 2.4)	5.5, 8.7	1	17	0.6 (0.1, 4.5)	33.2, 28.8
Gas Plant	41	434	3	16	2.0 (0.6, 6.9)	23.5, 10.7	2	4	5.3 (1.1,25.0)	33.9, 25.3
Treating	39	419	5	31	1.7 (0.6, 4.7)	5.2, 7.3	1	10	1.0 (0.1, 8.2)	13.6, 17.0
Utilities	40	422	4	28	1.5 (0.5, 4.5)	13.5, 10.1	2	11	1.9 (0.4, 8.7)	25.2, 21.4
Office - General*	33	341	11	109	1.0 (0.5, 2.1)	6.6, 12.7	2	50	0.4 (0.1, 1.5)	18.5, 24.2
Research & Quality Control Labs.*	39	409	5	41	1.3 (0.5, 3.4)	12.7, 15.5	2	25	0.8 (0.2, 3.5)	26.7, 23.6
Light Ends*	39	428	5	22	2.5 (0.9, 6.7)	14.1, 11.9	2	9	2.3 (0.5,10.7)	28.9, 23.0
Catalytic Cracking*	39	414	5	36	1.5 (0.6, 4.0)	10.1, 11.2	2	18	1.1 (0.3, 5.1)	19.7, 15.4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JOB TASKS										
Controlman	10	160	34	290	1.9 (0.9, 3.9)	16.8, 15.9	19	170	1.3 (0.7, 2.3)	26.9, 23.6
Machinist	35	394	9	56	1.8 (0.8, 3.9)	13.2, 12.8	5	28	1.9 (0.7, 5.2)	20.2, 21.3
Pipefitter	30	331	14	119	1.3 (0.7, 2.5)	6.7, 7.1	4	36	1.2 (0.4, 3.4)	20.2, 19.5
Yard Work	13	209	31	241	2.1 (1.1, 4.0)	2.6, 2.8	2	16	1.3 (0.3, 5.8)	12.2, 16.7
Cleaner	32	378	12	72	2.0 (1.0, 4.0)	2.4, 1.8	1	4	2.6 (0.3,21.9)	13.0, 13.1
Manager	30	294	14	156	0.9 (0.5, 1.7)	10.5, 16.2	3	81	0.3 (0.1, 1.1)	30.3, 25.5
Equipment Operator	39	398	5	52	1.0 (0.4, 2.6)	6.5, 6.4	1	7	1.5 (0.2,12.1)	25.7, 22.1
Structural Steel*	21	265	23	185	1.6 (0.9, 2.9)	11.6, 10.0	12	74	1.9 (1.0, 3.8)	20.1, 20.9
Carpenter, Insulator, Mason*	41	377	3	73	0.4 (0.1, 1.2)	10.1, 6.7	1	19	0.5 (0.1, 3.9)	28.8, 22.5
Laboratory Work - General*	40	412	4	38	1.1 (0.4, 3.2)	13.9, 13.3	2	21	1.0 (0.2, 4.3)	26.7, 20.3
Metal Work*	34	405	10	45	2.6 (1.3, 5.6)	8.3, 12.2	2	21	1.0 (0.2, 4.3)	27.4, 22.2
Craft & Maintenance*	4	85	40	365	2.3 (0.8, 6.5)	13.5, 12.9	20	177	1.3 (0.7, 2.4)	23.9, 23.0
SPECIFIC PROCESS UNIT - JOB TASK										
M&Y - Machinist	35	394	9	56	1.8 (0.8, 3.9)	13.1, 12.8	5	29	1.9 (0.7, 5.0)	20.3, 20.6
M&Y - Pipefitter	30	332	14	118	1.3 (0.7, 2.6)	6.8, 6.9	4	34	1.2 (0.4, 3.6)	20.4, 19.7
RS&M - Controlman	40	384	4	66	0.6 (0.2, 1.7)	18.3, 8.3	3	20	1.6 (0.5, 5.5)	23.9, 21.0
M&Y - Yard Work	13	210	31	240	2.1 (1.1, 4.1)	2.6, 2.8	2	17	1.2 (0.3, 5.4)	12.2, 15.9
CVPS - Controlman	33	348	11	102	1.1 (0.6, 2.3)	6.4, 11.3	1	42	0.2 (0.1, 1.4)	27.1, 21.8
P&S - Controlman	35	372	9	78	1.2 (0.6, 2.7)	5.2, 7.1	1	12	0.8 (0.1, 6.7)	30.0, 26.4
M&Y - Cleaner	32	382	12	68	2.1 (1.1, 4.2)	2.4, 1.8	1	4	2.6 (0.3,21.9)	13.0, 12.7
Utilities - Controlman	40	424	4	26	1.6 (0.5, 4.9)	13.9, 8.5	2	10	2.1 (0.5, 9.6)	26.0, 16.2
GP - Controlman	41	434	3	16	2.0 (0.6, 6.9)	22.8, 10.3	2	5	4.2 (0.9,19.8)	32.8, 21.9
M&Y - Structural Steel	39	417	5	33	1.6 (0.6, 4.4)	12.7, 8.6	2	10	2.1 (0.5, 9.6)	29.1, 21.7
FCC - Controlman	40	417	4	33	1.3 (0.4, 3.7)	11.9, 11.8	3	18	1.8 (0.5, 6.1)	15.5, 15.4

* Grouped category

** In years: first number is for cases second for controls. Case years adjusted as described in text

ABLE 8

KIDNEY CANCER CASE CONTROL ANALYSIS RESULTS

	Never So Employed		Ever So Employed				Longest Job Held			
	Cases	Controls	Cases	Controls	RR(95%CI)	Av.Duration**	Cases	Controls	RR(95%CI)	Av.Duration**
PROCESS UNIT										
Maintenance & Yard (M&Y)	5	84	19	366	0.8 (0.3, 2.4)	17.0, 13.8	13	187	1.7 (0.7, 3.8)	22.5, 23.7
Crude, Vacuum Pipe Still (CVPS)	20	342	4	108	0.6 (0.2, 1.9)	12.2, 11.4	3	43	1.4 (0.4, 4.7)	16.7, 22.9
Receipt, Storage & Movement (RS&M)	20	380	4	70	1.1 (0.4, 3.3)	13.4, 10.3	2	25	1.5 (0.4, 6.9)	25.3, 24.8
Packaging & Shipping (P&S)	20	365	4	85	0.9 (0.3, 2.6)	9.2, 8.7	1	17	1.0 (0.1, 8.2)	33.2, 28.8
Delayed Coking, Pressure Coking (DC)	21	397	3	53	1.1 (0.3, 3.7)	1.0, 2.9	0	4	--	-- , 16.0
Treating	22	419	2	31	1.2 (0.3, 5.5)	1.6, 7.3	0	10	--	-- , 17.0
Catalytic Cracking*	22	414	2	36	1.0 (0.2, 4.6)	9.7, 11.2	1	18	1.0 (0.1, 8.2)	17.4, 15.4
Packaging*	19	335	5	115	0.8 (0.3, 2.1)	20.2, 10.2	3	28	2.2 (0.6, 7.5)	33.1, 29.4
JOB TASKS										
Controlman	8	160	16	290	1.1 (0.5, 2.6)	15.5, 15.9	9	170	1.0 (0.4, 2.3)	26.3, 23.6
Manager	14	294	10	156	1.3 (0.6, 3.1)	13.3, 16.2	5	81	1.2 (0.4, 3.3)	21.8, 25.5
Yard Work	13	209	11	241	0.7 (0.3, 1.7)	5.0, 2.8	2	16	2.5 (0.6,10.9)	14.1, 16.7
Pipefitter	18	331	6	119	0.9 (0.4, 2.4)	6.7, 7.1	3	36	1.6 (0.5, 5.7)	11.3, 19.5
Machinist	21	394	3	56	1.0 (0.3, 3.5)	10.8, 12.8	1	28	0.7 (0.1, 5.0)	12.5, 21.3
Carpenter	21	418	3	32	1.9 (0.5, 6.5)	10.1, 6.4	2	13	3.1 (0.7,13.4)	27.9, 22.7
Equipment Operator	20	398	4	52	1.5 (0.5, 4.6)	2.9, 6.4	1	7	2.8 (0.4,21.4)	10.9, 22.1
Cleaner	20	378	4	72	1.1 (0.3, 3.2)	2.4, 1.8	0	4	--	-- , 13.1
Structural Steel*	13	265	11	185	1.2 (0.5, 2.8)	7.7, 10.0	4	74	1.1 (0.3, 3.1)	11,5, 20.9
General Maintenance Tasks*	11	195	13	255	0.9 (0.4, 2.1)	4.4, 3.4	4	22	3.9 (1.3,11.5)	10.8, 17.4
Carpenter, Insulator, Mason*	19	377	5	73	1.4 (0.5, 3.8)	6.3, 6.7	1	19	1.0 (0.1, 7.7)	28.8, 22.5
Metal Work*	21	405	3	45	1.3 (0.4, 4.5)	8.4, 12.2	0	21	--	-- , 22.2
Craft & Maintenance*	5	85	19	365	0.9 (0.3, 2.4)	12.1, 12.9	9	177	0.9 (0.4, 2.2)	16.7, 23.0
SPECIFIC PROCESS UNIT - JOB TASK										
M&Y - Manager	18	397	6	53	2.5 (1.0, 6.4)	14.6, 10.3	4	16	5.4 (1.9,15.8)	19.1, 21.1
M&Y - Yard Work	13	210	11	240	0.7 (0.3, 1.7)	5.0, 2.3	4	17	5.1 (1.8,14.8)	10.9, 15.9
CVPS - Controlman	20	348	4	101	0.7 (0.2, 2.0)	12.1, 11.3	3	42	1.4 (0.4, 4.8)	16.5, 21.8
RS&M - Controlman	20	384	4	66	1.2 (0.4, 3.5)	12.0, 8.3	2	20	2.0 (0.4, 8.7)	22.4, 21.0
M&Y - Pipefitter	18	332	6	118	0.9 (0.4, 2.4)	6.7, 6.9	3	34	1.7 (0.5, 6.1)	11.3, 19.7
P&S - Controlman	20	372	4	78	1.0 (0.3, 2.9)	8.4, 7.1	1	12	1.6 (0.2,12.5)	30.0, 26.4
M&Y - Machinist	21	394	3	56	1.0 (0.3, 3.5)	10.8, 12.8	1	29	0.6 (0.1, 4.8)	12.5, 20.9
M&Y - Carpenter	21	419	3	31	1.9 (0.6, 6.7)	10.1, 10.2	1	12	1.[illegible] (0.2,12.5)	27.9, 23.2
M&Y - Equipment Operator	20	401	4	49	1.6 (0.5, 4.9)	2.9, 6.5	0	8	--	-- , 20.3
M&Y - Cleaner	20	382	4	68	1.1 (0.4, 3.4)	2.5, 1.8	0	4	--	-- , 12.7

* grouped category

** by years; first number is for cases second for controls Case years adjusted as described in text

DISCUSSION

Texaco Mortality Study covers employment at all Texaco locations of refining, petrochemical. and research facilities in operation during 1947 to 1977. For those white males with work histories available, two different types of analyses, cohort studies by job and case-control studies of specific causes of death, were used to determine if any workplace characteristics were more common among those persons dying from certain causes of death than in the rest of the cohort.

In interpreting the work history variables, an understanding of worker movement within the workplace is necessary. Typically, most new employes begin in general yard and maintenance jobs, working there for only a short period of the time, and then moving on to controlman on a specific process unit or specific craft jobs for the remainder of their active employment.

Although an attempt was made to group the job categories by potential exposures and responsibilities, in many instances limited information is available on the potential chemical exposures before the 1970s. Most jobs in a refinery involve exposures to a wide variety of straight chain and aromatic hydrocarbons. Also, most of the decedents in this study began work before 1940 and some as early as 1903. Some jobs, process units, refining techniques, and exposures have changed substantially throughout this century. It is, therefore, impossible to classify a job category by levels of exposure to specific chemicals.

Several limitations are present in this study. No information on lifestyle factors, such as smoking, was available and could not be controlled. Two of the causes of death of interest, pancreas cancer and kidney cancer, have been associated with smoking. However, the **SMRs** for cancer of the lung and diseases of the respiratory system were very low for the totalcohort. No estimates of exposure to specific agents in the workplace are available; therefore, no dose-response trends could be examined, and only length of employment trends are considered in the case-control studies. Possible differences in calendar time between the case groups and the controls are not taken into account. Some exposures encountered during the 1940s and before are likely to be different from exposures in the 1970s. The latency period in the younger and more recent employees may not be adequate to determine if the trends are changing over time. Many comparisons were performed on these data, and some statistically significant results are expected to be due to chance.

The major strengths *of* the study are the large number of persons in the total cohort and the fact that there is a fairly complete characterization of the working lifetime of most of these men for all of the facilities in operation. Follow-up is nearly complete, and the work history records are believed to be accurate. Even with the large numbers in the total cohort, however, the number of persons in many of the job groups is small, particularly in the case-control analyses. The small numbers may preclude the possibility of reaching any definite conclusions.

These results suggest several workplace locations which may be associatedwith increased risk of specific causes of death; however, as noted earlier in the text, most of the associations are not supported by a longer employment duration in the cases than the controls. Those associations which should be examined in future studies to determine if the trends continue over time are summarized below.

Although nearly half of the pancreas cases ever worked in the manager job, the suggestion of an occupational link is not supported by a longer job duration at this time. Seven of the 43 brain tumor cases were ever employed in the quality control laboratories with five cases employed in this unit the longest. Whether using the criteria of ever worked or longest job held, the rate ratios for this job category are consistently elevated. The brain tumor cases worked longer in the laboratories than the controls; 21 vs. 14 years for ever worked, and 28 vs. 25 years for longest job worked, respectively. The rate ratio remains elevated when research laboratory workers are also included, but the difference in average duration is less pronounced. The RRs for general laboratory **job** tasks are also elevated, although the adjusted average time spent in those tasks is slightly less for the brain tumor cases than the controls.

Although the rate ratios for leukemia are elevated for three process units, utilities, asphalt plants, and lube oil refining. the average job duration is considerably shorter for the cases than the controls. **Also.** except for the utilities. the same associations are not seen with longest job held.

Twelve of the 58 lymphatic cancer cases were ever employed on fluid catalytic cracking units (**RR**5 3.1), but there is no difference in the length of employment between the cases and the controls. Duration of employment trends do not support any of the excess RRs for stomach cancer. Six of the **24** kidney cancer cases held a job at the manager level in maintenance and worked an average of nearly five years longer than **the** controls, but the time difference is not apparent in the longest job held analysis.

It is possible that any association of workplace exposure and death from these causes may be due to procedures or workplace practices that have been discontinued. In order to evaluate this possibility, the cohort will need to be updated to see if the trends observed in the 1940s and 1950s continue through the 1970s and 1980s. Industrial hygiene measurements of actual workplace exposures to specific agents were begun in the 1970s and became an ongoing activity in the late 1970s. This information can be used in the future to evaluate exposures in any process units or job tasks indicated by future analyses.

APPENDIX:

JOB TASK AND PROCESS UNIT DESCRIPTIONS

I.A. JOB TASK GROUPINGS

1. **MANAGER**
accountant, administrative assistant, chief chemist, clerical, computer operator, draftsman, employe relations, foreman, manager, nurse, secretary, storekeeper, supervisor—engineer, instrument specialist, professional field staff, salaried technical assistant—cook, gateman, nontechnical field staff, timekeeper, watchman—salesworker

2. **CONTROLMAN, OPERATOR**
bargeman, barrel filler, bottomman, car loader and bracer, coke worker, compressorman, controlman, counterman, dockman, fillerman, fireman, gauger (except coke), helper on a unit (except specific craft), hydrotreater, operator (except driver), pumper, rackman, stillman, tank car tester, treater, truck loader, utilityman, water treater

3. **LAB**
chemist, professional lab staff—lab helper, technical lab staff, tester—bottlewasher, nontechnical lab staff

4. **CARPENTER, INSULATOR, MASON**
carpenter—bricklayer, concrete worker, mason—asbestos worker, gunitor, insulator

5. **PAINTER**
painter, stenciler, sandblaster

6. **ELECTRICAL**
electrician—electric instrumentman, instrument—meterman

7. **METAL WORK**
boilermaker, car repairman—tinsmith—acetylene burner, welder—lead burner

8. **STRUCTURAL STEEL**
.agent, repairman, rigger, steel erector, steel repairman—pipefitter, headupman, heat backup—blacksmith, handyman, machinist, sheetmetal worker, tool repairman

9. **EQUIPMENT OPERATOR**
crane operator, heavy equipment operator, rail operator, special equipment operator, truck, tractor, trailer, railway driver

10. **CLEANER**
drum, still, tank, tube cleaner

11. **GENERAL MAINTENANCE & YARD**
construction, general maintenance—recoverylsalvage—boiler, craft helper, general helper (yard), laborer, maintenance, yard job—mechanic—clerk -1, designer, engineer helper, inspector, meterman, technical field staff

12. **CRAFTS—MAINTENANCE**
Groups 4—11

I.B. PROCESS UNIT GROUPINGS

1 **PRODUCT HANDLING**
bulk oil department, tank batteries, loading rack, product blending and movement, pipeline, pump house, receipt packing and shipping, RP&S docks, receipt storage and movement, water transport, transfer pumping and gauging

2. **CRUDE UNITS**
crude pressure stills, crude unit, crude stills, desalter, pressure pipe stills, vacuum pipe stills, vertical stills, steam stills, lube stills, pressure stills, badger pipe stills

3. **COKING**
delayed coking, pressure coke stills

4. **REFORMING**
crude recovery, hydrotreaters, catalytic reforming, udex, H-2, platformer — aromatics

5. **SULFUR**
sulfur plant, sulfur recovery

6. **CATALYTIC CRACKING**
cracking, fluid catalytic cracking, recovery area

7. **HOLMES-MANLEY PROCESS**
Homes-Manley vertical still, thermal cracking — visbreaking

8. **LIGHT END**
alkylation, isomerization — polymerization — light hydrocarbons — AOSU, compression plant, gas plant, stabilizer

9. **LUBE OIL REFINING**
motor oil unit — lube oil extraction (furfural) — lube oil extraction (propane), deasphalting — solvent dewaxing unit — paraffin plant, refrigeration plant — solvent refinishing, dewaxing plant — coal treating plant — clay treater plant, clay filter plant, filter plant

10. **GREASE**
grease plant

11. **ADDITIVES**
additive plant

12. **ETHYLENE & OLEFINS**
light olefins unit — ethylene

13. **TREATING**
acid plant, agitation, caustic, engine oil treating, heavy oil agitation, heavy oil treaters, light oil treaters, treating, bulk oil agitators, Linde

14. **PACKAGING**
case and canning, packaging and shipping, case and packing, barrel house — bulk oil, compounding, lube oils — storehouse, warehouse

15. **LAB**
analytical lab, **lab,** quality control, product control — research labs