TEXACO MORTALITY STUDY

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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 cohort 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,[2, 7] 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 Study 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	69	22	383	9,685
Eagle Point Plant	869	94	9	972	15,962
El Paso Plant	238	23	19	280	6,150
Houston Office	99	33	6	138	—
Lawrenceville 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	977	189	30	1,197	24,846
Montebello Research Lab	64	4	15	83	1,496
Port Arthur Research Lab	327	37	3	367	6,664
Unknown	0	3	3	3	—
Total	14,609	4,024	444	19,077	365,610

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 all 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 and length of follow-up. Except for that in the refinery worker study by Gaffey et al.[8] 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,[2] 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.[7] 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 and case-control studies of those causes of death which were elevated in this or other studies of refinery workers.

* Personal communication with the American Petroleum Institute.

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