American Journal of Industrial Medicine 11:189-202 (1987)

Texaco Mortality Study: III. A Cohort Study of Producing and Pipeline Workers

Barbara J. Divine, PhD, and Virginia Barron, MS

While there have been numerous epidemiology studies of refinery workers, no studies have been done on producing and pipeline workers. This is a retrospective follow-up study of all persons who were employed for at least 6 months at a Texaco producing or pipeline location and who worked at some time during the period 1946–1980. Of the 11,098 white men in the cohort, 8,964 were alive, 1,886 were known to be dead, and the vital status of the remaining 248 as of December 31, 1980 was unknown. The standardized mortality ratio (SMR) of 63 for all causes was significantly low, on the basis of 2,976 expected deaths. Statistically significant deficits also were seen for all major causes of death. Mortality patterns were also examined for the major job categories in these departments. Similar patterns of mortality were seen, although there was a significant excess of thyroid cancer in those employed as pumper-gaugers. However, it was based on only four cases.

Key words: carcinogens, environmental, longitudinal studies, mortality, neoplasms, crude oil, occupational diseases

INTRODUCTION

The petroleum industry is divided into five major operational segments: exploration, production, transportation, manufacturing, and marketing. While refinery workers (ie, manufacturing) have been the subject of many epidemiologic studies, there are little epidemiologic data on production and pipeline workers whose primary exposure is to crude oils, volatile light ends, and produced gases.

Crude oils contain, in addition to other hydrocarbons, varying amounts of polycyclic aromatic compounds and dissolved gases. Certain crude oils are rich in sulfur-containing compounds (sour crudes) and may have high concentrations of hydrogen sulfide. Additionally, for the average worker, petroleum production may also include rare exposures to other potentially hazardous substances, such as formaldehyde, asbestos, and mercury, as well as more frequent contact with caustics. There are also physical hazards such as explosive vapors, radioactive devices, and noise.

Texaco Inc., Houston, Texis (B.J.D., V.B.).
Ms. Barron's current address is EDS Corp., 7171 Forest Lane, One Forest Plaza, Suite 210. Dallas. TX 75230.
Address reprint requests to Dr. Barbara Divine. Texaco Inc.. P.O. Box 1404, Housron, TX 77251.
Accepted for publication July 8. 1986.

A number of studies have demonstrated that either high- or low-sulfur crude oil will produce skin tumors on rodents following repeated skin applications. Such studies have shown the effect both for crude oil and for fractions boiling at greater than 650°F. A recent toxicology study found certain crude oil fractions to be somewhat to moderately carcinogenic (American Petroleum Institute, unpublished study). In this mouse skin bioassay, 15–50% of the animals developed skin tumors, most of which were malignant. However, an earlier study in humans found no excess incidence of skin cancer in workers potentially exposed to the high-boiling, catalytically-cracked oils that are carcinogenic in toxicology testing [Wade, 1963]. The fact that no adverse effect was seen may reflect industrial hygiene and personal hygiene practices, and the study may not be completely relevant to producing workers exposed only to crude oil and not to cracked crudes.

Although no detailed mortality studies have been reported for workers in the production area of the petroleum industry, a number of studies have been conducted on workers in other segments. Recent epidemiology studies of refinery workers have shown elevated mortality rates for various causes of death including brain tumors, leukemia, stomach cancer, and pancreas cancer [Thomas et al, 1982; Hanis et al, 1982; Divine et al, 1985]; however, rates for the major causes of death were reduced. A study of marketing workers in Great Britain showed elevated mortality for kidney cancer (L. Rushton and M.R. Alderson, unpublished).

However, owing to the differences in working conditions and in substances handled, results of the above studies may not be applicable to producing workers. Producing workers are exposed principally to crude oil, and the primary route of exposure is by skin contact. Refinery workers, on the other hand, may handle the whole range of crude oil to finished products, including chemicals used in the manufacturing process, whereas marketing workers handle only finished products. For the last two groups, the primary route of exposure is inhalation.

This study is a retrospective follow-up study of Texaco producing and pipeline workers who were employed for at least 6 months and who worked between January 1, 1946 and December 31, 1980. The major objective of the study was to determine the patterns of mortality in these workers.

METHODS

The study cohort consists of all employees of Texaco Inc. who ever worked for at least 6 months at a US producing or pipeline location and who also worked for at least 1 day between January I, 1946 and December 31, 1980. Employees who met the eligibility requirements were identified by examination of all personnel folders at the division and district offices.

Data collected on each employee included name, social security number, race, sex, date of birth, and a complete work history, if available. Vital status information for those employees not known to be either dead or still active was obtained from the Social Security Administration (SSA). For those Texas residents with vital status unknown to the SSA, information was requested from the Texas Department of Public Safety. If no other information was available, vital status from the company records was used. Copies of death certificates were obtained either from company files at the time of data collection or from the states where the deaths occurred. All death certificates were coded for underlying cause of death by a nosologist according to the

Eighth Revision rules of the International Classification of Diseases (8th ICD). No conversion to an earlier revision was made as in an earlier Texaco study [Divine et al., 1985; Divine and Barron, 1986].

Complete work histories for each employee were coded. Each job consisted of a unit (eg, maintenance, office), a task (eg, roustabout, pumper-gauger), and the dates that the position was held. The job codes were based on the American Petroleum Institute Job Code Classification System of Petroleum Refineries and Selected Petrochemical Operations [1979] and were developed further in consultation with Texaco industrial hygienists.

Job history coding accounted for all periods of time between the cohort member's initial hire date and final termination date or the study end date, whichever came first. Periods of not working for 1 month or longer were coded as such. When more than one job was held concurrently, all were coded with the same dates, and the person-years were divided evenly among the jobs.

Analysis of mortality was performed using Monson's computer program [Monson, 1974] to compare the observed and expected number of deaths, with the US white male population as the comparison group. Person-years were accrued beginning when the person met the cohort eligibility requirements or with the study start date, whichever came later. Those persons with vital status unknown were assumed to be lost to study on the date last observed. For subcohort analyses, ie, for those employed for a certain number of years or in a specific job group, person-years were accrued when the person had met the eligibility criteria or on the study start date, whichever came later.

Because of the large number of different tasks and units, task and unit categories with similar responsibilities and potential exposures were grouped into larger categories. The groups were chosen by a Texaco industrial hygienist most familiar with producing and pipeline operations. Results are presented for those employed for at least 5 years in the grouped jobs.

RESULTS

There were 12,894 persons eligible for inclusion in the study cohort. Table I shows the number of subjects according to sex, race, and vital status as of the study end date, December 31, 1980. Those persons with unknown race (n = 563) were assumed to be white. White males made up 86.1% of the total cohort and 96.9% of the decedents. All results reported hereafter are for the cohort of white males.

Of the 11,098 total white male cohort, 8,964 (80.8%) were alive at the study end date, 1,886 (17.0%) were deceased, and 248 (2.2%) had vital status unknown.

TABLE I. Texaco Producing and Pipeline Workers 1946–1980 by Race. Sex. and Vital *Status*

	Vital status: No. (percent)			
Race and sex	Alive	Dead	Unknown	Total
White males	8,964 (80.8)	1,886 (17.0)	248 (2.2)	11,098
Nonwhite males	420 (97.2)	12 (2.8)	0	432
White females	971 (74.9)	48 (3.7)	278 (21.4)	1,297
Nonwhite females	64 (95.5)	0	3 (4.5)	67
Total	10.419	1.946	529	12.894

TABLE II. Texaco Producing and Pipeline Workers: SMRs for Selected Causes of Death by Length of Employment for White Males, 1946–1980*

	Employed 6 months or more			
Cause (ICD 8th)	Observed deaths	Expected deaths	SMR	95% C.I.
All causes (001–998)	1.886	2,976.4	63	61-66
All infective and parasitic diseases (000–139)	17	42.9	40	23-63
All cancer (140-209)	393	581.1	68	61-75
Cancer of digestive system (150-159)	105	168.7	62	51-75
Cancer of stomach (151)	13	33.0	39	21-67
Cancer of large intestine (153)	40	54.1	74	53-101
Cancer of pancreas (157)	27	32.0	84	56-123
Cancer of lung (162)	109	179.0	61	50-73
Cancer of prostate (185)	41	43.7	94	67-127
Cancer of kidney (189)	5	14.1	35	11-83
Cancer of bladder (188)	16	19.0	84	48-137
Cancer of skin (172,173)	7	9.8	72	29-148
Cancer of brain (191,192)	11	15.9	69	34-124
Cancer of thyroid (193)	4	1.2	342	92-876
Lymphosarcoma (200)	7	11.8	59	24-122
Hodgkin disease (201)	4	6.6	60	16-154
Leukemia (204-207)	25	22.7	110	71-163
Cancer of other lymphatic tissue (202,203,208)	12	13.5	89	46-155
Benign neoplasms (210-239)	11	7.7	142	71-255
Endocrine, metabolic diseases (240-279)	13	48.7	27	14-46
Diseases of circulatory system (390–458)	1.041	1,580.3	66	62-70
Arteriosclerotic heart disease (410–413)	753	1,085.5.	69	65-75
Vascular lesions of CNS (430–438)	160	218.5	73	62-86
Respiratory diseases (460-519)	103	184.9	56	45-68
Emphysema (492)	29	46.1	63	42-90
Diseases of digestive system (520–577)	50	136.2	37	27-48
Cirrhosis of liver (571)	13	64.7	20	11-34
Diseases of G-U system (580-629)	17	44.0	39	23-62
External causes of death (800-998)	123	260.4	47	39-56
Accidents (800-949)	91	177.6	51	41-63

*C.I., confidence interval.

Over one-third were active employees, and nearly one-haif had either retired or resigned by the end of the study period. The cohort is fairly young, with 26% hired in the last decade of the study. Most of the deaths occurred in older employees, 70% with 20 years or more of service.

There were 220,414 person-years of observation. Death certificates were obtained for all but 65 (3.4%) of the decedents. These 65 deaths are included in the all-causes standardized mortality ratio (SMR) but not in the cause-specific SMRs. Only SMRs $\geqslant$ 110 and based on four or more deaths will be mentioned in the text.

Table II shows the observed and expected numbers of deaths, the SMRs, and their 95% confidence intervals for the total cohort, for those employed for 5 years or more with 20 years latency (n = 5,637), and for those employed for 20 years or more (n = 4,575). There were 2,976.4 deaths expected for the total cohort, giving

TABLE 11. Texaco Producing and Pipeline Workers: SMRs for Selected Causes of Death by Length of Employment for White, 1946–1980* (continued)

Employed 5 years or more with 20 years latency				Employed 20 years or more			
Observed deaths	Expected deaths	SMR	95% C.I.	Observed deaths	Expected deaths	SMR	95% C.I.
1,641	24 13.8	68	65–71	1,309	*2,050.8*	*64*	60–67
14	26.4	53	29–89	14	22.3	63	34–106
354	493.1	72	65–80	280	421.8	66	59–75
97	144.1	67	55–82	74	123.0	60	47–76
13	27.3	48	25–81	10	23.3	43	21–79
36	47.1	76	54–106	29	40.2	72	48–104
27	27.7	97	64–142	20	23.7	84	52–130
99	156.2	63	52–77	77	134.5	57	45–72
40	41.5	96	69–131	35	35.0	100	70–139
5	11.8	42	14–99	4	10.1	40	11–101
15	17.2	87	49–144	11	14.7	75	37–134
5	7.0	71	23–166	3	5.9	50	10–147
7	11.0	*64*	26–132	5	9.4	53	17–124
4	1.0	423	114–1,083	4	0.8	496	133–1.270
6	9.1	66	24–144	4	7.7	52	14–132
3	3.6	84	17–245	3	3.0	99	20–290
19	17.6	108	65–168	14	14.9	94	51–157
11	11.8	94	47–168	11	10.0	110	55–196
9	5.6	162	74–308	6	4.7	127	46–277
10	40.9	24	12–45	8	34.7	23	10-45
937	1,358.4	69	65–74	756	1,153.5	66	61–70
669	935.7	71	66–77	533	796.1	67	61–73
149	193.9	77	65–90	126	163.3	77	64–92
96	162.9	59	48–72	78	138.4	56'	45–70
25	42.6	59	38–87	22	36.4	60	38–92
41	102.8	40	29–54	34	87.4	39	27–54
9	47.0	19	9–36	6	40.0	15	5–33
17	34.2	50	29–80	14	28.8	49	27–82
66	123.5	53	41–68	44	103.3	43	31–57
50	83.4	60	44–79	35	69.8	50	35–70

an all-causes SMR of *63*. This deficit is statistically significant. Large and statistically significant deficits are seen for almost every major cause of death including all cancer (SMR = 68), cancer of the lung (SMR = 62), arteriosclerotic heart disease (SMR = 70), vascular lesions of the central nervous system (SMR = 71), respiratory disease (SMR = 58), and all external causes of death (SMR = 47).

For the cohort as a whole, there are a few causes of death in which the SMR is greater than 100; however, in each instance, the lower confidence limit does not exceed 100. The highest SMR (342) is for cancer of the thyroid, with four deaths observed and 1.2 expected. Other causes of death in which the SMR is greater than 100 are leukemia (SMR = 110), benign neoplasms (SMR = 142), and symptoms, senility, and ill defined conditions (SMR = 116). The patterns of mortality are essentially the same for the two subgroups, although the SMR for cancer of the thyroid becomes statistically significant.

TABLE III. Texaco Producing and Pipeline Workers: SMRs for Selected Causes of Death of White Males, 1946–1980*

Cause (ICD 8th)	All producing workers				All pipeline workers			
	Observed deaths	Expected deaths	SMR	95% C.I.	Observed deaths	Expected deaths	SMR	95% C.I.
All causes (001-998)	1,371	2,130.1	64	61-68	517	859.4	60	55-66
All infective and parasitic diseases (000-139)	12	30.4	40	20-69	5	12.8	39	13-91
All cancer (140-209)	279	409.3	68	60-77	114	173.5	66	54-79
Cancer of digestive system (150-159)	69	118.6	58	45-74	36	50.4	71	50-99
Cancer of stomach (151)	8	23.4	34	15-68	≤	9.7	51	17-120
Cancer of large intestine (153)	26	38.0	68	45-100	14	16.2	87	47-145
Cancer of pancreas (157)	17	22.4	76	44-121	10	9.7	103	49-190
Cancer of lung (162)	82	124.6	66	52-82	27	54.8	49	32-72
Cancer of prostate (185)	31	30.8	101	68-143	10	12.9	78	37-143
Cancer of kidney (189)	5	9.9	50	16-117	0	4.2	0	0-87
Cancer of bladder (188)	14	13.3	105	58-177	2	5.8	35	4-126
Cancer of skin (172,173)	4	7.2	56	15-142	3	2.6	115	23-335
Cancer of brain (191,192)	8	11.5	70	30-137	3	4.5	67	13-195
Cancer of thyroid (193)	4	0.8	483	130-1,236	0	0.3	0	0-1,066
Lymphosarcoma (200)	3	8.4	36	7-104	4	3.4	117	31-300
Hodgkin disease (201)	2	5.0	40	4-144	2	1.7	115	13-416
Leukemia (204-207)	16	16.3	98	56-159	9	6.5	139	63-264
Cancer of other lymphatic tissue (202,203,208)	10	9.5	105	50-193	2	4.1	49	6-178
Benign neoplasms (210-239)	7	5.5	126	51-260	4	2.2	179	48-458
Endocrine, metabolic diseases (240-279)	9	34.8	26	12-49	4	14.1	28	8-73
Diseases of circulatory system (390-458)	771	1,211.0	69	64-74	272	462.4	59	52-66
Arteriosclerotic heart disease (410-413)	565	886.6	74	68-80	190	321.0	59	51-68
Vascular lesions of CNS (430-438)	123	156.7	78	65-94	37	62.1	60	42-82
Respiratory diseases (460-519)	74	130.2	57	45-71	29	55.2	53	35-75
Emphysema (492)	21	31.7	66	41-101	8	14.4	55	24-109
Diseases of digestive system (520-577)	30	97.7	31	21-44	20	38.9	51	31-79
Cirrhosis of liver (571)	8	46.8	17	7-34	5	18.2	28	9-64
Diseases of G-U system (580-629)	11	31.8	35	17-62	6	12.4	48	18-105
External causes of death (800-998)	102	203.5	50	41-61	21	62.7	34	21-51
Accidents (800-949)	77	139.2	55	44-69	14	42.9	33	18-55

*C.I., confidence interval.

TABLE IV. Texaco Producing and Pipeline Workers: Activities Associated With Grouped Job Categories

Job category	Activities
Unexposed	Office work, supervision, engineering
Pumper	Responsible for running of wells, pumps, and other oil field equipment; determines oil production of leases and wells
Roustabout	Performs general oil field or gas plant construction and repair: entry level position
Pipeline, field	Performs maintenance on pipelines and pump stations, operates pump stations, gauges tanks
Maintenance	Responsible for construction, repair, and maintenance of producing and pipeline facilities and equipment
Gas plant	Inspects and maintains mechanical equipment at a gas plant
Drilling	Responsible for the operation of equipment on the drilling site

Table III shows the observed and expected numbers of deaths, the SMRs, and their 95% confidence intervals for producing workers (n = 8,943) and for pipeline workers (n = 2,169). There are 14 people (two deaths) who are in both groups. Significant deficits of mortality are again seen for all of the major causes of death. For producing workers, a nonsignificant elevation is seen for benign neoplasms (SMR = 126). A significantly elevated SMR is seen for cancer of the thyroid (SMR = 483), based on four deaths observed and 0.8 expected. For the pipeline workers, elevated SMRs are seen for lymphosarcoma (SMR = 117), leukemia (SMR = 139), and benign neoplasms (SMR = 179). None of these is significant.

Work History Analysis

There were 11,034 white males with work histories available for analysis. The job categories examined were as follows: unexposed, pumper in producing, roustabout in producing, pipeline field personnel, maintenance, gas plant, and drilling. Table IV shows some of the job activities associated with each category. Table V shows the observed and expected numbers of deaths, the SMRs, and their 95% confidence intervals for those employed 5 years or more in the job groups. The all-causes SMRs show statistically significant deficits, as do the major causes of death.

For the group of workers with little or no likely exposure, primarily office workers and supervisory personnel, deficits are seen for almost all causes of death. The only elevated SMRs are for cancer of the brain (SMR = 137) and cancer of other lymphatic tissue (SMR = 156). Neither is statistically significant.

For producing workers who worked 5 years or more in pumper-gauger-type jobs, slight nonsignificant elevations are seen for cancer of other lymphatic tissue (SMR = 127) and for cancer of the bladder (SMR = 111). All four workers who developed cancer of the thyroid worked for 5 years or more in this job category and the SMR is significantly elevated (SMR = 975). Two of the thyroid cancer decedents also worked for more than 5 years in roustabout-type jobs in producing (SMR = 556). The roustabout category also shows a nonsignificant SMR for leukemia (SMR = 119).

TABLE V. Texaco Producing and Pipeline Workers: SMRs for Selected Causes of Death for Those Employed 5 Years or More in [illegible]*

Cause (ICD 8th)	Unexposed (n = 2,331) Observed deaths	Expected deaths	SMR	95% C.I.	Producing, pumpers (n = 2,443) Observed deaths	Expected deaths	SMR	95% C.I.
All causes (001-998)	396	661.1	60	54-66	711	1,039.2	68	63-74
All infective and parasitic diseases (000-139)	5	8.5	59	19-138	5	13.6	37	12-86
All cancer (140-209)	100	133.6	75	61-91	136	205.6	66	55-78
Cancer of digestive system (150-159)	27	38.2	71	47-103	34	61.2	56	38-78
Cancer of stomach (151)	5	7.3	69	22-161	4	12.1	33	9-85
Cancer of large intestine (153)	12	12.3	97	50-170	13	19.6	66	35-113
Cancer of pancreas (157)	4	7.4	54	15-138	10	11.5	87	42-160
Cancer of lung (162)	28	42.7	66	44-95	44	63.0	70	51-94
Cancer of prostate (185)	8	9.6	83	36-164	13	17.1	76	40-130
Cancer of kidney (189)	2	3.3	60	7-219	2	3.1	41	5-146
Cancer of bladder (188)	3	4.3	71	14-206	8	7.2	111	48-219
Cancer of skin (172,173)	1	2.3	45	1-250	2	3.1	65	7-234
Cancer of brain (191,192)	5	3.7	137	44-320	4	4.9	82	22-211
Cancer of thyroid (193)	0	0.3	0	0-1,377	4	0.4	975	262-2,497
Lymphosarcoma (200)	1	2.7	37	0-208	1	4.0	25	0-141
Hodgkin disease (201)	2	1.4	147	17-532	0	1.8	0	0-205
Leukemia (204-207)	5	5.0	100	32-234	4	7.7	52	14-134
Cancer of other lymphatic tissue (202,203,208)	5	3.2	156	50-365	6	4.7	127	46-276
Benign neoplasms (210-239)	2	1.7	118	13-426	3	2.5	120	24-351
Endocrine, metabolic diseases (240-279)	5	11.0	45	15-106	7	17.3	41	16-84
Diseases of circulatory system (390-458)	206	354.1	58	50-67	418	579.6	72	65-79
Arteriosclerotic heart disease (410-413)	145	246.3	59	50-69	304	395.6	77	68-86
Vascular lesions of CNS (430-438)	29	47.4	61	01-88	71	83.3	85	67-108
Respiratory diseases (460-519)	15	41.4	36	20-60	36	67.7	53	37-74
Emphysema (492)	3	10.5	29	6-84	8	17.2	47	20-92
Diseases of digestive system (520-577)	12	31.1	39	20-67	15	45.5	33	18-54
Cirrhosis of liver (571)	4	15.4	26	7-66	2	20.6	10	1-35
Diseases of G-U system (580-629)	3	9.2	33	7-95	7	15.6	45	18-92
External causes of death (800-998)	18	50.6	36	21-56	46	62.8	73	54-98
Accidents (800-949)	13	33.9	38	20-66	36	92.7	84	59-117

Cause (ICD 8th)	Producing, roustabouts (n = 2,733) Observed deaths	Expected deaths	SMR	95% C.I.	Pipeline, field (n = 1,065) Observed deaths	Expected deaths	SMR	95% C.I.
All causes (001–998)	591	889.1	66	61–72	327	574.0	57	51–63
All infective and parasitic diseases (000–139)	4	12.0	33	9–85	4	8.2	49	13–126
All cancer (140–209)	116	179.4	65	53–78	70	117.5	60	46–75
Cancer of digestive system (150–159)	25	51.5	49	31–72	25	34.3	73	47–108
Cancer of stomach (151)	3	9.9	30	6–89	2	6.6	31	3–110
Cancer of large intestine (153)	9	16.5	55	25–104	10	11.1	90	43–166
Cancer of pancreas (157)	6	10.0	60	22–131	8	6.6	121	52–239
Cancer of lung(162)	40	57.1	70	50–95	14	37.3	38	20–63
Cancer of prostate (185)	13	12.7	102	54–175	7	9.1	77	31–159
Cancer of kidney (189)	1	4.4	23	0–125	0	2.8	0	0–129
Cancer of bladder (188)	6	5.7	105	39–230	1	4.0	25	0–139
Cancer of skin (172,173)	1	3.0	34	0–188	2	1.7	121	14–437
Cancer of brain (191,192)	2	4.9	40	5–146	1	2.9	35	0–194
Cancer of thyroid (193)	2	0.4	556	63–2,009	0	0.2	0	0–1,585
Lymphosarcoma (200)	1	3.6	28	0–153	2	2.3	88	10–319
Hodgkin disease (201)	1	1.9	54	1–298	1	1.0	97	1–539
Leukemia (204–207)	8	6.7	119	51–235	5	4.3	117	38–273
Cancer of other lymphatic tissue (202,203,208)	4	4.2	94	25–242	2	2.8	73	8–262
Benign neoplasms (210–239)	2	2.3	86	10–312	3	1.5	206	41–603
Endocrine, metabolic diseases (240–279)	3	14.7	20	4–60	1	9.5	10	0–58
Diseases of circulatory system (390–458)	337	476.0	71	63–79	180	315.0	57	49–66
Arteriosclerotic heart disease (410–413)	257	331.1	78	68–88	127	219.2	58	48–69
Vascular lesions of CNS (430–438)	44	63.4	69	50–93	25	42.6	59	38–87
Respiratory diseases (460–519)	37	55.2	67	47–92	18	38.0	47	28–75
Emphysema (492)	11	14.0	78	39–140	4	10.2	39	11–101
Diseases of digestive system (520–577)	14	42.1	33	18–56	10	25.4	39	19–73
Cirrhosis of liver (571)	6	20.8	29	11–63	1	11.6	9	0–48
Diseases of G-U system (580–629)	7	12.5	56	22–115	5	8.2	61	20–143
External causes of death (800–998)	38	68.1	56	39–77	11	34.7	32	16–57
Accidents (800–949)	28	45.8	61	41–88	7	23.7	30	12–61

(continued)

TABLE V. Texaco Producing and Pipeline Workers: SMRs for Selected Causes of Death for Those Employed 5 Years or More in Selected Job Categories (White Males, 1946–1980)* (continued)

	Maintenance (n = 1,182)				Gas plant (n = 352)			
Cause (ICD 8th)	Observed deaths	Expected deaths	SMR	95% C.I.	Observed deaths	Expected deaths	SMR	95% C.I.
All causes (001–998)	308	465.8	66	59–74	72	114.3	63	49–79
All infective and parasitic diseases (000–139)	3	6.1	49	10–143	0	1.3	0	0–293
All cancer (140–209)	68	95.8	71	55–90	15	23.6	64	36–105
Cancer of digestive system (150–159)	17	27.7	61	36–98	5	6.8	74	24–173
Cancer of stomach (151)	2	5.3	38	4–137	0	1.3	0	0–293
Cancer of large intestine (153)	5	8.9	56	18–131	2	2.2	90	10–326
Cancer of pancreas (157)	3	5.4	56	11–163	2	1.3	152	17–550
Cancer of lung (162)	23	30.8	75	47–112	4	7.6	52	14–134
Cancer of prostate (185)	5	7.1	71	23–165	2	1.9	107	12–388
Cancer of kidney (189)	2	2.4	85	10–308	0	0.6	0	0–643
Cancer of bladder (188)	2	3.2	63	7–229	0	0.8	0	0–466
Cancer of skin (172,173)	0	1.4	0	0–256	0	0.4	0	0–1,038
Cancer of brain (191,192)	1	2.4	41	1–229	0	0.6	0	0–651
Cancer of thyroid (193)	1	0.2	529	7–2,942	0	0.04	0	0–8,237
Lymphosarcoma (200)	1	1.9	54	1–299	1	0.4	229	3–1,276
Hodgkin disease (201)	0	0.9	0	0–429	0	0.2	0	0–1,988
Leukemia (204–207)	5	3.5	144	47–337	0	0.8	0	0–438
Cancer of other lymphatic tissue (202,203,208)	0	2.3	0	0–162	1	0.6	175	2–972
Benign neoplasms (210–239)	2	1.2	170	19–612	0	0.3	0	0–1,343
Endocrine, metabolic diseases (240–279)	1	7.8	13	0–72	0	1.9	0	0–190
Diseases of circulatory system (390–458)	184	254.0	72	62–84	47	63.2	74	55–99
Arteriosclerotic heart disease (410–413)	135	177.0	76	64–90	35	43.8	80	56–111
Vascular lesions of CNS (430–438)	26	33.9	77	50–112	6	8.8	69	25–149
Respiratory diseases (460–519)	24	30.1	80	51–119	3	7.6	40	8–115
Emphysema (492)	7	7.9	88	35–182	1	1.9	52	1–287
Diseases of digestive system (520–577)	3	21.2	14	3–41	1	5.0	20	0–111
Cirrhosis of liver (571)	0	10.2	0	0–36	1	2.4	42	1–233
Diseases of G-U system (580–629)	0	6.5	0	0–57	2	1.6	126	14–457
External causes of death (800–998)	10	29.7	34	16–62	1	6.6	15	0–84
Accidents (800–949)	9	20.0	45	21–85	1	4.5	22	0–125

	Observed deaths	Expected deaths	SMR	95% C.I.
All causes (001-998)	115	167.5	69	57-82
All infective and parasitic diseases (000-139)	1	2.3	44	1-244
All cancer (140-209)	26	34.0	77	50-112
Cancer of digestive system (150-159)	9	9.7	93	42-177
Cancer of stomach (151)	1	1.8	54	1-302
Cancer of large intestine (153)	3	3.1	97	20-284
Cancer of pancreas (157)	3	1.9	159	32-465
Cancer of lung (162)	3	11.0	27	5-80
Cancer of prostate (185)	4	2.3	177	48-453
Cancer of kidney (189)	0	0.9	0	0-430
Cancer of bladder (188)	2	1.0	192	22-691
Cancer of skin (172,173)	0	0.6	0	0-642
Cancer of brain (191,192)	1	1.0	103	1-570
Cancer of thyroid (193)	0	0.07	0	0-5,346
Lymphosarcoma (200)	0	0.7	0	0-525
Hodgkin disease (201)	0	0.4	0	0-1011
Leukemia (204-207)	1	1.3	79	1-441
Cancer of other lymphatic tissue (202,203,208)	1	0.8	124	2-691
Benign neoplasms (210-239)	1	0.5	224	3-1,248
Endocrine, metabolic diseases (240-279)	0	2.8	0	0-133
Diseases of circulatory system (390-458)	68	89.1	76	59-97
Arteriosclerotic heart disease (410-413)	48	62.4	77	57-102
Vascular lesions of CNS (430-438)	14	11.5	122	66-204
Respiratory diseases (460-519)	3	10.2	29	6-86
Emphysema (492)	0	2.6	0	0-141
Diseases of digestive system (520-577)	3	8.2	37	7-107
Cirrhosis of liver (571)	2	4.1	48	5-174
Diseases of G-U system (580-629)	4	2.3	172	46-441
External causes of death (800-998)	6	13.1	46	17-100
	[illegible]	[illegible]	57	18-133

*C.I., confidence interval.

For those employed for 5 years or more as pipeline workers (excluding office and supervisory personnel), elevated SMRs are seen for cancer of the pancreas (SMR = 121) and leukemia (SMR = 117). Neither is significant.

For those employed as maintenance workers in either producing or pipeline for 5 or more years, the only elevated SMR is for leukemia (SMR = 144). For the gas plant job category, no elevated SMRs are seen for any cause with four or more deaths. For the drilling category, elevated SMRs are seen for cancer of the prostate (SMR = 177), vascular lesions of the CNS (SMR = 113), and diseases of the genitourinary system (SMR = 172). Again, none of these is significant.

DISCUSSION

The most striking result of this study is the significantly low overall SMR that is seen for all the major causes of death and among all the subcohorts examined. This SMR (63) is lower than that found in most of the other cohort mortality studies in the petroleum industry [Hanis et al, 1982; Divine et al, 1985; Rushton and Alderson, unpublished; Wen et al, 19831. Even when the analysis is restricted to those employed for 20 years or more or to those with 20 years latency, the SMRs increase only slightly. In addition to the healthy worker effect, it is believed that the wages and benefits provided to Texaco employees have had beneficial effects on mortality. These effects appear to be more marked for diseases in which medical care and preventive medicine have an impact, eg, infectious disease and heart disease.

The highest SMR seen was for cancer of the thyroid; however, it is based on only four cases. The cases are all long-term producing department employees who were employed predominantly as pumper-gaugers. The expected exposures in this job are to crude oil, hydrocarbon vapors, hydrogen sulfide, caustic, water treatment chemicals, and noise; none has been associated with thyroid cancer.

The SMR for benign and unspecified neoplasms was also elevated. Of the 11 deaths, five were unspecified brain tumors, and one was a benign brain tumor. There were 3.7 expected unspecified brain tumors giving an SMR of 135. There were 1.2 benign brain tumors expected. If ail brain tumors, malignant, benign, and unspecified, are combined, the SMR for the group is 84. If the analysis is restricted to those employed for 5 years or more with 20 years of latency, the benign and unspecified brain tumor SMR increases to 152, but the all-brain-tumor SMR does not change. Therefore, there is overall no brain tumor excess. The brain tumor decedents did not appear to be restricted to any specific job category. No other clusters were seen in the benign and unspecified neoplasms category.

Another elevated SMR seen for the entire cohort is leukemia. However, the excess is small (SMR = 110), and it disappears when the analysis is restricted to those employed for 20 years or more. While an increase is seen in the SMR for cancer of other lymphatic tissue for those employed for 20 years or more (SMR = 110), it is small and nonsignificant. The SMRs for the 20-year latency group are similar to those for the entire cohort for these two causes of death.

Both the producing and pipeline subcohorts show patterns similar to those of the entire cohort, as do each of the job groups. Although some SMRs are elevated in

each group, none of the elevations is statistically significant except for cancer of the thyroid, and most are based on fewer than five deaths. No further analysis of any of the causes of death appears indicated.

One surprising finding was the significantly low SMR (61) for cancer of the lung. Similarly low SMRs were seen for all of the subgroups analyzed. Although this was seen in the earlier Texaco study [Divine et al, 1985], those workers spent most of their working time in areas where smoking is prohibited. Producing and pipeline workers, on the other hand, work in a less restrictive outdoor environment and, therefore, have greater access to smoking opportunities. This deficit is in contrast to an earlier case-control study in Louisiana that found that oilfield workers had an odds ratio of 2.33 for lung cancer as compared with the control group [Gottleib, 1980].

While an attempt was made to look for any cluster of deaths in specific job groups, the results from Table V should be interpreted with caution. It is not possible to identify specific chemicals and levels of exposures that are linked exclusively with a specific job. Jobs were grouped based on a company industrial hygienist's best estimate of those having similar responsibilities and exposures. It is likely that some of these exposures and work tasks may have changed substantially over time. Many of the people held a number of different jobs throughout their working time with Texaco and may be counted in more than one group. Based on a comparison with the earlier Texaco cohort, it is likely that few of this group had refinery-, research-, or petrochemical-related exposures. There were only 12 people who overlapped between the two cohorts [Divine et al, 1985; Divine and Barron, 1986].

The major exposure for these workers is likely to be dermal exposure to crude oil. It has been suggested that this may lead to an increased risk of skin cancer. No excess was seen; however, because of the extremely low mortality associated with skin cancer, this type of study is not well suited to uncover any possible associations.

A recent hospital-based case-control study of testicular cancer found a significant association with work in the crude petroleum and natural gas extraction industry, with an odds ratio of 2.29 [Mills et al, 1984]. However, no deaths from testicular cancer were seen in this study, although 3.2 were expected. The upper confidence limit is 115, which is well below the odds ratio seen in the case-control study.

In summary, the mortality of Texaco producing and pipeline workers was substantially lower than expected, and large deficits were seen for all major causes of death. A further detailed examination of the cohort by grouped job categories did not uncover any jobs or diseases warranting concern.

REFERENCES

American Petroleum Institute (1979): "Job Code Classification System Part 1. Petroleum Refineries and Selected Petrochemical Operations." Washington, DC: American Petroleum Institute.

Divine BJ. Barron V, Kaplan SD (1985): Texaco Mortality Study. I. Mortality among refinery, petrochemical. and research workers. J Occup Med 27:445–447.

Divine BJ. Baron V (1986): Texaco Mortality Study. II. Patterns of mortality among white males by specific job groups. Am J Indust Med 10:371–381.

Gottlieb MS (1980): Lung cancer and the petroleum industry in Louisiana. J Occup Med 22:384–388.

Hanis NM. Holmes TM, Shallenberger LG. Jones KE (1982): Epidemiologic study of refinery and chemical plant workers. J Occup Med 24:203–212.

Mills PK. Newell GR. Johnson DE (1984): Testicular cancer associated with employment in agriculture and oil and natural gas extraction. Lancet 1:207–210.

Monson RR (1972): Analysis of relative survival and proportional mortality. Comput Biomed Res 7:325–332.

Thomas TL, Waxweiler RJ, Moure-Eraso R, Itaya S, Fraumeni JF (1982): Mortality patterns among workers in three Texas oil refineries. J Occup Med 24:135–141.

Wade L (1963): Observations on skin cancer among refinery workers. Arch Environ Health 6:730–735.

Wen CP, Tsai SP, McClellan WA, Gibson RL (1983): Long-term mortality study of oil refinery workers. I. Mortality of hourly and salaried workers. Am J Epidemiol 118:526–542.