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Texaco Mortality Study: II. Patterns of Mortality Among White Males by Specific Job Groups

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While an earlier report on the Texaco Mortality Study cohort showed no statistically significant elevations for any cause of death for the white males, it did not preclude any excess risk of mortality within subgroups of workers. In this study, an employee's complete job history was used to determine his work categories, and patterns of mortality were examined for the more common job categories. All of the job categories examined showed deficits for mortality overall, and the patterns seen were similar to those for the entire cohort. Significant elevations were seen in pancreas cancer mortality for office and managerial people and in leukemia mortality for pipefitters and boilermakers. Other elevations of particular interest based on five or more deaths were brain cancer for laboratory workers and benign neoplasms in pipefitters and boilermakers. These associations were examined by latency and years worked, and no consistently positive associations were seen. It was not possible to take into account calendar time of exposure in this type of analysis, nor could any specific chemicals or levels of exposure be associated with the job categories where the standardized mortality ratios were elevated.

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

INTRODUCTION

The Texaco Mortality Study (TMS) is a cohort mortality study of refinery, petrochemical, and research workers who were employed at least five years and who worked between 1947 and 1977. The first paper on the **TMS** cohort discussed the overall patterns of mortality among the white males [Divine et al, 1985]. The major finding of the study was a significant deficit for all the major causes of death. No statistically significant elevations were seen for any specific cause of death. However, small elevations were seen for pancreatic cancer, brain cancer, leukemia, other lymphatic cancer, and benign neoplasms. The question remained whether an increased risk of mortality in a subgroup of workers was obscured in the analysis of the cohort as a whole. This paper examines the mortality patterns for white men employed in specific jobs in order to determine if any workplace locations or tasks are associated with an increased risk of mortality. The above-mentioned causes with elevated

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standardized mortality ratios (SMRs) are examined, in particular, in order to determine if they are associated with any particular job group.

In this study, a worker's job history at participating locations was used to group him into one or more subcohorts for analysis. Although numerous mortality studies of petroleum workers have been carried out, none have examined the complete work histories of the entire cohort. Work histories have been used mainly in case-control studies within a cohort [Hanis et al, 1982] or to identify subcohorts exposed to a specific chemical or process unit [Tsai et al, 1983; Wen et al, 19851.

METHODS

The cohort consisted of all persons employed five years or more at a Texaco refinery, petrochemical plant, or research laboratory and who worked at least one day between January 1, 1947, and December 31, 1977. Follow-up through the study end date was done using company records and information from the Social Security Administration. Death certificates were requested for all known deaths. Further details are in the previous paper on this cohort [Divine et al, 1985]. In addition to the demographic data, available work history data were also used.

Each job held by an employee consisted of a unit (eg, crude still, maintenance), a task (eg, operator, pipefitter), and the dates that position was held. The task and unit codes were based on the American Petroleum Institute (API) Job Code Classification System of Petroleum Refineries and Selected Petrochemical Operations [1979]. Job history coding accounted for all periods of time between a subject's initial hire date and final termination date, or the common closing date of December 31, 1977. Periods of not working for one month or longer were coded as such.

Because much of the cohort experienced numerous job changes over relatively short periods of time, the following method was developed for selecting jobs to be coded on each work history. An employee's initial job was coded, Job changes which occurred at least 6 months subsequent to the last coded job were also coded. Job changes which occurred within the 6 months were ignored. This method continued until the employee transferred, terminated, died, or until the study end date was reached. When two or more jobs were held concurrently, they were all coded with the time apportioned equally. If either of two conditions existed, a job change was also coded: transfer to another facility, or employment in a task or unit of special interest.

For a quality control check of the job history coding, a systematic sample of employee work histories was selected for duplicate coding by the original coder and for recoding by a randomly selected alternate coder. Error rates were less than 10%.

Specific jobs (units, tasks, and combinations thereof) to be analyzed were selected in consultation with company industrial hygienists. In addition, certain tasks and units with common exposures or responsibilities were grouped together for analysis. The job subcohorts were defined as those ever employed, those employed one year or more, and those employed 5 years or more in the job. The results from four major job groups (office, maintenance, operations, and laboratory) are presented. Although many other job groups were analyzed. only results for the job category of pipefitters and boilermakers are presented because two of the SMRs were significantly elevated. These causes of deaths, plus two others in two of the major job groups, are also analyzed in more detail.

Person-years were counted after the date at which a person had worked the requisite length of time in the job, met the eligibility requirements for the study, or the study beginning date—whichever came last. For analysis by duration of employment, the years employed in the specific job were used. Expected numbers of deaths based on the U.S. white male population of similar age and calendar time were calculated using the Monson program [Monson, 19741. This program was also used to generate the observed and expected numbers for the analysis of latency and duration.

RESULTS

There were 18,798 white men who were eligible for inclusion in the cohort and for whom work histories were located. Those who had only demographic data available were excluded from this analysis (n = 279). The mean year of birth for this latter group was 1907 (about 13 years less than for the former group), the mean year first employed was 1937 (eight years less), and the mean year last employed was 1960 (10 years less).

Thirty-six percent of the cohort with a work history was less than 30 years old at entry into the study, 35.4% was aged 30–39, 18.3% was 40–49, and 10.3% was 50 and over. The average age at entry was 36. The cohort was followed for an average of 19 years. The average age at entry and the average follow-up was similar for each of the job category groups.

There were 70,163 jobs recorded for the total cohort. The average length of time a job was held was 6.2 years. The job with the greatest number of person-years was pipefitter; the job held most often was yard laborer, although the average length of time spent in this job was short (2 years). Table I shows the number of persons employed in the major job subgroups, the average number of person-years spent in each, and the total number of person-years of exposure.

Tables II–VI show the observed number of deaths, the SMRs, and the 95% confidence limits associated with each for the major job categories, plus the job group of pipefitters and boilermakers. It should be noted that for all the analysis groups, the all causes SMRs and their confidence limits are less than 100.

All of the job groups show deficits for the major causes of death, such as all cancer, lung cancer, cardiovascular disease, and external causes of death. Most of these and many of the other causes of death are significantly low. Most groups show slight elevations for those causes which were elevated for all white males, including pancreatic cancer, leukemia, brain cancer, other lymphatic cancer, and benign neoplasms [Divine et al, 1985].

TABLE I. Job Categories and Number of Persons and Person-Years of Exposure

Grouped job category subcohort	No. of persons	No. of person-years of exposure	Average years held
Office personnel	6.969	117,714	12.79
Operations	12,102	225,928	11.53
Maintenance	13.569	260.903	8.90
Laboratory	2.698	51,676	13.12

TABLE II. SMRs for Selected Causes in White Males Employed as Office and Managerial Workers, by Length of Time Employed

	> 1 Year			> 5 Years		
Cause of death (ICD 7th)*	Observed deaths	SMR	95% CI	Observed deaths	SMR	95% CI
All causes (000–998)	1,445	75	(75–79)	1,134	72	(68–76)
All infective and parasitic diseases (001–138)	7	26	(10–53)	5	23	(7–54)
All cancer (140–205)	275	74	(66–83)	210	69	(60–79)
Cancer of digestive system (150–159)	92	81	(65–99)	72	77	(60–97)
Cancer of stomach (151)	13	55	(29–93)	9	46	(21–88)
Cancer of large intestine (153)	27	77	(51–112)	22	76	(48–116)
Cancer of pancreas (157)	32	151	(103–213)	25	143	(93–212)
Cancer of lung (162,163)	59	53	(41–69)	47	51	(38–68)
Cancer of prostate (177)	20	69	(42–107)	18	75	(44–119)
Cancer of kidney (180)	9	100	(46–190)	7	95	(38–195)
Cancer of bladder (181)	11	85	(42–152)	9	84	(38–160)
Cancer of skin (190)	5	88	(28–206)	3	65	(13–191)
Cancer of brain (193)	6	65	(24–142)	4	54	(15–138)
Lymphosarcoma (200)	6	78	(28–169)	4	64	(17–163)
Hodgkin's disease (201)	1	27	(0–150)	1	34	(0–188)
Leukemia (204)	18	124	(74–197)	11	93	(46–167)
Cancer of other lymphatic tissue (202,203, 205)	8	97	(67–136)	6	92	(34–201)
Benign neoplasms (210–239)	5	109	(35–255)	3	81	(16–236)
Endocrine, metabolic diseases (240–289)	22	61	(38–92)	18	60	(36–95)
Vascular lesions of CNS (330–334)	113	72	(60–87)	92	72	(58–88)
Diseases of circulatory system (400–468)	727	79	(73–85)	570	75	(69–82)
Arteriosclerotic heart disease (420)	592	80	(73–86)	466	76	(70–84)
Respiratory diseases (470–527)	55	48	(36–63)	46	49	(36–65)
Emphysema (527)	15	46	(26–76)	12	44	(23–77)
Diseases of digestive system (530–587)	40	46	(33–62)	33	47	(32–65)
Cirrhosis of liver (581)	19	47	(29–74)	15	46	(26–77)
Diseases of G-U system (590–639)	17	57	(33–92)	13	54	(29–93)
External causes of death (800–998)	80	62	(49–78)	58	57	(43–74)
Accidents (800–962)	54	62	(46–81)	47	62	(45–84)

*ICD 8th Revision codes for 1968–1977 deaths were converted to ICD 7th Revision.

Those employed in the office and professional job categories for one or more years show a statistically significant increased rate of cancer of the pancreas (SMR = 151). However, the SMR drops to 143 and is no longer significant for the group employed five years or more. Those employed as operators show elevated SMRs for the same causes as for the total cohort, although none are significant. The only causes showing higher SMRs for the five-years-or-more group than for the one-year-or-more group are cancer of the pancreas (SMR = 103,119) and cancer of the prostate (SMR = 90,107).

Those employed as maintenance workers also show nonsignificant elevations for the above causes of death plus skin cancer. Those causes where the elevated SMR

TABLE III. SMRs for Selected Causes in White Males Employed as Operators by Length of Time Employed

Cause of death (ICD 7th)*	> 1 Year			> 5 Years		
	Observed deaths	SMR	95% CI	Observed deaths	SMR	95% CI
All causes (000–998)	2,274	77	(73-80)	1.771	77	(73–80)
All infective and parasitic diseases (001–138)	17	38	(22–61)	15	44	(24–72)
All cancer (140–205)	425	75	(68–82)	1,328	74	(66–83)
Cancer of digestive system (150–159)	119	70	(58–83)	93	69	(56–85)
Cancer of stomach (151)	30	84	(57–120)	23	82	(52–123)
Cancer of large intestine (153)	28	53	(35–77)	20	49	(30–75)
Cancer of pancreas (157)	33	103	(71–144)	30	119	(80–170)
Cancer of lung (162.163)	108	63	(52–77)	83	63	(50–78)
Cancer of prostate (177)	37	90	(63–124)	35	107	(74–149)
Cancer of kidney (180)	11	80	(39–141)	9	83	(38–158)
Cancer of bladder (181)	10	53	(25–97)	9	60	(27–114)
Cancer of skin (190)	3	33	(7–95)	2	29	(3–103)
Cancer of brain (193)	19	123	(74–192)	13	112	(59–191)
Lymphosarcoma (200)	13	106	(56–181)	8	85	(36–167)
Hodgkin's disease (201)	7	106	(43–219)	4	82	(22–210)
Leukemia (204)	31	137	(93–194)	21	120	(74–184)
Cancer of other lymphatic tissue (202,203,205)	16	132	(75–214)	12	127	(66–223)
Benign neoplasms (210–239)	9	121	(55–229)	6	105	(38–229)
Endocrine, metabolic diseases (240–289)	50	90	(67–119)	40	93	(66–126)
Vascular lesions of CNS (330–334)	195	86	(74–98)	147	82	(69–96)
Diseases of circulatory system (400-468)	1,120	80	(76–85)	878	81	(75–86)
Arteriosclerotic heart disease (420)	932	83	(78–89)	730	83	(77–89)
Respiratory diseases (470–527)	99	58	(47–71)	77	58	(46–72)
Emphysema (527)	36	74	(52–103)	27	71	(47–103)
Diseases of digestive system (530–587)	86	62	(49–76)	72	67	(53–85)
Cirrhosis of liver (581)	41	62	(45–84)	33	66	(45–93)
Diseases of G-U system (590–639)	29	64	(43–92)	21	60	(37–91)
External causes of death (800–998)	112	48	(40–58)	87	51	(41–63)
Accidents (800–962)	75	47	(37–59)	58	50	(38–65)

*ICD 8th Revision codes for 1968–1977 deaths were converted to ICD 7th Revision.

increases for the one-year-or-more to the five-years-or-more group are: cancer of the pancreas (SMR = 117,140), cancer of the kidney (SMR = 96,129). cancer of the skin (SMR = 103,130), cancer of the brain (SMR = 103,127), Hodgkin's disease (SMR = 86,138), cancer of other lymphatic tissue (SMR = 142,161), and benign neoplasms (SMR = 140,162).

The elevations found for those employed for one year or more as laboratory workers include cancers of the brain, pancreas, and skin, and benign neoplasms. The SMR of 210 for cancer of the brain increases to 221 for those employed five years or more. The SMR for benign neoplasms increases from 209 to 261. None of these elevations, however, is statistically significant.

TABLE IV. SMRs for Selected Causes in **White Males Employed as Maintenance Workers by Length of Time Employed**

	> 1 Year			>5 Years		
Cause of Death (ICD 7th)*	Observed deaths	SMR	95% CI	Observed deaths	SMR	95% CI
All causes (000–998)	2,358	77	(74–80)	1,511	77	(73–81)
All infective and parasitic diseases (001–138)	12	26	(13–46)	2	7	(1–25)
All cancer (140–205)	473	80	(73–88)	326	86	(77–96)
Cancer of digestive system (150–159)	132	75	(62–88)	93	82	(66–100)
Cancer of stomach (151)	29	79	(53–114)	19	60	(48–125)
Cancer of large intestine (153)	36	66	(46–92)	25	71	(46–105)
Cancer of pancreas (157)	39	117	(83–160)	30	140	(94–200)
Cancer of lung (162,163)	124	69	(58–83)	81	72	(57–89)
Cancer of prostate (177)	36	87	(61–120)	25	91	(59–134)
Cancer of kidney (180)	14	96	(52–161)	12	129	(67–226)
Cancer of bladder (181)	11	57	(28–101)	7	55	(22–114)
Cancer of skin (190)	10	103	(49–189)	8	130	(56–257)
Cancer of brain (193)	17	103	(60–166)	13	127	(68–218)
Lymphosarcoma (200)	6	46	(17–101)	2	24	(3–88)
Hodgkin's disease (201)	6	86	(31–186)	6	138	(50–299)
Leukemia (204)	27	115	(76–167)	14	93	(51–156)
Cancer of other lymphatic tissue (202,203,205)	18	142	(84–225)	13	161	(86–275)
Benign neoplasms (210–239)	11	140	(70–251)	8	162	(70–319)
Endocrine, metabolic diseases (240–289)	48	83	(62–111)	33	89	(61–125)
Vascular lesions of CNS (330–334)	192	83	(72–96)	133	88	(73–104)
Diseases of circulatory system	1,184	82	(78–87)	735	79	(74–85)
Arteriosclerotic heart disease (420)	969	83	(78–89)	596	80	(74–87)
Respiratory diseases (470–527)	82	47	(37–58)	50	44	(33–58)
Emphysema (527)	27	54	(36–79)	14	43	(24–73)
Diseases of digestive system (530–587)	80	55	(43–68)	53	57	(43–75)
Cirrhosis of liver (581)	34	48	(33–68)	16	37	(21–59)
Diseases of G-U system (590–639)	25	54	(35–80)	17	57	(33–91)
External causes of death (800–998)	113	46	(38–55)	68	45	(35–57)
Accidents (800–962)	80	48	(38–59)	48	46	(34–61)

*ICD 8th Revision codes for 1968–1977 deaths were converted to ICD 7th Revision.

From the analyses of numerous task and unit subcohorts, one group was singled out for further analysis. The group of pipefitters and boilermakers employed one year or more showed elevations in cancers of the pancreas and kidney, lymphosarcoma, leukemia, other lymphatic cancers and benign neoplasms. A statistically significant SMR of 212 for leukemia in those employed one year or more increased to 285 for those five years or more. This group also showed increasing SMRs with increasing years of employment for cancer of the kidney (SMR = 143,193), lymphosarcoma (SMR = 117,133), and benign neoplasms (SMR = 193.369). The latter SMR is also statistically significant.

TABLE V. SMRs for Selected Causes in White Males Employed as Laboratory Workers by Length of Time Employed

	> 1 Year			> 5 Years		
Cause (ICD 7th)*	Observed deaths	SMR	95% CI	Observed deaths	SMR	95% CI
All causes (000–998)	328	**64**	(57–71)	255	62	(55–70)
All infective and parasitic diseases (001–138)	3	40	(8–116)	3	51	(10–149)
All cancer (140–205)	**64**	63	(48–80)	52	**64**	(48–84)
Cancer of digestive system (150–159)	18	63	(37–99)	11	49	(24–87)
Cancer of stomach (151)	3	54	(11–158)	2	46	(5–166)
Cancer of large intestine (153)	7	78	(31–162)	6	**85**	(31–185)
Cancer of pancreas (157)	6	105	(38–229)	3	66	(13–193)
Cancer of lung (162.163)	18	**55**	(32–86)	17	**64**	(37–103)
Cancer of prostate (177)	1	**18**	(0–99)	1	23	(0–130)
Cancer of kidney (180)	1	38	(0–212)	1	48	(1–265)
Cancer of bladder (181)	1	34	(0–190)	1	**44**	(1–244)
Cancer of skin (190)	2	109	(12–394)	1	67	(1–375)
Cancer of brain (193)	7	210	(84–432)	6	221	(81431)
Lymphosarcoma (200)	1	42	(1–236)	1	53	(1–293)
Hodgkin's disease (201)	1	72	(1–403)	1	90	(1–498)
Leukemia (204)	3	74	(15–218)	3	94	(19–274)
Cancer of other lymphatic tissue (202,203,205)	1	43	(1–242)	0	0	(0–199)
Benign neoplasms (210–239)	3	209	(42–610)	3	261	(52–761)
Endocrine, metabolic disease (240–289)	6	63	(23–137)	**5**	66	(21–155)
Vascular lesions of CNS (300–334)	26	79	(52–116)	19	75	(45–117)
Diseases of circulatory system (400–468)	152	65	(55–76)	119	**64**	(53–77)
Arteriosclerotic heart disease (420)	127	66	(55–79)	100	66	(53–80)
Respiratory diseases (470–527)	13	46	(24–79)	9	41	(19–77)
Emphysema (527)	7	86	(34–177)	**5**	78	(25–183)
Diseases of digestive system (530–587)	8	30	(13–58)	3	14	(3–40)
Cirrhosis of liver (581)	4	28	(7–71)	2	17	(2–62)
Diseases of G-U system (590–639)	1	14	(0–80)	0	0	(0–68)
External causes of death (800–998)	32	**64**	(44–90)	28	69	(46–100)
Accidents (800–962)	19	**56**	(34–88)	**18**	66	(39–105)

*ICD 8th Revision codes for 1968–1977 deaths were converted to ICD 7th Revision.

The significantly elevated **SMRs** were examined further, looking at latency from the starting date in the job and the number of years worked in the job. None of the job categories showed an increasing risk of disease with increasing length of employment and latency. Table VII shows the **SMRs** for pancreatic cancer for the office and managerial workers. The **SMRs** decrease with both latency and number of years workcd, although all but two of the **35** deaths occurred after 20 or more years of latency. Table VIII shows similar **SMRs** for brain cancer in laboratory workers. The SMR is highest for those who worked less than 10 years in the job and **is** lowest for those who worked **as** laboratory workers more than 20 years. **All** seven cases occurred after **20** or more years latency.

TABLE VI. SMRs for Selected Causes in White Males Employed as Pipefitters and Boilermakers by Length of Time Employed

	> 1 Year			> 5 Years		
Cause of death (ICD 7th)*	Observed deaths	SMR	95% CI	Observed deaths	SMR	95% CI
All causes (000–998)	852	80	(75–86)	458	82	(75–90)
All infective and parasitic diseases (001–138)	4	25	(7–64)	1	12	(0–68)
All cancer (140–205)	170	84	(72–98)	91	85	(69–105)
Cancer of digestive system (150–159)	48	77	(57–103)	24	74	(47–110)
Cancer of stomach (151)	13	99	(53–170)	6	88	(32–191)
Cancer of large intestine (153)	13	68	(36–117)	5	50	(16–117)
Cancer of pancreas (157)	12	104	(54–182)	6	99	(36–215)
Cancer of lung (162,163)	35	59	(41–82)	19	60	(36–94)
Cancer of prostate (177)	13	82	(44–141)	8	99	(43–195)
Cancer of kidney (180)	7	143	(57–295)	5	193	(62–449)
Cancer of bladder (181)	1	14	(0–79)	1	27	(0–151)
Cancer of skin (190)	2	64	(7–230)	1	60	(1–336)
Cancer of brain (193)	5	98	(31–228)	2	73	(8–265)
Lymphosarcoma (200)	5	117	(38–274)	3	133	(27–387)
Hodgkin's disease (201)	1	46	(1–256)	1	88	(1–488)
Leukemia (204)	17	212	(123–339)	12	285	(147–498)
Cancer of other lymphatic tissue (202,203,205)	7	164	(66–338)	1	44	(1–246)
Benign neoplasms (210–239)	5	193	(62–451)	5	369	(119–861)
Endocrine, metabolic disease (240–289)	17	85	(50–136)	7	67	(27–138)
Vascular lesions of CNS (330–334)	65	76	(58–97)	36	82	(57–113)
Diseases of circulatory system (400-468)	443	88	(80–96)	238	90	(79–102)
Arteriosclerotic heart disease (420)	366	90	(81–100)	196	92	(80–106)
Respiratory diseases (470–527)	32	51	(35–73)	16	49	(28–80)
Emphysema (527)	9	51	(23–97)	5	54	(17–125)
Diseases of digestive system (530–587)	23	48	(30–72)	10	39	(19–72)
Cirrhosis of liver (581)	9	41	(19–78)	2	17	(2–62)
Diseases of G-U system (590–639)	8	48	(21–95)	3	35	(7–103)
External causes of death (800–998)	45	60	(44–80)	26	67	(44–98)
Accidents (800–962)	30	58	(39–83)	18	68	(40–107)

*ICD 8th Revision codes for 1968–1977 deaths were converted to ICD 7th Revision.

TABLE VII. SMRs for Pancreas Cancer in Office and Managerial Workers by Latency and Years Worked

Years worked in job	Latency: < 20 Years				Latency: ≥ 20 Years				Total			
	Obs	Exp	SMR	95% CI	Obs	Exp	SMR	95% CI	Obs	Exp	SMR	95% CI
0–9	2	0.79	253	(28–914)	15	8.24	182	(102–300)	17	9.03	188	(110–301)
10–19	—	0.62	—	—	9	5.14	175	(70–313)	9	5.77	156	(71–296)
20+	—	—	—	—	9	9.26	97	(44–185)	9	9.26	97	(44–185)
Total	2	1.42	141	(16–510)	33	22.64	146	(100–205)	35	24.06	145	(101–202)

TABLE VIII. SMRs for Brain Cancer in Laboratory Workers by Latency and Years Worked

Years worked (in job)	Latency: <20 Years Obs	Exp	SMR	95% CI	≥20 Years Obs	Exp	SMR	95% CI	Total Obs	Exp	SMR	95% CI
0–9	0	0.49	0	—	5	1.23	408	(131–952)	5	1.72	292	(94–680)
10–19	0	0.44	0	—	0	0.54	0	—	0	0.97	0	—
20+	—	0	—	—	2	1.21	166	(19–599)	2	1.21	166	(19–599)
Total	0	0.92	0		7	2.97	236	(95–486)	7	3.89	180	(72–371)

TABLE IX. SMRs for Leukemia in Pipefitters and Boilermakers by Latency and Years Worked

Years worked in job	Latency: <20 Years Obs	Exp	SMR	95% CI	≥20 Years Obs	Exp	SMR	95% CI	Total Obs	Exp	SMR	95% CI
0–9	1	1.03	97	(1–542)	11	8.04	137	(68–245)	12	9.07	132	(68–231)
10–19	2	0.36	552	(62–1,995)	4	1.00	400	(108–1,024)	6	1.36	441	(161–959)
20+	—	—	—	—	3	1.75	171	(34–500)	3	1.75	171	(34–500)
Total	3	1.39	216	(43–631)	18	10.80	167	(99–264)	21	12.18	172	(107–264)

TABLE X. SMRs for Benign Neoplasms in Pipefitters and Boilermakers by Latency and Years Worked

Years worked in job	Latency: <20 Years Obs	Exp	SMR	95% CI	≥20 Years Obs	Exp	SMR	95% CI	Total Obs	Exp	SMR	95% CI
0–9	0	0.49	0	—	0	2.46	0	—	0	2.95	0	—
10–19	1	0.16	610	(8–3,393)	3	0.30	1,000	(201–2,922)	4	0.46	862	(232–2.202)
20+	—	—	—	—	1	0.54	185	(2–1,028)	1	0.54	185	(2–1,028)
Total	1	0.65	154	(2–856)	4	3.30	121		5	3.95	127	(41–295)

Table IX shows the SMRs for leukemia in pipefitters and boilermakers. Most of the 21 deaths occurred in those who worked less than ten years in this job and those with 20 or more years of latency, with no other category containing five or more deaths. Examining years employed in the job, the SMR increases for those employed 10–19 years in the job and decreases for those employed more than 20 years. No consistent pattern is seen.

Table X shows the SMRs for benign neoplasms for those who worked as pipefitters and boilermakers. Four of the five deaths cluster in the group who worked in this job for 10–19 years, giving very high SMRs which increase with increasing latency. One death occurred in those who worked 20 or more years after 20 years of latency. However, the number of deaths in each cell is three or less. Again, the pattern is not consistent.

DISCUSSION

Earlier mortality studies of refinery workers generally have looked at all plant personnel or at hourly workers (Hanis et al, 1982; Hanis *et* al, 1979; Rushton and

Alderson, 1981; Theriault and Goulet, 1979; Gaffey et al, 1974; Thomas et al, 1980). Occasionally the overall cohort is subdivided, using factors such as length of employment or time period first employed. Some studies have used the work history to define cohort subgroups exposed to a specific chemical or process [Tsai et al, 1983; Wen et al, 19851. One study looked at exposed vs nonexposed workers [Hanis et al, 19791, and another used the last job title to divide the cohort into three exposure intensity groups [Gaffey et al, 1974]. None of these studies used the employees' complete work histories to determine multiple job groups for analysis.

This study was an attempt to determine if mortality rates for any specific cause of death were elevated for employees who worked in specific job categories. Those causes of death which showed elevated SMRs for the total cohort were also studied in detail to determine if they clustered in any job categories. Complete work histories at TMS participating locations were used to categorize the workers into subgroups based on jobs held and length of time held. All job categories showed significant deficits for the all causes of death category, and large deficits were seen for almost all the major causes of death for each subgroup. Essentially, the mortality patterns in the job subcohorts were very similar to those for the entire cohort of white males [Divine et al, 1985].

Most of the causes of death with elevated SMRs are based on small numbers of deaths. When the cohort is subdivided into job categories, the number of deaths becomes even smaller. Although some SMRs are elevated when examined by latency and years worked, most are based on fewer than five deaths. No patterns of increasing SMRs with increasing latency and number of years worked are seen for any of the job groups. The SMR is elevated for the job subcohorts of office and managerial workers and pancreatic cancer; laboratory workers and brain cancer; and pipefitters and boilermakers and leukemia and benign neoplasms; however, the results of more specific analyses do not support a causal association. Any trends seen should be interpreted with caution, since SMRs are indirectly adjusted ratios, and the underlying age distributions are likely to be dissimilar. Furthermore, because of the small number of deaths, the SMRs are very unstable and the confidence limits are very wide. Although many of the SMRs seem to decrease with increasing duration of employment, the confidence limits overlap to such an extent that the opposite effect cannot be ruled out.

A major problem in carrying out these analyses was deciding what criteria to use in assigning persons to the specific job groups. Typically, a person was first hired into one of the entry-level positions such as yard laborer. In the first several months to years, he had numerous job changes. Also, at many of the plants, an employee may have had as many as 12 concurrent jobs listed on the work record, with no means of determining how much time was spent in each job. This list of concurrent jobs also changed frequently. Usually, after a few years of numerous job changes, the employee settled into a specific craft or became an operator on a specific process unit.

These patterns of numerous job changes make it difficult to decide which job(s) should be considered when assigning persons to job cohorts. If each job ever held is used, certain entry-level positions would include most of the cohort, and persons with many job changes would be counted many times. If the longest job held is used, a person is only counted once but the earliest and possibly the jobs with the greatest potential for exposure would be ignored.

For each job, three cohorts were defined: ever employed. employed one year or more, and employed five years or more. Essentially, the patterns were similar for

all groups. However, the numbers exposed became small and the results unstable for many of the job groups as length of employment increased.

These results should be interpreted with caution. Most of the elevated SMRs are based on very few cases. In addition, because of the small number of deaths for the causes of interest in the job subcohorts, calendar time of exposure was not taken into consideration. Numerous comparisons were done, and one out of 20 results could be statistically significant by chance alone.

An attempt was made to group tasks and units with similar exposures and responsibilities; however, almost all jobs in a refinery involve exposures to a wide variety of straight chain and aromatic hydrocarbons. Only limited information is available on the chemicals to which these persons were exposed for the periods before the 1970s. Employees with a large number of job changes have the potential for exposure to almost every chemical in the workplace. Also, most of the decedents in this study were hired before 1940, and some as early as 1903. Some of the 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. These factors would tend to bias against finding a positive association.

In summary, an examination of work history by grouped job categories shows deficits for the leading causes of death. Although some elevated SMRs are seen, the small numbers and inconsistent trends preclude drawing conclusions about whether these elevations may be work-related. Further investigations of this cohort will be carried out, including case-control studies of the causes of death of interest and updates of the cohort over time.

REFERENCES

American Petroleum Institute (1979): Job Code Classification System Part I — Petroleum Refineries and Selected Petrochemical Operations. Washington. D.C.

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

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

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

Hanis NM, Stavrake KM, Fowler JL (1979): Cancer mortality in oil refinery workers. J Occup Med 21:167-174.

Monson RR (1974): Analysis of relative survival arid proportional mortality. Comput Biomed Res 7:325-332.

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

Theriault G, Goulet I (1979): A mortality study of oil refinery workers. J Occup Med 21:367-370.

Thomas TL, Decouflé P. Moure-Eraso R (1980): Mortality aniong workers cniployed in petroleum refining and petrochemical plants. J Occup Med 22:97-103.

Tsai SP, Wen CP. Weiss NS. et al (1983): Retrospective mortality and medical surveillance studies of workers in benzene areas of retineries. J Occup Med 25:685-692.

Wen CP, Tsai SP, Weiss NS, et al (1985): Long-term mortality study of oil refinery workers. IV. Exposure to the lubricating-dewaxing process. JNCI 74:11-18.