

A MORTALITY STUDY OF
PETROLEUM REFINERY WORKERS:
SOCIAL SECURITY FOLLOW-UP

API Project OH-1 #129

Final Report - September 23, 1975

Submitted to:
American Petroleum Institute
1801 K Street, N.W.
Washington, D.C. 20006

by:
Tabershaw/Cooper Associates, Inc.
2180 Milvia Street
Berkeley, California 94704

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II. Follow-up

Table 1 shows the present status of the study population, after inclusion of the Social Security information. The overall follow-up rate is now 99 percent. The lowest follow-up rate for any refinery is 94 percent, in one of the medium sized establishments. The Social Security search uncovered 29 additional deaths, for a total of 1,194. As a result of further efforts to obtain death certificates, these documents are now in hand for all but 10 of the 1,194 deaths.

III. Results

Tables 2 to 5 show SMRs by cause for various subgroups of the study population, and are the updated versions of Tables 6 to 9 in the original report. There are a few additional changes in Table 5, which compares different exposure groups, because some of the deaths in the diabetes and "other causes" categories were reexamined and placed in different exposure categories.

The addition of the 759 men traced through Social Security added 5,499 person years of observation, but left the results essentially unchanged. The only substantial change is an increase in the SMR for genital cancer from 101 to 111, with the addition of two deaths, and a corresponding increase in the SMR for some of the subgroups displayed in the other tables. In view of the fact that one of the original group of genital cancers occurred in a man who had been employed for only two years, it is not clear what significance should be attached to this cause of death.

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I. Introduction

The original report "A Mortality Study of Petroleum Refinery Workers" presented the results of a follow-up study of 20,163 petroleum refinery workers, in which those who had left employment were traced by mail. Ninety-four percent of the study population was successfully traced in this way.

In that report, the untraced workers were omitted from the analysis. For example, a man who worked for five years during the study period, and then left and was lost to follow-up, was counted as making no contribution to the study, even though he was known to have been alive for five of the ten years of the study period.

In spite of this conservative treatment of the untraced workers, there was a remote possibility that the findings of the study might be changed if all or most of these men could be found. Consequently, the Social Security Administration was requested to determine, for each of the missing workers, whether (1) he was still making contributions, (2) he was receiving benefits, or (3) a death claim had been filed, and if so, where and when.

On the basis of this information, and from the death certificates obtained for the deaths so found, the relevant tables in the original report were updated. This report presents those tables, and an additional analysis of the pattern of mortality from lymphomas.

Table 1

Study Population of Refinery Workers by Plant Number

Plant Number	Total	Status in Plant Records				Followup Status			Death Certificates		Percent Followup
		Now Working	Retired	Term.	Died	Alive	Dead	Unknown	Rec'd.	Not Rec'd.	
All	20163	13724	3574	2152	713	18677	1194	292	1184	10	99
1	3438	1791	458	1093	96	3160	154	124	152	2	96
2	619	395	127	91	6	595	10	14	10	0	98
3	651	468	135	22	26	605	43	3	43	0	99
4	197	141	39	9	8	184	12	1	12	0	99
5	68	0	68	0	0	58	10	0	10	0	100
6	1960	1381	425	62	92	1804	151	5	151	0	99
7	2625	1806	604	113	102	2408	201	16	201	0	99
8	505	351	94	50	10	478	19	8	19	0	98
9	1666	954	513	117	82	1498	159	9	156	3	99
10	4999	3838	766	223	172	4719	262	18	261	1	99
11	684	421	58	194	11	614	28	42	28	0	94
12	563	492	3	63	5	530	6	27	6	0	95
13	336	262	42	16	16	313	22	1	22	0	99
14	246	206	21	12	7	236	7	3	6	1	99
15	299	262	17	13	7	285	10	4	10	0	99
16	129	96	16	10	7	119	10	0	10	0	100
17	1178	860	188	64	66	1071	90	17	87	3	99

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Because of the age and stability of the study population, it was possible to identify one more subgroup that had experienced extremely long exposures plus a sizable latent period. This group consisted of 5,145 men who had been hired before 1943. They constitute a group all of whom had at least 20 years of exposure, and for whom the 20th year of exposure occurred at least 10 years before the closing date of the study. The motivation for examining this group was primarily to answer a general criticism by NIOSH of broad studies such as the present one. The NIOSH position appears to be that the only worthwhile place to look for chronic effects of exposure is in groups with several decades of work experience followed by a latent period, and that the longer the exposure and the longer the latent period, the more likely it is that an effect will be found.

The results for those hired before 1943 are shown in Table 6, and do not appear to support the NIOSH position. The only real difference between this group and the total study population is that the excess mortality from lymphomas has entirely disappeared. The consequences of this observation are investigated in detail in a separate progress report on the lymphoma deaths.

OBSERVED DEATHS/EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY CAUSE, JAN. 1, 1962,
TO DEC. 31, 1971, IN MALE EMPLOYEES OF PETROLEUM REFINERIES, BY DATE OF HIRE

Cause of death with I.C.D. number	Hired before 1/1/62		Hired 1/1/62 or later	
	obs/exp	SMR	obs/exp	SMR
All causes	1181/1691.4	70**	13/33.7	39**
Tuberculosis (001-019)	3/12.2	25	0/0.2	0
Tuberculosis of respiratory system (001-008)	3/11.6	26	0/0.1	0
Malignant neoplasms (140-205)	271/331.2	83**	4/3.2	125
Malignant neoplasms, buccal cavity & pharynx (140-140)	7/12.1	58	0/0.1	0
Malignant neoplasms, digestive organs & peritoneum (150-159)	82/97.1	85	1/0.6	167
Malignant neoplasms, respiratory system (160-164)	93/114.2	82*	0/0.6	0
Malignant neoplasms, genital organs (170-179)	18/17.1	106	1/0.3	333
Malignant neoplasms, urinary organs (180-181)	6/17.1	35**	0/0.1	0
Leukemia & leukemia (204)	11/12.2	91	0/0.4	0
Lymphomas (200-203, 205)	24/19.2	126	0/0.6	0
Diabetes mellitus (260)	11/24.5	45**	0/0.4	0
Major cardiovascular & renal diseases (330-334, 400-468, 592-594)	650/886.0	74**	2/6.0	33
Vascular lesions affecting CNS (330-334)	57/106.9	54**	0/0.8	0
Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)	12/17.1	71	0/0.4	0
Arteriosclerotic heart disease (420)	510/611.5	84**	1/3.3	30
Nonrheumatic endocarditis (421, 422)	7/29.5	24**	0/0.2	0
Hypertensive heart disease (440-443)	11/36.4	30**	0/0.2	0
Other hypertensive disease (444-447)	5/7.9	64	0/0.1	0
Chronic & unspecified nephritis & renal sclerosis (592-594)	6/10.6	57	1/0.3	333
Influenza & pneumonia (480-493)	11/15.1	32**	0/0.6	0
Ulcer of stomach & duodenum (540, 541)	12/13.7	88	0/0.1	0
Appendicitis (550-553)	6/1.7	0	0/0.0	0
Hernia & intestinal obstruction (560, 561, 570)	1/5.9	17	0/0.1	0
Gastritis, duodenitis, enteritis & colitis (543, 571, 572)	3/4.6	66	0/0.1	0
Cirrhosis of liver (581)	24/51.0	47**	0/0.8	0
Hyperplasia of prostate (610)	0/2.0	0	0/0.0	0
Symptoms, senility & ill-defined conditions (780-795)	14/24.8	57**	0/0.6	0
All other diseases (residual)	73/135.2	54**	1/2.8	36
Motor vehicle accidents (810-835)	27/51.0	53**	4/8.5	47
Other accidents (800-802, 840-962)	38/60.0	64**	1/4.9	20
Suicide (963, 970-979)	23/36.1	64**	1/2.4	42
Homicide (964, 980-985)	10/16.4	61*	0/3.0	0
Number of workers	14870	4932		
Person-Years	128624	14029		

*Significant at 5% level.

**Significant at 1% level.

CAUSE OF DEATH WITH I.C.D. NUMBER
OBSERVED DEATHS/EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY CAUSE, 1961-1967
TO DEC. 31, 1971, IN ALL MALE EMPLOYEES OF PETROLEUM REFINERIES

Cause of death with I.C.D. number	obs/exp	SMR
All causes	1194/1725.0	69**
Tuberculosis (001-019)		
Tuberculosis of respiratory system (001-008)	3/12.4	24
Malignant neoplasms (140-205)	3/11.7	26
Malignant neoplasms, buccal cavity & pharynx (140-148)	275/334.4	83**
Malignant neoplasms, digestive organs & peritoneum (150-159)	7/12.2	58*
Malignant neoplasms, respiratory system (160-164)	83/97.7	86
Malignant neoplasms, genital organs (170-179)	93/114.8	82*
Malignant neoplasms, urinary organs (180-181)	19/17.3	111
Leukemia & aleukemia (204)	6/17.2	35**
Lymphomas (200-203, 205)	11/12.5	89
Diabetes mellitus (260)	24/19.7	123
Major cardiovascular & renal diseases (330-334, 400-468, 592-594)	11/24.9	45**
Vascular lesions affecting CNS (330-334)	652/892.0	74**
Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)	57/107.7	53**
Arteriosclerotic heart disease (420)	12/17.4	70
Nonrheumatic endocarditis (421, 422)	511/614.8	84**
Hypertensive heart disease (440-443)	7/29.7	24**
Other hypertensive disease (444-447)	11/36.7	30**
Chronic & unspecified nephritis & renal sclerosis (592-594)	5/8.0	63
Influenza & pneumonia (480-493)	7/11.0	64
Ulcer of stomach & duodenum (540, 541)	11/35.7	31**
Appendicitis (550-553)	12/13.8	88
Hernia & intestinal obstruction (560, 561, 570)	0/1.7	0
Gastritis, duodenitis, enteritis & colitis (543, 571, 572)	1/6.0	17
Cirrhosis of liver (581)	3/4.7	64
Hyperplasia of prostate (610)	24/51.8	47**
Symptoms, senility & ill-defined conditions (780-795)	0/2.0	0
All other diseases (residual)	14/25.4	56**
Motor vehicle accidents (810-835)	74/137.9	54**
Other accidents (800-802, 840-962)	31/59.5	53**
Suicide (963, 970-979)	39/64.9	61**
Homicide (964, 980-985)	24/38.5	63**
Number of workers	10/19.4	52**
Person-years	19802	
	142652	

*Significant at 5% level.

**Significant at 1% level.

OBSERVED DEATHS/EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY CAUSE, JAN. 1, 1967.
TO DEC. 31, 1971, IN MALE EMPLOYEES OF PETROLEUM REFINERIES,
BY JOB CLASSIFICATION WITH RESPECT TO HYDROCARBON EXPOSURE

Cause of death with I.C.D. number	Job Classification					
	High			Low		
	obs/exp	SMR	obs/exp	obs/exp	SMR	SMR
All causes	499/748.2	67**	528/767.7	167/209.3	69**	80**
Tuberculosis (001-019)	1/5.4	19	2/5.5	0/1.5	37	0
Tuberculosis of respiratory system (001-000)	1/5.1	20	2/5.2	0/1.4	39	0
Malignant neoplasms (140-205)	124/144.6	87	120/149.0	31/40.8	81**	77
Malignant neoplasms, buccal cavity & pharynx (140-148)	4/5.3	76	3/5.4	0/1.5	56	0
Malignant neoplasms, digestive organs & peritoneum (150-159)	36/42.2	86	37/43.5	10/12.0	85	85
Malignant neoplasms, respiratory system (160-164)	45/49.7	91	39/51.3	9/13.9	76*	66
Malignant neoplasms, genital organs (170-179)	10/7.4	136	9/7.7	0/2.3	117	0
Malignant neoplasms, urinary organs (180-181)	2/7.4	27	3/7.7	1/2.1	39	48
Leukemia & leukemia (204)	3/5.4	56	4/5.6	4/1.5	72	271
Lymphomas (200-203, 205)	11/9.6	129	9/8.8	4/2.4	103	170
Diabetes mellitus (260)	2/10.8	19	3/11.1	6/3.0	27	204
Diabetes cardiovascular & renal diseases (330-334, 400-468, 592-594)	269/385.8	70**	282/396.9	101/109.5	71**	94
Major cardiovascular affecting CNS (330-334)	17/46.4	37**	28/47.8	12/13.5	59**	90
Vascular lesions affecting CNS (330-334)	5/7.6	66	2/7.7	5/2.0	26	255
Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)	215/266.0	82**	218/273.7	78/75.2	80**	106
Arteriosclerotic heart disease (420)	2/12.8	16	3/13.2	2/3.7	23	55
Nonrheumatic endocarditis (421, 422)	6/15.9	38**	5/16.3	0/4.5	31**	0
Hypertensive heart disease (440-443)	3/3.5	87	1/3.5	1/1.0	29	102
Other hypertensive disease (444-447)	0/4.8	0	6/4.9	1/1.3	123	78
Chronic & unspecified nephritis & renal sclerosis (592-594)	2/15.5	13	8/15.8	1/4.4	51**	23
Influenza & pneumonia (480-493)	4/6.0	67	6/6.2	2/1.7	97	120
Ulcer of stomach & duodenum (540, 541)	0/0.8	0	0/0.8	0/0.2	0	0
Appendicitis (550-553)	0/2.6	0	1/2.7	0/0.7	37	0
Hernia & intestinal obstruction (560, 561, 570)	2/2.0	101	1/2.1	0/0.6	48	0
Gastritis, duodenitis, enteritis & colitis (543, 571, 572)	11/22.8	49**	10/23.0	3/6.0	44**	51
Cirrhosis of liver (581)	0/0.9	0	0/0.9	0/0.3	0	0
Hyperplasia of prostate (610)	3/11.1	27	10/11.3	1/3.0	89	34
Symptoms, senility & ill-defined conditions (780-795)	31/59.6	53**	34/61.2	9/16.6	56**	55*
All other diseases (residual)	15/26.1	58**	13/26.6	3/6.9	49**	44
Motor vehicle accidents (810-835)	15/28.6	53**	22/28.9	2/7.5	76	27
Other accidents (800-802, 840-962)	13/17.0	77	9/17.1	2/4.4	53**	46
Suicide (963, 970-979)	2/8.6	23	5/8.6	3/2.2	58	139
Homicide (964, 980-985)						
Number of workers	8424		9071		2307	
Person-years	63034		63431		16193	

*Significant at 5% level.
**Significant at 1% level.

CAUSE OF DEATH WITH I.C.D. NUMBER
TO DEC. 31, 1971, IN MALE EMPLOYEES OF PETROLEUM REFINERIES, BY DATE OF HIRE

Cause of death with I.C.D. number	Hired before 1/1/52		Hired 1/1/52 or Later
	obs/exp	SMR	obs/exp
All causes	1123/1607.9	70**	71/117.2
Tuberculosis (001-019)	3/11.5	26	0/0.8
Tuberculosis of respiratory system (001-008)	3/10.9	28	0/0.7
Malignant neoplasms (140-205)	261/319.4	82**	14/15.0
Malignant neoplasms, buccal cavity & pharynx (140-148)	5/11.7	43**	2/0.5
Malignant neoplasms, digestive organs & peritoneum (150-159)	78/94.3	83	5/3.4
Malignant neoplasms, respiratory system (160-164)	92/110.9	83*	1/3.9
Malignant neoplasms, genital organs (170-179)	17/16.6	103	2/0.7
Malignant neoplasms, urinary organs (180-181)	6/16.6	36**	0/0.5
Leukemia & aleukemia (204)	10/11.4	88	1/1.1
Lymphomas (200-203, 205)	23/17.9	129	1/1.8
Diabetes mellitus (260)	10/23.4	43**	1/1.6
Major cardiovascular & renal diseases (330-334, 400-468, 592-594)	627/856.9	74**	25/35.1
Vascular lesions affecting CNS (330-334)	55/103.7	53**	2/3.9
Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)	12/15.9	76	0/1.6
Arteriosclerotic heart disease (420)	489/592.6	83**	22/22.2
Nonrheumatic endocarditis (421, 422)	7/28.6	25**	0/1.1
Hypertensive heart disease (440-443)	11/35.2	31**	0/1.4
Other hypertensive disease (444-447)	5/7.4	68	0/0.6
Chronic & unspecified nephritis & renal sclerosis (592-594)	6/9.8	62	1/1.2
Influenza & pneumonia (480-493)	11/33.3	33**	0/2.4
Ulcer of stomach & duodenum (540, 541)	12/13.2	91	0/0.7
Appendicitis (550-553)	0/1.6	0	0/0.1
Hernia & intestinal obstruction (560, 561, 570)	1/5.7	18	0/0.3
Gastritis, duodenitis, enteritis & colitis (543, 571, 572)	3/4.3	70	0/0.4
Cirrhosis of liver (581)	22/47.5	47**	2/4.4
Hyperplasia of prostate (610)	0/2.0	0	0/0.0
Symptoms, senility & ill-defined conditions (780-795)	14/23.2	61*	0/2.2
All other diseases (residual)	71/128.1	56**	3/9.6
Motor vehicle accidents (810-835)	23/41.9	55**	8/17.7
Other accidents (800-802, 840-962)	31/51.9	60**	8/13.0
Suicide (963, 970-979)	19/31.5	61**	5/7.0
Homicide (964, 980-985)	9/12.5	72	1/6.9
Number of workers	12408		7394
Person-years	106696		35960

*Significant at 5% level.

**Significant at 1% level.

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**OBSERVED DEATHS/EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS BY CAUSE, JAN. 1, 1962,
TO DEC. 31, 1971, IN MALE EMPLOYEES OF PETROLEUM REFINERIES HIRED BEFORE 1/1/43**

Cause of death with I.C.D. number	obs/exp	SMR
All causes	617/919.3	67**
Tuberculosis (001-019)	2/6.4	31
Tuberculosis of respiratory system (001-008)	2/6.1	33
Malignant neoplasms (140-205)	146/188.3	78**
Malignant neoplasms, buccal cavity & pharynx (140-148)	1/6.7	15
Malignant neoplasms, digestive organs & peritoneum (150-159)	43/56.7	76*
Malignant neoplasms, respiratory system (160-164)	56/65.5	86
Malignant neoplasms, genital organs (170-179)	11/10.9	101
Malignant neoplasms, urinary organs (180-181)	5/10.1	50*
Leukemia & leukemia (204)	676.4	94
Lymphomas (200-203, 205)	9/9.7	93
Diabetes mellitus (260)	9/13.6	67
Major cardiovascular & renal diseases (330-334, 400-460, 592-594)	360/507.0	71**
Vascular lesions affecting CNS (330-334)	36/63.4	57**
Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)	2/8.2	25
Arteriosclerotic heart disease (420)	286/349.8	82**
Nonrheumatic endocarditis (421, 422)	6/17.4	35**
Hypertensive heart disease (440-443)	5/20.9	24**
Other hypertensive disease (444-447)	2/4.0	50
Chronic & unspecified nephritis & renal sclerosis (592-594)	2/5.1	39
Influenza & pneumonia (480-493)	5/18.9	27**
Ulcer of stomach & duodenum (540, 541)	7/7.6	93
Appendicitis (550-553)	0/0.9	0
Hernia & intestinal obstruction (560, 561, 570)	0/3.4	0
Gastritis, duodenitis, enteritis & colitis (543, 571, 572)	0/2.4	0
Cirrhosis of liver (581)	11/23.6	47**
Hyperplasia of prostate (610)	0/1.4	0
Symptoms, senility & ill-defined conditions (780-795)	7/12.5	56*
All other diseases (residual)	39/73.4	53**
Motor vehicle accidents (810-835)	5/17.8	28**
Other accidents (800-802, 840-962)	10/23.6	43**
Suicide (963, 970-979)	11/14.3	77
Homicide (964, 980-985)	2/4.2	48
Number of workers	5145	
Person-years	43741	

*Significant at 5% level.

**Significant at 1% level.

See chapter 16, 1975