

BRAIN CANCER AMONG OCAW MEMBERS IN THREE TEXAS OIL REFINERIES

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INTRODUCTION

In a study of mortality patterns among active members of the Oil, Chemical, and Atomic Workers International Union (OCAW) in Texas, an increased relative frequency of brain cancer deaths among white males working in oil refineries and petrochemical plants was reported.¹ Among 1722 deaths, 25 brain cancers were observed, whereas only 14 were expected. Data from five oil refineries with at least 100 deaths were examined separately, and significantly increased frequencies of brain cancer deaths were found in two of them (Refineries A and C). In a third refinery, the observed number of brain cancer deaths was greater than expected (Refinery B), but the difference was not statistically significant.

Refineries A, B, and C are located within 20 miles of each other in the Beaumont/Port Arthur area of the Texas Gulf coast, a region with a heavy concentration of the petroleum and chemical industries. All three were constructed shortly after the discovery of oil in the area during the early 1900's and have been in continuous operation for well over 60 years. Although technology has changed over time, production processes at the three plants are very similar, consisting primarily of standard refinery operations that separate crude oil into various components including fuels, petroleum solvents, lubricating oils, petroleum wax, greases, and other products. The OCAW represents primarily production and maintenance workers employed by the refineries.

Because of the limited nature of the original set of deaths (i.e., only active Union members), efforts were made to assemble a more complete set of deaths, including retirees. Although we have examined mortality patterns for all causes of death, this report focuses on the patterns of brain cancer mortality among active and retired OCAW members employed at Refineries A, B, and C. We also present preliminary results of a case-control study of brain cancer deaths among active Union members at Refineries A and C.

PROPORTIONATE MORTALITY STUDY

Materials and Methods

Data on active members for the original study were obtained from the Membership Department at OCAW headquarters in Denver, Colorado. Subsequently, for the present study, records of the Union locals representing workers at Refineries A, B, and C were reviewed to determine whether data were available to identify deaths among their retired members. The Union local representing Refineries A and B has maintained records of deceased members, including retirees, since about 1943; however, nearly 90% of the recorded retiree deaths occurred after 1959. Records of retiree deaths within the Union local representing Refinery C were available only since 1972. The original study group, which was limited to active deaths that occurred between 1947 and 1977, was expanded to include all deaths known to the Union locals that occurred among active and retired members between 1943 and 1978. In addition, all deaths that occurred during 1979 were obtained from the Union local representing Refinery C. Together this included 1194 retiree deaths and 154 additional active-member deaths.

Information on membership status, date, and place of death were abstracted from Union records. Cause of death, age, sex, and race were determined from death certificates obtained from state vital records offices. Underlying cause of death was coded to the 8th Revision of the International Classification of Diseases (ICDA)² by a qualified nosologist according to the rules in effect at the time of death. This report focuses on deaths from malignant tumors of the brain and central nervous system (ICDA codes 191 and 192) and benign and unspecified tumors of the brain (ICDA 225 and 238) among white males. It is felt that malignant tumors are often placed in the benign and unspecified category as a result of death certificate coding rules. For instance, the term "brain tumor" is often used clinically to describe brain cancer, but for purposes of classification, this diagnosis would fall into the benign/unspecified category. For several analyses, therefore, data for malignant and benign/unspecified tumors were combined.

Observed deaths from brain tumors were compared to expected numbers calculated by three methods, with appropriate adjustments for age and calendar time. One approach computed cause-specific expected values from the relative frequencies of all deaths among U. S. white males, with the ratio of observed to expected deaths being the Proportionate Mortality Ratio (PMR).³ Expected deaths for malignant brain tumors were also calculated using proportions of all cancer deaths among white males in the total United States and in the two-county region in which the three refineries are located. In this approach, the corresponding ratios of observed to expected deaths are called the Proportionate Cancer Mortality Ratio (PCMR) and the County Proportionate Cancer Mortality Ratio (CPCMR). Statistical significance was determined by a summary chi-square test with one degree of freedom.⁴ Ratios and chi-squares were not computed when both the observed and expected numbers of death were less than 5.

TABLE 1
DISTRIBUTION OF WHITE MALE OCAW
DECEDENTS BY AGE AT DEATH

Age (years)	Number	Percent
< 50	383	18.0
50-64	865	40.6
65+	884	41.4
Total	2132	100.0

Interpretation of the results is subject to several limitations in methodology. If the OCAW study group has a lower mortality rate for all causes than U. S. white males, PMR's represent inflated estimates of cause-specific risks. Since the PCMR and CPCMR are based on the proportion of total cancer deaths, they might be better estimates of brain cancer risk among workers in the three refineries if the age-specific rates for total cancer in the study group resemble those of the corresponding standard population. Since the three ratios are based on the relative frequency of specific causes of death, excesses for some causes will be accompanied by deficits of others. Finally, because of multiple comparisons, one would expect a few ratios to be statistically significant based on chance alone.

Results

About 92% of the death certificates requested from state vital records offices were obtained. Because of small numbers, females and nonwhites were excluded from this analysis. One death from brain cancer occurred among 28 females. One malignant brain tumor and two unspecified tumors of the brain were observed among 377 nonwhite male decedents.

TABLE 1 shows the age distribution of white male decedents employed by Refineries A, B, and C. Less than 20% were under age 50 at death. As shown in TABLE 2, the study group was almost evenly divided between active and retired Union members.

PMR's for major causes of death among active and retired Union members are shown in TABLE 3 for the three refineries combined. A more detailed presentation of mortality patterns by membership status (active, retired) and refinery will be reported elsewhere.⁵ PMR's for total cancer and circulatory disease were significantly

TABLE 2
DISTRIBUTION OF WHITE MALE
OCAW DECEDENTS EMPLOYED IN RE-
FINERIES A, B, AND C BY MEMBERSHIP
STATUS AT DEATH

Status	Number	Percent
Active	1040	48.8
Retired	1092	51.2
Total	2132	100.0

TABLE 3
MORTALITY PATTERNS AMONG ACTIVE AND RETIRED OCAW MEMBERS EMPLOYED
BY REFINERIES A, B, AND C, 1943-1978

Underlying Cause of Death (8th Revision, ICDA)	Observed Deaths	Expected Deaths*	PMR†
All Causes of Death	2132	2132.0	1.00
All Cancer (140-209)	474	400.8	1.19‡
Circulatory Disease (390-458)	1177	1124.1	1.05‡
Respiratory Disease (460-519)	65	123.0	0.53‡
Digestive Disease (520-577)	77	103.5	0.74‡
Accidents, Suicide, Homicide (800-998)	198	203.3	0.97
All Other Causes	141	177.3	0.79‡

* Expected deaths based on proportionate mortality for U.S. white males.

† PMR = (observed deaths)/(expected deaths).

‡ Statistically significant at the 0.05 level.

elevated and more prominent among active than retired Union members. The relative frequency of respiratory disease deaths was low, especially among active Union members (PMR = 0.35). There were relative deficits of deaths from digestive disease, violence, and "all other causes."

Among active and retired members, there were 27 deaths from malignant brain tumors (TABLE 4). This was significantly greater than expected based on the relative frequency of brain cancer among all causes of death (PMR) and among all cancer deaths for U. S. white males (PCMR). The CPCMR was also elevated but not statistically significant.

Relative frequencies of brain tumor deaths are shown in TABLE 5 by membership status at death. The observed number of malignant brain tumor deaths was greater than expected among both active and retired workers, but the difference was statistically significant only among active workers. Both the PMR (2.41) and PCMR (1.87) were statistically significant among active members in the three refineries

TABLE 4
BRAIN CANCER MORTALITY (ICDA CODES 191 & 192) AMONG WHITE MALE ACTIVE AND
RETIRED OCAW MEMBERS EMPLOYED BY REFINERIES A, B, AND C, 1943-1978

	Observed Deaths	Expected Deaths	Ratio Obs/Exp
Proportionate Mortality—U.S. White Males (PMR)	27	11.8	2.28*
Proportionate Cancer Mortality—U.S. White Males (PCMR)	27	14.7	1.83*
County Proportionate Cancer Mortality—White Males in a two-county region (CPCMR)	27	18.4	1.47

* Statistically significant at the 0.01 level.

TABLE 5

BRAIN CANCER MORTALITY AMONG WHITE MALE OCAW MEMBERS EMPLOYED BY REFINERIES A, B, AND C
BY MEMBERSHIP STATUS AT DEATH, 1943-1978

	Malignant Brain Tumor (ICDA 191, 192)				Benign & Unspecified Brain Tumors (ICDA 225,238)				Total			
	Observed Deaths	Expected Deaths*	PMR†	Expected Deaths‡	PCMR§	Observed Deaths	Expected Deaths*	PMR†	Observed Deaths	Expected Deaths*	PMR†	
Refinery A												
Active (N = 484)	10	3.8	2.62**	4.5	2.24**	2	1.2	—	12	5.1	2.36**	
Retired (N = 524)	4	1.8	—	2.0	—	0	0.6	—	4	2.4	—	
Total (N = 1008)	14	5.6	2.50**	6.4	2.17**	2	1.9	—	16	7.5	2.14**	
Refinery B												
Active (N = 346)	5	2.8	1.81	3.7	1.34	3	0.9	—	8	3.7	2.19**	
Retired (N = 382)	2	1.2	—	1.4	—	0	0.4	—	2	1.6	—	
Total (N = 728)	7	4.0	1.76	5.2	1.36	3	1.3	—	10	5.3	1.90	
Refinery C												
Active (N = 210)	5	1.7	3.02**	2.5	1.97	0	0.5	—	5	2.2	2.31	
Retired (N = 186)	1	0.6	—	0.6	—	1	0.2	—	2	0.8	—	
Total (N = 396)	6	2.3	2.65**	3.1	1.92	1	0.7	—	7	3.0	2.35**	
A, B, C Combined												
Active (N = 1040)	20	8.3	2.42**	10.7	1.86**	5	2.6	1.88	25	10.9	2.29**	
Retired (N = 1092)	7	3.6	1.94	4.0	1.75	1	1.2	—	8	4.8	1.65	
Total (N = 2132)	27	11.8	2.28**	14.7	1.83**	6	3.9	1.54	33	15.7	2.10**	

* Based on proportionate mortality for U.S. white males.

† PMR = (observed deaths)/(expected deaths).

‡ Based on proportionate cancer mortality for U.S. white males.

§ PCMR = (observed deaths)/(expected deaths).

** Statistically significant at the 0.05 level.

—, Not calculated.

combined. An elevated frequency of benign and unspecified brain tumors was seen among active workers but not among retirees.

The relative frequencies of brain cancer deaths were elevated among workers at each of the three refineries (TABLE 5). There was more than a twofold relative excess of brain tumor deaths among Union members at refineries A and C. The weakest association was seen among OCAW members at Refinery B with ten brain tumor deaths observed and less than six expected. A cohort mortality study of all workers at Refinery B is reported in this volume by Wen.

TABLE 6 shows PMR's for brain tumors by age at death and calendar period. Brain tumor deaths were excessive among all age groups, but the PMR was statistically significant only among decedents in the 50-64 age group. Analyses by year of death indicated a fourfold increase of brain tumor deaths in the earliest time period. Although the difference between observed and expected numbers declined substantially, PMR's were elevated in later time periods. The magnitude of the difference between the observed and expected deaths generally decreased over time for each age group. There were no brain tumor deaths observed among decedents age 65+ in the earlier time periods due to the small number of retiree deaths reported prior to 1960.

CASE-CONTROL STUDY

Materials and Methods

For the 14 cases of brain cancer (ICDA 191 and 192) identified in the original study of active OCAW members in Refineries A and C, controls were selected from Union members who worked in the same refineries but died of other causes of death. The three white males who matched closest on the basis of year of death, age at death, and length of Union membership were chosen as controls for each case. Complete work histories for cases and controls were obtained from plant personnel records in Refineries A and C. Employment records for three workers at Refinery C were not available and work histories were reconstructed from plant seniority lists. Work history information prior to 1947 is missing from these lists; therefore, information on jobs held between first employment and 1947 was recorded as "unknown."

Broad categories of job-title-department combinations were created for analytic purposes (TABLE 7). Work histories for each study subject were summarized by calculating the length of time worked in a particular employment category and length between first employment in a category and death (latency period). For any category with at least five cases, the percent of cases and controls that were employed at least one day was calculated to evaluate possible clustering of cases within specific work areas. In addition, the mean length of employment and mean latency period were computed for cases and controls who ever worked in the category. No statistical tests were performed because of the small number of cases, and because work histories for the additional 23 brain tumor cases and their controls are still to be collected.

Results

There were three employment categories in which at least five brain cancer cases were employed: (1) The "Motor Oil" category includes some of the "second-step" refining operations after the initial cracking process, such as the manufacture of lubricating oils, paraffin wax, and some solvents. (2) The "Maintenance and

TABLE 6
 BRAIN CANCER MORTALITY (ICDA 191, 192, 225, 238) AMONG WHITE MALE ACTIVE AND RETIRED OCAW MEMBERS EMPLOYED
 BY REFINERIES A, B, AND C BY AGE AND CALENDAR TIME*

Age at Death (in years)	Year at Death														
	1943-49			1950-59			1960-69			1970-78			Total		
	O	E	PMR†	O	E	PMR	O	E	PMR	O	E	PMR	O	E	PMR
< 50	3	0.7	—	4	1.8	—	1	1.8	—	2	0.9	—	10	5.2	1.93
50-64	2	0.5	—	6	2.1	2.85**	5	2.6	1.94	4	2.4	—	17	7.6	2.24**
65+	0	0.0	—	0	0.1	—	3	1.0	—	3	1.8	—	6	3.0	2.02
Total	5	1.2	4.25**	10	4.0	2.50**	9	5.4	1.67	9	5.2	1.74	33	15.7	2.10**

* O = observed deaths. E = expected deaths based on proportionate mortality for U.S. white males.

† PMR = (observed deaths)/(expected deaths).

** Statistically significant at the 0.05 level.

—, Not calculated.

TABLE 7
 CATEGORY GROUPINGS FOR
 REFINERIES A AND C

Crude Oil	Receipt and Movement
Motor Oil	Docks
Solvent Dewaxing Unit	Pump Houses
Deasphalting Unit	Ethyl Plant
Furfural Unit	Grease Plant
Motor Oil Unit	Laboratory
Lube Plant	Motor Transportation
Paraffin Plant	Miscellaneous Other
Toluene	
Treating	
Coking	
Utilities	
Maintenance and Labor	
Construction	
Machine shop	
Painting	
Pipefitting	
Sawmill	
Welding	
Still and Tank Cleaning	
Miscellaneous Other	

Labor” category encompasses a wide variety of activities such as construction, painting, pipefitting, still and tank cleaning, and welding. Both skilled and unskilled workers in this category who worked in all areas of the refinery were included. Because entry level jobs were usually general labor positions, most refinery employees worked in Maintenance and Labor at some time. (3) The “Receipt and Movement” category covers work in pumping stations as well as ship and truck loading and unloading activities, and includes all processes necessary for the movement of crude oil and refinery products from one point to another.

TABLE 8 shows the number and percent of cases and controls ever employed in each of the three categories. A larger percentage of cases than controls were employed in each category; however, the only substantial difference was seen in Receipt and Movement.

The mean length of employment in the Motor Oil category was much higher for cases than controls (TABLE 8). In the Maintenance and Labor category, cases worked for an average of 9 years while controls worked an average of 13 years. In the Receipt and Movement category, the average time worked by the cases did not differ greatly from the controls.

The mean latency period was lower for cases than controls in the Motor Oil and Maintenance and Labor categories (TABLE 8). In Receipt and Movement cases died an average of 27 years after first employment in that category, while controls died an average of 13.5 years after first employment.

DISCUSSION

Although findings are not conclusive, this study suggests an association between brain cancer risk and exposures in the oil refining industry. Expanding the set

TABLE 8
DISTRIBUTION OF BRAIN CANCER CASES AND CONTROLS EVER EMPLOYED IN SELECTED
DEPARTMENT CATEGORIES

	Motor Oil		Maintenance and Labor		Receipt and Movement		Any Category	
	N	%	N	%	N	%	N	%
Cases	5	35.7	13	92.9	5	35.7	14	100.0
Controls	14	33.3	37	88.1	5	11.9	42	100.0

	Length of Employment (years)							
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Cases	14.6	0.3-33.5	8.9	0.1-24.8	8.1	0.1-30.5	25.8	13.1-40.7
Controls	8.1	0.1-29.2	12.9	0.1-34.2	7.5	0.1-22.5	28.4	13.1-43.9

	Latency Period (years)							
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Cases	16.8	7.8-35.8	22.9	5.1-38.5	26.8	7.9-40.6	25.8	13.1-40.7
Controls	20.5	0.1-38.7	25.7	11.3-43.8	13.5	4.7-22.4	28.4	13.1-43.9

of data from an earlier PMR study¹ to include retiree deaths did not change patterns previously seen for brain cancer in Refineries A and C. Indeed, this step uncovered an increased relative frequency of brain tumor deaths among workers at Refinery B. The relative excess of brain tumors was more prominent among active Union members, although a nonsignificant increase was seen among retirees.

The limitations of the PMR methodology are well known, especially when applied to active worker deaths.^{6,7} However, this approach is useful in generating hypotheses that can be tested by more analytic and definitive studies. By limiting the analyses to cancer deaths, the PCMR approach may compensate for limitations of the PMR due to the "healthy worker effect," assuming that the rate for total cancer in the population from which the study group was taken is not too different from that in the comparison population. PCMR's for brain cancer in our study were elevated among active and retired Union members and among workers in each refinery.

When utilizing the white male population of a two-county area as a standard for comparison, the CPCMR for brain cancer was elevated but was not statistically significant. However, the population of this two-county area may not be an appropriate comparison group, since about 25% of the total workforce in this area is employed in the petroleum and chemical industries.⁸⁻¹⁰ In addition, although the difference was not statistically significant, average annual age-adjusted brain cancer death rates during 1950-1969 among residents of both counties were higher than those for the total United States.¹¹ If exposures in the petroleum and chemical industries account for the higher rates of brain cancer in the two counties, the CPCMR would underestimate brain cancer risk in our study group.

Preliminary analyses from a case-control study based on a review of employment records indicated some refinery operations that might require further

evaluation, although the results at present are inconclusive because of small numbers. The study will be bolstered, however, by information to be collected from work histories of all 33 brain tumor cases among white males, plus four cases among females and nonwhites also employed in the three refineries.

Our findings are noteworthy in view of the excess risk of brain cancer reported in several occupational studies. Clusters of brain cancer have been studied in other petrochemical plants in the Texas Gulf coast region, as reported elsewhere in this volume. A Canadian cohort study of petroleum refinery workers reported more brain cancer deaths than were expected.¹² High risks of brain cancer have been associated also with the vinyl chloride, pharmaceutical, and rubber industries.¹³⁻¹⁷

In summary, our updated PMR analyses covering active and retired members of the OCAW employed by three petroleum refineries suggest that refinery workers have an elevated risk of brain cancer. More definitive studies are necessary to estimate the risks and identify the specific exposures that may be responsible.

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