



# Texaco Mortality Study

## I. Mortality Among Refinery, Petrochemical, and Research Workers

Barbara J. Divine, Ph.D.; Virginia Barron, M.S.; and Samuel D. Kaplan, M.D.

The Texaco mortality study is a retrospective follow-up study of all persons who were employed for at least five years in a refining, petrochemical, or research facility and who worked at some time during the period 1947 through 1977. Of the 19,077 white men in the cohort, 74,609 were alive, 4,024 were known to be dead, and the vital status of the remaining 444 was unknown as of Dec. 31, 1977. The standardized mortality ratio (SMR) of 75 for all causes was significantly low, on the basis of 5,332 expected deaths. Statistically significant deficits also were seen for all major causes of death and for cancer of many sites, including lung, stomach, bladder, and colon. The SMR was greater than 700 for six causes of death: pancreas cancer, brain cancer, leukemia, Hodgkin's disease, other lymphatic cancer, and benign neoplasms. However, none of these increases was statistically significant, and all SMRs except that for benign neoplasms (SMR = 748) were under 779.

A number of frequently cited studies have examined patterns of mortality among petroleum workers. While most have shown overall standardized mortality ratios (SMRs) to be lower than those of the general population, elevated numbers of deaths have been observed for cancers of several sites, including lung,<sup>1,3</sup> skin,<sup>1,2,4</sup> nasal cavity and sinuses,<sup>1,4</sup> digestive system,<sup>2,5</sup> malignant brain,<sup>2,4,6</sup> pancreas,<sup>2,7</sup> kidney,<sup>7</sup> lymphoma,<sup>6,8</sup> leukemia,<sup>2,6</sup> and bone.<sup>9</sup> However, the elevations are not found consistently in all the studies.

This report concerns the cohort of white males who were employed five years or more at Texaco refineries, research laboratories, or chemical plants and who worked any time during the period 1947 through 1977. The major objective of the study was to determine the patterns of mortality among these workers and, in particular, to determine if any of the elevated causes of death found in

other petroleum worker populations also occurred in the Texaco population.

### Materials and Methods

The study cohort consists of all employees of Texaco Inc. who worked at the refinery, petrochemical, and research facilities for a minimum of five years prior to Dec. 31, 1977, with at least one day of employment between Jan. 1, 1947, and Dec. 31, 1977. These employees were identified from personnel system rosters of all employees who separated from the company between 1947 and 1978 and from personnel listings of employees active in 1978. (Information on the rosters of separated employees included only the last job; therefore, employees who transferred to other facilities could not be identified. However, most transfers involved management personnel. Also excluded were employees of the administrative, engineering, and medical services departments and employees of a former subsidiary who terminated before 1955 and whose work records were not retained.)

Data collected on each employee included name, Social Security number, race, sex, date of birth, and a complete occupational history, when available. Vital status information for former employees was obtained from company records, where available, or from the Social Security Administration. Copies of death certificates were obtained either from the work record or from the state where the death occurred. The underlying cause of death identified on each death certificate was coded by a nosologist according to the seventh revision of the *International Classification of Diseases* for deaths through 1967 and according to the eighth revision for deaths occurring after 1967. All codes were converted to the seventh revision for the analysis.

In the analysis of mortality, persons for whom vital status was unknown were assumed to have been lost on the date last employed. Analysis was done using the Monson computer program<sup>10</sup> to compare the observed and expected number of deaths using the U.S. white male population as the comparison group. Person-years were counted beginning either on the date when the employee had worked five years or on the study begin date, Jan. 1, 1937, which-

From Texaco Inc., Houston (Dr. Divine and Ms. Barron); and SRI International, Menlo Park, Calif. (Dr. Kaplan).

Address correspondence to 1 Allen Center, P.O. Box 1404, Houston, TX 77251 (Dr. Divine).

| SMRs for Selected Causes of Death Among White Males, 1947 Through 1977 |                           |                           |     |                            |
|------------------------------------------------------------------------|---------------------------|---------------------------|-----|----------------------------|
| Cause<br>(ICD Seventh Revision)                                        | Observed No.<br>of Deaths | Expected No.<br>of Deaths | SMR | 95%<br>Confidence Interval |
| All causes (001-998)                                                   | 4,024                     | 5,331.8                   | 75  | 73-78                      |
| All infective & parasitic<br>diseases (001-138)                        | 22                        | 80.3                      | 27  | 17-41                      |
| All cancer (140-205)                                                   | 767                       | 1,019.4                   | 75  | 70-81                      |
| Cancer of<br>digestive system                                          | 215                       | 306.8                     | 70  | 61-80                      |
| Cancer of stomach                                                      | 45                        | 63.9                      | 70  | 51-94                      |
| Cancer of<br>large intestine                                           | 64                        | 94.3                      | 68  | 52-87                      |
| Cancer of pancreas                                                     | 62                        | 57.7                      | 107 | 82-138                     |
| Cancer of lung                                                         | 182                       | 306.0                     | 59  | 51-69                      |
| Cancer of prostate                                                     | 62                        | 73.1                      | 85  | 65-109                     |
| Cancer of kidney                                                       | 24                        | 25.1                      | 96  | 61-142                     |
| Cancer of bladder                                                      | 19                        | 33.9                      | 56  | 34-87                      |
| Cancer of skin                                                         | 14                        | 16.7                      | 84  | 46-140                     |
| Cancer of brain                                                        | 31                        | 28.0                      | 111 | 75-157                     |
| Lymphosarcoma                                                          | 20                        | 22.2                      | 90  | 55-139                     |
| Hodgkin's disease                                                      | 13                        | 12.0                      | 108 | 58-185                     |
| Leukemia                                                               | 48                        | 40.7                      | 118 | 87-156                     |
| Cancer of other<br>lymphatic tissue                                    | 25                        | 21.8                      | 115 | 74-170                     |
| Benign neoplasms                                                       | 20                        | 13.5                      | 148 | 91-229                     |
| Endocrine, metabolic diseases                                          | 78                        | 99.6                      | 78  | 62-98                      |
| Vascular lesions of<br>central nervous system                          | 322                       | 406.2                     | 79  | 71-88                      |
| Diseases of circulatory system<br>Arteriosclerotic<br>heart disease    | 1,975                     | 2,495.7                   | 79  | 76-83                      |
| Respiratory diseases                                                   | 159                       | 303.8                     | 52  | 45-61                      |
| Emphysema                                                              | 52                        | 86.1                      | 60  | 45-79                      |
| Diseases of digestive system<br>Cirrhosis of liver                     | 141                       | 252.1                     | 56  | 47-66                      |
| Diseases of<br>genitourinary system                                    | 56                        | 120.0                     | 47  | 35-61                      |
| External causes of death                                               | 43                        | 81.0                      | 53  | 38-71                      |
| Accidents                                                              | 227                       | 423.7                     | 54  | 47-61                      |
|                                                                        | 152                       | 289.0                     | 53  | 45-62                      |

ever was later. Decedents for whom no death certificate was obtained are included in the calculation of the all-causes SMR, but not in calculating cause-specific results.

## Results

There were 21,314 persons eligible for inclusion in the study cohort. Those person of unknown race (n = 344) or sex (n=28) were assumed to be white and male. This report is restricted to the 19,077 white males since they made up 90% of the total cohort and 94% of the deaths. Of these, 14,609 (76.6%) were alive as of Dec. 31, 1977, 4,024 (21.1%) were deceased, and 444 (2.3%) had vital status unknown. Death certificates were obtained for all but 152 (3.8%) of the decedents. Of those alive at the study end date, 46% were still active and more than 25% were retired. One third of the total cohort and three fourths of those who died before the end of the study period were first employed before 1940. More than half of the cohort

members and three fourths of those who died were employed for 20 years or more.

There were 4,024 deaths observed and 5,331.8 expected, giving a significantly reduced SMR of 75 (Table). Most striking is the statistically significant deficit seen for every major cause of death category, including all malignant neoplasms (SMR=75), cancer of the digestive organs (SMR=70), cancer of the lung (SMR=59), metabolic diseases (SMR=78), diabetes (SMR=80), diseases of the nervous system (SMR=81), vascular lesions of the central nervous system (SMR=79), arteriosclerotic heart disease (SMR=81), all respiratory diseases (SMR=52), all diseases of the digestive system (SMR=56), and all external causes of death (SMR=54).

There are a few causes of death for which the SMR is greater than 100, although none of the increases is significant. The highest SMR (148) is for benign and unspecified neoplasms (20 deaths observed and 13.5 expected). Thir-

teen of these were brain tumors (9.0 expected; SMR = 144). The SMR for cancer of the brain and CNS was slightly elevated at 111. Other causes of death for which the SMR was elevated are cancer of the pancreas (SMR = 107), Hodgkin's disease (SMR = 108), leukemia (SMR = 118), and cancer of other lymphatic tissue (SMR = 115).

## Discussion

This study of white male employees of Texaco refinery, research, and petrochemical facilities shows large deficits for all the major causes of death. The study covers more than 19,000 men during a 31-year period of observation with 358,029 person-years of observation. Although an overall SMR less than 100 is expected because of the "healthy worker effect," the SMR of 75 for all causes is lower than is usually seen in published reports of petroleum workers studies of this size and length of follow-up<sup>4,9</sup>, with the exception of the refinery workers study by Gaffey et al,<sup>8</sup> which had only 10 years of follow-up.

Several factors may have favorably influenced the overall SMR. New Texaco employees are required to pass a preemployment physical examination, although any selection effect from this should not extend beyond the first few years of employment. While it was thought that excluding those employed less than five years might have lowered some SMRs or obscured some excess causes of death, the analysis of workers employed one year or more at Texaco's largest refinery showed SMRs slightly lower than those for workers employed five years or more, with similar patterns of death for both groups.

Many of the categories with large deficits are causes for which mortality rates have declined considerably, e.g., parasitic and infectious diseases (SMR = 27) and heart disease (SMR = 81). One factor affecting this is that wage and health care benefits provide Texaco employees with a comfortable standard of living and access to quality medical care. Those causes of death with SMRs above 100, in contrast, tend to be ones with high case fatality rates and short average duration, for which access to medical care would make little difference. In addition, the healthy worker effect is relatively weak for neoplasms.

There are a few types of cancer for which SMRs are greater than 100. These are cancer of the pancreas, cancer of the brain, leukemia, other lymphatic neoplasms, and benign neoplasms. Mortality from these causes has also been found to be elevated in other studies of petroleum workers. While cancers of the pancreas and of the brain, in particular, have been associated with refinery employment,<sup>2,5,7</sup> the SMRs observed in this study are much lower than those seen in other studies, are elevated less than 10%, and reflect excesses of fewer than five deaths.

Other investigators have reported excesses for cancers of the digestive system,<sup>2,4,5</sup> stomach,<sup>2</sup> lung,<sup>1,3,11</sup> and skin.<sup>14</sup> However, deficits for these causes were seen in the Texaco cohort. Recent animal studies have associated exposure to gasoline with an increased risk of kidney cancer,<sup>12</sup> and one refinery worker cohort study has shown an elevated SMR for kidney cancer; however, this study shows no indication of an excess risk (SMR = 96). The low SMR for cancer of the lung (SMR = 59) is particularly striking and may be attributed in part to the nonsmoking rules in effect throughout the plants.

In summary, this study has shown a favorable mortality experience for refinery, research, and petrochemical workers at Texaco Inc. Significant deficits were observed for most causes of death, even some that were found to be elevated in other studies of petroleum workers. No significant increases were seen. Further analyses of the elevated causes of death are in progress, as are analyses of mortality patterns for work area subcohorts.

## Acknowledgment

Health departments of various states, including the state of New Jersey, cooperated in providing copies of death certificates for deceased members of the cohort.

## References

1. Blot WJ, Brinton LA, Fraumeni JF, et al: Cancer mortality in U.S. counties with petroleum industries. *Science* **198**:51-53, 1977.
2. Thomas TL, Decoufle P, Moure-Eraso R: Mortality among workers employed in petroleum refining and petrochemical plants. *J Occup Med* **22**:97-103, 1980.
3. Hanis NM, Stavrakys KM, Fowler JL: Cancer mortality in oil refinery workers. *J Occup Med* **21**:167-174, 1979.
4. Rushton L, Alderson MR: An epidemiological survey of eight oil refineries in Britain. *Br J Ind Med* **38**:225-234, 1981.
5. Theriault G, Goulet I: A mortality study of oil refinery workers. *J Occup Med* **21**:367-370, 1979.
6. Thomas TL, Waxweiler RI, Moure-Eraso R, et al: Mortality patterns among workers in three Texas oil refineries. *J Occup Med* **24**:135-141, 1982.
7. Hanis NM, Holmes TM, Shallenberger LC, et al: Epidemiologic study of refinery and chemical plant workers. *J Occup Med* **24**:203-212, 1982.
8. Caffey W, Weaver NK, Tabershaw IPA: Mortality Study of Petroleum Refinery Workers. Washington, D.C.: The American Petroleum Institute, 1974.
9. Wen CP, Tsai SP, McClellan WA, et al: Long-term mortality study of oil refinery workers: I. Mortality of hourly and salaried workers. *Am J Epidemiol* **118**:526-542, 1983.
10. Monson RR: Analysis of relative survival and proportional mortality. *Comput Biomed Res* **7**:325-332, 1972.
11. Gottlieb MS: Lung cancer and the petroleum industry in Louisiana. *J Occup Med* **22**:384-388, 1980.
12. MacFarland HN: Chronic gasoline toxicity, in MacFarland HN, Holdsworth CE, MacGregor JA, et al (Eds.): Proceedings of the Symposium The Toxicology of Petroleum Hydrocarbons. American Petroleum Institute, Washington, D.C.: 1982.