

FINAL REPORT

AN EPIDEMIOLOGIC MORTALITY STUDY OF MOBIL OIL CORPORATION EMPLOYEES AT THE PAULSBORO, NEW JERSEY, REFINERY

Submitted to
Mobil Oil Corporation

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EXECUTIVE SUMMARY

Environmental Health Associates (EHA), an independent research organization, recently completed a retrospective mortality study of workers at Mobil's Paulsboro refinery. Observed mortality among these workers was compared to expected mortality based on the U.S. population, standardized for age, sex, race, and calendar time. In general, the Paulsboro workers experienced 16.7% less mortality from all causes combined than the U.S. population. This statistically significant finding is frequently attributed to the "healthy worker effect": the initial selection of healthier individuals and maintenance of their healthier status through benefits associated with employment. This study found no evidence of excess risk for some of the cancers (e.g., leukemia, lung and digestive organs) previously reported to be associated with refinery employment. A noteworthy finding, however, is more deaths than expected from prostatic cancer among white males with 20 or more years of employment. Additional analyses of data available in the present study did not identify an occupational agent(s) or condition(s) responsible for the excess. Further study is planned to better understand the nature of the prostatic cancer findings.

The Paulsboro study population includes 4,263 workers who were employed within the refinery gates for a minimum of one year total between 1 January 1946 and 31 December 1979. Departments not reporting to the refinery management (e.g., medical) were excluded. The majority of the study population is male (93%) and white (89%). Race is unknown for 149 (4%) of the cohort. Most workers were hired between the ages of 20 and 30, and a large number started employment in the 1940s or 1950s. Since vital status was followed through 1979, a latency period (first employment to end of observation) of up to 30 years is possible for those cohort members hired in the 1940s. As a result, excesses in certain causes of death with long

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latency periods should be detectable. As of 31 December 1979, there were 1,164 individuals (27% of the study population) identified as deceased; death certificates were located for 1,130 (97%). Vital status was unknown for 94 (2%) of the cohort. These follow-up percentages for vital status and death certificates are considered more than adequate in studies of this kind.

Among the entire study population, deaths from all causes combined were 16.7% lower than expected. This finding was statistically significant, meaning there is a high probability that it is not due to chance. Significantly fewer deaths than expected were also observed for individual causes including: accidents (motor vehicles and others), and non-malignant diseases of the nervous, circulatory, respiratory, and digestive systems. For all cancers combined and several individual cancer sites (buccal cavity, liver, skin, bladder, kidney, etc.), there were fewer than expected deaths, but this was not significant. Mortality from brain cancer, rectal cancer, pancreatic cancer and leukemia was similar to that expected.

Separate analyses were conducted for white males, non-white males, and females. Too few non-white females (12) were available for separate analysis, and were combined with the white females for analysis. Deaths among the 3,647 white males were similar to the entire study group in terms of comparison to expectations. Among the white males with 20 or more years of employment, a statistically significant excess from prostatic cancer was detected. However, additional analysis based on the limited work history data available in the present study did not identify any agent(s) or condition(s) associated with the excess. For both non-white males (312) and females (304), fewer deaths than expected were observed for all causes combined, and none of the cause-specific SMRs examined was significantly higher than expected.

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In summary, the Paulsboro mortality study adds to the information already available from other petroleum companies' cohort studies, which together indicate a better overall mortality experience for refinery workers when compared to the general U.S. population.

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INTRODUCTION

A number of epidemiologic studies of petroleum refinery workers have been conducted. The first large-scale industry-wide study [Tabershaw/Cooper Associates, 1974] was sponsored by the American Petroleum Institute, and consisted of 20,163 workers employed in 17 refineries for at least a year between 1 January 1962 and 31 December 1971. The study ascertained vital status of 94% of the cohort as of 31 December 1971 and identified 1165 deaths.

Men with the lowest estimated exposure to atmospheric hydrocarbons had the highest mortality from cardiovascular and renal diseases, digestive cancer and ulcers of the stomach and duodenum. The report suggested that this finding might have been a function of differing physical demands in job categories, with different exposures, and of social and economic differences in the different exposure groups. On the other hand, mortality from a number of causes of death appeared to be exposure-related (increased mortality with higher exposure), including respiratory cancer, lymphomas, and genital cancer, although none was statistically significant. Since mortality from lymphomas exceeded the expected value and appeared to be exposure-related, the report suggested additional investigations to determine the possible relationship between lymphomas and employment at petroleum refineries.

A relatively small study was conducted on 1,205 men employed for more than five years in a Canadian oil refinery in East Montreal between 1928 and 1976 [Theriault and Goulet, 1979]. Of the total cohort, 190 (16%) were lost to follow-up and their vital status remained unknown at the end of the study.

In this group of Canadian oil refinery workers, the overall mortality was lower than that in the general population, the overall SMR being 78.43. There

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was no significant difference in the total cancer mortality rate between the refinery workers and the Quebec population (SMR = 89.29). In particular, lung cancer was less frequent than expected (3 observed vs. 7.42 expected). However, analysis by latency indicated a significant excess of brain cancer among those with a latent period of less than 20 years (3 observed vs. 0.46 expected, SMR = 652); but no common exposure was found among these three cases. Finally, though cancer of the digestive system was not significantly elevated (12 observed vs. 10.22 expected), the report suggested that this finding, combined with an elevated number of deaths due to diseases of the digestive system, should be given further attention.

Hanis et al [1979] conducted a cohort mortality study of 15,032 active or retired male employees (1964-73) of a Canadian petroleum company to determine the cause-specific mortality experience of workers exposed to petroleum and its by-products. A total of 865 (6%) employees were lost to follow-up. During the 10-year period of observation, 1,511 deaths were identified in the cohort.

Mortality from all malignant neoplasms in the exposed group was significantly above that in the non-exposed. In particular, comparison of the exposed and non-exposed workers revealed a significant excess among the former of cancers of esophagus and stomach (3-fold risk), and trachea, bronchus and lung (2-fold risk). Furthermore, exposed workers exhibited increasing stomach and lung cancer mortality with increasing duration of employment. When refinery workers were compared with non-refinery workers without consideration of exposure to petroleum in either group, the refinery workers were found to have twice the risk of cancer of the intestines (including rectum). Based on this observation, the authors concluded

that "the presence on a refinery site of a carcinogen other than petroleum has not been ruled out, and further study is urged."

During the last few years, the National Cancer Institute (NCI) has published a number of proportional mortality analyses on members of the Oil, Chemical, and Atomic Workers International Union (OCAW) in Texas. The latest published report was based on 2,509 active and retired OCAW members who worked at three oil refineries in the Beaumont and Port Arthur areas in Texas [Thomas et al, 1982]. Deaths that occurred between 1943 and 1979 were identified from union membership records of the OCAW headquarters in Denver and from the records of union locals in Texas. Age-adjusted cause-specific Proportionate Mortality Ratios (PMRs) were calculated using the mortality experience of the U.S. general population as a standard.

Excess mortality from stomach cancer occurred among active union members at Refinery A, and among active and retired union members at Refineries B and C. PMRs for leukemia, multiple myeloma, and other lymphomas were elevated, especially among retired workers. Mortality due to brain tumors was significantly elevated among active members at all three refineries and slightly elevated among retirees at Refineries A and C. Based on these PMR findings, the authors concluded that "oil refinery workers may have elevated risks of these cancers" and, in general, mortality from these cancers increased with length of employment and latency.

A mortality study of 34,781 workers employed for at least a year between 1 January 1950 and 31 December 1975 at eight oil refineries in Britain determined the vital status of more than 99% of the cohort [Rushton and Alderson, 1981a]. Of the 4,406 deaths identified during the observation period, cause of death was determined for all except four. Expected deaths were calculated based on the

mortality rates for all males in England, Wales and Scotland, with adjustment for regional variation in mortality for the English and Welsh refineries.

The observed overall mortality experience was significantly less than the expected (SMR = 84, $p<0.0001$). Mortality from all cancers, lung cancer, heart disease, stroke, bronchitis, and pneumonia was also significantly low. On the other hand, significant mortality excess was found in all 8 refineries for cancer of the nasal cavities and sinuses, and for melanoma. Furthermore, in several refineries and several occupational groups, significant mortality excess was observed in cancer of the esophagus, stomach, intestines, rectum, and lymphosarcoma.

In the above cohort study, there was a slight deficit of observed leukemia deaths when compared with the expected based on national rates (30 observed vs. 31.96 expected). Because these oil refinery workers were likely exposed to benzene, a case-control study of all deaths with a mention of leukemia on the death certificate (36 cases) in the original cohort was conducted, with the specific objective to investigate the role of benzene exposure in these leukemia deaths [Rushton and Alderson, 1981b]. The potential benzene exposure of these cases was compared with that of controls selected from the total refinery population. Although no information was available on measurement of benzene in the work environment, job histories were obtained and were used to allocate each study subject to a benzene exposure level of low, medium or high. When length of service was taken into consideration, the risk for those men with medium or high exposure to benzene relative to those with low exposure was 2-fold ($p=0.05$). Thus, the authors concluded that there was an increase in the risk of leukemia

in the group to whose exposure to benzene was assessed as medium or high, but there was no evidence that the risk increased with length of service. Furthermore, the authors argued that, since no leukemia excess was found in the overall cohort study, the risk affected only a very small proportion of men within the refinery workforce.

A recent cohort mortality study consisted of 8,666 regular employees who worked at least one month during the period 1 January 1970 through 31 December 1977, and retirees who were alive as of 1 January 1970 at the Exxon Baton Rouge refinery and chemical plant [Hanis et al, 1982]. A total of 835 (9.6%) were lost to follow-up, and 1,199 were identified to have died. Of those identified as deceased, 1,075 (90%) were retired and the remaining 124 died while employed. Death certificates were obtained for 97% of the deceased. Expected death rates by cause were calculated using the U.S. death rates as the standard, adjusted for age, sex, race and calendar year.

The study found a significantly low overall mortality for the entire cohort (SMR = 92). However, the authors noted that analyses by specific site of cancer revealed elevated SMRs for cancer of the kidney, testis, brain/central nervous system, pancreas and lymphopoietic tissue; although none of these elevations was statistically significant. Because a previous study found an association between pancreatic cancer and employment in the oil refinery industry, as well as residence near refineries in Louisiana [Pickle and Gottlieb, 1980], and the observation that one additional death from cancer of the pancreas in this study would result in a significant SMR, examination of work history of all the pancreatic cancer deaths was conducted. However, the attempt failed to identify a specific agent for the excess.

Some preliminary results from the American Petroleum Institute-Memorial Sloan Kettering Cancer Center (API-MSKCC) Prospective Morbidity and Mortality Study have been released [Schottenfeld et al, 1981]. This program was a registry of mortality and cancer incidence for the petroleum industry and consisted of some 96,000 employees from 19 U.S. companies. Deaths among both active (unless transferred to non-participating divisions) and retired employees and cancer incidence among active employees during 1977 and 1979 were reported to MSKCC by participating companies. Cause-specific mortality was compared to U.S. death rates and site-specific cancer incidence to the Surveillance, Epidemiology, and End Results data of the National Cancer Institute, adjusted for age, sex and race.

The overall mortality of the study population was significantly lower than that of the U.S. population (SMR = 55). Mortality from heart diseases, strokes and accidents was decreased significantly. On the other hand, mortality from cancer of the rectum, brain, and melanoma was elevated, although not statistically significant. Lung cancer mortality was significantly lower than the expected.

Cancer incidence data indicated an elevated incidence of cancer of the larynx but a deficit in lung cancer, although neither was statistically significant. A statistically significant increase in incidence of acute and chronic lymphocytic leukemias was observed in refinery workers (Standardized Incidence Ratio = 274).

Each of the studies reviewed above has its own limitations. For example, the API study [Tabershaw/Cooper Associates, 1974] had a very short follow-up, and there were problems in the exposure classification used in that study. The Theriault and Goulet [1979] study consisted of a very small cohort, and the per-

