



National Institute for Occupational Safety and Health Announcement of Findings

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Glossary of Terms

Case-Control Study: An epidemiologic study that compares people with disease, such as leukemia, to a similar group of people without that disease. Study results indicate which group was more likely exposed to one or more agents.

Cohort: A group of persons identified by common characteristics, e.g., specific employment, who are studied over a period of time.

Cohort Mortality Study: An epidemiologic study that evaluates causes of death and may examine their relationship with prior exposures.

Confidence Interval (CI): Confidence intervals reflect uncertainty in the risk estimates. Larger intervals indicate greater uncertainty.

External Ionizing Radiation: Natural or man-made (x-rays) radiation that originates outside the body and is capable of damaging human tissue.

Odds Ratio (OR): Estimates the probability of exposure among those with a disease (cases) and those without that disease (controls).

Portsmouth Naval Shipyard (PNS) Leukemia Case-Control Study

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Study Rationale: This study analyzed the relationship between external ionizing radiation and leukemia mortality among civilian employees of the Portsmouth Naval Shipyard (PNS) to help determine whether occupational exposures to radiation were associated with a risk for leukemia. Exposure assessments for benzene and carbon tetrachloride were also completed since these chemicals might also cause leukemia. The study is part of an ongoing program of research to evaluate whether occupational exposures are associated with adverse health effects among workers at U.S. nuclear facilities. The PNS Cohort Mortality Study, which is being simultaneously reported with this case-control study, identified no excess in the number of leukemia deaths among radiation-monitored and non-monitored workers combined. However, the PNS Cohort Mortality Study did show that, based on statistical evidence, the risk of dying from leukemia was greater for workers with higher external ionizing radiation exposures. The PNS studies were completed through the partnership of NIOSH, the U.S. Navy, PNS employees, and the U.S. Department of Energy.

Study Population: The study population included 115 PNS employees who had died from leukemia. They were compared with a total of 460 other PNS workers who served as controls. All workers in this study were selected from the 37,853 civilians employed at the Shipyard for at least one day between January 1, 1952 and December 31, 1992. Thirty-four of the leukemia cases and 167 controls were monitored for ionizing radiation exposures while employed at PNS.

How This Study Was Done: This study included a thorough analysis of a potential association between leukemia deaths and external ionizing radiation exposures within the PNS cohort. Work-related medical x-rays were included as a source of external ionizing radiation exposure. Medical screening of workers at the Shipyard included photofluorographic examinations of the chest before the early 1970s, a method used extensively in the U.S. for tuberculosis screening that resulted in higher levels of ionizing radiation exposure than standard x-ray examinations. Other factors such as potential exposure to benzene or carbon tetrachloride and radiation worker status were also included in the analysis.

Study Results: Using statistical methods, the study found a small increase in leukemia mortality associated with external radiation exposure (OR=1.08 at 10 mSv; 95% CI=1.01, 1.16), while adjusting for factors that might have a bearing on risk, such as gender, radiation worker status, and duration of possible exposure to benzene or carbon tetrachloride. In the PNS cohort analysis, the leukemia risk for radiation workers with less than 1 mSv cumulative exposure is estimated to be 0.33% over a working life-time. The result of this case-control study is equivalent to about an 8% increase, statistically, in the risk of leukemia death at 10 mSv (1 rem) cumulative exposure; that is, the risk would



increase from 0.33% to 0.36% at 10 mSv. Among all workers who received more than 10 mSv, the lifetime risk of overall leukemia mortality is 1.1%. Each photofluorographic chest x-ray examination added 1.5 mSv to the cumulative ionizing radiation dose estimate for some workers employed prior to the early 1970s. Each direct x-ray examinations of the chest, the same method commonly used today, added about 0.04 mSv. A positive relationship was also observed between leukemia mortality and duration of employment in jobs with potential exposures to benzene or carbon tetrachloride (OR=1.03 at one year of exposure, 95% CI=1.01, 1.06; OR=1.17 at five years of exposure, 95% CI=1.05, 1.32).

Study Limitations:

- The relatively small number of leukemia cases (34) among radiation workers makes it difficult for us to be certain of the findings.
- We tried to obtain accurate exposure information but records were not always available so sometimes estimates were made. These estimates cause some uncertainty in the conclusions. For example, exposure estimates for benzene and carbon tetrachloride were not available for individual workers. Estimates for these exposures were based on the total time employed in shops and job titles where they were used.
- A small number of work-related medical x-ray examinations may have been underestimated due to missing information.

Conclusions: The case-control study results suggest that leukemia mortality risk increased with increasing cumulative occupational ionizing radiation dose among PNS workers. The magnitude of increase in leukemia risk is consistent with other radiation epidemiology study results. Workers potentially exposed to benzene or carbon tetrachloride for longer periods of time also appear to have greater risk of death from leukemia. Uncertainty in the risk estimates, i.e., the rather wide confidence intervals, is attributed to the relatively small number of leukemia deaths (34) among radiation-monitored workers and reliance on job titles and shops to estimate benzene and carbon tetrachloride exposures instead of individual monitoring results for these chemicals.

Related Study Nearing Completion: To overcome some limitations, a much larger leukemia case-control study among workers from PNS and four U.S. Department of Energy sites is underway. This larger study, which is nearing completion, should provide substantially more information about the relationship between leukemia and radiation.

Publications:

Daniels RD, Taulbee TD and Chen P [2004]. Radiation exposure assessment for Portsmouth Naval Shipyard health studies. *Radiat Prot Dosimetry*, 111:139-50.

Daniels, RD, Kubale, TL, Spitz, HB [2005]. Radiation exposure from work-related medical x-rays at the Portsmouth Naval Shipyard. *Am J Indust Med*. 47:206-216.

Kubale, TL, Daniels RD, Yiin JH, et al. [2004]. A nested case-control study of leukemia and ionizing radiation at the Portsmouth Naval Shipyard. Cincinnati, OH: National Institute for Occupational Safety and Health/Health-Related Energy Research Branch; NIOSH No. 2005-104, 182 pgs.

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For a copy of the final report, call: 1-800-356-4674

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<http://www.cdc.gov/niosh/2001-133.html>

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