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.

Relative Risk (RR): Risk of disease or death among an exposed group compared with risk among an unexposed group.

Standardized Mortality Ratio (SMR): Ratio of the number of deaths observed in the study group to the number of deaths expected based on comparison with an external population.

Portsmouth Naval Shipyard (PNS) Cohort Mortality Study

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Study Rationale: This study was done to evaluate the causes of deaths for all Portsmouth Naval Shipyard (PNS) workers and to evaluate whether a relationship exists between exposure to low-level external ionizing radiation and death from certain cancers. The PNS Leukemia Case-Control Study, which is being simultaneously reported with this cohort mortality study, was done subsequently to further examine the question of potential relationship between external ionizing radiation and leukemia mortality. These studies are 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 study is part of an ongoing research effort involving partnership between NIOSH, the U.S. Navy, PNS employees, and the U.S. Department of Energy.

Study Population: The study included all 37,853 civilian workers employed at PNS for at least one day between January 1, 1952 and December 31, 1992. To ensure appropriate comparisons with previous studies of PNS workers, this cohort was divided into three subgroups: exposed radiation workers, unexposed radiation workers, and non-radiation-monitored workers.

How This Study Was Done: Causes of death were determined through 1996 for the entire PNS cohort. For each cause, deaths among all PNS workers were compared with the number that would be expected based on United States population death rates. External radiation exposure information was collected and verified for each radiation-monitored worker. Death rates for lung cancer and leukemia among radiation workers with higher radiation doses were compared with those among workers with lower doses. Likelihood of smoking and exposures to asbestos, welding fume and solvents were also considered in the analysis.

Study Results: Slightly fewer total deaths occurred in the full cohort than expected based on comparisons with the U.S. population (SMR=0.95, 95% CI 0.93-0.96, n=12,393). Fewer deaths than expected were observed for tuberculosis, diseases of the heart, circulatory system, digestive system, and for accidents and violence. Slightly more deaths than expected occurred for all cancers combined (SMR=1.06, 95% CI=1.02-1.10, n=3,192). More asbestosis deaths than expected were seen in radiation-monitored workers but not other workers, most likely due to the presence of asbestos in radiation controlled areas. Workers who had not been monitored for radiation exposures had more deaths than expected from causes historically associated with smoking, such as lung cancer and emphysema.

The number of leukemia deaths for all monitored and non-monitored workers combined was no different from the number expected (SMR=1.01, 95% CI 0.84-1.22, n=115). However, exposed radiation-monitored workers with greater cumulative radiation

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doses appeared to have an increased risk of leukemia mortality (RR=1.11 at 10 mSv of cumulative exposure, 95% CI 0.99-1.38). A more thorough assessment of the leukemia association with radiation exposures has been completed in a case-control study, as described in the National Institute for Occupational Safety and Health Announcement of Findings: Portsmouth Naval Shipyard Leukemia Case-Control Study.

In the full cohort, more deaths than expected occurred for cancers of the lung (SMR=1.11, 95% CI=1.05-1.18, n=1,099) and esophagus (SMR=1.36, 95% CI=1.11-1.67, n=97). Lung cancer mortality appeared to be positively associated with radiation exposure when no other exposures were considered. However, when three other factors historically associated with lung cancer were taken into account, i.e., smoking probability and welding fume and asbestos exposures, the lung cancer association with radiation exposure was no longer seen.

Study Limitations:

- Data for non-radiation exposures such as welding fume, asbestos and chemical solvents were not available for individual workers. Estimates for these exposures were based on shops and job titles and are therefore a source of uncertainty.
- Similarly, data for smoking were not available for most workers. Likelihood of smoking was instead assigned by job title.

Conclusions: Overall mortality for the PNS cohort was slightly less than expected. Several findings differed by subgroup: elevations in asbestosis deaths were seen only in radiation-monitored workers, and higher risk of death was observed for several smoking-related causes of death among non-radiation-monitored workers. A dose-response association was observed between external ionizing radiation exposure and leukemia mortality, but not lung cancer, after including information about other exposures. To help clarify these results, findings for leukemia and lung cancer are being examined further. Results from a case-control study of the relationship between leukemia mortality and exposures to external radiation and solvents in PNS workers are being simultaneously reported. Additionally, a larger leukemia case-control study that includes workers from PNS and four U.S. Department of Energy sites is nearing completion. Whether a relationship exists between lung cancer mortality and exposures to external radiation, asbestos, and welding fume is being further investigated in a case-control study planned for completion within the next year.

Publications:

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

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.

Silver SR, Daniels RD, Taulbee TD, et al. [2004]. Differences in Mortality by Radiation Monitoring Status in an Expanded Cohort of Portsmouth Naval Shipyard Workers. *JOEM*, 46(7):677-689.

Yiin JH, Schubauer-Berigan MK, Silver SR, et al. [2005]. Risk of lung cancer and leukemia from exposure to ionizing radiation and potential confounders among workers at the Portsmouth Naval Shipyard. *Radiation Research*, 163:603–613.

The findings and conclusions in this document are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

Further NIOSH Information

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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