



Lung Cancer and Exposure to Ionizing Radiation

Summary: Studies conducted at the Los Alamos National Laboratory and other nuclear facilities suggest an increased likelihood of developing lung cancer for workers who have been exposed to ionizing radiation. These findings are consistent with the determination of the National Research Council's BEIR V committee that lung tissue is sensitive to ionizing radiation. Lung cancer is a "specified" cancer under the Energy Employees Occupational Illness Compensation Program Act. Historically, lung cancer incidence and mortality ranked among the lowest in the state for both Los Alamos and Rio Arriba Counties. Incidence means new cases of cancer, while mortality means deaths due to cancer.

What is Lung Cancer?

The lungs are part of the respiratory system. Cancers that begin in the lungs are divided into two major types, non-small cell lung cancer and small cell lung cancer, depending on how the cells look under a microscope. Each type of lung cancer grows and spreads in different ways and is treated differently. Within these types, lung cancer may be named for the type of cells in which the cancer develops. (National Cancer Institute)

Findings of Human Health Research Studies

Human health research studies compare the patterns of disease among groups of people with different amounts of exposure to a suspected risk factor. Below are results reported from such studies of lung cancer among people exposed to ionizing radiation.

All of these studies found increased risk and possible increases in lung cancer risk among exposed groups. Statistically significant is a term used to mean that the connection between the health outcome and the exposure was strong enough that it was unlikely to be due to chance. Several of these studies directly measured personal exposure to radiation. The research included incidence studies, which look at new cases of cancer. These can track health more quickly and accurately than mortality studies of deaths due to cancer. Adding to the strength of the findings is that increasing rates of lung cancer were observed with higher doses in some studies.

Studies of Los Alamos National Laboratory (LANL) Workers

Research conducted of LANL workers provides the most direct evidence about possible relationships between a health problem and workplace exposures at LANL.

- **Mortality Study up to 1991:** Possible increase in lung cancer deaths were observed in a study of plutonium workers with body burdens of at least 2 nanocuries (a measure of radiation exposure) who were first employed at LANL between 1943 and 1977.²¹

* Findings were statistically significant (strong evidence)

+ Evidence of a dose-response relationship (strongest evidence)



- **Manhattan Project Workers:** Three cases of lung cancer have occurred in the 26 Manhattan project workers enrolled in a long-term study. All three had histories of cigarette smoking.¹⁷
- **Zia Study (unpublished):** Possible increase in lung cancer deaths were found among Hispanic males who were employed between 1946 and 1978 and exposed to external radiation and/or plutonium.¹⁵

Studies of Other Nuclear Workers in the United States

The next most relevant evidence comes from studies of workers in similar occupations with the same types of exposures. Listed below are studies that looked at lung cancer and workplace exposures among nuclear workers in other parts of the United States.

- **Atomic Weapons Establishment of the U.K.:** A possible increase in lung cancer was found in an analysis of the 3,044 workers who were monitored for plutonium who were employed between 1951 and 1982, and then followed through 1982, when compared to other (non-plutonium) radiation workers.⁵³
- **Fernald, Ohio:** A possible increase in lung cancer deaths was seen in a study of 4,014 uranium processing workers who were employed between 1951 and 1989, and then followed through 1989. A strong effect was observed in cases of internal doses of at least 20 rem (a measure of radiation dose) in combination with an external radiation dose of at least 5 rem.¹
- **Hanford, Washington:** A possible increase in lung cancer deaths (and all respiratory cancers combined) was found in a study of women who were employed between 1944 and 1978, and then followed through 1981.⁵² A possible increase in lung cancer deaths was also found in 24,900 males who were employed between 1944 and 1972, and followed through 1972.⁵¹
- **Mayak, Russia:** Risk of lung cancer correlated with high body burdens of plutonium in a case-control study of 162 cases of lung cancer that were diagnosed in Mayak workers between 1962 and 1991.⁶³ Adenocarcinoma was the kind of lung cancer most frequently associated with plutonium.
- **Mound, Ohio:** A possible increase in lung cancer deaths was found in a study of white males ever employed at Mound or monitored for polonium-210, between 1944 and 1972. The highest risk was among workers hired during World War II. Also, a possible increase in lung cancer deaths was found in 3,229 males monitored for external radiation between 1943 and 1979.⁴³
- **Oak Ridge:** Increasing rates of lung cancer deaths (and all respiratory system cancers combined) was found with increasing doses of external radiation in a study of 28,008 white males who were employed at least 30 days between 1943 and 1947, and then followed

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through 1979.⁶⁴ *+ A “notable” increase in the rate of lung cancer was found in a study of 106,000 workers employed between 1943 and 1985.⁶⁵

- **Oak Ridge K-25 Gaseous Diffusion Plant:** Increase in deaths due to lung cancer (and all respiratory system cancers combined) were observed in a study of males employed from 1945 to 1984.¹⁸ *
- **Oak Ridge, Tennessee Eastman:** Increase in lung cancer deaths was found in 18,869 males employed between 1943 and 1947 in a uranium conversion and enrichment plant.⁶⁶ *
- **Oak Ridge X-10:** About a 5% increased risk of death due to lung cancer was found for each 1 rem (a measure of radiation dose) of external radiation dose in a study of 8,318 males who were employed between 1943 and 1972, and then followed through 1984.⁵⁷ * For doses received after age 45, the increased risk was sometimes greater than 5% per 1 rem.⁶⁷
- **Oak Ridge Y-12:** Increase in deaths due to lung cancer were seen in a study of 6,781 males who were employed at least 30 days between 1947 and 1974.* Risk was greatest for workers who had both gamma and alpha radiation doses of at least 5 rem (a measure of radiation dose) each.²³ When followed through 1990, the rates of death due to lung cancer were highest for those with 5 to 19 years of exposure, and 10 to 29 years since first exposure.²⁴
- **Oak Ridge Welders:** A possible increase in deaths due to lung cancer (and all respiratory cancers combined) were found in a study of 1,059 white male welders who were hired between 1943 and 1973, and then followed through 1973. The biggest risk may have been for those who worked at least a year welding at K-25 (a lot of nickel alloy).⁶⁸
- **Rocketdyne/Atomics International, Santa Susana, California:** A possible increase in rates of death due to lung cancer was observed with increasing doses of external radiation in a study of 4,563 workers who were monitored between 1950 and 1993, and then followed through 1994.²⁷ +
- **Rocky Flats, Colorado:** A small increase in lung cancer was seen in a study of 5,413 white males with a plutonium body burden of at least 2 nanocuries (a measure of radiation exposure) employed for at least two years between 1952 and 1979, when a 10-year latent period (time following exposure for the disease to develop) is assumed.²⁸
- **Savannah River Site:** A possible increase in risk of lung cancer deaths was found in hourly and salaried white males, especially those who worked at least 90 days before 1974 or were first hired before 1955.⁴⁴
- **Uranium Operations at Several Plants (Y-12, Mallinckrodt & Fernald):** A possible increase in lung cancer deaths was found in workers with internal doses of at least 25 rem (a

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measure of radiation dose). Risk of lung cancer from external radiation may be higher for workers hired at age 45+.⁶⁹

- **West Chicago (Kerr-McGee) Thorium Plant:** A possible increase in lung cancer deaths was observed in 1,352 men who were first employed between 1940 and 1954, and then followed through 1976. A similar effect was found among 1,446 men who were first employed between 1955 and 1969.⁴⁵

Studies of Other Nuclear Workers World-Wide

Below are studies of nuclear workers outside of the United States that looked at lung cancer in connection with radiation exposures.

- **Sellafield, England:** A possible increase in lung cancer incidence (tumors) was found in a study of 5,203 plutonium workers who were employed between 1947 and 1976, and then followed through 1992, when compared to other radiation workers.³
- **3 Nuclear Workforces in the U.K.:** An increase in lung cancer deaths was found in a study of 10,185 workers who were “ever monitored” for radionuclides like Zn-65, Fe-59, Co-60 and Cr-51.* A possible increase in rate of death due to lung cancer was seen with increasing time since first being monitored for plutonium (in 12,498 plutonium workers)²⁹.⁺
- **Atomic Energy Establishment of U.K.:** Increasing rates of lung cancer deaths were found with increasing doses of external radiation in females who were employed between 1946 and 1979, and then followed through 1986.⁶ *⁺
- **Canadian Radiation Workers:** An increase in lung cancer incidence was found in a study of 191,300+ male and female workers who were first exposed to radiation between 1951 and 1988.⁴⁷ *
- **Mayak, Russia:** An increase in lung cancer deaths was seen in a study of workers with plutonium body burdens who were first employed between 1948 and 1958, and then followed through 1993.* The biggest risks were in workers 50+ years old. Increasing rates of lung cancer deaths were found with increasing alpha dose to the lung.⁷⁰ ⁺

Studies of Other Ionizing Radiation Exposures

Studies among other groups of people who were not nuclear workers can also be significant as evidence of possible increases in lung cancer among those who have been exposed to ionizing radiation. Most other research has been conducted of people exposed to atomic bombs.

- **Atomic bomb Survivors:** In studies performed to date, there is reported evidence of increased rates of lung cancer deaths (and all respiratory cancers combined)⁵⁴ with increasing doses of radiation in a study of 86,572 survivors.⁸ *⁺

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⁺ Evidence of a dose-response relationship (strongest evidence)

Other Research and Policy Findings

- **Yes.** The National Research Council's BEIR V committee concluded that lung tissue is sensitive to ionizing radiation. The committee conducted an intensive analysis of radiation-induced lung cancer. Among the issues they addressed are the bases for apparent gender differences; interaction with smoking; and dose rate effects in animal studies.⁹

The National Research Council advises the U.S. government on scientific matters. Their Committee on Biological Effects of Exposure to Ionizing Radiations (BEIR) V reviewed sensitivity of parts of the body to radiation. Their findings are based mostly on studies of cancer among atomic bomb survivors, as well as on some of the available information on the biology of the body, animal studies, and other evidence. The greatest risk is at high exposure levels.

Is Lung cancer a "Specified" Cancer Under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA)?

- **Yes.** Lung Cancer is a "specified" cancer under the EEOICPA consideration of Special Exposure Cohorts

Policy makers have identified certain types of cancer among energy employees at nuclear facilities, including those employed at Los Alamos National Laboratory, as being potentially related to occupational exposures under the EEOICPA.

What Are Other Risk Factors for Lung Cancer?

In considering the risks of occupational exposure to ionizing radiation leading to lung cancer, it is important to understand other risk factors. The following is a list of other possible risk factors for lung cancer.

- **Smoking.** Smoking is an important risk factor for lung cancer.¹²
- **Air pollutants.** Exposure to radon, asbestos, and second hand tobacco smoke may lead to lung cancer. Researchers have also found a link between lung cancer and exposure to certain other air pollutants, such as by-products of the combustion of diesel and other fossil fuels.
- **Certain lung diseases.** Lung diseases such as tuberculosis (TB), increase a person's chance of developing lung cancer.
- A person who has had lung cancer once is more likely to develop a second lung cancer compared with a person who has never had lung cancer. Quitting smoking after lung cancer is diagnosed may prevent the development of a second lung cancer.

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These factors may add to any risk due to workplace exposure to ionizing radiation.

Rates of Lung Cancer in Exposed Counties

Los Alamos County

There have been low rates of lung cancer reported in Los Alamos County for both cancer incidence and mortality. Los Alamos County:

- Ranked 28th in lung cancer incidence and
- Ranked 30th in mortality among the 33 counties in New Mexico from 1970 to 1996.³³
- In recent years there have been about five to six cases annually in the county.^{13, 14}

Rio Arriba County

There have been low rates of lung cancer reported in Rio Arriba County for both cancer incidence and mortality. Rio Arriba County:

- Ranked 30th in lung cancer incidence and
- 29th in mortality among the 33 counties in New Mexico from 1970 to 1996.³³

* Findings were statistically significant (strong evidence)

+ Evidence of a dose-response relationship (strongest evidence)