Center for Environmental Health Studies (617) 482-9485
44 Farnsworth Street, Boston, MA 02210 http://www.jsi.com

Brain Cancer and Exposure to Ionizing Radiation

Summary: There is strong evidence that brain cancer may be associated with exposure to ionizing radiation. This evidence is based upon studies conducted at Los Alamos National Laboratory, studies of nuclear workers at other sites, and others exposed to ionizing radiation. This is consistent with the National Research Council's finding that brain tissue is sensitive to ionizing radiation. There remains some scientific debate as to whether brain cancer in nuclear workers may be due to radiation or chemical exposures. Brain cancer is designated as a "specified" cancer under the Energy Employees Occupational Illness Compensation Program Act. Historically, brain cancer incidence and mortality have been among the highest in the state for Los Alamos County. Incidence and mortality in Rio Arriba County have been higher than average New Mexico county rates. Incidence means new cases of cancer, while mortality means deaths due to cancer.

What Is Brain Cancer?

Brain cancer is cancer that starts in the brain tissues. The brain is part of the body's central nervous system. Cancers that start in many other sites in the body can spread (metastasize) to the brain, but are not brain cancer. Benign tumors that are not cancer, but are still of concern, can also form in the brain. (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 brain cancer among people exposed to ionizing radiation.

All of these studies found increases and possible increases in brain cancer among certain groups of exposed workers. 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. An asterisk (*) was placed by statistically significant findings. The research was mostly mortality studies, which look at death due to brain cancer as an outcome. Incidence studies of those newly diagnosed with brain cancer can be more timely and accurate. Adding to the strength of the findings is that increasing rates of brain 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 1990:** Research conducted at LANL (among workers up through 1990) showed evidence that the risk among workers of dying from brain cancer increased with greater amounts of exposure to external radiation measured by TDL radiation badges.* [1]

This study presents strong evidence that was unlikely to be due to chance (was statistically significant). Supporting the evidence of a relationship, a pattern, called a dose-response trend was seen where the proportion of workers who died of brain cancer increased among those who received higher exposures. Further adding to the strength of this study is that it is based on direct personal measurements of exposure. A limitation of the study may be that is a mortality study of death from cancer rather than an incidence study of new cases.

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 brain cancer and workplace exposures among nuclear workers in other parts of the United States.

- **Fernald, Ohio:** A possible increase in brain cancer deaths was observed in a study of uranium processing workers who were employed from 1951 to 1989, and then followed through 1989.[1]

- **Lawrence Livermore, California:** An increased incidence of nervous system tumors *other than brain tumors* was found in males employed between 1969 and 1980.[2]

- **Oak Ridge Y-12, Tennessee:** Studies observed a possible increase in brain cancer deaths in workers who were employed from 1947 to 1974. But the researchers who conducted these studies were not confident that it was due to radiation.[3, 4]

- **Rocketdyne/Atomics International, Santa Susana, California:** There was a possible increase in brain cancer deaths in workers who were monitored for internal or external radiation between 1950 and 1993, and followed to 1995.[5, 6, 7]

- **Rocky Flats, Colorado**: A Possible increase in brain cancer deaths was observed among white males who worked for at least two years from 1952 to 1979, and were followed to 1980. [8]

Studies of Other Nuclear Workers Worldwide

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

- **Three Nuclear Workforces in the U.K.:** Increasing rates of brain cancer deaths were found with increasing number of years since workers were first monitored for plutonium.[9] *

- **Sellafield, England:** A possible increase in brain cancer deaths was seen in plutonium workers when compared to non-radiation workers.[3]

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 brain 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:** An increasing incidence of nervous system tumors, especially schwannomas, was seen with increasing doses of radiation.[+*10]A possible increase has been observed in malignant (cancerous) and other brain tumor deaths in A-bomb survivors who were followed through 1978. There was further evidence of a dose-response trend between reconstructed exposures and the risk of death from brain cancer.[11]

Other Research and Policy Findings

Is the Brain Sensitive to Radiation?

- **Yes.** According to the National Research Council's BEIR V Committee, the tissues of the brain are sensitive to the cancer-causing effects of ionizing radiation.[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 Brain Cancer a "Specified" Cancer Under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA)?

- **Yes.** Brain 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 Brain Cancer?

In considering the cancer risk from exposure to ionizing radiation at work, it is important to understand other risk factors. Below is a list of other possible risk factors for brain cancer.

- There is scientific debate over whether brain cancer in nuclear workers is due to radiation[31] or chemicals.[24]
- Some types of brain tumors are more frequent among workers in certain industries, such as oil refining, rubber manufacturing, and drug manufacturing. Other studies have shown that chemists and embalmers have a higher incidence of brain tumors
- Researchers are studying families with a history of brain tumors to see whether heredity is a factor.

These factors may add to any risk due to workplace exposure to ionizing radiation. Smoking is unlikely to be related to brain cancer.

What Makes Brain Cancer and Radiation Exposure Difficult to Study?

There are difficulties in all human studies because one cannot determine all exposures and track all health outcomes for everyone who may have been affected. In cancer this is especially the case as the cancer may take many years to develop to the point of diagnosis and possible death (disease latency). Brain cancer research is made particularly difficult due to errors in diagnosing brain cancer. Primary cancers of many other sites in the body can spread (metastasize) to the brain. This may lead to some of these other cancers to be incorrectly thought to be brain cancer. It is important to make sure that the disease is primary brain cancer.[12]

Radiation also causes brain tumors that are not cancerous (benign). To further complicate matters, brain tumors that are cancerous (malignant) are often incorrectly classified as "benign" or "other and unspecified" tumors. A growing number of researchers believe that all brain tumors (benign *and* malignant *and* unspecified) should be counted in studies of nuclear and chemical workers.[31]

Rates of Brain Cancer In Exposed Counties

Los Alamos County

There have been high rates of brain cancer reported in Los Alamos County for both brain cancer incidence and mortality.

- Los Alamos County ranked third highest in brain cancer incidence from 1970 to 1996 of the 33 counties in New Mexico.[13]
- Los Alamos County also ranked third highest in brain cancer mortality from 1970 to 1996 of the 33 counties in New Mexico.[33]
- In the 1950's, there was a statistically significant increase in brain cancer deaths in females in Los Alamos County.[14]
- During the mid- to late- 1980's brain cancer rates in Los Alamos County were 60 to 80% higher than in the U.S. or state-wide, contributing to public concern over a cluster. [15]
- In recent years, one to two new cases have been diagnosed each year in Los Alamos County.[14]

Rio Arriba County

Rates of brain cancer reported in Rio Arriba County have been somewhat higher than average county rates for both brain cancer incidence and mortality. These higher rates may be due to chance fluctuations in area rates.

- Rio Arriba County ranked 11th in brain cancer incidence from 1970 to 1996 of the 33 counties in New Mexico.
- Rio Arriba County ranked 12th in brain cancer mortality from 1970 to 1996 of the 33 counties in New Mexico. [33]

[1] Wiggs LD, Johnson ER, Cox-DeVore CA, Voelz GL. Mortality through 1990 among white male workers at the Los Alamos National Laboratory: considering exposures to plutonium and external ionizing radiation. Health Physics 1994;67(6):557-586.

[2] Reynolds P, Austin DF. Cancer incidence among employees of the Lawrence Livermore National Laboratory, 1969-1980. The Western Journal of Medicine 1985;142(2):214-218.

[3] Checkoway H, Pierce N, Crawford-Brown DJ, Cragle D. Radiation doses and cause-specific mortality among workers at a nuclear materials fabrication plant. American Journal of Epidemiology 1988; 127(2):255-266.

[4] Loomis DP, Wolf SH. Mortality of workers at a nuclear materials production plant at Oak Ridge, Tennessee, 1947-1990. American Journal of Industrial Medicine 1996;29:131-141.

[5] Ritz B, Morgenstern H, Froines J, Young BB. Effects of exposure to external ionizing radiation on cancer mortality in nuclear workers monitored for radiation at Rocketdyne/Atomics International. American Journal of Industrial Medicine 1999;35:21-31.

[6] Ritz B, Morgenstern H, Crawford-Brown DJ, Young B. The effects of internal radiation exposure on cancer mortality in nuclear workers at Rocketdyne/Atomics International. Environmental Health Perspectives 2000;108(8):743-751.

[7] Morgenstern H, Froines J, Ritz B, Young B. Final Report; Epidemiologic Study to Determine Possible Adverse Effects to Rocketdyne/Atomics International Workers from Exposure to Ionizing Radiation. Berkeley, CA: Public Health Institute, 1997.

[8] Wilkinson GS, Tietjen GL, Wiggs LD, Galke WA, Acquavella JF, Reyes M, Voelz GL, Waxweiler RJ. Mortality among plutonium and other radiation workers at a plutonium weapons facility. American Journal of Epidemiology 1987;125(2):231-250.

[9] Carpenter LM, Higgins CD, Douglas AJ, Maconochie NES, Omar RZ, Fraser P, Beral V, Smith PG. Cancer mortality in relation to monitoring for radionuclide exposure in three UK nuclear industry workforces. British Journal of Cancer 1998;78:1224-1232.

[10] Preston DL, Ron E, Yonehara S, Kobuke T, Fujii H, Kishikawa M, et al. Tumors of the nervous system and pituitary gland associated with atomic bomb radiation exposure. Journal of the National Cancer Institute 2002;94(20):1555-1563.

[11] Alexander VaD, J.H. Reappraisal of brain tumor risk among U.S. nuclear workers: a 10-year review. Occupational Medicine: State of the Art Reviews 2001;16(2):289-315.

[12] New Mexico Department of Health. Steering Committee Meeting Minutes, Third Meeting. In: Los Alamos Cancer Rate Study: Phase I. Santa Fe, NM; 1992. p. 21.

[13] Athas WF. Cancer in New Mexico 1970-1996: Changing Patterns and Emerging Trends. Santa Fe, NM: New Mexico Department of Health, 1998.

[14] Riggan WB, Acquavella JF, Beaubier J, Mason TJ. U.S. Cancer Mortality Rates and Trends, 1950-1979. Bethesda, MD: U.S. Government Printing Office; 1983.

[15] Athas WF, Key CR. Los Alamos Cancer Rate Study: Phase I; Cancer Incidence in Los Alamos County, 1970-1990; Final Report. Santa Fe, NM: New Mexico Department of Health, Division of Epidemiology, Evaluation and Planning University of New Mexico Cancer Center, New Mexico tumor Registry, 1993; March 1993.