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## **Introduction to Cancer and Workers Exposed to Ionizing Radiation A Review of the Research Literature**

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# Cancer and Workers Exposed to Ionizing Radiation

*A Review of the Research Literature*



**May 2003**



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Cancer and Workers Exposed to Ionizing Radiation: *A Review of Research Literature* is based on research conducted by Ken Silver.

The report was produced in conjunction with the JSI Center for Environmental Health Studies (JSI) by Terry Greene, Gretchen Latowsky, and Ken Silver with the assistance of Andrew Einhorn and Carol Rougvie.

This review is part of the initiative: *Worker and Community-Based Self Help on Epidemiology, Surveillance, and Compensation Rights at Los Alamos*, supported by a grant from the Citizens' Monitoring and Technical Assessment Fund. The initiative is being conducted by JSI Center For Environmental Health Studies in collaboration with the worker organization Citizens for LANL Employee Rights (CLER) and the community-based organization El Rio Arriba Environmental Health Association (El RAEHA). Cover photos of Los Alamos National Laboratory from the LANL website.

March, 2003

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# Radiation and Cancer Risk

## Summary

Workers at the Los Alamos National Laboratory who may have been exposed to radiation have questions about the potential health effects of that exposure. In particular, they have voiced concern about potential links between exposure to ionizing radiation and specific types of cancer. This booklet includes the latest information from health studies of cancer risks to nuclear workers around the world. It was compiled to serve as a resource for those who have worked in nuclear industries, in particular the Los Alamos National Laboratory (LANL), their families, and communities.

Within the booklet is a series of fact sheets organized by type of cancer (bladder cancer, bone cancer, brain cancer, etc). Each fact sheet lists the findings of studies on radiation and these specific cancers. Of importance to many former employees and their families is whether the cancer has been designated under the Energy Employees Occupational Illness Compensation Program Act Of 2000 (EEOICP Act) as a “specified” cancer. Workers who had “specified” types of cancer may more easily meet the eligibility requirements for compensation, if and when “special exposure cohorts” are established at LANL.

Information is also included in the fact sheets on county rates for each type of cancer in Los Alamos and Rio Arriba counties, in which the Los Alamos National Laboratory is the major employer. High cancer rates in these counties may be an indication that occupational exposures play a role. They also may indicate a need for better health care for diagnosis and treatment.

This research overview is part of an initiative: *Worker and Community-Based Self Help on Epidemiology, Surveillance, and Compensation Rights at Los Alamos*. The project is supported by a grant from the Citizens' Monitoring and Technical Assessment Fund. It is being conducted by JSI Center For Environmental Health Studies (JSI) in collaboration with the worker organization Citizens for LANL Employee Rights (CLER) and the community-based organization El Rio Arriba Environmental Health Association (El RAEHA). The goal is to advance worker understanding and participation in important decision making. Experts invited to the community conducted a series of workshops covering such topics as occupational health and safety, epidemiology, health effects of exposure to radiation and asbestos, the role of occupational studies in setting exposure standards, and worker compensation. This report is among articles and fact sheets made available to workers and residents.

# The Purpose of This Guide

For those who are impacted by cancer that may be due to employment at a nuclear facility there are few places to turn to for information that is objective and up-to-date. The concerns of exposed individuals tend to fall through the cracks of government agencies, the medical profession, and anti-nuclear groups. This guide attempts to provide useful, objective information for those who have worked in nuclear industries, in particular the Los Alamos National Laboratory (LANL). In it you will find summarized results of health studies conducted at LANL and across the world to determine whether specific types of cancer may arise from radiation exposure. Rates of cancer in Rio Arriba and Los Alamos counties are also included. This information can be of value to the broader community in efforts to best protect residents and act on health concerns.

## Background:

### The Energy Employees Occupational Illness Compensation Program Act of 2000 (EEOICA)

Established in recognition that Federal nuclear activities have been “ultra-hazardous” entailing “unique dangers” including recurring exposures to radioactive substances that, even in small amounts, can cause medical harm, the Energy Employees Occupational Illness Compensation Program Act (EEOICA) notes that:

*Over the past 20 years, more than two dozen scientific findings have emerged that indicate that certain of such employees are experiencing increased risks of dying from cancer and non-malignant diseases. Several of these studies have also established a correlation between excess diseases and exposure to radiation and beryllium.*

Stating concerns over workers’ lack of knowledge of the risks and frequently unmonitored exposure, Congress enacted this legislation to remedy “inadequate worker compensation” and poor agency “self-regulation.”<sup>1</sup> This guide has information on the research leading to this act and some of the types of cancers that may be eligible for compensation.

### The Lack of Information Resources

Until recently, the government has not been a valuable source of health information regarding cancer risk for individuals who may have been affected by radiation exposure.

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<sup>1</sup> ENERGY EMPLOYEES OCCUPATIONAL ILLNESS COMPENSATION PROGRAM ACT OF 2000, AS AMENDED, 42 U.S.C. § 7384 et seq. PART A— ESTABLISHMENT OF COMPENSATION PROGRAM AND COMPENSATION FUND § 7384. Findings; sense of Congress

For many years, occupational cancer risks to employees of Los Alamos and other nuclear facilities were denied by the government and its contractors. Thanks to recent policy changes these issues are finally available for review and discussion. Contributions of leaders such as Secretary of Energy Bill Richardson (1998-2001) who was willing to confront these problems head-on are uniquely valuable and very important to future protection of workers.

A wealth of research on radiation exposure and cancer risk has accumulated over the years and is on file in government agencies. Unfortunately, the information is not readily available in a format that can be useful to the general public as they seek to protect their health, obtain appropriate health care, and address concerns.

Those turning to the medical community for information about exposures and possible health effects, have often found providers unable to provide adequate assistance. Few physicians are trained in occupational medicine. Fewer still are able to undertake the legal and ethical duties that come with making a diagnosis of occupational cancer. All too frequently physicians focus solely on an individual's personal "lifestyle" factors and overlook their workplace exposures as possible causes of cancer. This can be due, in part, to the uncertainties of occupational cancer. Another factor is the time consuming process of documenting and proving a case when patients are facing medical termination or workers' compensation proceedings. Physicians need additional training, support, and leadership to recognize and respond effectively to occupational illnesses.

Nonprofit advocacy organizations have also been largely unable to meet the needs of individuals for information. While anti-nuclear and environmental organizations have played an essential role in raising society's general awareness of hazards, few of these groups are able to provide technical assistance to individuals. Moreover, the quality of information disseminated by anti-nuclear groups varies greatly.

Families sometimes rely on speculative, alternative health ideas about the health effects of radiation and chemicals when they have available to them a growing body of mainstream medical and scientific studies to help determine and address work-related illness. The information in this booklet has been prepared to provide workers and their families with objective information that they can share with their regular doctor. It may require more time and effort, but working with a mainstream doctor is an important step to obtaining quality care. In addition, an opinion based on evidence from credible research is far more valuable than an opinion from an alternative doctor when working with authorities to obtain appropriate compensation for harm.

#### The Problems with Epidemiology

Before reviewing the information in this booklet, it is important to consider the limitations of research on environmental exposure and human health. Studies listed in this document attempt to answer whether radiation may result in specific types of cancer. The science of studying patterns of disease in human populations to determine cause and

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effect between exposures and health outcomes is called "epidemiology." Think of the term epidemics. Epidemiological studies linking exposures to human health are always extremely difficult to conduct and by nature have many limitations. Unfortunately, such studies are seldom a satisfying way of responding to worker and community concerns about cancer.

One problem with epidemiology is the stringent statistical standards scientists require before they will recognize a problem as "significant." By tradition, scientists need to be 95 percent sure that the patterns of illness observed are not due to chance. These stringent standards of proof can usually be met only in studies of very large human populations. This is the concept of statistical power. Several thousand workers may have to be studied to have even a chance of finding a "statistically significant" increase of a specific kind of cancer. Most epidemiological studies are lacking in the statistical power needed to detect small ? but real ? increases in cancer.

Yet another problem with epidemiological studies is that people are unique individuals. A group of people who work together may have similar exposures on the job, but may differ in how much they smoke, drink, eat, where they live, their genetic backgrounds, and previous job exposures. These confounding factors enter into every epidemiological study. Unlike studies of test animals, people are not caged and given known exposures. Instead they move freely in an environment with many pollutants, sometimes choosing to cause harm to themselves through lifestyle choices. Scientists have statistical methods to cope with confounding. But these methods only work when large numbers of people are enrolled in a study.

Despite these limitations, epidemiological studies are the most relevant source of information about human health risks. The studies conducted on cancer and radiation exposure have grown over the years so that a wide body of information is now available. When supplemented with new information on the biology of cancer, they can provide strong evidence as to the actual risks.



## **What is in This Guide?**

### Health Study Summaries:

This booklet is organized into a series of fact sheets on specific types of cancer: bladder cancer, bone cancer, brain cancer, etc. Each fact sheet lists the outcomes of studies on radiation and these specific cancers, ordered in relevance to LANL workers. The first listing, therefore, is of studies conducted among LANL workers themselves. Next are studies of other nuclear workers in the United States followed by studies of other nuclear workers world-wide. Finally studies of those survivors of the Atomic bomb who were exposed to radiation are listed. Further evidence is presented as to whether, in the opinion of the National Research Council, the cancer site (the bladder, the brain, etc.) has been found to be sensitive to radiation.

### Regulatory Listing As Related to Radiation Exposure:

Whether the cancer has been included among the "Specified" cancers under the EEOICP Act may be of particular current relevance to families. If a "Special Exposure Cohorts" has been determined to exist at a Department of Energy site, then compensation for "Specified" cancers is a simple matter. If a special exposure cohort does not exist, then the compensation process entails additional burdens of proof. Chief among these is the need to establish a high enough level of personal exposure at the workplace to have "reasonably" caused cancer in the view of the regulatory agencies. This is determined through a complex model to recreate exposures from job histories. It is unclear how much ability workers will have to evaluate and challenge the findings of this model.

### Other Risk Factors:

Listed are other risk factors for the type of cancer. These include whether the cancer is among those that may be related to smoking. This is because smoking is a major factor in several cancers. Keep in mind that if smoking is a factor, it does not rule out that radiation exposures or other workplace exposures could have contributed to the development of the cancer. In some cases, exposure to smoking and workplace hazards can combine to add or even multiply risks. This might also be true for other risk factors. Some people, for example, may be at higher risk for cancer due to their personal or family history. Such individuals may be at higher cancer risk (more susceptible) when exposed to radiation.

## County Patterns of Cancer:

The fact sheets summarize the data on cancer rates in Los Alamos and Rio Arriba counties in which the Los Alamos National Laboratory is the major employer. The rates of cancer incidence (cases reported as they are diagnosed) and mortality (persons who died specifically due to having had that type of cancer) are included. The ranking of the counties from one (highest in the State of New Mexico) to thirty-third (lowest in the State of New Mexico) is provided. High rates in these counties serve as an indication that occupational exposures may play a role. They also may indicate a need for better health care for diagnosis and treatment.

## **Key Terms:**

A few key concepts are employed throughout this booklet:

**Incidence** is how many people are diagnosed as having an illness. **Mortality** is how many people died from it.

**Latent period** for cancer is the time from when a person is first exposed to a cancer-causing substance until the disease shows up. Most cancers take at least 10 years to show up (leukemia is an exception in that it can take as little as two years). Epidemiologists make various assumptions about latency when analyzing data in health studies.

**Follow-up period** is the average length of time since people in the study were first exposed. For radiation-related cancer, the longer the follow-up period the more likely it is to observe an increase in cancer because of the latent period discussed above. High rates of cancer in a group of radiation workers may be lost in studies with short follow-up periods.

**A dose-response relationship** is one of the strongest forms of proof in health studies. In a group of workers, when the risk of cancer increases with the dose of radiation, it's a strong signal that radiation is causing that kind of cancer.

## *A Few More Words About... Words*

Scientists use precise language. This booklet tries to do the same, but without the jargon. For readers who like a little jargon, here's the justification behind our precise choice of words.

**Statistically significant** is a term used to mean that the association between the health outcome and the exposure was strong enough that it was not thought to be due to chance. An asterisk (\*) was placed by these findings.

**Possible** means that the association was on the border of being statistically significant.

**Increasing** is the red flag for a dose-response relationship, one of the strongest forms of proof in health studies. A dose response relationship is the relationship between the dose of radiation and the health response observed. The symbol + was used to indicate a dose-response relationship.

**Race:** Many worker health studies limit enrollment to "white" men. Scientifically, studying one racial group is intended to allow any effects of exposure to be seen more clearly without any influence of racial differences in genetics or other factors that may affect health. But some epidemiologists have started to question whether, in the real world, it's a form of discrimination.

This can be a source of confusion in New Mexico. When health studies use the racial label "white," it usually includes Hispanic people. In this booklet racial and ethnic terms have been omitted, except in two situations:

- 1) when race highlights an issue important to the community; and
- 2) when racial distinctions were made at the stage of analyzing the data.

People of color may have been disproportionately assigned to hazardous work, especially in years past. So it's important to consider how racial and ethnic minorities' higher exposures may have caused higher rates of illness. However, for a given dose of radiation there is no evidence that ethnic or racial groups differ in susceptibility to illness.

#### **Technical Notes:**

Possible was used in the case of a test for trend that is of borderline statistical significance; or an effect measure (SMR or SIR) of 110 or higher, but with a confidence interval (or "error bar") that includes unity (SMR=100; no difference between the exposed and comparison groups). When an increase of cancer was not statistically significant, at least five cases were required to label these as possible increases.

However, there are two exceptions. First, in studies of the LANL workforce it was important to report all observed increases, with appropriate words of caution included. Second, in studies of other workforces, it was important to convey the researchers' own interpretations. Readers may form their own opinions on the basis of the overall evidence for a specific kind of cancer.

When an increase in cancer was statistically significant, an asterisk was used to identify significance (\*), the word possible was dropped.

## How Communities Can Use This Information

In addition to individuals making use of the information in this booklet, the findings of these studies raise important issues that need to be addressed at the community level. These are discussed below. First is the need to address county health disparities as evidenced by high rates of cancer observed in Rio Arriba and Los Alamos County versus other New Mexico counties. Second, arguments both for and against more studies should be considered. In cases where more study would be of value, recent advancements in participatory, community-based approaches are discussed as a means to enhance their accuracy and usefulness to those affected.

### The Need to Address County Health Disparities

Several kinds of cancer show rates of high incidence (cases diagnosed) and/or high mortality (deaths) that are of concern. High rates in these counties versus other New Mexico counties need to be investigated as a possible indicator of cancer impacts due to exposures at LANL. Whether or not these cancer rates are due to exposure at LANL, their patterns indicate a need for greater health care resources for early diagnosis and treatment in Rio Arriba and/or Los Alamos counties.

**Hodgkin's Disease.** Studies of several nuclear workforces, including LANL, have shown dose-response relationships between Hodgkin's disease and external radiation<sup>21; 49; 67</sup> or possible increases in death rates<sup>50; 1; 18</sup> or incidence.<sup>3</sup> Rio Arriba County ranked second in incidence and first in mortality due to Hodgkin's disease among the 33 counties in New Mexico (1970-1996). In an apparent failure in early diagnosis and treatment, the Los Alamos County's mortality ranking (sixth highest) was much worse than its ranking for incidence (twenty-fifth). Regardless of whether Hodgkin's disease is work-related, LANL is the major public institution in common to both Los Alamos and Rio Arriba counties. The Lab's resources are among those that could be applied to early diagnosis and treatment of Hodgkin's disease to improve this trend.

**Multiple Myeloma.** Rio Arriba County ranked highest among the 33 counties in New Mexico in mortality due to multiple myeloma (1970-1996).<sup>33</sup> Ionizing radiation is an accepted cause of multiple myeloma, with strong evidence available from studies of U.S.<sup>71</sup> and British nuclear workers.<sup>4</sup> State-of-the-art treatments involving transplants of bone marrow created from a person's own stem cells are available out-of-state. Access to these treatments by LANL families affected by multiple myeloma may help improve survival statistics in Rio Arriba County.

**Bladder Cancer.** Early detection and treatment of bladder cancer are succeeding in Los Alamos County, but failing badly in Rio Arriba County. Although ranked low in incidence of bladder cancer (twentieth), Rio Arriba County ranked highest in mortality.<sup>33</sup> The opposite is true in Los Alamos County: Los Alamos County ranked fifth highest in incidence but only number thirty-two in mortality. So a person is a lot more

likely to survive bladder cancer if s/he lives in Los Alamos County. As the major public institution in common to Los Alamos and Rio Arriba, LANL could help ensure that residents of Rio Arriba County enjoy the same access to medical procedures that have proven effective in saving lives on the Hill.

**Testicular Cancer.** While mortality is low, Los Alamos County ranks highest in the incidence of testicular cancer among the 33 counties in New Mexico (1970-1996).<sup>33</sup>

**Other Cancers.** Regardless of the cause, differences between incidence and mortality rankings indicate that Rio Arriba County also needs help with early detection and treatment of liver and cervical cancers.<sup>33</sup>

## **The Case For and Against "More Studies"**

Reviewing this compilation of studies on radiation and cancer highlights the need for certain additional studies to be conducted. At the same time, it is important to recognize the many cases where more study would not be useful and where what is needed instead is action on what we already know. Both cases are discussed below, along with recommendations to make use of community-based approaches in any new studies that are conducted.

### The Case Against More Studies

There are good reasons NOT to call for "more studies" of LANL worker health. Epidemiology is expensive and time-consuming. It rarely produces definitive results, for reasons noted above. Typically, epidemiologists wind up recommending "more studies." A second reason not to push for more studies is political. Proposing to "study the problem" only delays taking action on what we already know.

A third reason not to advocate for more studies is the historical lack of community benefits from carrying out costly research projects. In theory, communities should derive great benefits from interacting with outside experts. Young people should enjoy graduate research opportunities. The latest scientific knowledge should be translated into terms the community understands. And, to the extent that science brings out "the truth," government policies should then be fine-tuned to fix real problems. In reality, New Mexico communities have experienced research projects in which experts come in, collect their data, and return to their research institutions. Frequently this information is not shared with the community in a meaningful way and is not available for workers and residents to use to advocate for their own protection.

## The Case For More Studies

Despite these reasons to be cautious about getting involved in health studies, important questions have been raised through studies to date of LANL workers that have not yet been answered. Those affected could benefit from additional research targeted to address these concerns.

**Bone Cancer:** LANL researchers conducted a study of 5,424 employees of Zia Corporation between 1946 and 1978. One striking discovery was seven cases of bone cancer, three of which were angiosarcoma of bone, "a very rare tumor." Because plutonium and other radionuclides are known to accumulate in bone, the researchers called for further investigation to determine whether the bone cancers were work-related.<sup>15</sup> The study also found increased death rates due to cancer of the stomach, liver, pancreas and leukemia.

A draft of the study was provided to the funding agency the National Institute for Occupational Safety and Health (NIOSH) on November 24, 1992 and was never completed. It is important to note that the study had major problems with following up with individuals over time and missing exposure records. From a roster of 14,428 workers hired by Zia between 1946 and 1978, only 5,424 had adequate records. The draft version submitted to NIOSH in November 1992 needed improved follow-up before it could be circulated for scientific scrutiny.

The Zia study should be revisited. One good reason is that LANL claims that only a single case of bone cancer has ever occurred in its workers exposed to plutonium.<sup>17</sup> Russian scientists studying plutonium workers have pooled bone cancers together with connective tissue cancers.<sup>20</sup> Doing the same at LANL could provide a partial scientific basis for addressing the concerns of families affected by leiomyosarcoma.

**Brain Cancer:** In 1991, concern about "environmental" brain cancer in Los Alamos grabbed media attention around the world, leading to a DOE-funded study by New Mexico state agencies. The study reached negative conclusions.<sup>35</sup> Meanwhile, LANL's own researchers discovered a dose-response relationship between external radiation and brain cancer deaths in LANL employees.<sup>21</sup> This passed almost without notice. About six to 12 brain cancer deaths, occurring between 1943 and 1990, form the basis for this discovery. This raises the obvious next questions:

- \* Where did they work?
- \* What were they exposed to?
- \* Did they have any work processes or operations in common?

It would be important to answer these questions and make the findings public.

**Mesothelioma:** This rare, fatal cancer of the chest or abdominal wall is almost always caused by exposure to asbestos. In the 1990's there were one or two cases per year of

mesothelioma among current and former LANL workers. [Department of Environmental Health Sciences, 1999] Graphs of the incidence of mesothelioma in Los Alamos and Rio Arriba counties in the 1990's are almost identical. They show sharp increases in incidence.<sup>14</sup> Dr. Chester Rail, a former LANL industrial hygiene engineer, has engaged in efforts to bring asbestos hazards to the attention of management as well as ongoing concerns about asbestos heavily contaminated with plutonium and other radionuclides in certain areas of the Lab.

LANL workers are not alone. Nuclear weapons employees in England have high rates of mesothelioma.<sup>3; 29;</sup> Back in the U.S., there were six cases of mesothelioma among the first 260 workers autopsied in the U.S. Transuranics Registry program (a registry of persons who were exposed to plutonium).<sup>18; 78</sup>

The families of LANL workers who died from mesothelioma need to be provided with accurate information about the kind of cancer, its cause, and their legal rights. They should not be led to believe that it was just another "lung cancer," with no definite cause. Another 23 current LANL or JCI employees have evidence of asbestosis, non-cancerous scarring of the lungs caused by asbestos exposure, on their x-rays. Another 104 current or former workers may have pleural abnormalities on their x-rays, also a sign of past exposure to asbestos.[Department of Environmental Health Sciences, 1999]

**Testicular Cancer:** As mentioned previously, Los Alamos County ranks highest in the incidence of testicular cancer among the 33 counties in New Mexico (1970-1996).<sup>33</sup> However, almost no one in the county dies from the disease. Most men in the county are employed at LANL, where they get regular medical check-ups. A study of Anglo employees showed a possible increase in the incidence of testicular cancer in men employed for at least one year between 1969 and 1978, although this was based on just three cases.<sup>16</sup>

A dose-response relationship between external radiation and the incidence of testicular cancer has been reported in Canadian radiation workers.<sup>47</sup> Men monitored for tritium in England's nuclear plants had an increased rate of death due to testicular cancer.<sup>29</sup> It has long been known that plutonium is retained in the testis. We now know that plutonium's retention in the testis is longer than for other tissues.<sup>78</sup>

Anecdotally, three former LANL workers have expressed concerns about:

- \* work practices that allowed for direct gamma irradiation of the groin
- \* benign cysts on the scrotum
- \* pain in the testis, in the absence of a diagnosed illness.

All three cases were exposed to plutonium on the job at LANL.

It is time to take a closer look at the possible associations between testicular cancer and occupational exposure to external radiation.

## Community-Based Research

If additional studies are conducted, new methods involving partnership with those affected can increase their usefulness. Some qualified scientists conduct their studies of workers in a "community-based" way. They do more than seek "input" from affected workers, families, and labor organizations. Citizens and their organizations are involved in every aspect of such studies. It may be due to improved input by those affected that when a community-based approach was taken to studying DOE contractor employees (at the Rocketdyne facility in California) evidence of several kinds of cancer in association with external and internal radiation was discovered. An advisory panel, which included union and community representatives along with scientific experts, conducted all of its business in public over the several years of the study. In addition to peer-reviewed publications in top scientific journals,<sup>1; 25; 26</sup> a non-technical booklet was distributed to explain the results of the study to the public. Such models promise a range of benefits as they improve research, serve the needs of those affected, and strengthen the community's capacity to address the problem into the future.