

Human Studies Project Team *Fact Sheet*

Los Alamos
NATIONAL LABORATORY

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(revised)

Los Alamos Involvement in the Human Studies of Plutonium

Background

As Los Alamos scientists used increasingly larger amounts of plutonium in the Manhattan Project work of 1944 and 1945, they recognized that strict precautions were necessary to protect workers from this hazardous substance. However, no definitive information was available that could be used to establish plutonium tolerance limits for humans or to measure occupational exposures. (Tolerance limit or dose was the terminology used at that time.) In 1945, the Manhattan Engineering District authorized human studies for the collection of these important data.

Basis of Tolerance Limit

In January 1944, milligram quantities of plutonium were first delivered to Los Alamos for its work in the Manhattan Project. At that time, Project scientists had proposed a tentative safe tolerance limit of 5 micrograms of internally deposited plutonium as a standard for Project sites. This tolerance limit for plutonium was based on limits adopted for use in the radium dial-painting industries. By comparing the equivalent radiation depositions of plutonium and radium, the Manhattan Project's Medical Division speculated that plutonium was one-fiftieth as toxic as radium, hence the 5-microgram limit.

Animal Studies of Plutonium Initiated in 1944

Because of the lack of knowledge about plutonium's toxicity, animal metabolic studies were initiated in 1944 at three Manhattan Project laboratories: the University of California Radiation Laboratory at Berkeley, the Metallurgical Laboratory at the University of Chicago, and the University of Rochester School of Medicine and Dentistry.

These studies showed that plutonium depositions in the body (body burdens) could be determined by measuring the concentrations of plutonium in urine samples. The excretion model based on animal data would be a means to monitor workers for evidence of plutonium exposure. In June 1944, data from the Chicago animal studies indicated

- that the excretion rates for plutonium among the various types of laboratory animals could vary by as much as a factor of 5, and
- that humans probably would daily excrete 0.01% of the plutonium retained in their bodies.

An animal study at Los Alamos, authorized by Los Alamos Laboratory Director J. Robert Oppenheimer in August 1944, was initiated because Los Alamos personnel wanted a method to detect plutonium burdens less than 5 micrograms. These studies showed that the percentage of plutonium excreted by rats was independent of the total amount administered: regardless of the size of the dose, the percentage of plutonium excreted remained the same. Los Alamos Health Group personnel saw this information as critical for evaluating occupational exposures to plutonium based on the analysis of urine samples

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Need for Further Studies

By February 1945, the animal-derived 0.01% excretion model had been used at Los Alamos to estimate plutonium burdens for personnel who were working with large amounts of plutonium. Urine analysis results obtained in February and March 1945 suggested that some of the workers might have approached or exceeded a burden of 1 microgram. The concern was that doses to workers would exceed the 5-microgram level as larger quantities of plutonium were processed.

In a letter dated March 29, 1945, addressed to Colonel Stafford Warren, Director of the Manhattan District Medical Division at Oak Ridge, Oppenheimer pointed out that the hazards of working with plutonium at Los Alamos were probably much more serious than were those at other Project sites. The risk associated with 5-microgram depositions and the uncertainty associated with the animal-derived excretion rate were reasons for Oppenheimer to endorse a series of animal and human studies aimed at protection for plutonium workers.

Human Studies of Plutonium Authorized

The subsequent human plutonium injection studies authorized by the Manhattan Engineering District involved 18 hospitalized patients in four locations:

- one patient at Oak Ridge.
- three patients at the University of Chicago,
- three patients at the University of California, Berkeley, and
- eleven patients at the University of Rochester School of Medicine and Dentistry.

The purpose of these studies was to

- decrease the uncertainty of extrapolating animal experimental data to humans,
- provide data on the deposition and excretion of plutonium by humans, and
- provide a quantitative basis for determining plutonium exposures to workers and establish criteria for removing personnel from further exposure.

Oak Ridge study.

In April 1945, the Manhattan Project's Medical Division, headquartered at Oak Ridge, Tennessee, arranged for a hospitalized patient at Oak Ridge to be injected with a plutonium solution (this solution was not provided by Los Alamos). A sample of this solution, as well as urine, fecal, and other biological samples, was collected and shipped to Los Alamos for analysis. The first series of urine samples were analyzed for their plutonium activity on April 24, 1945. None of these biological samples remain at Los Alamos.

Chicago and University of California, Berkeley, studies.

Los Alamos did not participate in these studies.

Rochester studies.

From October 1945 to July 1946, eleven patients at the University of Rochester School of Medicine and Dentistry each received one injection of a plutonium solution supplied by Los Alamos. Urine, fecal, and other biological samples

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were sent to Los Alamos for radiochemical analysis. None of these samples remain at Los Alamos.

Results

The results of these studies were valuable to scientists in their efforts to find ways to ensure protection for plutonium workers. Below are some of the findings:

- The injection of a single dose of up to 100 micrograms of plutonium had no acute subjective or objective clinical effects on the patients.
- As with laboratory animals, the skeletal system was the major site of plutonium deposition.
- An equation (the Langham equation) was derived that describes the excretion rate of plutonium as a function of time after exposure.
- The biological half-life (the time it takes the body to excrete half of its original plutonium deposition) was estimated to be about 118 years.

The results of these studies continue to play a major role in nuclear health-monitoring activities. Today health physicists still rely on these findings to estimate plutonium exposures and to ensure radiation protection for workers. The principal findings of these studies have been confirmed by evaluations of occupationally exposed workers.

Published Report

A classified report (LA-1151) on the Rochester studies was prepared in 1950 by Wright Langham, who was principal investigator for this research at Los Alamos. The information was declassified in May 1971 and republished in the 25th anniversary special issue of *Health Physics*, June 1980. The results of the Rochester study have been cited in several open literature publications beginning in the late 1950s.

During recent reviews of the Rochester records, tabulation errors were noted in several sets of data. These errors did not significantly change the conclusions of the studies or the health protection methods derived from them.