RADIATION EXPOSURE LIABILITY: THE BURDEN OF RESPONSIBILITY AND COMPENSATION IN CIVILIAN AND MILITARY NUCLEAR VENTURES

By

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ABSTRACT

Since Enrico Fermi first discovered that neutrons could split atoms in 1934, peaceful and militaristic uses of nuclear energy have become prevalent in our society. Two case studies, Three Mile Island and the Nevada Test Site, allow for the examination of radiation injury liability in the context of existing radiation compensation systems. The Price-Anderson Nuclear Industries Indemnity Act, which governs civilian nuclear use, and the Radiation Exposure Compensation Act, which governs compensation for military nuclear weapons tests, are compared to determine the most efficient compensation system. Issues such as determining compensable diseases, establishing rigid criteria, and a heavy burden of proof define the efficiency of each system. A compensation system combining elements of the existing civilian and military compensation systems is proposed, which can be applied to future nuclear ventures such as the Yucca Mountain Repository.

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Contents

Introduction

Since Enrico Fermi first discovered that neutrons could split atoms in 1934, peaceful and militaristic uses of nuclear energy have become prevalent in our society. According to the Nuclear Energy Institute, thirty-one states in the United States are home to 104 operating nuclear power reactors. The largest nuclear power plant is Palo Verde in Arizona, boasting a power output of 3,872 MW, while the smallest nuclear power plant is Ft. Calhoun in Nebraska, which produces 478 MW of power. To place this in context, a 1,000-MWe reactor at 90% capacity factor operating for one year would generate 7.9 billion KWh of electricity—enough to supply electricity for 740,000 households (Nuclear Energy Institute, 2007). Shifting focus to the military, as of February 2003, the United States possessed 10,729 intact nuclear warheads with 274 warheads awaiting dismantlement. It is estimated that over 128,000 nuclear warheads have been built worldwide since 1945, with all but two percent of these warheads being built by the United States (55 percent or 70,000+) and Russia (43 percent or 55,000+) (Center for Defense Information, 2003). Thus, it is clear that the use of nuclear energy in the United States will not be phased out in the near future.

The harnessing of nuclear energy, whether it be for civilian or militaristic use, is accompanied by several policy issues. Namely, (1) Should nuclear reactors and weapons testing be permitted close to large populations? (2) What operating and safety procedures will adequately protect workers and the public from harmful radiation exposure? And (3) In the event of accidental exposure, who should be held accountable to provide compensation to those affected? By building upon a civilian and military case study, Three Mile Island and the Nevada Test Site, respectively, this thesis will aim to analyze the existing radiation exposure compensation systems, judge their effective components, and offer suggestions to improve the efficiency of future radiation exposure liability policies.

Health Consequences of Radiation Exposure

Before compensation schedules can be evaluated, the health consequences of radiation exposure must be discussed. With the exception of the atomic bomb victims of Hiroshima and Nagasaki, information concerning the effects of high radiation dose levels on people has been acquired through experiments involving lab animals. While some scientists believe it is justified to estimate the effects of low-level radiation on people by linearly extrapolating from the death rate caused by high radiation levels, others believe the rate at which the dose is administered may create an asymptotic flattening of the death rate at low levels of radiation. The linear relationship is assumed in practice because it is the more conservative estimation. No matter which theory is believed, scientists agree that there is no distinct lower threshold below which delayed effects of radiation and the development of cancer absolutely will not occur (Riley, 2003).

Increased cancer risk is the main long-term hazard associated with radiation exposure. Scientists have conducted numerous dose-response studies attempting to quantify the relationship between radiation exposure and cancer risk. Models have been created combining a person's sex, exposure age, and age at observation to calculate lifetime radiation-related risk. In the most widely utilized model, lifetime radiation-related risk can be calculated by:

> Summing estimated age-specific risks over the remaining lifetime following exposure, adjusted for the statistical likelihood of dying from some unrelated cause before any radiation-related cancer is diagnosed (Simon, Bouville, & Land, 2006, p. 54).

From this model, scientists estimated the radiation-related lifetime cancer risk for leukemia, thyroid cancer, and all cancers combined from external radiation sources. The estimates are illustrated in Figure 1below:

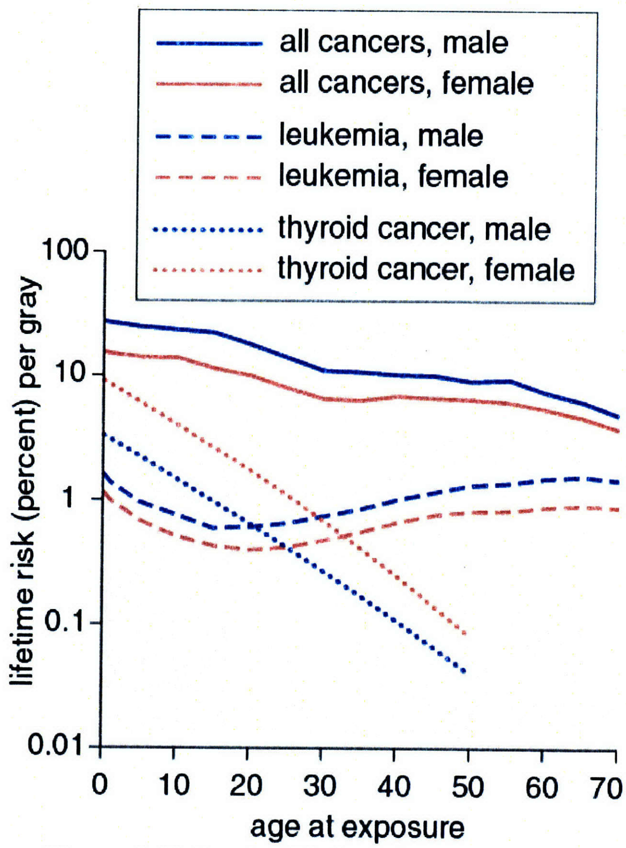


Figure 1: Estimated lifetime risk per gray of developing certain cancers as a function of age at exposure.

One of the main issues related to compensation of radiation exposure is determining whether the disease was a result of the exposure event or due to natural causes. Thus, it is necessary to understand the relationship between the disease and radiation. In the figure above, leukemia and thyroid cancer, two of the latent effects of radiation exposure, are modeled. Leukemia is a malignant cancer of the bone marrow and blood that is characterized by the uncontrolled accumulation of blood cells. It is generally believed that exposure to fifty to one hundred units or more of radiation will increase the cases of leukemia beyond the natural incidence rate. In the United States, the natural incidence of leukemia is estimated to be 44,240 cases per year. Leukemia is expected to strike ten times as many adults (40,440) as children (3,800) defined as people under the age of nineteen (Leukemia & Lymphoma Society, 2007). Scientists do not agree on the dose-rate curve or relationship between the amount of radiation received and the increased incidence of leukemia. However, evidence exists that for exposures of fifty to one hundred units and above, the curve is linear. In other words, an increase in the units of radiation exposure will result in a corresponding and constant increase in the incidence of leukemia (Estep, 1960).

The natural incidence of thyroid cancer in the United States is rare - 0.97 percent in females and 0.36 percent in males. In addition, thyroid cancer has a fatality rate of less than ten percent. Thus, it difficult to study fallout-related thyroid cancer risk in all but the most heavily exposed populations. Thyroid cancer risks from external radiation are related to gender and to age at exposure, with the highest risks occurring among women exposed as young children

(Simon, Bouville, & Land, 2006). Thyroid cancer in exposed populations is believed to be caused by the accumulation of Iodine-131, a fission product, in the thyroid. Similar to leukemia, scientists are not in agreement concerning the levels of radiation exposure required to push the incidence of thyroid cancer beyond the naturally occurring rate.

Case Studies

Although the nuclear industry has had a relatively safe record since its inception, several incidents have led the general public to be exposed to small doses of radiation. While the stringent guidelines governing the handling of radioactive material make it safer than handling many other types of hazardous materials associated with other industries, the public's fear of the unknown and unseen makes radiation an intimidating entity. In order to discuss public opinion and radiation injury liability, it is useful to examine case studies concerning public exposure to radiation. The Three Mile Island accident is probably the most notorious commercial reactor accident in the United States. Examining the events that occurred at Three Mile Island will shed light on compensation system of civilian power reactors. In order to examine the compensation system for military activities, it is useful to examine the Nevada Test Site atmospheric tests that occurred during the 1950's and 1960's.

Three Mile Island (TMI)

On March 28, 1979, the Three Mile Island Unit 2 (TMI-2) nuclear power plant near Middletown, Pennsylvania suffered a partial meltdown. Although it led to no immediate deaths or injuries to plant employees or people residing in the surrounding neighborhoods, it has become the most notorious commercial nuclear power plant accident in the United States. The TMI accident resulted in the reevaluation of nuclear safety systems across the United States and spawned concerns about radiation injury liability in connection with the Price-Anderson Indemnities Act.

Summary of Events

The accident at Three Mile Island was the result of a combination of events - equipment malfunctions, problems in the reactor design, and worker error. At 4am on March 28, 1979, a minor malfunction in the secondary cooling circuit caused the primary coolant temperature to rise. This triggered a reactor SCRAM or automatic shut down of the reactor. Immediately, the primary system's pressure began to increase, which caused a pilot-operated relief valve (a valve located at the top of the pressurizer) to open. The valve should have closed when the pressure decreased by a certain amount, but it remained open. The control room instrumentation failed to indicate that the valve was still open. Thus, primary cooling water poured out of the stuck-open valve, causing the reactor core to overheat due to the residual decay heat.

There was no instrumentation in the control room indicating the level of coolant in the core. Instead, the operators used the pressurizer level to determine the level of water in the core tank. Since the pressurizer level was high, they assumed that the core was properly covered with coolant. As a result, as alarms rang and warning lights flashed, the operators did not realize that the plant was experiencing a loss-of-coolant accident. Steam then formed in the reactor primary cooling system. The mixture of steam and water running through the cooling pumps caused them to vibrate. As a corrective action, the operators shut down the pumps, ending the forced cooling of the reactor core. As the reactor coolant boiled away, the reactor's fuel core was uncovered. The zirconium cladding holding the fuel pellets ruptured and the fuel pellets began to melt and release radioactive material into the cooling water.

When the reactor's core was uncovered, a high-temperature chemical reaction between water and the zirconium fuel cladding produced hydrogen gas. During the afternoon of March 28, 1979, the reactor building pressure spiked, indicating a hydrogen burn had occurred. A hydrogen gas "bubble" formed at the top of the reactor vessel, which the Nuclear Regulatory Commission initially believed could explode and rupture the pressure vessel. In a worst case scenario, the core would fall and possibly break containment. Thus, from March 30th until April 1st operators removed the hydrogen gas "bubble" by periodically opening the vent valve on the reactor cooling system pressurizer. This resulted in the release of radioactive noble gases (primarily iodine and xenon) to the area surrounding Three Mile Island. It was later determined that the hydrogen bubble could not explode due to lack of oxygen in the pressure vessel. In total, it took operators over fourteen hours to reestablish cooling to the core.

Health Effects

Several investigations and computer models have been implemented to estimate the total radiation exposure over a five-mile radius of Three Mile Island in the ten days following the accident. Studies conducted by Gur et al., Hatch et al, and Talbott et al., have divided the area into sectors and developed mean likely whole-body gamma dose estimates dependent on location and amount of time each person spent in the sector (1983; 1991; 2000). Data from a 1976 airborne radon survey were incorporated into the estimates to determine natural environmental background dose rates prior to the accident. Figure 2 below illustrates the estimated whole-body gamma dose people within a 5-mile radius of Three Mile Island were exposed to:

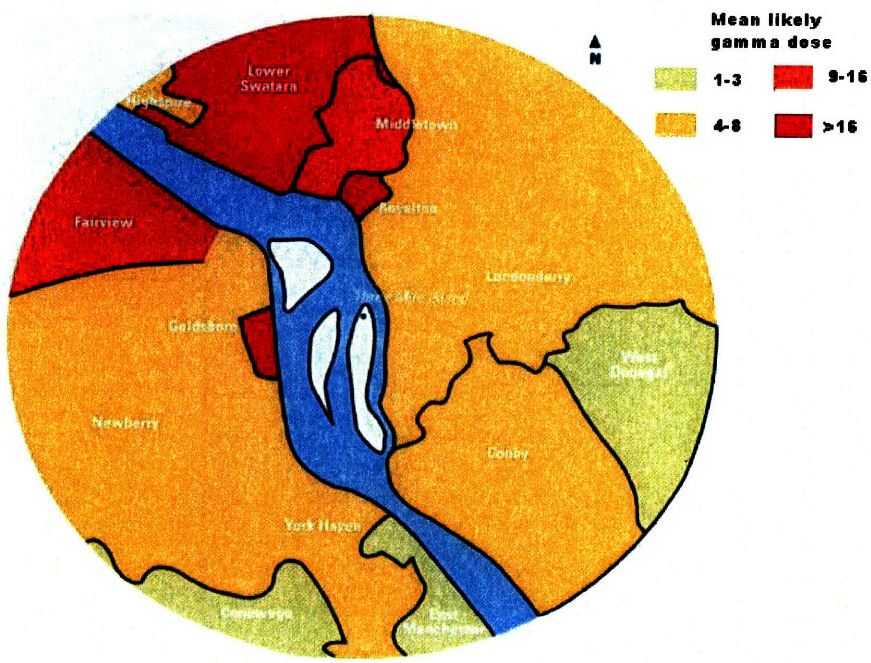


Figure 2. Estimated whole-body gamma dose (mR) within a 5-mile radius of Three Mile Island (Talbott, et al., 2000)

It is estimated that over the ten day period following the accident:

> Approximately 15% (5,032 individuals) were exposed to >40 mrem (0.4 mSv) maximum γ-radiation... The average likely γ-dose was 10.4 mrem (0.10 mSv), with 3,539 individuals (11.1%) exposed to >20 mrem (0.20 mSV) [and] less than 2.1% received the highest levels of estimated maximum or likely γ-radiation (Talbott, et al., 2000, p. 547).

To place these doses in a more understandable context, 100 mrem is equivalent to about a third of the average background level of radiation received by United States residents in a year (American Nuclear Society).

Within two months of the Three Mile Island accident, the Pennsylvania Department of Health created a TMI Population Registry to track the biological effects of the radiation exposure on the local population. A total of 32,135 people residing within a five mile radius of TMI were interviewed about "sociodemographic information, medical history, cigarette smoking status, and previous radiation exposure history" (Talbott, et al., 2000). About 94% of the TMI Population enrolled in the Registry.

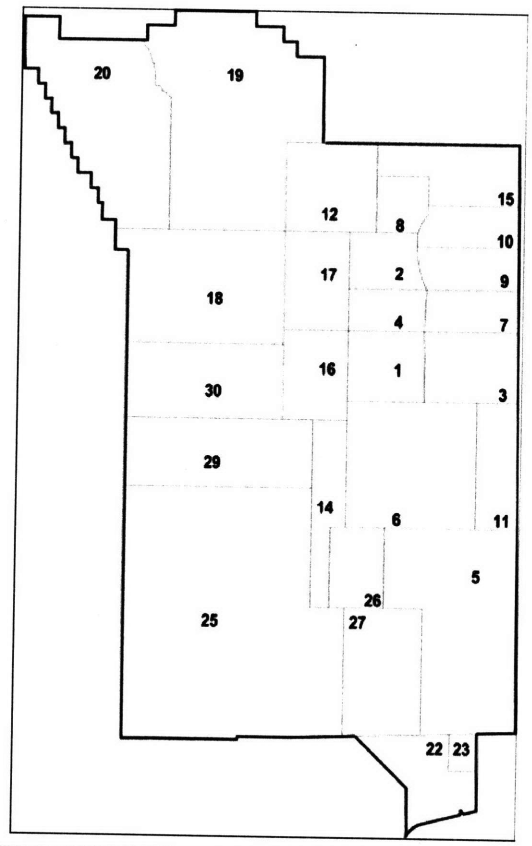
In a joint study between the University of Pittsburgh and the Pennsylvania Department of Health, the mortality experiences of the 32,135 members of the TMI cohort were examined over the period from 1979 to1992. Initially it was found that the frequency of heart disease mortality was significantly elevated for both men and women in the TMI cohort as compared to heart disease mortality in neighboring counties unaffected by the Three Mile Island accident. However, when confounding variables such as previous medical history, lifestyle choices, and natural background radiation were considered, the elevations in heart disease were no longer significant. The cancer mortality was the same for the TMI cohort and the population of surrounding counties. Thus, it was determined that the radiation levels the TMI cohort were exposed to following the accident did not have a significant impact on the mortality experience of members in the cohort (Talbott, et al., 2000).

Nevada Test Site

The Nevada Test Site, located approximately sixty-five miles northwest of Las Vegas, is a 1,375 square mile outdoor laboratory and national experimental center (United States Department of Energy/National Nuclear Security Administration, 2007). The site's first atomic weapon test was conducted above the desert floor of Frenchman Flat on January 27, 1951. Officially, 100 atmospheric nuclear tests were conducted at the Nevada Test Site, ranging in yield from less than 1 ton equivalent TNT to 74 kiloton equivalent TNT. In addition to atmospheric weapons test, the United States conducted cratering tests to evaluate the feasibility of using nuclear weapons as a means of excavation. The largest cratering event was Project Sedan, a 104 kiloton equivalent TNT detonation. Atmospheric nuclear weapons tests and cratering events were responsible for the radioactive fallout the American population was exposed to from January 1951 to July 1962. However, not all weapons tests produced fallout. Of the one hundred atmospheric tests, sixty-one were determined to produce fallout outside the Nevada Testing Site compound (Department of Health and Human Services, 2005). Since July 1962, all United

States nuclear weapons tests have been underground (United States Department of Energy, 2000). Figure 3 below depicts the thirty areas comprising the Nevada Test Site and details the number of tests and detonations that have occurred at each area since the creation of the site:

Area on the Nevada Test Site	Number of Tests	Number of Detonations
1	8	9
2	144	169
3	266	288
4	40	44
5	19	19
6	4	6
7	92	92
8	13	15
9	115	133
10	57	71
11	9	9
12	61	62
15	3	3
16	6	6
18	5	5
19	36	36
20	49	49
30	1	5
TOTAL	928	1,021



Major Test Regions on the Nevada Test Site	
Region	Area(s) on the Nevada Test Site
Frenchman Flat	5, 11
Pahute Mesa	19, 20
Rainier Mesa	12
Yucca Flat	1, 2, 3, 4, 6, 7, 8, 9, 10

Figure 3. Map of the Nevada Test Site regions with table detailing number of nuclear tests and detonations per area (United States Department of Energy, 2000).

Physics of an Atmospheric Nuclear Weapon Explosion

In order to understand the consequences of an atmospheric nuclear weapon test, the physics governing nuclear explosions must be understood. In nuclear explosions caused by fissionable material, a free neutron enters the nucleus of a fissionable atom causing it to split into two smaller atoms, which are called fission products. Large amounts of energy are released from the redistribution of protons and neutrons in the fission products. Nuclear weapons generally use plutonium-239, which is artificially derived from uranium-238. According to Glasstone & Dolan, "The complete fission of 1 pound of uranium or plutonium releases as much explosive energy as does the explosion of about 8,000 (short) tons of TNT" (1977, p. 1.17). The efficiency of a fission weapon is less than one hundred percent. Thus, the radioactive material that does not fission remains in the weapon residue after detonation.

Immediately after the nuclear weapon is detonated, an extremely high temperature, gaseous fireball is formed. The thermal radiation associated with the fireball can start fires and cause skin burns at appreciable distances from ground zero (the site of detonation). Long range gamma rays and neutrons associated with the fission process or that result from the decay of the fission products contribute to the high dose rates. Very soon after the explosion, a destructive shock (or blast) wave develops in the air and moves rapidly away from the fireball. The fireball then begins to ascend, drawing the surrounding air inward and upward. Air currents, or afterwinds, raise dirt and debris from the earth's surface. As the nuclear residue and vaporized materials rise, they expand, cool, and condense into a radioactive cloud. This cloud combines with the dirt and debris the afterwinds have accumulated to form what is commonly referred to as the nuclear mushroom cloud. The now radioactive particles are dispersed by the wind (Glasstone & Dolan, 1977).

Due to varying wind speeds and directions, radioactive material can be spread over large areas. Because they are heavier, large particles settle locally, while lighter, smaller particles may travel much further from the detonation site. Conventionally, fallout is deemed local within 50 to 500km from ground zero, regional within 500-3,000 kilometers of ground zero, and global if the particles settle greater than 3,000 kilometers from the detonation site. Since radioactivity decays over time, the highest radiation exposures are in areas of local fallout. By the time radiation settles regionally or globally, the particles have already begun to decay, reducing the dose received from the particle. In addition to wind dispersion, precipitation can result in localized concentrations of radioactive material at or far from the test site. Finally, if the atmospheric explosion caused radioactive material to be launched 10 kilometers or more above ground and into the stratosphere, there is a possibility that it could remain in the stratosphere and disperse homogeneously as global fallout (Simon, Bouville, & Land, 2006).

Exposure and Health Effects

Fallout deposition on the ground results in external and internal radiation exposure for the local population. External exposure refers to irradiation from radionuclides outside of the body. External irradiation occurs from "submersion in air contaminated with gamma-emitting radionuclides; and/or the decay of gamma-emitting radionuclides deposited on the ground" (Department of Health and Human Services, 2005, p. 27). Generally, external irradiation from submersion in contaminated air is insignificant in dose exposure estimates for counties downwind of the Nevada Test Site. Since shielding by buildings reduces exposure, doses to people are dependent on their lifestyles. Specifically, dose depends on how much time they spend outdoors. In contrast, internal exposure refers to irradiations that occur when radionuclides enter the body through inhalation of contaminated air or ingestion of contaminated water or food (Department of Health and Human Services, 2005). The largest means of exposure to Iodine-131 occurred through the ingestion of contaminated dairy products. Specifically, fallout from the Nevada Test Site landed onto neighboring vegetation, which was then consumed by grazing animals such as cows. While eating beef from cows exposed to Iodine-131 posed minimal health risks, the iodine did collect in the cows' milk, which was unknowingly distributed to the United States population, especially children (National Cancer Institute, 2002). Furthermore, radioiodine ingested or inhaled by mothers was transferred to infants by the mother's breast milk. Iodine-131, which concentrates in the thyroid gland, has a half-life of about eight days. Thus, considerable amounts of Iodine-131 were deposited onto vegetation and transferred to dairy products before the radionuclide could decay (Simon, Bouville, & Land, 2006).

Numerous studies have been conducted to estimate the radiation doses to populations downwind of the Nevada Test Site. Scientists are in agreement that internal irradiation doses were much smaller than those from external irradiation, except for those received by the thyroid. As previously mentioned, populations were exposed to Iodine-131, which accumulates in the thyroid, through the consumption of contaminated dairy products. The Department of Health and Human Services created a model to estimate doses from internal irradiation resulting from ingesting contaminated food. The model relied on age-dependent rates of consumption estimates for different food types such as milk, beef, vegetables, etc. For all Nevada Test Site atmospheric tests, it is estimated that the total organ dose for people who were adults in 1951 is 0.1 mGy to the red bone marrow and 5 mGy to the thyroid. For people born in 1951 (children during the period of atmospheric testing) the estimated dose to the red bone marrow is 0.12 mGy and 30 mGy to the thyroid (Department of Health and Human Services, 2005). Figure 4 below illustrates the external and internal dose to the red bone marrow and thyroid as a result of fallout deposition from the Nevada Test Site:

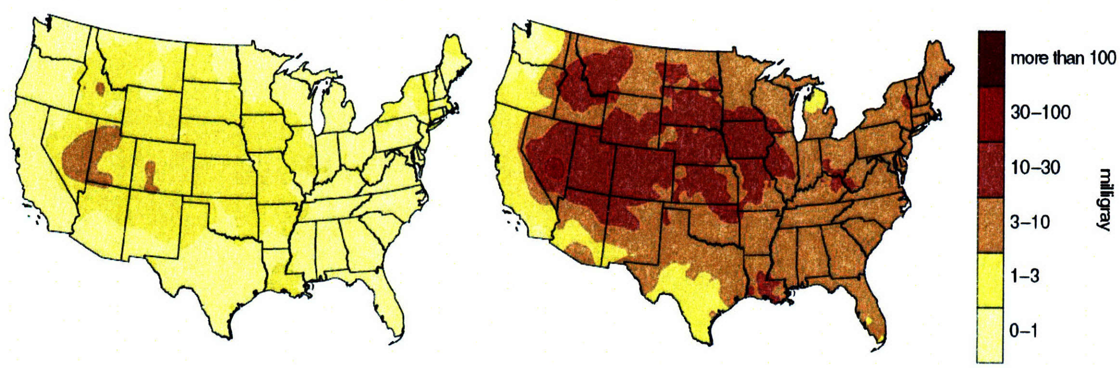


Figure 4. Total external and internal dose to the red bone marrow (left) and thyroid (right) from all Nevada tests (Simon, Bouville, & Land, 2006).

In another study conducted by the University of Utah, the average radiation dose received by adults to the bone marrow was 3 mGy, while the maximum was 30 mGy. For children, the average thyroid dose was estimated to be 120 mGy, with a maximum of 1,400 mGy (Simon, Bouville, & Land, 2006). As it can be seen, scientists do not agree upon the dose received by downwinders from the Nevada Test Site fallout.

An alternative way to evaluate exposure and consequences of the Nevada Test Site fallout is to examine risk models. In 1997, the National Cancer Institute evaluated the risks of developing thyroid cancer from Nevada Test Site fallout exposure. It is estimated that 49,000 fallout-related incidents of thyroid cancer would occur in the United States, mostly among people who were under the age of 20 from 1951-1957. The 95-percent uncertainty limits of this estimate are 11,200 and 212,000. For comparison purposes, 400,000 lifetime thyroid cancers would be expected in the same population without fallout exposure.

Scientists also look at incidences of leukemia when trying to evaluate the consequences of radiation exposure. Leukemia, which originates in the bone marrow, appears relatively soon after exposure and produces noticeably higher rates for populations exposed to fallout than for those unexposed. The National Cancer Institute estimates 1,750 fallout-related incidents of leukemia deaths will occur in the United States, with 1,100 from external exposure and 650 from internal exposure from the Nevada Test Site fallout. In comparison, 1.5 million leukemia cases would be expected in the same population without fallout exposure. In addition, according to the National Cancer Institute:

> About 22,000 radiation-related cancers, half of them fatal, might eventually result from external exposure from NTS and global fallout, compared to

the current lifetime cancer rate of 42 percent (corresponding to about 60 million of the 1952 population (Simon, Bouville, & Land, 2006, p. 56).

A caveat to this discussion is that even though populations were exposed to fallout about sixty years ago, only about half of the predicted total number of cancers have manifested to date.

Existing Legislation for Compensation

After determining the radiation doses the general public was exposed to as a result of Three Mile Island and the Nevada Test Site activities, the question becomes "What is the most efficient means of compensating victims for their injuries?" Civilian power reactors are protected through various insurance systems governed by the Price-Anderson Nuclear Industries Indemnity Act. While there is no law detailing compensation schemes for all military nuclear activities, the Radiation Exposure Compensation Act outlines the compensation scheme for people affected by the Nevada Test Site activities. This section will discuss the procedures for filing a claim under each Act and summarize where the funding for each compensation system is acquired.

Price-Anderson Nuclear Industries Indemnity Act

The Atomic Energy Acts of 1946 and 1954 authorized civilian control of atomic energy. Specifically, the acts stated that nuclear power development and management would be under civilian, private industry control, as opposed to military control. The U.S. Atomic Energy Commission was established to oversee the nation's nuclear activities. Despite having the authority to develop nuclear reactors, private industry was hesitant to invest in the nuclear industry due to the risk of incurring a huge financial liability in the case of a nuclear accident. Thus, the Price-Anderson Nuclear Industries Indemnity Act was enacted with the following objectives:

> (1) To establish a mechanism for compensating the public for personal injury or property damage in the event of a nuclear accident and (2) to encourage the development of nuclear power (United States General Accounting Office, 2004).

The Price-Anderson Act removes prevents private industry from having to incur the total financial burden associated with a nuclear accident. It accomplishes this task by creating a system of private insurance and government indemnities to cover the off-site consequences of a nuclear accident. In addition, it provides "umbrella" coverage that limits the liability of all workers connected to the nuclear activity including, but not limited to contractors, vendors, architects, and engineers (United States General Accounting Office, 1987)

Funding for the Price-Anderson Act

When the Price-Anderson Act was enacted in 1957, private insurance was required to fund $60 million in liability coverage. Any monetary claims that fell within this maximum amount were to be paid by the nuclear insurance companies. In addition to this, the federal government would provide $500 million in indemnity per incident. Thus, there was a $560 million limit on liability. This number was completely arbitrary. At the time the act was passed, nuclear insurance companies stated they would be willing to provide $60 million in liability coverage, while Congress decided that a $500 million contribution would not disturb the Federal budget (United States General Accounting Office, 1980).

Several amendments have been made to the Price-Anderson Act due to inflation and more extensive studies on the cost of a serious nuclear accident. These amendments have resulted in the nuclear insurance companies raising their liability coverage. In addition, a 1975 amendment to the Price-Anderson Act was passed with the goal of phasing out the federal government's indemnity contribution. Thus, the Nuclear Regulatory Commission now requires the private licensees to pay a pro-rated share of the damages into the Price-Anderson Fund. This secondary insurance requires each licensee to pay up to $5 million in retrospective premiums per facility owned per incident if a nuclear accident results in costs exceeding the primary insurance coverage. The Nuclear Regulatory Commission is authorized to adjust the maximum amount of the retrospective premium every five years based on the aggregate change in the Consumer Price Index for urban consumers (United States General Accounting Office, 2004). As of 2003, the American Nuclear Insurers informed the Nuclear Regulatory Commission that $300 million per site in primary liability coverage was available from its insurance pool. Furthermore, the Nuclear Regulatory Commission raised the retrospective premium per reactor to $10 million with the maximum obligatory payment being $95.8 million per reactor per accident. Thus, with 104 operating nuclear power plants, the secondary insurance pool totals approximately $10 billion (United States General Accounting Office, 2004). It is important to note that the Price-Anderson Fund is not paid into unless a nuclear accident occurs. However, contingency plans must be in place for fund administrators to raise the funds and expedite payment to claimants.

Payout of Funds

In the event of a nuclear accident, the Nuclear Regulatory Commission must submit a report detailing the costs of the accident to both the federal courts and Congress. If the monetary claims exceed both the primary insurance coverage and the secondary Price-Anderson fund, the President must submit a proposal recommending how to raise funds for government indemnity and the plans for compensating individuals affected by the accident. Unlike most liability lawsuits, the Price-Anderson Act automatically transfers jurisdiction to federal courts, despite the location of the nuclear accident. In addition, individuals cannot claim punitive damages against companies nor can companies defend any action for damages on the grounds that the private licensee was not responsible for the incident. In other words, the act does not place blame on the private companies when dealing with compensation cases. However, the private companies may still be fined by the Nuclear Regulatory Commission or subject to criminal prosecution for breaches of safety regulations. Finally, claimants are given an open-ended time limit in that they must file their claim three years from the time damage is discovered. In turn, a single Federal court will deal with all claims from the same incident, prioritizing payouts and distributing funds equitably if the funds are insufficient (United States General Accounting Office, 2004).

Since the Price-Anderson Act was put into effect, nuclear insurance pools have paid $151 million for claims In addition, the Department of Energy has paid

$65 million. The Three Mile Island incident, which was previously discussed, falls under the Price-Anderson Act since Three Mile Island was a commercial power reactor. Under the Price-Anderson Act, 3,170 claimants received $1.2 million for living expenses associated with voluntary evacuation from areas immediately surrounding the Three Mile Island plant. In addition, six hundred thirty-six individuals were compensation $92,000 in lost wages. Although scientists believe that the radiation exposure of individuals residing in the surrounding areas of Three Mile Island were insufficient to cause health damages, $70 million ($42 million in indemnity settlements and $28 million in expenses) have been paid out to local residents. All of these payments were covered by the primary insurance coverage. Hence, no funds were needed from or contributed to the secondary insurance fund by the private companies (American Nuclear Society, 2005).

Radiation Exposure Compensation Act (RECA)

On October 15, 1990, Congress enacted the Radiation Exposure Compensation Act (RECA) in order to provide partial restitution to individuals affected by the aboveground atomic weapons tests at the Nevada Test Site. Under RECA, individuals or their eligible surviving beneficiaries can file claims for suffering related to various cancers, lung diseases, and renal diseases that resulted from their radiation exposure. The Radiation Exposure Compensation Program (RECP), a division of the Department of Justice Civil Division's Tort Branch is responsible for processing claims. The Attorney General is responsible for processing and approving or denying the claims (Jones, 2005).

Filing a Claim under RECA

Under the 1990 Radiation Exposure Compensation Act, fixed amounts were determined for compensating individuals in the following categories: 1) on-site participants (people who were present and participated in aboveground nuclear weapons testing at the test site locations); 2) downwinders (people living in predetermined counties downwind of the Nevada Test Site); and 3) uranium miners. On-site participants were entitled to $75,000, downwinders to $50,000, and uranium miners to $100,000 (United States Department of Justice, 2004). Figure 5 below illustrates the areas eligible for compensation under RECA:

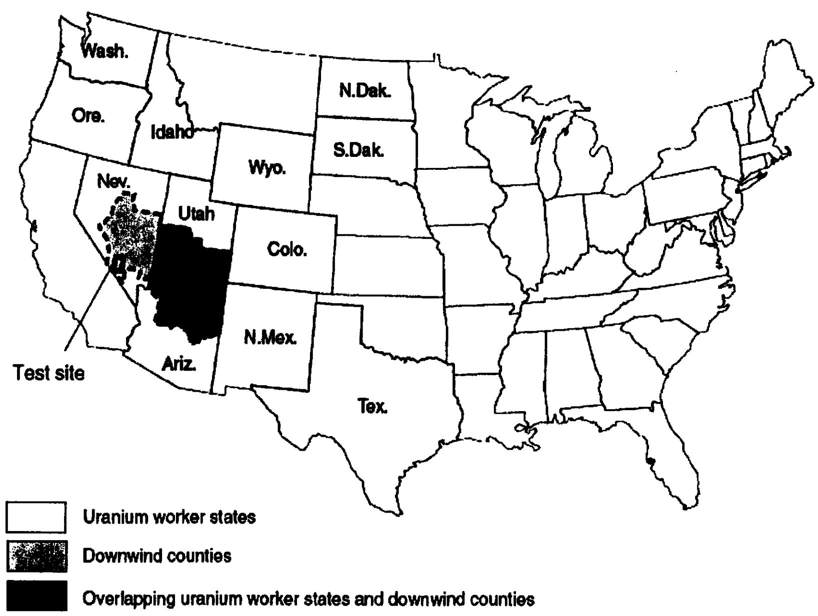


Figure 5. Map of areas eligible for RECA compensation (Caldwell, 2007)

On July 10, 2000, Congress passed the Radiation Exposure Compensation Act Amendments of 2000. These amendments added two new claimant categories, modified the medical documentation requirements, lowered the radiation exposure threshold for uranium miners, and identified additional illnesses eligible for compensation. The two new claimant categories, uranium mill workers and uranium ore transporters, are each entitled to $100,000 (United States Department of Justice, 2004).

In order to receive compensation, the claimant or eligible surviving beneficiary, must submit the appropriate claim form with supporting documentation to RECP. Eligibility is determined based on the amount of radiation exposure (dose threshold), the duration of exposure, and the type of illness the claimant manifested. The following table summarizes the eligibility requirements and compensable diseases under the Radiation Exposure Compensation Act:

Table 1. RECA requirements and compensable diseases for claimant categories (Jones, 2003)

Claimant Category	Time Period	Examples of Diseases Covered	Other Requirements
Onsite Participant	Designated atmospheric nuclear tests from July 16, 1945-December 31, 1962.	Certain types of leukemia, lung cancer, and lymphomas, multiple myeloma, and primary cancer of the thyroid, male or female breast, esophagus, stomach, pharynx, small intestine, pancreas, bile ducts, gall bladder, salivary gland, urinary bladder, brain, colon, ovary, or liver (certain types).	The payment to the victim may be offset by payments received by the victim from the Department of Veterans Affairs based on the same radiation-related illness.
Downwinder	A period of at least 2 years from January 21,1951-October 31, 1958, or for the period between June 30 and July 31, 1962.	Certain types of leukemia, lung cancer, multiple myeloma, lymphomas, and primary cancer of the thyroid, male or female breast, esophagus, stomach, pharynx, small intestine, pancreas, bile ducts, gall bladder, salivary gland, urinary bladder, brain, colon, ovary, or liver.	For those exposed prior to age 21, and subsequently contract any medically recognized form of acute or chronic leukemia, other than chronic lymphocytic leukemia, a period of only 1 year, from January 21, 1951 to October 31, 1958, is required.
Uranium Mine Employee	Any time from January 1, 1942-December 31, 1971.	Lung cancer and nonmalignant respiratory disease.	Victims must have been exposed to at least 40 working level months of radiation or determine employment in a mine for 1 full year. Aboveground miners are included. Additional states may apply for inclusion as a covered state.
Uranium Ore Transporter **Uranium Mil Employee**	Any time from January 1, 1942-December 31, 1971.	Lung cancer, nonmalignant respiratory diseases, renal cancer, and other chronic renal disease, including nephritis and kidney tubal tissue injury.	Victims must have worked for at least 1 year during the relevant time period.

The claim is then reviewed by RECP and approved or denied. If a claim is approved, the claimant is sent an “acceptance of payment” form, which must be returned to RECP with the claimant’s bank information before payment is issued.

If a claim is denied, the claimant may pursue two options before seeking judicial review in a U.S. district court. First, the claimant may refile their claim up to three times with new corroborating documentation that was not included in the initial claim in order to correct the deficiency that resulted in the claim denial. Second, they may write an appeal within sixty days of the decision to a Civil Division appeals officer, who may affirm or reverse the decision. Alternatively, the appeals officer may return the claim to RECP for further action if deemed appropriate (Caldwell, 2007). As of April 21, 2008 the claims to date for the Radiation Exposure Compensation System were as follows:

Table 2. Summary of claims filed under the Radiation Exposure Compensation Act as of April 21, 2008 (United States Department of Justice, 2004)

Claim Type	Pending	Approved	%Approved / Disposed	$ Approved	Denied	Total
Onsite Participant	84	1,180	44.6	$84,270,573	1,465	2,729
Downwinder	395	11,967	77.9	$598,320,000	3,388	15,750
Uranium Miner	178	4,797	63.0	$478,974,560	2,812	7,787
Uranium Ore Transporter	13	229	73.6	$22,900,000	82	324
Uranium Miller	41	1,104	79.6	$110,400,000	283	1,428
Total	711	19,277	70.6	$1,294,865,132	8,030	28,108

Funding for RECA

Compensation is paid out by the Department of the Treasury from the RECA Trust Fund. In order to establish the Trust Fund, Congress appropriated $200,750,000 in the first two years of the Radiation Exposure Compensation Program. Money remaining in the Trust Fund at the end of any given fiscal year is carried over into the fund for the next fiscal year. The RECA Trust Fund is scheduled to be terminated in 2022 (Jones, 2003).

Trust Fund money is used solely for compensation. Thus, several measures have been taken to ensure adequate funding for the RECA Trust Fund. First, the Department of Justice's administrative expenses for the Radiation Exposure Compensation Program are paid for through a separate appropriations account. The average administration cost for the program is $2.5 million per year. In addition, Congress enacted the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 to help alleviate strain on the Trust Fund. This Act declared that compensation for uranium miners, ore transporters, and millers will come from the Department of Labor's Energy Employees Occupational Illness Compensation Program (Jones, 2005). This relieved burdens on the RECA Trust Fund since these three claimant categories are entitled to $100,000, the largest of the fixed compensation amounts. Finally, the National Defense Authorization Act for fiscal year 2002 provided funding for the RECA Trust Fund to cover a 10-year period. Instead of Congress having to vote about appropriations each fiscal year, specific amounts have been established for appropriation to the RECA Trust Fund from 2002 through 2011 (Jones, 2003).

Comparison of Government and Civilian Compensation Programs

According to Brooks, redress for injustices can be divided into two categories: reparations and settlements. Reparations are forms of redress that include an apology for the injustice. This may be an official statement of apology or monetary compensation in addition to an apology. On the other hand, settlements do not concede any fault and thus do not include apologies. Settlements come in the form of monetary compensation or an investment of money and/or services to the victims' community in lieu of individually compensating victims (Brooks, 1999).

Individuals that are compensated through the Price-Anderson Act are receiving a settlement, whereas individuals that are compensated through the Radiation Exposure Compensation Act are receiving reparation. Thus, one of the major criticisms of the Price-Anderson Act is the issue of no fault liability. As previously mentioned, the Price-Anderson Act prevents victims from suing reactor operators and Department of Energy contractors including manufacturers and vendors. In addition, jurisdiction over the accident falls to the federal district court, preventing victims from utilizing state laws which may offer victim protection or compensation that surpasses those protections granted by the federal government. In addition, in some cases monetary compensation may not be what victims seek. Instead, they may want the responsible party to admit to their wrongdoing and simply offer an apology.

Another difference between the governmental and civilian compensation programs is the funding for the compensation funds. The RECA Trust Fund has money available for immediate use. The balance is handled by the U.S. Treasury. On the other hand, the Price-Anderson Trust Fund has a balance of zero. The Price-Anderson Fund is not paid into until an accident occurs. If the damages of the nuclear accident exceed the $300 million primary insurance covers, the operators of the 104 operating nuclear reactors covered under the Price-Anderson Act must pay up to $95.8 million per reactor to cover costs in retrospective premiums capped at $10 million per year. However, the Nuclear Regulatory Commission does not verify whether or not the nuclear reactors have $10 million available for immediate disposal to compensate victims. Instead, the private companies simply need to provide a contingency plan on how they intend to raise the money. Thus, it is unclear whether or not the money for secondary insurance would even be available to compensate victims in the event of a serious accident. Most likely, Congress, and thus the taxpayers, would have to foot the bill for the compensation fund. With that said, the Price-Anderson Act is very vague concerning the government's financial role in the event of insufficient funds from the nuclear industry. In fact, most of the Price-Anderson amendments have focused on phasing out government involvement in the fund.

Another concern when dealing with radiological accidents is the statute of limitations. As previously mentioned, many radiation induced diseases take years to manifest symptoms in the victim. According to the Radiation Exposure Compensation Act, the victim or their surviving beneficiary may file the claim. Since the atmospheric tests conducted at the Nevada Test Site ended in the 60s, there seems to be no statute of limitations for filing a claim. The only set limit on compensation is the fact that the RECA Trust Fund will be terminated in 2022 (Jones, 2003). It is safe to assume that seventy years is ample time for radiation induced diseases to manifest and for documents supporting the claim to be collected. In contrast, under the Price-Anderson Act, claimants are given an open-ended time limit in that they must file their claim three years from the time damage is discovered. The beginning of the three years is difficult to establish if symptoms begin to manifest, but the disease is not properly diagnosed until a later date. In other words, does this mean that the three years begins when a victim displays signs of anemia or when the victim is officially diagnosed with leukemia? Moreover, if the victim dies before filing a claim, the procedures for a surviving beneficiary to file a claim are unclear.

Controversial Issues Concerning Compensation

The problem with developing a single compensation system to service both civilian and military nuclear ventures is that no one seems to agree on the best method for processing claims and issuing payouts. The parties responsible for exposing nearby populations to radioactive release do not want to pay for medical bills if it is not conclusive that the disease was caused by the radioactive release. Thus, the three main issues of controversy are: (1) What diseases should be compensated? (2) Who is eligible for compensation? (3) How do people prove their eligibility?

What Should Be Compensated?

Leukemia and Other Cancers

Under the existing compensation systems, leukemia and other cancers are compensable if the claimant can document radiation exposure significant enough to induce cancer. The exposure level required to induce cancer is debatable, but in the Three Mile Island class action lawsuit, the required dose was stated to be in excess of ten Rems (Public Broadcasting Service). While some scientists disagree on the causal relationship between low-level irradiation and some cancers, there seems to be a correlation between Iodine-131 exposure and thyroid cancer as well as Strontium-90 exposure and bone cancer (Estep, 1960).

Even if causation can be established between exposure and cancer induction, the question becomes, "At what stage of the illness is compensation justifiable?" To explain, in typical worker's compensation programs, workers are compensated for loss of wages or disabilities. However, if a worker develops leukemia due to nuclear activities, they will not experience decreased earning capacity until a long period after exposure. According to Estep,

> In the case of chronic leukemia, real disability lasts perhaps only two months before death. An acute leukemia victim, however, will be disabled several months between onslaught and death if untreated, but still less than a year even if treated (1960, p. 267).

To further complicate the situation, chronic or acute leukemia may not manifest until after retirement. Thus, there is no decrease in earning capacity. The treatment for chronic leukemia is relatively inexpensive out-treatment care. However, acute leukemia often requires hospitalization and is substantially more expensive (Estep, 1960). Administers of a radiation compensation system must decide whether or not to compensate chronic and acute leukemia victims for the same amount. They must also decide if only treatment expenses will be compensated or additional funds will be appropriated for pain and suffering. If additional funds are granted, should people be given a predetermined sum for pain and suffering or be compensated a certain amount per day of suffering until death? It is clear that these questions have no definite right or wrong answer.

Increased Susceptibility to Disease

Scientists generally agree that significant radiation exposure increases a person's general susceptibility to diseases when he may be exposure to in the future. To illustrate why increased susceptibility to disease may be compensable, Estep provides the example of a pharmaceutical employee that has experienced significant radiation exposure. After exposure, it may be unsafe for the pharmaceutical employee to continue working in the laboratory due to the higher than normal chance of being exposed to diseases in that particular work environment. Similarly, doctors, nurses, ambulance workers, or anyone else in the medical field may find it difficult to continue their profession knowing that the radiation exposure they experienced makes them more susceptible to contract diseases they come in contact with. Thus, the question becomes whether or not increased susceptibility to disease is like a disability in that it prevents the exposed individual from performing their job duties.

Although there is no decreased earning capacity if they choose to stay in the same job position, what is compensable should they choose to switch professions? Should change in pay rate, education expenses, or pain and suffering for having to abandon a beloved career be compensable? Clearly it is impossible to prove that the exposed individual would contract a disease in the future because of their previous radiation exposure. Increased susceptibility should not be compensated unless a disease manifests in the exposed individual.

Shortened Life Span

Although many scientists agree that irradiation shortens a victim's life expectancy, there is no consensus as to what levels of irradiation corresponds to how many days lost in a victim's life span. Thus, shortened life span should not be compensable unless a person experiences accelerated demise associated with a certain radiation induced disease. Once again, there is no way to prove that an individual would have lived longer without radiation exposure, unless they died from a disease known to be radiation induced.

Sterility and Genetic Damage

Many scientists believe that irradiation can impair the ability to have children. In addition, radiation exposure may increase the chance of having deformed offspring (Estep, 1960). Unless the victim produced healthy children prior to radiation exposure, it will be difficult to prove that irradiation, rather than naturally occurring biological factors, caused the sterility or deformation of the offspring. While parents caring for a deformed child should be compensated to help with child care and living expenses, sterility should not be compensated. Compensating sterility would involve having to determine the monetary value of a child's life. In addition, it is impossible to determine how many children the claimant would have had if they were never exposed to radiation.

In addition to sterility, genetic damage may result from overexposure to radiation. Genetic damages include "cleft palate, club food, cross-eyes, mental deficiency, or any one of perhaps hundreds of identifiable deformities" (Estep, 1960, p. 265). Since mutations are often harmful to man, radiation induced increases in the normal mutation rate often result in latent, non-specific deformities or death. While scientists agree high levels of radiation exposure during pregnancy can harm the fetus, it is unclear how many generations in the future will suffer as a result of the irradiation of the pregnant woman. In other words, there is a possibility that the genetic mutation will be passed along to future generations either creating deformities in their offspring or preventing them from reproducing. It would be a bureaucratic nightmare to have to track and compensate five, ten, or twenty generations beyond the initial victim's exposure. The government and civilian nuclear companies should only be held liable to compensate the generation immediately following the exposed individual.

Rigid Criteria

Many compensation systems, such as the RECA Trust Fund place strict eligibility criteria such as limitations on the types of diseases that will be compensated, the duration of stay in a certain area, and the levels of exposure an individual receives. While the most harmful civilian radiological incident, Three Mile Island, did release radionuclides into the surrounding area, most scientists agree the levels were not high enough to induce any diseases in the general public. Thus, this section on eligibility requirements is primarily focused on the claimants downwind of the Nevada Test Site.

A major criticism of RECA is that only certain diseases are compensable. Thus, even if a claimant lived in the correct geographical area for the required time frame, they will not be compensated if they do not have one of the qualifying diseases. This is referred to by downwinders as having the "wrong kind of cancer." In her investigations, Boutte took a woman's statement who explained:

> My father never had a problem and then boom, he had brain cancer. They told us it wasn't caused by fallout, but then my mother got cancer and they paid us because it was the right kind for compensation (Boutte, 2002, p. 41).

Hence, although the woman's mother and father both met the eligibility requirements of geographical location and time frame, only her mother's breast cancer was compensated, while her father's brain cancer was not on the list of RECA diseases. Both died from the radiation-induced cancers, but one was told he did not have the "right kind of cancer."

Another problem downwinders encounter when seeking compensation is having the "right cancer in the wrong place." Although scientists agree that fallout from the Nevada Test Site was carried across the entire continental United States (see Figure 4), only certain counties are eligible for compensation under RECA. Due to heavy rainstorms, there were certain "hot spots" for radioactive iodine exposure in areas such as Idaho, Colorado, Montana, South Dakota, and Utah. While many people in these areas have developed thyroid cancer, a compensable disease, they are ineligible for compensation under RECA because they do not live in one of the counties designated as an affected area.

Finally, there have been some cases where individuals are diagnosed with a compensable disease, but do not meet the age-specific deadlines for exposure. For example, Boutte interviewed a woman who just turned forty when she was exposed to fallout (2002). At the age of eighty-nine, she was diagnosed with breast cancer, a compensable disease, but was denied compensation because she missed the age exposure deadline by a few months. While the incidence of naturally occurring cancer does increase with age, larger extensions to the statute of limitations for filing for compensation should be granted in cases of latent manifestation of compensable diseases.

Burden of Proof

Once the eligibility requirements for compensation are established, claimants must prove their eligibility. This burden of proof takes the form of compiling detailed medical records, documenting residence in a designated area, and determining physical presence in an area during specific time periods. Since many effects of radiation are latent, claimants may be asked to provide these documents years later, which often proves to be troublesome.

In some cases, medical terminology changes affect eligibility. For example, in 1971, a man was diagnosed with fibrosarcoma, a non-compensable disease. He underwent surgery and follow-up visits for treatment. Years later, the symptoms diagnosed as fibrosarcoma would be diagnosed as non-Hodgkin's lymphoma, a compensable disease. However, since non-Hodgkin's lymphoma did not exist in 1971, and physicians' records were not as detailed as they are now, there are no records indicating the man suffered from non-Hodgkin's lymphoma. Although the family doctor wrote a note explaining the change in medical terminology, the Justice Department rejected the claim on the basis that the document was not "contemporaneous" (Boutte, 2002). Physicians familiar with changes in medical nomenclature should be added to compensation committees to ensure that medical terminology does not prevent compensation where it is due.

Another common problem encountered when claimants seek compensation is their inability to provide documents proving residence. In many cases, claimants may have lived with friends or family. Thus, there are no utility bills or property taxes in their name. Affidavits from neighbors testifying to the claimants' residence in the area at the time are not sufficient proof to establish residency. In addition, people who were just visiting or driving through the area at the time may have been exposed to equal amounts of radiation as the surrounding population if they were present when a radioactive cloud passed by. However, they will never be able to prove a physical presence in the area. Thus, even if these claimants suffer or die from compensable diseases, they are ineligible for compensation.

In an attempt to exclude compensation of diseases that were caused by lifestyle choices such as smoking or alcohol consumption, claimants are asked about how much they smoked, how much alcohol they drank, and in some cases are asked to prove the estimates are true. This applies more to the Radiation Exposure Compensation Act than the Price-Anderson Act. Under the 1990 version of RECA, many miners were excluded from compensation based on the rigid definition of a smoker being "one pack per year in a lifetime" (Brugge & Goble, 2003). In addition, many claimants were unable to prove that they did not consume alcohol unless they were active members of the Church of Jesus Christ of Latter-day Saints, which prohibits alcohol consumption by members. Once again, claims are filed decades after the event. Is it fair to ask people to document their lifestyle twenty or thirty years ago?

Native Americans

Thus far, the discussion has centered around populations residing in cities and towns neighboring the source of the radiation exposure. Especially where the Nevada Test Site is concerned, special consideration must be given to Native American populations in the surrounding area. Often they do not seek the help of a licensed medical professional, opting to deal with the alternative medicine "doctor" in their tribe. Thus, there are no official medical records documenting their illnesses. In addition, for claims made by surviving beneficiaries, documents proving relationships must be provided. In many cases, Native Americans are unable to provide marriage licenses, birth certificates, or even death certificates to document their claim. The question then becomes, "How should claims made by tribal populations be handled?"

Legal Precedents

Throughout the history of the nuclear industry in the United States, the general public has always perceived low-level radiation from a nuclear facility as more dangerous than those from other practices including medical x-rays or sunbathing. After the incidents at the Nevada Test Site and Three Mile Island questions began to arise about extending worker's compensation to cover radiation induced injuries and developing a system to assure the public adequate funding for compensation in case of a nuclear accident. Initially, the first law suits filed against the nuclear industry were to compensate for economic losses or structural damage to property. In 1951, uranium miners at the Nevada Test Site began filing claims for lost wages due to mines being temporarily shut down or permanently abandoned due to high levels of radioactivity. In 1956, in the case *Bullock v. United States*, sheep ranchers sued the government under the Federal Tort Claims Act for livestock injuries and deaths. The ranchers' claim was rejected because they could not meet the heavy burden of proof that the government's atmospheric testing caused the death of their livestock (Titus, 1986).

The general public did not begin associating radiation exposure with health effects until the 1970's, almost twenty years after atmospheric testing at the Nevada Test Site began. In 1972, the health consequences of radiation exposure were made public by the cases *Nunamaker v. United States* and *Robert v. United States.* These two cases focused on an incident that occurred In December 1970, when an underground shot named Baneberry vented unexpectedly, contaminating hundreds of test site workers. Nunamaker and Robert developed leukemia, allegedly due to high levels of radiation exposure that day. Although both men died of leukemia in 1974, their widows pursued the

$8 million lawsuit against the federal government until 1983. Although the federal court ruled that the government neglected to evacuate and decontaminate the area in a timely manner, the radiation exposures were not high enough to cause the workers' leukemia. As a result, the plaintiffs were not compensated for damage (Boutte, 2002). Furthermore, a precedent was set that mere exposure would not be enough for compensation; instead, victims must be exposed to certain levels of radiation in order to establish causation.

The Nevada Test Site

By 1980, approximately 1,000 claims were filed against the United States government for injuries allegedly induced by the atmospheric nuclear weapons testing program (U.S. House of Representatives, 1980). In 1979, a class action lawsuit, *Irene H. Allen et al v the United States*, was filed by 1,2000 plaintiffs who were exposed to varying amounts of radiation as a result of atmospheric weapons testing at the Nevada Test Site. From the pool of plaintiffs, twenty-four test cases were selected representing the most common types of injuries and deaths allegedly caused by the NTS fallout. In 1984, ten plaintiffs were awarded $2.66 million after the judge ruled the government liable for eight cases of leukemia, one of thyroid cancer, and one of breast cancer (Titus, 1986). For the remaining fourteen cases, the proof of causation was found to be insufficient. However, the judgment was reversed on appeal and the Supreme Court refused to hear the case in 1988 (Fradkin, 1989).

The significance of the Allen case was the recognition that direct proof of causation was impossible. The Court ruled:

> Where a defendant who negligently creates a radiation hazard which puts an identifiable population group at increased risk, and a member of that group develops a biological condition which is consistent with having been caused by the hazard to which he has been negligently subjected, such consistency having been demonstrated by substantial appropriate, persuasive and connecting factors, a fact finder may reasonably conclude that the hazard caused the condition absent persuasive proof to the contrary offered by the defendant(Schaffer, 1985, p. 273).

In other words, the court eliminated the requirement of proving causation, replacing it with a requirement to demonstrate a 'consistency' between the risk associated with the defendant's actions and the injury sustained by the plaintiff. Thus, the defendant is required to rebut the inference of causation. According to Riley, this contradicts the *Price Anderson Act* that governs civilian nuclear power plants. Under the Price-Anderson Act, the claimant must prove that the injury resulted from the nuclear accident in question (Riley, 2003).

The principle of shifting the burden of proof to the defendant was extended to the case *Sindell v Abbott Laboratories.* In this case, the plaintiff developed cancer after ingesting DES when pregnant had ingested DES when pregnant, but was unable to present evidence linking her injury to a particular drug manufacturer. Each of the nine manufacturers sued had to gather evidence absolving them of the incident. If the burden of proof could not be met, the manufacturer was held liable for a proportion of its share of the DES market (Riley, 2003).

Congressional Hearings

In 1978, Congressman Tim Carter from Kentucky organized a Congressional hearing discussing military personnel involvement in the nuclear testing program. For the first time, the military and Atomic Energy Commission admitted that mistakes were made concerning atmospheric testing (Titus, 1986). In 1979, Congressional hearings were held to discuss the health effects of low level radiation on the general public downwind of the Nevada Test Site. The Subcommittee on Oversight and Investigations concluded that:

> 1) the federal government had been negligent during the atmospheric testing of nuclear weapons at the Nevada site; 2) exposure to fallout from the atomospheric (sic) tests in Nevada was, more likely than not, the cause of adverse health conditions suffered by many downwind residents; 3) some 4,400 sheep deaths in Nevada and Utah were attributable to nuclear fallout and ranchers should be compensated; and 4) some type of legislative compensation program was needed because of the difficulties of seeking compensation under the Federal Tort Claims Act (Boutte, 2002, pp. 43-44).

These Congressional hearings prompted Congress to propose and eventually pass the Radiation Exposure Compensation Act.

Three Mile Island

Following the Three Mile Island accident, various lawsuits were filed in State and Federal courts in Pennsylvania, seeking compensation for injuries and property damage. From these legal battles, several radiation litigation precedents were established. In the cases of *O'Connor v Commonwealth Edison Company* and *In re TMI*, the court concluded that a radiation dose within the permissible dose limits cannot result in liability to a person who received that dose. Although the principle of ALARA (As Low as Reasonably Achievable) keeps doses lower than the established numerical dose limits set by the Nuclear Regulatory Commission, the court ruled that a jury cannot set its own dose limits in negligence cases under the pretext of applying ALARA (Riley, 2003).

Within weeks of the Three Mile Island accident, a class action suit was filed against Metropolitan Edison Company (a subsidiary of General Public Utilities) on behalf of all the businesses and residents within 25 miles of the plant. Ten test cases were chosen by the Pennsylvania district court from over 2,000 personal injury claims alleging a variety of health injuries caused by gamma radiation exposure. After numerous appeals, in June 1996, district court judge Sylvia Rambo dismissed the lawsuit granting summary judgment in favor of the defendants.

The first issue the court focused on was whether or not plaintiffs were exposed to radiation released from Three Mile Island during the Three Mile Island Accident. Judge Rambo ruled that the plaintiffs were unable to identify which radionuclides were released from TMI during the accident and in what quantities they were released. However, the plaintiffs were most likely exposed to minimal levels of ionizing radiation (under 100 mR) since the defendants conceded that readings at the plant boundaries exceeded the 0.5 R regulatory threshold during the accident.

The next issue considered was whether or not radiation released from Three Mile Island was the cause of the plaintiffs' injuries. The court ruled that it could not find the defendant liable because the plaintiffs were unable to provide evidence of exposure to a dose of radiation capable of inducing their neoplasms (in excess of 10 rems). The testimony of the plaintiff's expert witness was dismissed as purely speculative (Public Broadcasting Service). Thus, by providing actual radiation reading at the plant boundaries at the time of the accident, the defendant was able to absolve itself of causation since the plaintiff's were unable to provide substantial evidence to support their claim.

In lieu of Three Mile Island, a new type of radiation injury was developed: the nuclear phobia. Nuclear phobia describes the harm and consequences associated with fear and nervous shock of being involved in or having someone close associated with a nuclear incident. The issue surrounding nuclear phobia is whether or not it should be considered psychological damage. If it is psychological damage, should it be compensable? In the United States, the case *Metropolitan Edison v People against Nuclear Energy et al* served as a test case to determine the court's opinion on the issue of nuclear phobia. Although the Court of Appeals for the District of Columbia found that the Nuclear Regulatory Commission (NRC) was required to consider whether the risk of an accident after the restart of the Three Mile Island (TMI) nuclear plant might psychologically harm the community surrounding Three Mile Island, the United States Supreme Court reversed this decision. The Supreme Court ruled that the risk of another accident was not an effect on the physical community. In addition, "the causal chain from renewed operation of TMI-1 to psychological health damage was too attenuated" (Riley, 2003, p. 308). Thus, the precedent was set that nuclear phobia is not compensable in the United States.

Suggestions for Improving the Compensation Systems

After analyzing the existing compensation systems, it is evident that the most efficient system would combine elements from both the civilian (Price-Anderson Act) and military (Radiation Exposure Compensation Act) practices. First, the point of issuing compensation payments is to correct an injustice inflicted on a population. Thus, reparations should be in the form of redress, in that an official statement of apology should be included. This is not present in the Price-Anderson Act since no liability is assumed by the private company that owns the nuclear reactor.

To ensure the public that the compensation policies will in fact protect their interests and help pay their medical expenses, the compensation fund should have money available for immediate withdrawal. This would require a change in the organization of the Price-Anderson Act in that retrospective contributions to the fund will have to be eliminated. Nuclear reactors should be required to deposit at least a fraction of their retrospective payments into an account held by the United States Treasury to be dispensed in the event of an accidental radiological release in excess of primary insurance coverage. This is similar to the RECA Trust Fund. The military compensation system should be adjusted to mimic the Price-Anderson Act in that all responsible parties should have to contribute to the fund. In other words, each military branch – Army, Air Force, Navy, etc. – should contribute money from their allotted annual budget to prevent the federal government from having to produce compensation funds by decreasing funding to other groups.

Finally, there should be no statute of limitations within a claimant's lifetime and only the next immediate generation's birth defects should be compensable. In the event that a person's lifetime is shortened by a compensable disease, the surviving beneficiary should have ten years to collect the appropriate documents and file a claim. To relieve the heavy burden of proof, in cases with reasonable doubt regarding whether or not to compensate a claim, judgment for the claim should be in favor of the claimant. Moreover, instead of trying to exclude undeserving claimants based on rigid definitions of lifestyle choices (such as the pack a year definition of a smoker), risk analysis should be performed to set an upper limit of consumption where risk doubles or triples. Claimants falling into consumption rates exceeding the upper limit will no longer be given the benefit of the doubt. Moreover, eligibility document requirements for cultural groups such as the Native Americans should be relaxed to include tribal records as official documents.

Conclusion

While the Radiation Exposure Compensation Act is unique to the case of the Nevada Test Site, it can be generalized to all military operations just as the Price-Anderson Act applies to all nuclear reactor operations. The weaknesses of each system involve debatable issues such as what should be compensated, determining compensation eligibility, and setting standards for proving eligibility. There is no clear, correct way of addressing these issues. Compensation systems should simply incorporate lessons learned from previous case studies such as the Nevada Test Site and Three Mile Island compensation schemes in order to actively correct obvious flaws in the system.

With stricter safety guidelines and a heightened awareness of the effects of radiation exposure, why is the issue of compensation still a concern in the 21st century? First, none of the existing compensation systems include how to deal with acts of nuclear terrorism. If a population is exposed to a dirty bomb or even worse an atomic bomb, who is responsible for compensating the victims? Should the federal government have to pay claims for failure to protect its citizens or should an international trial be conducted mandating that reparations be paid by the responsible party or country such as German reparations following World War I? In addition, the United States may venture into nuclear endeavors that are neither totally civilian nor totally military activities. In cases of combined civilian and military efforts, which type of compensation system should be followed?

Finally, with the future plans to use Yucca Mountain as a spent fuel repository, it is necessary to define a compensation system for accidental exposure to nearby populations. In order to correct some of the problems of the past, attention should be given to the Nevada Test Site example. Lessons learned in that case include: implementing stricter monitoring of dose levels and wind patterns and analyzing of the risk of radioactive material leaking into the water table. Should we wait until nearby populations begin to exhibit radiation related diseases or should we develop a compensation system ahead of time so that claims may be awarded immediately? It is clear that issues concerning liability for radiation exposure compensation will be prevalent in American society until definitive dose-response curves are developed. Until then, compensation systems will have to be unique to the radiological source/event of the exposure.

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