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Radiation Is Everywhere, but How to Rate Harm?

By DENISE GRADY

Since the first reports last month of damage to nuclear reactors at the Fukushima Daiichi power plant, the lingering question has been whether drifting plumes of radioactive elements from the plant will harm people in Japan or other parts of the world. For many people, the biggest fear is [cancer](#).

Certain levels of radiation exposure are known to increase the risk of cancer, but scientists disagree about the effects of very low doses of the sort that may have occurred so far in Japan.

Some researchers say it is reasonable to use data from high doses to calculate the risk of smaller and smaller doses. They argue that any exposure to radiation raises the risk of cancer, though probably by only a small amount in the case of small doses.

But others say that estimating risk for doses near zero is nonsensical, and some believe there is a threshold dose, or limit below which there is no risk from exposure.

Dr. John Boice, for example, a professor of medicine at [Vanderbilt University](#) who studies radiation effects in humans, warns that risk calculations based on tiny doses are themselves risky.

He argues that there is little data on doses below about 10 rem, but that some risk estimates nonetheless go down to a tenth of a rem or less. (He is also the scientific director of the [International Epidemiology Institute](#) in Rockville, Md., a private group that studies radiation with grants from government and industry.)

“I can take a low dose, multiply it by a million people and estimate a risk,” Dr. Boice said, but he said professional groups like the [Health Physics Society](#) discourage it. “We say, don’t do that. Don’t multiply a tiny dose by millions and say there will be thousands of deaths. It’s inappropriate, misleading and alarmist. You’ve gone orders of magnitude below where we have proof of any effects at all.”

But Dr. David Brenner, director of the [Center for Radiological Research at Columbia University](#), is among those who believe there is no threshold. Radiation damages DNA, he says, and just one damaged cell can become the seed of a cancer, though it takes decades to develop. He is studying the possibility that in terms of causing cancer, low doses of radiation might be more dangerous than calculations based on high doses would predict.

Current estimates by government agencies for risks from low doses rely on extrapolation from higher doses. In the United States, most government agencies use a unit called the rem to measure radiation doses. (Europe and Asia use the unit millisievert, which equals 0.1 rem.) According to the [Environmental Protection Agency](#), people receive 0.3 rem per year from natural background radiation.

If 10,000 people are each exposed to 1 rem, in small doses over a lifetime (above the natural background exposure), according to the agency, the radiation will cause five or six excess deaths from cancer. In a group that size, about 2,000 would normally die from cancers not caused by radiation, so the extra dose would raise the total to 2,005 or 2,006.

So far only minute amounts of radioactivity from the Japanese reactors have been detected in the United States, in milk on both the East and West Coasts, and in rainfall in Massachusetts. American officials say instruments can detect levels so vanishingly small — far below the natural background level of radiation — that they pose no threat.

In parts of Japan, radioactivity has been detected at various times in milk, meat, vegetables and tap water, on the ground and in the sea around the power plant.

Levels in tap water in certain areas have sometimes been high enough for authorities to tell people to drink bottled water, and the Japanese government has banned the shipment of milk and produce from some prefectures.

Milk from those regions has been found to contain radioactive iodine, which accumulates in the thyroid gland and can cause cancer, especially in children. Levels in the milk have exceeded those considered a cause for concern in the United States.

A quarter mile from the Fukushima plant (residents have been evacuated from a 12-mile zone around the plant) radiation levels of 0.1 rem per hour have been measured, and researchers agree that four days of such exposure would increase a person's risk of cancer. But some would argue that an even shorter exposure would raise the risk.

Many of today's risk estimates are based on a study of 200,000 people who survived the atomic bombing of Hiroshima and Nagasaki in August 1945. More than 40 percent are still alive.

The research has been going on for 63 years, and an article reviewing its findings was published in March in the journal [Disaster Medicine and Public Health Preparedness](#).

So far, it is uncertain how relevant the results from bomb survivors are to members of the public in Japan who may have been exposed to radiation from the reactors.

“One concern is trying to find out what dose these people actually received” from the Fukushima reactors, said Dr. Evan B. Douple, the first author of the article on the bomb survivors and the associate chief of research at the [Radiation Effects Research Foundation](#) in Hiroshima, which studies the survivors and is paid for by the governments of Japan and the United States. It is the successor to the Atomic Bomb Casualty Commission, which was created in 1947.

Dr. Douple said the method of exposure was also different: The bomb survivors received their entire doses all at once to the full body, but exposure from the reactors may be gradual.

“Here radioisotopes are drifting in water and air, and not necessarily producing an external whole-body exposure and are being taken up in very small doses into the body,” he said. “So far the information we've been receiving is that actually the doses of exposure are not what one would call intermediate or high doses, but are very low.”

The bomb survivors received radiation doses ranging from negligible to high; high would be 200 rem or more, what Dr. Douple called a “barely sublethal dose.” But 61,000 people were estimated to have received half a rem or less, and 28,000 received half a rem to 10 rem.

Their doses were calculated based on factors like how close they were to the center of the bomb and whether they were inside buildings. For comparison, the study also includes 26,000 people who lived in the same cities but were not exposed to radiation because they were not present during the bombings.

The researchers monitored the two groups — exposed and nonexposed — to determine whether radiation caused disease.

Radiation did increase the risk of cancer. “But the risk of cancer is quite low, lower than what the public might expect,” said Dr. Douple. He said that the researchers themselves had expected to find more cancer than they did.

Among the survivors, leukemia was the first cancer to appear. Cases increased within five years of the bombing and then began declining at the 10-year mark.

Of 120,000 survivors in one study group, 219 with radiation exposure had died of leukemia from 1950 through 2002, the latest year with published data. But only 98 of those cases, or 45 percent, were excess deaths attributed to radiation.

However, when the leukemia deaths were sorted by radiation dose, it was clear that risk increased with dose. Among people who received the highest doses (100 rem or more), 86 percent of the leukemia deaths were a result of radiation, compared with only 36 percent of the leukemia deaths in those with exposures from 10 rem to 50 rem. Among those who received half a rem to 10 rem, only 4 of 77 leukemia deaths, or 5 percent, were estimated to be excess deaths caused by radiation.

Solid **tumors** — affecting the colon, breast, liver, lung or other organs — took longer than leukemia to develop, Dr. Douple said.

In a study group of 100,000, there were 7,851 deaths from solid cancers among people exposed to radiation, but only 850, or 11 percent, were estimated to be excess cancer deaths due to radiation. As with leukemia, the risk increased with radiation dose. Some organs were more sensitive than others. For instance, radiation increased cancer risk in the breast, but not the prostate.

Dr. Douple emphasized that at very low doses, the risk was also very low. But he also said that there was no indication of a threshold, or a level below which acute radiation exposure would have no effect, or a smaller effect than would be predicted based on higher exposures.

Does the bomb data apply to Fukushima? Hiroshima and Nagasaki were the worst case, Dr. Douple said. It is possible to extrapolate from them to the very low-dose range detected so far, but in doing so, he said, there are “big uncertainties.”

But he added that Japanese scientists from the institute have been summoned to Tokyo, to help figure out what the potential health effects might be and to plan ways to detect and study them.