THE PANIC OVER FUKUSHIMA

Japan's nuclear accident was a great human tragedy, but its long-term health effects have been exaggerated—and the virtues of nuclear power remain.

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Denver has particularly high natural radioactivity. It comes primarily from radioactive radon gas, emitted from tiny concentrations of uranium found in local granite. If you live there, you get, on average, an extra dose of 0.30 rem (cSv) of radiation per year (on top of the 0.62 rem (cSv) that the average American absorbs annually from various sources). A rem (radiation equivalent man) (1 rem = 1 centiSievert = 1 cSv) is the unit of measure used to gauge radiation damage to human tissue.

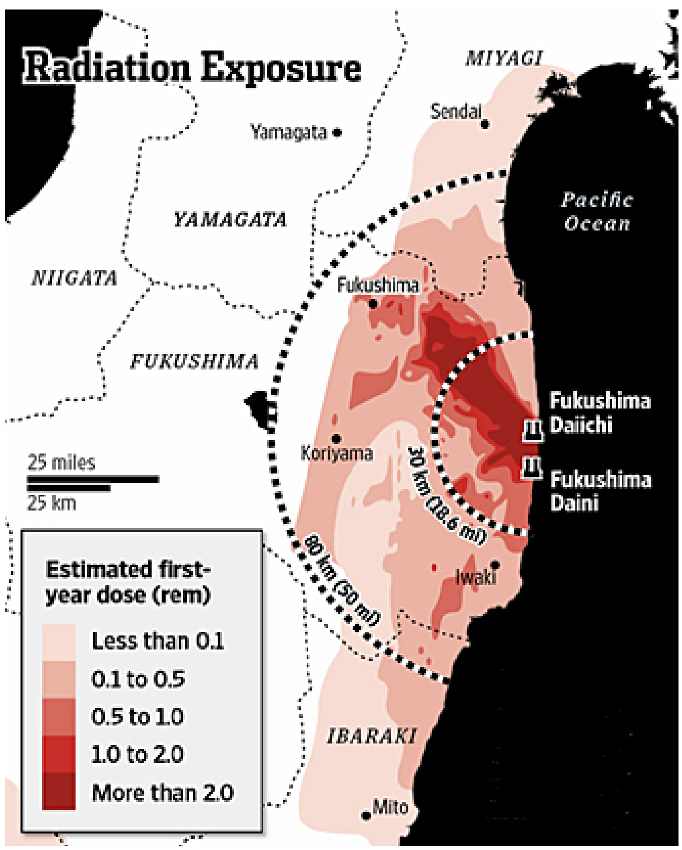

Figure 1. Radiation exposure from the Fukushima accident. Source: Richard A. Muller, "Energy for Future Presidents, The Science behind the Headlines," based on a map from the National Security Agency, The Wall Street Journal.

The International Commission on Radiological Protection (ICRP) recommends evacuation of a locality whenever the excess radiation dose exceeds 0.10 rem (cSv) per year. But that's one-third of what I call the "Denver dose." Applied strictly, the ICRP standard would seem to require the immediate evacuation of Denver.

It is worth noting that, despite its high radiation levels, Denver generally has a lower cancer rate than the rest of the United States. Some scientists interpret this as evidence that low levels of radiation induce cancer resistance; I think it is more likely that lifestyle differences account for the disparity.

Now consider the most famous victim of the March 2011 tsunami in Japan: the Fukushima Daiichi nuclear power plant. Two workers at the reactor were killed by the tsunami, which is believed to have been 50 feet high at the site.

But over the following weeks and months, the fear grew that the ultimate victims of this damaged nuke would number in the thousands or tens of thousands. The "hot spots" in Japan that frightened many people showed radiation at the level of 0.10 rem (cSv), a number quite small compared with the average excess dose that people happily live with in Denver.

What explains the disparity? Why this enormous difference in what is considered an acceptable level of exposure to radiation?

In hindsight, it is hard to resist the conclusion that the policies enacted in the wake of the disaster in Japan—particularly the long-term evacuation of large areas and the virtual termination of the Japanese nuclear power industry—were expressions of panic. I would go further and suggest that these well-intended measures did far more harm than good, not least in limiting the prospects of a source of energy that is safe, abundant and (as compared with its rivals) relatively benign for the environmental health of our planet.

If you are exposed to a dose of 100.00 rem (cSv) or more, you will get sick right away from radiation illness. You know what that's like from people who have had radiation therapy: nausea, loss of hair, a general feeling of weakness. In the Fukushima accident, nobody got a dose this big; workers were restricted in their hours of exposure to try to make sure that none received a dose greater than 25.00 rem (cSv) (although some exceeded this level). At a larger dose—250.00 to 350.00 rem (cSv) —the symptoms become life-threatening. Essential enzymes are damaged, and your chance of dying (if untreated) is 50%.

Nevertheless, even a small number of rem can trigger an eventual cancer. A dose of 25.00 rem (cSv) causes no radiation illness, but it gives you a 1% chance of getting cancer—in addition to the 20% chance you already have from "natural" causes. For larger doses, the danger is proportional to the dose, so a 50-rem (cSv) dose gives you a 2% chance of getting cancer; 75.00 rem (cSv) ups that to 3%. The cancer effects of these doses, from 25.00 to 75.00 rem (cSv), are well established by studies of the excess cancers caused by the atomic bombs at Hiroshima and Nagasaki in 1945. (A recent study of butterflies near Fukushima confirms the well-known fact that radiation leads to mutations in insects and other simple life-forms. Research on those exposed to the atomic bombs shows, however, no similar mutations in higher species such as humans.)

Here's another way to calculate the danger of radiation: If 25.00 rem (cSv) gives you a 1% chance of getting cancer, then a dose of 2,500 rem (cSv) (25 rem (cSv) times 100) implies that you will get cancer (a 100% chance). We can call this a cancer dose. A dose that high would kill you from radiation illness, but if spread out over 1,000 people, so that everyone received 2.50 rem (cSv) on average, the 2,500 rem (cSv) would still induce just one extra cancer. That is, even if shared, the total number of damaged cells would be the same. Rem (cSv) measures radiation damage, and if there is one cancer's worth of damage, it doesn't matter how many people share that risk.

In short, if you want to know how many excess cancers there will be, multiply the population by the average dose per person and then divide by 2,500 (the cancer dose described above).

In Fukushima, the area exposed to the greatest radiation—a swath of land some 10 miles wide and 35 miles long—had an estimated first-year dose of more than 2 rem (cSv). Some locations recorded doses as high as 22 rem (cSv) (total exposure before evacuation). Afterward, the levels of radiation dropped quickly; the largest component came from iodine, and its level dropped by 50% every eight days.

How many cancers will such a dose trigger? To calculate an answer, assume that the entire population of that 2-rem(cSv)-plus region, about 22,000 people, received the highest dose: 22 rem (cSv). (This obviously overestimates the danger.) The number of excess cancers expected is the dose (22 rem(cSv)) multiplied by the population (22,000), divided by 2,500. This equals 194 excess cancers.

Let's compare that to the number of normal cancers in the same group. Even without the accident, the cancer rate is about 20% of the population, or 4,400 cancers. Can the additional 194 be detected? Yes, because many of them will be thyroid cancer, which is normally rare (but treatable). Other kinds of cancer will probably not be observable, because of the natural statistical variation of cancers.

Sadly, many of those 4,400 who die from "normal" cancer will die believing that their illness was caused by the nuclear reactor. That is human nature; we search for reasons behind our tragedies. Of the roughly 100,000 survivors of the Hiroshima and Nagasaki blasts, we can estimate that about 20,000 have died or will die from cancer. But in only about 800 of these cases was the cancer caused by the bombs. We know that by looking at similar cities. Hiroshima and Nagasaki have experienced an increase in cancer among those exposed, but it is only a small increment of the natural rate. Yet far more than the estimated 800 victims attribute their cancers to the bomb.

What about the outlying regions of Fukushima? The next radiation zone around the reactor had a population of about 40,000 and an average dose of 1.50 rem (cSv). This yields a total dose of 60,000 total rem (cSv) (40,000 times 1.5), making the number of expected extra cancers 24 (60,000 divided by 2,500).

These numbers are tragic, but they are smaller than the impression that people got from much of the news coverage in the wake of the disaster. Thanks to the early evacuation, the total number of deaths from the radioactive release in the Fukushima region will almost certainly be less than my figures above. A more reasonable estimate, using average exposures rather than the maximum ones, is 100 extra cancer deaths. That is bad, to be sure, but that number is minuscule compared with the 15,000 deaths caused by the tsunami.

What about more distant regions? Even a tiny bit of radiation averaged over a huge population could conceivably cause cancer. But we are immersed in "natural" radioactivity from cosmic rays (radiation coming from space) and from the Earth (uranium, thorium and naturally radioactive potassium in the ground). These natural levels are typically 0.30 rem (cSv) per year. We also are exposed to an additional 0.30 rem (cSv) if we include average medical exposures from X-rays and other medical treatments. Some areas, like Denver, have even higher natural levels.

The most thoughtful high-number estimate of deaths that will be caused by the Fukushima disaster comes from Richard Garwin, a renowned nuclear expert. He has written that the best estimate for the number of deaths is about 1,500—well above my estimate but still only 10% of the immediate tsunami deaths.

Dr. Garwin uses the same numbers that I use, but he extrapolates forward in time 70 years to the continuing damage that residual radiation could cause, assuming that the radiation cannot be covered, cleaned or washed away, and that the population of Fukushima doesn't change. Moreover, he ignores the sort of argument that I have made about the Denver dose and includes in the calculation the numbers of deaths expected from tiny doses, assuming that even small exposures are proportionately dangerous. (This is an assumption that has also been adopted by the U.S. National Academy of Sciences.)

I don't dispute Dr. Garwin's number, but I believe it has to be understood in context. If you apply the same approach to Denver, you have to take into account the fact that the Denver dose is delivered every year. Over 70 years, it sums to 0.30 rem (cSv) times 70, or 21 rem (cSv) per person. If you multiply that by 600,000 people (the current population of Denver) and divide by the cancer dose of 2,500 rem (cSv), you get the expected cancer excess in Denver. That figure is 5,000, over three times higher than Dr. Garwin's number for Fukushima.

I am uncomfortable with these large numbers of predicted deaths. They are based on a theory that assumes proportionality in the way that radiation increases the likelihood of cancer—a theory that has never been tested, will not be tested in the foreseeable future, and which is known to fail for leukemia.

I can't be sure that the theory is wrong, but I consider these relatively large numbers for Denver and Fukushima to be misleading. Remember that Denver has a lower cancer rate than the rest of the U.S., not a higher one. There is a strong argument for ignoring radiation dangers below the level of the Denver dose. In doing so, we would be ignoring risks that are unobservable and which we routinely ignore (and properly so) in other circumstances.

Even though Dr. Garwin predicts 1,500 eventual deaths from the nuclear accident in Japan, he says the figure is small enough that the long-term evacuation of Fukushima itself would probably cause more harm than good. Evacuation causes disruption to lives that is hard to quantify but very real.

Some people believe that the proportionality assumption about radiation should be made because it gives a "conservative" estimate of possible risks. But beware of that adjective. What is conservative depends on your agenda. Is a conservative estimate one that likely overestimates deaths? If so, then it is likely to lead to more disruption through evacuation and panic. Is that truly conservative?

Another way to overestimate the deaths is to use a much higher value for the induced cancer risk than has been determined by the best scientific studies. I think the most useful estimate is the one I've given: From the radiation so far, perhaps 100 induced cancers. Residents of Fukushima who are concerned that residual radiation will cause additional risk can avoid that by leaving, but they need to recognize that any additional cancers will be statistically unobservable, hidden well below those of natural cancer and the other dangers of modern life.

The tsunami that hit Japan in March 2011 was horrendous. Over 15,000 people were killed by the giant wave itself. The economic consequences of the reactor destruction were massive. The human consequences, in terms of death and evacuation, were also large. But the radiation deaths will likely be a number so small, compared with the tsunami deaths, that they should not be a central consideration in policy decisions.

The reactor at Fukushima wasn't designed to withstand a 9.0 earthquake or a 50-foot tsunami. Surrounding land was contaminated, and it will take years to recover. But it is remarkable how small the nuclear damage is compared with that of the earthquake and tsunami. The backup systems of the nuclear reactors in Japan (and in the U.S.) should be bolstered to make sure this never happens again. We should always learn from tragedy. But should the Fukushima accident be used as a reason for putting an end to nuclear power?

Nothing can be made absolutely safe. Must we design nuclear reactors to withstand everything imaginable? What about an asteroid or comet impact? Or a nuclear war? No, of course not; the damage from the asteroid or the war would far exceed the tiny added damage from the radioactivity released by a damaged nuclear power plant.

It is remarkable that so much attention has been given to the radioactive release from Fukushima, considering that the direct death and destruction from the tsunami was enormously greater. Perhaps the reason for the focus on the reactor meltdown is that it is a solvable problem; in contrast, there is no plausible way to protect Japan from 50-foot tsunamis. Do we order a permanent evacuation of the coast to 20 miles inland? Do we try to build a 50-foot-high sea wall all around the eastern coast, including Tokyo Bay?

Looking back more than a year after the event, it is clear that the Fukushima reactor complex, though nowhere close to state-of-the-art, was adequately designed to contain radiation. New reactors can be made even safer, of course, but the bottom line is that Fukushima passed the test.

The great tragedy of the Fukushima accident is that Japan shut down all its nuclear reactors. Even though officials have now turned two back on, the hardships and economic disruptions induced by this policy will be enormous and will dwarf any danger from the reactors themselves.