Fukushima and Reflections on Radiation as a Terror Weapon

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ABSTRACT

The number of radiation casualties from the March 2011 meltdown of Fukushima nuclear reactors stands at zero. In Fukushima Prefecture, the casualties from radiation terror number more than 1,600, exceeding direct deaths from the natural disaster in that area, because of government-mandated evacuation that forced people from their homes and usual support systems into crowded evacuation centers.

The U.S. is vulnerable to the same radiation terror as occurred in Japan because of using the wrong dose-response model, which is based on the linear no-threshold hypothesis (LNT), for assessing radiation health risks.

The effects of low-dose radiation are in fact grossly misstated. The resulting fear-based regulatory regime deprives people of life-saving technology. In the event of a nuclear detonation or dispersal of radioactive material, panic could cause preventable mass casualties, and ignorance- or fear-based official directives could thwart rescue efforts and produce disastrous economic and social disruption. At the same time, instrumentation designed to detect low doses may be incapable of measuring lethal levels.

The Effects of Nuclear Weapons

Since the shock and awe from the bombing of Hiroshima and Nagasaki brought World War II to a quick end, the mystique of the Bomb has cast a pall over peaceful uses of nuclear technology. The apocalyptic scenarios in post-war fiction (such as *On the Beach, Dr. Strangelove,* and *The Day After*) helped to imbue the public with terror of invisible, mysterious radiation. Once contaminated, a person's future was supposed to hold only dread—radiation sickness, cancer, monstrously deformed offspring.

It's a perfect blackmail weapon, and of course all the rogue nations or insurgencies in the world want to acquire one or more nuclear devices, or at least radiation dispersal devices (RDDs or "dirty bombs"). It is also naïve to think that the Cold War is over for good.

"We can turn USA into radioactive dust," stated Dmitry Kiselyov, head of the new Russian state television outlet, recently reminding the world that because of some 8,500 nuclear warheads, Russia can do whatever it pleases.[1]

His statement about radioactive dust is pure hyperbole. Nuclear weapons are awesomely destructive, but not primarily by producing radiation (leaving aside the neutron bomb or "enhanced radiation weapon"). They use nuclear fission or fusion to cause an enormous explosion. The predominant effect is the same as dropping a vast number of chemical explosive and incendiary devices. But with the atomic bomb, there is "more bang for the buck."

The Hiroshima bomb killed 78,500 people. In the fire raids on Tokyo of Mar 9, 1945, about 80,000 people were killed. That took about 300 B29s instead of one. Total surprise accounted for the extraordinarily high casualty rate in Hiroshima; only a few hundred people were in shelters that could have accommodated 100,000.[2]

Only 5% to 15% of immediate or short-term deaths at Hiroshima were caused by ionizing radiation. Perhaps 30% of those who died immediately had received a lethal dose of radiation, but the immediate cause of death was likely blast injury or burns.[3] There was virtually no fallout as the bomb was airburst. Although a measurable amount of induced radioactivity was found, it was not sufficient to cause harm to persons living in the two cities after the bombings.[4] Hiroshima was not turned into "radioactive dust." Trains were running within 48 hours, and today the city is a thriving modern metropolis.

Careful long-term follow-up of the atomic bomb survivors does not support the claim that the tiniest dose of radiation is harmful. There was an increase in leukemia beginning about 2 years later and peaking at 4 to 6 years, and in other cancers beginning about 10 years later. There was no evidence to suggest an increased risk of leukemia at an acute dose less than 50 rem (500 mSv).[5] At an acute dose of 100 mSv, a cancer risk 1.05 times normal was calculated.[6] It is often forgotten that any calculations based on survivors' data are valid only in the extremely high A-bomb dose-rate range. When applied at an environmental level, they will substantially overestimate effects.

So far, no excess risk of radiation-related disease has been detected in children of survivors.[7] No hereditary disorders were found in the children of highly irradiated parents.[8]

There is great public fear about inhalation or ingestion of radioactive substances. Fires from the atomic bombs, however, released far higher levels of nonradioactive toxins and carcinogens.[9]

A Reactor Is Not a Bomb

At meetings of Physicians for Social Responsibility that I attended in the 1980s, including one at the University of Arizona College of Medicine, which featured Helen Caldicott, M.D., pictures of mushroom clouds were prominently displayed next to the cooling towers of nuclear power plants and the sinister-appearing cloud of non-identified water vapor

surrounding them. The two images are linked in the public mind. When the topic of radiation hazard comes up, planning scenarios generally focus on nuclear power generating stations as though a disaster there were the equivalent of a nuclear attack. Ira Helfand, M.D., of Physicians for Social Responsibility said of Fukushima: "These reactors are inherently dangerous. They contain the equivalent of 1,000 nuclear bombs."[10]

Despite news from North Korea and Iran on proliferation of nuclear weapons, a recent article in the Columbia University alumni magazine states: "We had a difficult time imagining something bigger than three nuclear reactors in full meltdown, except, of course, if those reactors had been in, say, Georgia or Vermont or New York [instead of Fukushima]."[11] The author is participating in a documentary about nuclear energy, *The Atomic States of America*.[12]

Official pronouncements may cloak fear-mongering in claims of "conservatism" and "prudence." Apocalyptic consequences from a reactor mishap, however, are not just highly improbable but impossible, states the late Theodore Rockwell:

> We know a great deal about what is physically possible with nuclear reactors. We have demonstrated that **nuclear fuel retains most of its fission products**, even when molten. We have measured the limited distribution of the fission products that do escape, especially in a water environment. And we have seen how **most of what escapes clumps and drops out** and does not stay aloft to be carried far away. We know this with the same physical and chemical certainty that we know a power reactor cannot explode like an atomic bomb.
>
> And we know that **trivial amounts of radiation do not cause cancer or other harm**, and that computer models that multiply trivial individual radiation doses by millions of people to get thousands of cancer deaths are not just improbable. They are not conservative. They are simply wrong….
>
> Engineering analysis and tests show that **nothing could be done to a water-type nuclear power plant or its fuel that could lead to a serious public health hazard** [emphasis in original].[13]

A Brief History of Radiation Exposure Limits

The 1934 "tolerance dose" of 0.2 Roentgen/day (680 mGy/y, 68 rad/y) was based on 35 years of medical experience. The American Roentgen Ray Society stated that this exposure rate could be tolerated indefinitely. It is about one-hundredth of the erythema dose of 600 Roentgens/30 days, and equivalent to high natural background levels—and to the exposure rate in the "red area" around Fukushima.

The Roentgen (R) is a legacy unit of exposure to x-rays and gamma rays. One Roentgen deposits a dose of approximately 0.93 rad in soft tissue.[8]

There is no evidence of harm at this level. A study of British radiologists showed that those who entered the profession before 1921 had higher cancer mortality than their peers, while those who entered after 1920 had lower mortality from cancer and other causes.[14]

At a dose rate of 1,100 mGy/y (110 rad/y), which is more than 1,000 times the recommended limit of 1 mGy/y for the general public, the hematopoietic system provides full function and stability without increased tumor incidence.[15]

Standards were "changed in the 1950s because of strong political pressure by scientists and other influential people to create a social fear of low radiation from a-bomb testing during the arms race and abhorrence of nuclear war," writes Jerry Cuttler.[15] Since then, the International Commission on Radiological Protection (ICRP) has progressively tightened its standards for occupational and public exposures from 50 mSv/y and 5 mSv/y, respectively, (ICRP 1958) to 20 mSv/y and 1 mSv/y (ICRP 1991).[16] If these standards are to apply after an accident, it raises the question of whether Denver and many other places should be evacuated immediately. The excess dose received in Denver is 3 mSv/y—what Richard Muller calls the "Denver dose."[17]

Excess cancers are observed years after high doses of ionizing radiation, especially at high dose rates. But the concern about low, even negligible doses is wholly dependent on the linear no-threshold (LNT) hypothesis, and current regulatory limits are based on it.[18,19]

The disarmament movement's campaign to stop atmospheric testing of nuclear weapons exploited the LNT hypothesis. But the intellectual foundation was Hermann J. Muller's Nobel Prize lecture of 1946, citing conclusions later incorporated into what Edward Calabrese calls "the most important publication in the history of risk assessment": the 1956 report of the Biological Effects of Atomic Radiation (BEAR) Committee of the U.S. National Academy of Sciences (NAS).[20]

Muller won the Nobel Prize for demonstrating that X-rays cause mutations in male fruit fly germ cells. He argued that the dose-response was linear and that there was "no escape from the conclusion that there was no threshold." He warned the medical community about indiscriminate use of X-rays.

Even at the time of his lecture, however, Muller knew of concerns among his peers about his data, including inadequate reporting of research methods, small sample size, lack of data on quality control parameters, known problems with temperature control, lack of data on lethal clusters, sterility/fecundity, and selection criteria. Moreover the "very low dose" tested was many thousand-fold greater than human exposures to background radiation. More seriously, Muller failed to temper his remarks even though he knew about a very large study by Ernst Caspari and Curt Stern, using the lowest dose rate ever tested (2.5 R/day), that supported a threshold interpretation. Calabrese suggests that the lecture was more ideological than scientific.[21]

Stern never followed up on his commitment to provide more detail, but rather made the "problems" of data contradicting linearity disappear in a 1949 version of a meta-analysis. Calabrese

writes that Stern got the LNT model accepted through "multiple manipulations and obfuscations" that reinforced biases within the genetics community. A trans-science concept now known as the Precautionary Principle acted as an "intellectual virus," undercutting the integrity of data-driven processes, with a profound effect on policy that persists 60 years later.

The antinuclear LNT idea survives despite its implausibility and the lack of evidence of genetic effects in A-bomb survivors—and even in the face of extensive evidence of benefits of low-dose radiation. In fact, low-dose radiation reduces the normal mutation rate in fruit flies by a factor of three, states Cuttler.[22]

The nuclear industry experienced the imposition of strict controls very early, for reasons not made known to workers. In a remarkable 1985 interview,[23] the late Galen Winsor describes his work in the plutonium-processing facility at the Hanford Site in Washington State, which was part of the Manhattan Project. At first, workers were handling material with bare hands. Although no adverse effects had been reported, rules and monitors suddenly appeared without explanation, and those who asked questions or violated rules simply disappeared.

When he was safety officer at a nuclear generating facility, Winsor used to swim in the pool where the spent fuel rods were kept and the water was a pleasant 100 degrees Fahrenheit. (This is actually called the "swimming pool" at the Palo Verde nuclear generating facility near Phoenix, Arizona. On a special VIP tour more than 20 years ago, I was allowed to view the pool from a high platform—of course, swimming was forbidden, even unthinkable.) Winsor also kept a bottle of the water on his desk and drank a glass of it each day, he claimed. The authorities at the plant wanted everyone to think the pool was very dangerous, Winsor says he was told, lest anyone think it would be safe to steal the "inventory."

Nuclear "waste," though believed to be exceptionally dangerous, is easily contained and extremely valuable, Winsor states. If lines from water tanks holding high-level waste at Hanford leaked, the material was so thermally hot that it made its own glass, sealing itself off in the ground. Cesium-137 was packed into casks and shipped by railway to Oak Ridge National Laboratory in Tennessee, where it was pressed into pellets with barium titanate. With thermionic converters, these radioactive heat sources generated electricity without moving parts and were used to power transmitters in the U.S. Navy in the SNAP (Systems Nuclear Auxiliary Power) program.

The "waste" problem is frequently cited as an insurmountable obstacle to the expansion of nuclear power generation. Reprocessing is forbidden in the U.S., and the long-term nuclear waste repository at Yucca Mountain in Nevada has been defunded by the Obama Administration for political reasons.[24] While the gamma radiation from shielded materials may be negligible, the gradual leakage of long-lived isotopes into air or water could lead to deposition of alpha and beta emitters in body tissues through inhalation or ingestion by persons remote from the scene for a very long time. I recall much concern about strontium-90 from atmospheric testing of nuclear weapons when I was young. In Chernobyl and Fukushima, concern centers on I-131 and Cs-137.

Early nuclear workers in the U.S. and former U.S.S.R. carried large body burdens of plutonium and other isotopes; some were so radioactive that they set off alarms on radiation monitors at nuclear power plants. Winsor admitted to willfully violating the rules; he died at age 82 of Parkinson's disease. There is no evidence of shortened life expectancy in such workers, despite careful monitoring of many thousands of nuclear workers for more than 50 years.[25]

In 1959, the ICRP set a maximum permissible skeletal content for various radionuclides, including 3.7 kBq (0.1 μCi) for radium-226, which would deliver around 0.12 mGy/mon. The induction of cancer from skeletal deposition of radium was found to have a threshold at a cumulative dose of about 10 Gy (1,000 rad), calculated to be an equivalent dose of 200 Sv (20,000 rem), with a quality factor of 20 for alpha radiation. Later, Raabe showed that the three-dimensional dose-response relationship for radium-induced bone cancer can be described as a function of the average lifetime dose rate to target tissues rather than of cumulative dose. The ICRP-79 standards, however, assume an LNT model based on cumulative exposure.[26]

One Becquerel (Bq) means the quantity of material in which one atomic disintegration or nuclear transformation occurs per second, and many assume that means one potentially cancer-causing "hit" to the DNA. The DNA molecule, however, is not as stable as once was believed. About 10,000 measurable DNA-modifying events occur per hour in every mammalian cell owing to intrinsic causes, such as reactive oxygen species.[27] In comparison, a radiation dose of 1 mSv delivered evenly over a year would cause, on average, fewer than 10 DNA damaging events per year, or 0.03 events/cell/day. This is 6 million times lower than the natural rate of DNA damage that occurs in every person, Cuttler points out. "And this information has been known for more than 20 years."[16]

Current U.S. regulatory limits for radioactivity are 1.2 kBq/kg in water or foodstuffs. After Fukushima, Japanese authorities thought it might reassure people to cut these allowances to half, and then to one-tenth of international standards, but the result was apparently to increase rather than lower the level of fear.[25]

Rather than being based on fundamental science and data about actual effects, current standards are based on a mystical Precautionary Principle and false assumptions: a linear, no-threshold dose-response curve; consideration only of cumulative dose, disregarding dose rate and repair mechanisms; and calculating casualties from population dose (a concept with no biological meaning), multiplying a small or negligible risk to each individual by the number of individuals in the population.

The dose rate received by atomic bomb survivors was 2×10^{15} times larger than the Chernobyl dose rate in the U.S. "Extrapolating over such a vast span is neither scientifically justified nor epistemologically acceptable," writes Zbigniew Jaworowski.[28]

The standards are not "conservative." As Swedish

radiobiologist Gunnar Walinder stated in 1995, "The LNT hypothesis is a primitive, unscientific idea that cannot be justified by current scientific understanding." Further, "as practiced by the modern radiation protection community, the LNT hypothesis is one of the greatest scientific scandals of our time." Chernobyl victims, Cuttler said, suffered a "psychosis of fear."[15]

As Bobby Scott points out, the deterministic effects of high-dose radiation do have a threshold because they result from killing a large number of cells simultaneously. These include effects on the central nervous system, gastrointestinal system, and blood-forming system. Scott uses a standard hazard model to show that the likelihood of life-threatening radiation effects on Fukushima recovery workers is very low. He states that the invalid LNT model should not be used for predicting future excess cancers.[29]

Actual Effects of Inadvertent Exposures

For exposure to external gamma irradiation, the experience with up to 20 years of exposure in 10,000 people from Co-60 contaminated rebar used in the construction of Taiwan apartments stands as the key "experiment of nature."[30] These people received estimated effective radiation doses averaging 40 mSv/y (4 rem/y), with a range from 18 mSv/y–525 mSv/yr. The mean cumulative exposure was 600 mSv, or around 60 rem. Astonishingly, the cancer death rate for people living in these apartments steadily decreased until it was essentially zero. Over the entire time period, deaths from cancer averaged 3.5 per 100,000 person-years for the irradiated population, as compared with 116 per 100,000 person-years for the general population of Taiwan—an apparent 33-fold suppression of cancer deaths, or 20-fold if roughly adjusted for age distribution. Moreover, congenital defects in children born to parents living in the apartments were also reduced from an expected 46 in the general population over the 19 years to only 3 in the irradiated population—a 15-fold reduction.[31]

For internal exposures, the experiment of nature occurred in 1987, when a Cs-137 source was removed from an abandoned cancer-therapy clinic in Goiânia, Brazil, and sold to a scrap yard. Fragments fell into the hands of people who were intrigued by its blue light, and 249 people were contaminated, of whom 28 suffered skin burns, which required surgery in some cases. Four people died from acute radiation syndrome (ARS): one who had ingested > 1 million kBq, which would give a monthly effective dose of >6,500 mGy (650 rad), and three who had ingested between 100,000 and 1 million kBq. In 25 years, there have been no (zero) cases of cancer in the contaminated persons. In addition to receiving significant external radiation, 69 persons had ingested between 10 kBq and 100,000 kBq of Cs-137 (monthly dose 0.065 mGy–650 mGy).[32]

At Fukushima, the adult exposure to Cs-137 was less than 12 kBq in all cases, and in children less than 1.4 kBq, between November 2011 and February 2012. Normal body content of K-40 is 4.4 kBq, notes Wade Allison, emeritus professor of physics at the University of Oxford.[32]

Before Fukushima, the 1986 Chernobyl accident was the predominant horror scenario. Unlike at Fukushima, there were direct deaths of firefighters and workers. Of 134 heavily irradiated persons, 28 died soon after the accident due to acute radiation disease, and 106 persons remained alive. Of these 106, 22 died during the next 19 years, which gives the mortality rate of 1.09% per year, i.e. slightly higher than the 2000 mortality rate in Poland (0.98%), but much lower than the average 2000 mortality rate in Belarus (1.4%), Russia (1.38%), and Ukraine (1.65%). Among 17 Chernobyl survivors of the acute radiation syndrome who died before 2001, only 4 or 5 persons died because of neoplastic diseases. Thus in 2001 cancer deaths represented 24% or 29% of all deaths, i.e. not much different from the values of 23.0% for Poland in 1999, or 25.2% in Austria and 26.1% in Germany, both in 1990.[33] Most tellingly, the projections of thousands of late cancer deaths based on the LNT theory are in conflict with the observation that in comparison with general population of Russia, solid cancer mortality was 15% to 30% less than expected among the Russian emergency workers, and 5% less than expected among the population of the most contaminated areas.[34]

The "dead zones" around Chernobyl certainly do not support the idea that "the cockroaches will inherit the earth." The "dirtiest" radioactive site in Europe has become the region's biggest animal sanctuary—and the animals are normal.[35] Some 1,200 "self-settlers," mostly elderly women, have defied the authorities and returned to their homes, preferring radiation exposure to "dying of sadness." It is claimed that those who returned outlived those who did not by a decade.[36]

The only cancer reportedly observed in excess is thyroid. However, Jaworowski contends that this is probably an artifact of intense screening, as occult thyroid cancer is extremely common.[33]

About 400,000 persons were evacuated. At first, relocation was performed in areas where the lifetime (70 years) dose from Chernobyl fallout might be higher than 350 mSv (5 mSv/year). Later this limit was changed to 150 mSv (i.e. 2.1 mSv/year), and then to 70 mSv (1 mSv/year). The result of these unreasonable restrictions was "unspeakable tragedies of hundreds of thousands of people, economic and societal ruin of millions of inhabitants, and country scale losses of the order of tens or hundreds [of] billion[s in] US dollars."[33]

"Psychosis is the most grave and wide impact of this accident, both at the regional and global scale. It caused the greatest medical, economic and societal harm," Jaworowski concludes.[33]

Representative Doses

For perspective, some representative exposures and regulatory limits are given in Table 1. Most occupational and accidental exposures are less than the natural background

levels in some areas, where cancer rates and general health tend to be more favorable, not less.[13] For example, on the Greek island of Ikaria, the "island where people forget to die," the maximum dose rate is 35 mSv/y. Four times as many men reach the age of 90 there compared with the U.S. The *New York Times* attributes this to diet or perhaps herbal tea.[37]

The general adaptive response called hormesis has been discussed previously in this journal,[18,31,38] and mechanisms are described by Feinendegen et al.[39] The zero equivalence point is the dose rate beyond which the biphasic dose-response becomes harmful rather than protective.[31]

The change in units to those developed by the International Commission on Radiation Units (ICRU 1998) can cause considerable confusion; convenient conversion factors are given in Table 2.

Metric prefixes in common use include: tera = 10^{12}, giga = 10^{9}, mega = 10^{6}, kilo = 10^{3}, centi = 10^{-2}, milli = 10^{-3}, micro = 10^{-6}, nano = 10^{-9}, pico = 10^{-12}.

Table 1. Representative Doses and Dose Rates

Dose or dose rate Intl units	**Dose or dose rate** Old units	**Circumstances**
1 mSv/y	100 mrem/y	maximal excess nonoccupational, nonmedical exposure permitted in U.S.[41]
20 mSv/y	2,000 mrem/y, 2 rem/y	annual dose limit for radiation workers[41]
1-3 mSv/y	100-300 mrem/y	average natural background[33]
20 mSv/y	2 rem/y	"deliberate evacuation area" around Fukushima[16]
Up to 10 mSv/y	Up to 1 rem/y	9 mSv/y from regular flights by airline personnel between New York and Tokyo[40]
350 mSv/lifetime	35 rem/lifetime	initial Chernobyl evacuation level[33]
43.8 mSv/y	4.38 rem/y	at front of Chernobyl sarcophagus[40]
0.3 mSv	30 mrem	average exposure for resident of Europe to Chernobyl fallout over a period of 20 years[40]
100 mGy/y	10 rad/y	optimal hormetic exposure per some researchers[38]
> 200 mSv/y	> 20 rem/y	highest average background where people live normally[13]
20,000 mGy/y	2,000 rad/y	zero equivalence point[38]
>1,000 mSv acutely	>100 rem	acute radiation sickness likely[3]

Table 2. Conversions[41]

Unit	**Abbrev**	**Measurement of**	**Equivalent**
1 kilobecquerel	1 kBq	Activity	27 nanocuries
1 Becquerel	1 Bq	Activity	27 picocuries
1 Curie	1 Ci	Activity	37 gigabecquerels
1 microcurie	1 µCi	Activity	37 kilobecquerels
1 Sievert	1 Sv	Dose equivalent	100 rem
1 millisievert	1 mSv	Dose-equivalent	100 millirem
1 microsievert	1 µSv	Dose-equivalent	0.1 millirem
1 rem	1 rem	Dose-equivalent	10 millisieverts
1 millirem	1 mrem	Dose-equivalent	10 microsieverts
1 Gray	1 Gy	Dose	100 rads
1 milligray	1 mGy	Dose	100 millirads= 0.1 rad
1 rad	1 rad	Dose	10 milligrays= 1 centigray

Dose equivalents account for the greater biological effect in an organ or tissue of internal alpha and beta particles as compared with gamma rays.

Response to Fukushima

The March 2011 earthquake off Sendei, Japan, released energy equivalent to 336 megatons of TNT.[42] The 30-foot-high wall of water caused by the tsunami took out the back-up power supply to the cooling water pumps. Recorded deaths in the Fukushima Prefecture from the natural disasters were 1,603 as of Nov 30, 2013.[43] None of them were from radiation. Japan-wide, 19,000 casualties from the natural disaster were recorded by March 2012.[44] Half a million people lost their homes or livelihood, and millions were without water, heat, or electricity. On top of the losses from the natural disaster were the effects of radiation terror.

Some 470,000 persons were forced to evacuate, and on the third anniversary, some 267,000 were still not permitted to return home.[45] As of Nov 30, 2013, there were already 1,605 deaths associated with the evacuation in Fukushima Prefecture.[43]

In Fukushima City, technicians took radiation readings hourly at seven locations. There was a peak at about 17 µSv/hr, which declined rapidly and has remained around 1.6 µSv/hr for weeks. At this dose-rate, the exposure would be 14 mSv/yr. Even if the linear no-threshold hypothesis is true, the level is so low "that it may be impossible to tease out carcinogenic effects"—especially since 40% of all Japanese develop cancer.[6]

The Japanese government has told some evacuees that they will never be able to go home. Areas where radiation doses exceed 50 mSv/y (5 rem/y) are designated "no go" zones. Because of radiation fears, only 12% of evacuees in Tomioka, one of the most heavily contaminated zones, want to go back.[46]

One rice farmer, Naoto Matsumura, is defying government orders. He is constantly exposed to 17 times the "safe" level of radiation (a fraction of the 1934 tolerance level) in Tomioka, 6 miles from the Fukushima nuclear plant. He left for a short time, but returned because he couldn't endure the thought of animals left to fend for themselves. He now feeds his own 50 cows and two ostriches and makes rounds to feed neighbors' animals as well. Unfortunately, he was too late to save some of the hundreds of cattle left to starve in a barn.

Researchers at the Japan Aerospace Exploration Agency told him that he had the highest radiation level of anyone

they had tested—but he wouldn't get sick for 30 or 40 years. Matsumura says he intends to die at home.[47]

People are very concerned about radioactive contamination of food. Japanese officials found levels of iodine-131 up to seven times higher than "safe limits" in spinach collected from six farms as far as 75 miles from the reactors. They said that adverse effects might occur from eating 1 kg (2.2 lb) every day for a year—but the public was not reassured. "Specialists in risk communication would view radioactive spinach as a problem ranking high on anyone's 'dread-and-outrage' scale," writes Marion Nestle.[48]

The actual dose in the spinach was about 54,000 Bq/kg or 54 kBq/kg. (The dose of I-131 for treating hyperthyroidism is about 300,000 kBq, 5,500 times as much.)

There is also much concern about fish. Tim Worstall reports that the Fukushima-derived radiation in a steak from a Pacific bluefin tuna is about the equivalent of one-twentieth of a banana. More strikingly, the dose from cesium in the tuna is only 0.2% of that from the naturally occurring polonium-210 in the fish. Furthermore, the cesium content of the fish in August 2012 was down to half the levels found in August 2011.[49]

In lowering the amount of radioactivity allowed in food from 500 Bq/kg to 100 Bq/kg, Japan has likely banned bananas (about 15 Bq per banana and 6 or 7 bananas/kg) and Brazil nuts (which exceed the limits that may be released from a nuclear installation). The limits apply to cesium, not potassium (found in bananas) or radium (found in Brazil nuts), but the local municipalities making the measurements [like the human body] are unlikely to distinguish the source of the beta or alpha particles.[50]

The widespread belief that radiation is "unsafe at any dose," as asserted by Caldicott,[51] a founder of Physicians for Social Responsibility, naturally causes great anxiety. Clearly, the Japanese believe it: "No matter what protective gear you have on," said the leader of a Japanese rescue squad, "if you touch or inhale radioactive material, that means death."[52]

The units of measurement themselves are scary. Radiation meters may be calibrated in microsieverts; 100,000 µSv sounds frightening, but it is 100 mSv, the minimal acute dose associated with a small, about 5%, increase in cancer risk, if delivered at a very high dose rate.

Another scary number is the 36,000 terabequerels (~1 million curies [Ci]) of radioactivity that the plants "spewed"—which amounted to 11 kg of radioactive material out of the 60,000 kg of fuel per unit. Alarmists warned that the reactors contained about 134 million Ci of Cs-137 [mass = 3.2 g] or 85 times as much as was released at Chernobyl. In contrast, U.S. and Russian weapons complexes have released some 1.6 billion Ci, compared with a natural inventory of ~140 billion Ci in the oceans.[53]

Although no dire events have occurred yet, they surely will, alarmists predict: The Fukushima containment vessels for radioactive water are said to be leaking. This is a news hook for those who have been warning of consequences such as a "mass extinction event" and the potential death of "billions" of people ever since the tsunami occurred. For example, in an interview with *Russia Today*, Christina Consolo (@RadChick4cast) warns of an "apocalypse" that could make "at least the northern half of Japan uninhabitable" if it isn't already.[54] She also warns that North America is in "huge trouble." Her credentials: she's an "award-winning biomedical photographer and host of *Nuked Radio*," according to NaturalNews.com.

The economic costs of Japan's overreaction have been huge. Because of shutting down most of its 48 undamaged nuclear reactors, Japan's imports of fuel increased massively. This, coupled with slowdowns in manufacturing from power shortages, reversed Japan's trade balance from 20 years of surpluses to a $204 billion trade deficit between March 2011 and the end of 2013 and forced electricity bills up by more than 50%.[55]

Even though the total release of radioactive material from Fukushima was only one-sixth that at Chernobyl, the effect on nuclear power generation worldwide may be greater.

"Enthusiasm for a global nuclear revival has stalled—and not before time," writes Colin Macilwain. He states that there is a "downside too terrible to contemplate."[56]

Fears of radiation release are cited as the reason for shutting down reactors in Germany, located far from any prospect of a tsunami. A human chain of 60,000 protesters showed up in Stuttgart to protest nuclear energy. A nascent antinuclear movement has finally taken hold in France, which generates 75% of its electricity from nuclear and is thus half as dependent on Russian natural gas as the rest of Europe. Speaking of a "before and after Fukushima," France plans to spend $16 billion on an additional layer of defense, hardened bunkers with protected control rooms and reservoirs of coolant.[57] France is, however, unlikely to close down any reactors, writes William Tucker, and if it did, Italy, which shut down all its reactors after Chernobyl and imports 80% of its electricity, would probably collapse.[58]

A reporter recently called me, expressing concern that radioactive material from Fukushima was arriving in the Pacific Northwest, but the U.S. government was shutting down radiation monitors. The U.S. Environmental Protection Agency (EPA) maintains the RadNet system of radiologic monitoring stations (www.epa.gov/radnet), with more than 100 fixed air monitors and 40 deployable portable monitors. They have been able to identify fallout from Fukushima. Consolo writes extensively about the readings. Six of 12 sensors on the California coast were not functioning properly.

Concerns about this system are indeed justified, though not because of any realistic threat from Fukushima. Stations are not only too few, but unsuitable for monitoring a serious threat from nuclear terrorism or war. The RadNet's filter-based air monitoring system could miss fallout because it only samples intermittently and particles only remain

airborne for a short time. The data, which are in counts per minute, provide no meaningful dose information. Also, the vast array of highly sensitive detectors deployed among responders for purposes of interdiction or hazmat cleanup can become saturated [and useless] at high radiation levels, notes the National Capital Region planning document.[59] They may be unable to measure a dose higher than 10 mR/hr (0.1 mSv/hr). Authorities directing public response in the event of a nuclear detonation would receive erroneous and confusing information from responders carrying such instruments.

The Legacy of Nuclear Terror

U.S. public authorities' irrational response to radiation hazards, aided and abetted by activist physicians, has two sides. One is inability to respond to deadly threats, and the other is pathological overreaction to nonthreats or minimal threats.

The U.S. has virtually no ability to mitigate the effects of nuclear weapons despite the increasing likelihood of their use. These weapons are based on 60-year-old technology that is widely available. The perception that the threat is apocalyptic leads to denial. Even the minimal civil defense program we had in the 1950s has been almost totally dismantled, at least for the general public. Like survivors in the movie *The Day After*, many Americans might have to go to a museum to find a Geiger counter. Our first responders have instruments that alarm when a truck carrying medical waste passes by, or a person in an apartment three doors down from a patient has had a nuclear medicine scan. But these may not be able to distinguish a lethal threat from a load of bananas.

Setting exposure limits too low leads to panic and paralysis of recovery efforts. We need to modify those standards immediately and not wait for a crisis. Japan had to increase limits to enable people to keep working to bring the plant under control. But "when you relax the regime in the middle of an accident, you lose credibility immediately."[60]

A regulatory regime based on phantom risks calculated by using the LNT theory—what Edward Calabrese calls the "new homeopathy"—costs Western society about $2.5 billion for each hypothetical life saved.[33]

Worse than waste is the fact that diagnostic and therapeutic use of radiation is suppressed, as well as the disease-prevention use of the nonspecific adaptive response (hormesis).

Conclusion

The damage that could be caused by nuclear technology is amplified many-fold by extreme risk predictions based on false theory. Exposure limits need to be raised to realistic levels based on actual experience, and the LNT needs to be discarded and afforded the same credibility as Lysenkoism. This would deprive would-be aggressors of a terror weapon, encourage the development of robust protective measures against real threats, free up enormous resources for worthwhile uses, and spur the development of medical treatment utilizing the beneficial effects of low-dose radiation.

It is the responsibility of physicians to insist on honest appraisal of risks and benefits.

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