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David Ropeik

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The dangers of radiophobia

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ABSTRACT

Deep fear of nuclear radiation is widespread, yet research on radiation's biological effects finds that the level of alarm far exceeds the actual danger. This "radiophobia" has roots in the fear of nuclear weapons, but has been significantly reinforced and inflamed by accidents at nuclear power plants. Radiophobia does far more harm to human health than the radiation released by nuclear accidents. In some cases, the harm results from disaster response. The influence of radiophobia on society's energy choices poses great additional dangers.

KEYWORDS

Chernobyl; Fukushima; nuclear energy; radiation; radiophobia; risk perception

For all the fear and harm they have caused, nuclear power plant disasters and even nuclear weapon detonations have also been useful, warning us to be careful about how we wield the awesome power of the atom. These events have taught us a lot about the dangers of nuclear fission, whether it is being used to produce energy or make weapons. Unfortunately, however, though we now have all the examples we need to put nuclear risks into perspective, we have failed to do so. We should have learned by now that fear of radiation is vastly disproportionate to its actual dangers, and that between the fear and the radiation itself, the former has done much more harm.

Three Mile Island, Chernobyl, Fukushima: Few people had heard of these places until disasters at local nuclear power plants made them infamous worldwide, synonymous with danger and fear. The roots of that fear were firmly in place, of course, well before the disasters occurred, as Spencer Weart (2012) documented in *The Rise of Nuclear Fear*. Apprehension about nuclear radiation had been seared into the global public psyche by the horrors of the atomic bombs dropped on Hiroshima and Nagasaki. Radiation fears were the focus of the Ban the Bomb movement that arose in the following decades, which in turn gave rise to international protests against the danger of radioactive fallout from atmospheric testing of nuclear weapons. That movement helped give birth to modern environmentalism, which has ever since cited radiation from nuclear power as an example of the danger that human technology can pose to the natural world.

Three Mile Island, Chernobyl, and Fukushima all stoked alarm over radiation. They are proof, we are told, that fear is warranted. But an objective review of

those accidents makes clear that while radiation is indeed hazardous, what we also have to fear is fear itself.

The evidence is overwhelming. While the 1979 partial reactor meltdown at the Three Mile Island nuclear generating station in Pennsylvania was frightening, and remains the most serious accident in the history of US nuclear power, it did not release dangerous levels of radiation.

The disaster at Ukraine's Chernobyl Nuclear Power Plant in 1986 was a different matter. Huge amounts of radioactive material were emitted from a fire in the exposed nuclear core of one of its reactors, belching smoke directly into the air like some modern dragon's fearsome breath, heavily contaminating a wide region around the plant and carrying lower levels of contamination literally around the planet.

According to the International Atomic Energy Agency (IAEA), based on information available in 2006, the radiation released by the Chernobyl accident killed 50 workers and 15 children, the latter of thyroid cancer. The IAEA estimates that over the lifetime of the 200,000 workers who helped control the fire and contain the release of additional radioactive material, plus the 116,000 people evacuated and 270,000 residents in the more heavily contaminated areas – a total of 586,000 people – radiation might cause the premature death of an additional 3,940 people (IAEA 2006). That is a tragic loss of life to be sure, but represents a stunningly low risk rate of about two thirds of one percent.

As the United Nation's Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) summarized it, "Although those most highly exposed individuals are at an increased risk of radiation-associated effects, the

great majority of the population is not likely to experience serious health consequences as a result of radiation from the Chernobyl accident.” Michael Repacholi, manager of the World Health Organization’s Radiation Program, put it this way: “The [radiation] health effects of the accident were potentially horrific, but when you add them up using validated conclusions from good science, the public health effects were not nearly as substantial as had at first been feared” (World Health Organization 2005).

The mortality estimates from Chernobyl are based on studying what ionizing radiation exposure did to the survivors of nuclear weapons. The “validated conclusions from good science” to which Repacholi referred were drawn from the Life Span Study, a 70-years-and-counting epidemiological research effort following roughly 90,000 survivors of Hiroshima and Nagasaki (and their offspring) who were within 10 kilometers (km) of the hypocenter of the explosions. Tens of thousands of these people were within 2.5 km of the detonations and received frighteningly high doses of various types of ionizing radiation, including deeply penetrating neutron radiation. Thousands more were 3 to 10 km from the hypocenters and received low to moderate doses. Exposure was highest at the moment of detonation, but lasted for weeks and longer through continued exposure to fallout through food, water, and air (Life Span Study Report Series, Radiation Effects Research Foundation, Hiroshima, Japan, http://www.rerf.jp/library/archives_e/lstitle.html).

Of those roughly 90,000 atomic bomb survivors, fewer than 600 have died prematurely because of radiation-induced cancers, compared to the rate for the same cancers in the roughly 20,000 non-exposed Japanese who have been followed as a comparison cohort. In other words, exposure to atomic bomb-level doses of radiation raised the cancer mortality rate by about two thirds of one percent, roughly the rate predicted for the Chernobyl survivors. Bomb survivors exposed to 100 milliSieverts or less of radiation experienced no increases in radiogenic diseases compared with the non-exposed cohort. So, assuming that radiation at that level does harm, cases are so few that it doesn’t change the normal rates of radiation-related diseases. (This means that even assuming *any* exposure raises the risk above zero – as supposed by the hotly debated linear no-threshold model – the risk at low doses is miniscule.) Nor has there been any multi-generation genetic damage detected among the *hibakusha*, as the atomic bomb survivors are known in Japan.

Lessons from Chernobyl

We didn’t have this knowledge in the 1950s and 1960s as the fear of radiation was becoming commonly accepted,

but we do now, so we can compare harm from radiation at Chernobyl to the disaster’s non-radiological health impacts. Decades of research has established that fear of radiation did much more damage than radiation itself. As UNSCEAR reported, “Many other health problems have been noted in the populations that are not related to radiation exposure... Rates of depression doubled. Post Traumatic Stress Disorder was widespread, anxiety and alcoholism and suicidal thinking increased dramatically... People in the affected areas report negative assessments of their health and well-being, coupled with an exaggerated sense of the danger to their health from radiation exposure and a belief in a shorter life expectancy. Life expectancy of the evacuees dropped from 65 to 58 years... Anxiety over the health effects of radiation shows no signs of diminishing and may even be spreading.” In *Chernobyl’s Legacy: Health, Environmental and Socio-Economic Impacts*, a meta-analysis of 20 years of research, UNSCEAR said, “The mental health impact of Chernobyl is the largest public health problem caused by the accident to date” (IAEA 2006).

The evacuation and permanent displacement of more than 100,000 people – along with dishonest and confusing communication by authorities who were trying to tamp down fear – left tens of thousands of Chernobyl victims living in a state of perpetual stress. Stress is profoundly harmful to human health in a number of ways. It essentially puts the body in a persistent “freeze, flee, or fight” response, in which basic biological systems are turned up or down to concentrate the body’s energy on survival. Chronic stress raises heart rate and blood pressure and contributes to increased risk of cardiovascular disease. It suppresses the immune system and increases vulnerability to, and the severity of, infectious disease. Chronic stress such as that experienced by tens of thousands of Chernobyl victims increases the likelihood of type 2 (adult onset) diabetes, increases the likelihood and severity of clinical depression, and suppresses fertility, long-term memory, and bone growth (Sapolsky 2004).

There is a lot of research on what fear did to the mental health of the survivors, but practically none on the rates of stress-associated heart disease, stroke, or diabetes among the Chernobyl survivors compared to the general population. Given the general mental health findings, however, it is certain that rates of these major causes of morbidity and mortality increased, and that thousands of Chernobyl victims suffered one or more of these impacts.

What about the natural environment? Here, too, the disastrous nuclear power plant accidents offer constructive lessons. Chernobyl provided the first true

living laboratory for the field of radiation ecology, which blossomed in the wake of the accident. Extensive study of the environmental impact in the region around Chernobyl has found that, as with human health, fear of what radiation might do to the environment vastly exceeded the reality of the harm done. In 2006, UNSCEAR reported that "...the scientific assessments show that, except for the still closed, highly contaminated 30 kilometer area surrounding the reactor, and some closed lakes and restricted forests, radiation levels have mostly returned to acceptable levels" (IAEA 2005). More recent environmental assessments have found that even in the exclusion zone, an ecosystem is thriving in the absence of human activity, and that in general there is little sign of any harm from radiation. (The only animal populations that have suffered in the exclusion zone ecosystem are the pigeons and rats that once lived in the city of Pripyat, species that had become dependent on the humans who are now gone.) "In most areas the problems are economic and psychological, not health or environmental," according to Mikhail Balonov, the scientific secretary of the IAEA's Chernobyl Forum who has been involved with the Chernobyl recovery since the disaster occurred (World Health Organization 2005).

Fukushima fallout

If Chernobyl provides clear evidence of radiophobia – fear that far exceeds the actual risk and does harm all by itself – Fukushima makes the case even more dramatically. The two accidents were very different in nearly all the key specifics, including the cause, the nature and amount of radioactive material released, and the size and population of the area over which that material spread. One central aspect, though, was the same: A serious accident at a nuclear power plant spread fear of radiation worldwide. And as in the case of Chernobyl, rigorous research on the health effects of Fukushima found that fear of radiation has been far more harmful than the radiation itself.

In 2013, the World Health Organization (WHO) said: "Outside of the geographical areas most affected by radiation, even in locations within Fukushima prefecture, the predicted risks remain low and no observable increases in cancer above natural variation in baseline rates are anticipated." (This assessment was again based on the Life Span Study.) Even for the sensitive risk to fetal health, the WHO found that "[t]he estimated dose levels in Fukushima prefecture were also too low to affect fetal development or outcome of pregnancy and no increases, as a result of antenatal radiation exposure, in spontaneous

abortion, miscarriage, perinatal mortality, congenital defects or cognitive impairment are anticipated" (World Health Organization 2013).

The impacts of fear, though, have been huge. The death toll from the evacuation alone was dramatic. The authorities, not knowing how high radiation levels would get, hastily ordered 154,000 people out of a 20 km zone around the plant to avoid exposure, and thousands more in adjacent areas also fled. According to the Japan Times in 2014, local officials estimated the nuclear evacuation killed 1,656 people in Fukushima prefecture, 90 percent of whom were 65 or older. The earthquake and tsunami themselves only killed 1,607 in that prefecture.

In a study on the health effects of Fukushima evacuations, published in the April 2016 issue of *Clinical Oncology*, public health experts describe the effects of fear:

"Evacuation of the inpatients and elderly residents of nursing care facilities was hurriedly carried out by buses shortly after the accident. No medical personnel accompanied the evacuees who were laid down on the seats of the jam-packed buses with full protective suits on. No medical care, even food or water, was provided for many hours during the evacuation. As a result, scores of patients died in an evacuation that was supposedly intended to minimise radiation exposure. The life-threatening risk to these people was not radiation, but discontinuation of daily medical care. A recent study indicated that the severe health risk associated with the rapid evacuation of elderly residents from nursing care facilities after the Fukushima accident was 30 times higher than the radiation risk of the reference levels for evacuation that are recommended by the International Committee for Radiological Protection" (Hasegawa, et al. 2016).

As with Chernobyl, Fukushima's mental health toll was immense. The authors of the *Clinical Oncology* paper report that the accident "caused severe psychological distress in the residents from evacuation zones" with effects including "post-traumatic stress response, chronic anxiety and guilt, ambiguous loss, separated families and communities, and stigma." The authors go on: "In addition to psychiatric and mental health problems, there are lifestyle-related problems such as an increase[d] proportion of those overweight, an increased prevalence of hypertension, diabetes mellitus ... and changes in health-related behaviours among evacuees; all of which may lead to an increased cardiovascular disease risk in the future."

According to *Nature*, in 2012 a public health survey conducted on Fukushima survivors found that "roughly 15% of adults showed signs of extreme stress, five times the normal rate, and one in five showed signs

of mental trauma – a rate similar to that in first responders to the attacks of 11 September 2001 in the United States” (Brumfiel 2013).

Children’s health is suffering in many ways. In 2012, *The Guardian* reported that according to the Japanese education ministry, “Lingering fears of radiation have turned children from Fukushima into the most obese in Japan, according to a government study, as parents and schools continue to restrict the amount of time they spend outdoors” (McCurry 2012). The ministry’s survey found that children from Fukushima prefecture aged five to nine, as well as those aged 14 and 17, were the fattest in Japan, 20 percent heavier than the standard weight for their age. Obesity in six-year-old boys and eight-year-old girls doubled compared with the previous survey. Why? Because fear of radiation was causing parents and schools to keep kids inside.

Children are suffering in other ways too. Fear of radiation-induced thyroid cancer prompted officials to offer screening for any child, even though experts agreed that the levels of radiation to which kids had been exposed was too low to warrant such screening. To date, about 450,000 children have been examined, using a sensitive ultrasound screening technique well known to find abnormalities in most people’s thyroids, though in nearly all cases those abnormalities will never cause cancer. Such abnormalities were detected in half those kids, which anti-nuclear advocates immediately blamed on Fukushima, further feeding public radiophobia, despite the fact that ultrasound thyroid screening found similar rates in non-exposed kids elsewhere in Japan, as had a similar program in South Korea years earlier. Nonetheless, more than 100 children have had all or part of their thyroids removed, perhaps unnecessarily according to Kenji Shibuya, a public health specialist at the University of Tokyo, who called the screening “overdiagnosis and over-treatment” (Normile 2016). Health experts agree that it is highly unlikely radiation caused the childhood thyroid cancers found.

More than five years after the accident, fear of radiation is still harming the people of Fukushima. Most of the evacuated area is habitable again, either part or full-time, thanks to low initial radiation levels, radioactive decay, and massive clean-up. Evacuation orders for all but a few remaining contaminated hot spots have been fully or partially lifted. But close to 100,000 people refuse to return to their homes out of fear of radiation, a fear that is compounded by lack of trust in the officials and Japanese scientists who say it’s safe to go back.

The consequences of anxiety

The harm of our excessive fear of radiation goes far beyond the direct victims of nuclear power accidents. Radiophobia threatens us profoundly in other ways.

Most directly, it sickens and kills by increasing air pollution from the burning of fossil fuels. In the wake of Fukushima, Japan closed more than 50 nuclear power plants, which to that point had been providing 25 percent of the nation’s energy. The US Energy Information Agency reports that to replace that power, coal use in Japan increased 25 percent, and the use of oil for electric power generation doubled (US Energy Information Agency 2015). (Renewable energy – from sources like solar and wind power – increased just two percent.) Even though Japan is slowly edging toward reopening its nuclear fleet, re-starting many plants will be difficult because of excessively stringent new safety rules. In 2014, the Wall Street Journal reported that “[i]f the plans all come to fruition, Japan’s coal-fired power capacity would increase to around 47 gigawatts over the next decade or so, up 21 percent from the time right before the Fukushima accident” (Iwata 2014).

Burning coal and oil produces fine particulate air pollution, which the WHO calls “the greatest environmental risk to health – causing more than three million premature deaths worldwide every year.” (Natural gas, the use of which also increased in Japan, is mostly sulfur-free and does not produce fine particles.) Though the increased morbidity and mortality from particulate pollution in post-Fukushima Japan has not been quantified, it is inarguable that increased use of fossil fuels because of fear of nuclear power will sicken or kill thousands of people if it hasn’t already.

The same thing is happening in Germany. Driven by Green Party opposition to nuclear power, which is based largely on fear of radiation, Germany had been moving toward a gradual phase-out of nuclear energy even before Fukushima. But as a direct result of the disaster in Japan, Chancellor Angela Merkel, under intense pressure from the Green Party as well as general public opinion, withdrew a commitment to extend the operating lives of the nation’s 17 nuclear plants to 2022, and closed eight nuclear plants immediately. Germany has embarked on an ambitious program to close the other nine and move toward supplying all of the nation’s energy from renewable sources.

The *Energiewende*, as the German transition to renewable energy is called, has had dramatic success in moving toward its goal. Solar and wind power generation have grown by 20 percent as principal sources of energy in Germany since 2011, though they still

make up only 12.5 percent of overall power consumption (Federal Ministry for Economic Affairs and Energy 2016). However, unable to meet demand through renewable sources alone – particularly because of high demand from Germany’s energy-intensive heavy industries – the country has also increased coal use. Several new coal plants have opened or are about to (Andresen 2014). (Planning for many of these plants was underway before Fukushima, as German businesses planned for a non-nuclear future.) The European Environment Agency reports that since Fukushima, fine particle pollution in Germany from power production is up moderately over 2010 levels (European Energy Agency 2013).

There are no figures to quantify what this is doing to public health in Germany, but the public health literature is conclusive about what is likely happening. When fine particulate levels go up, so does sickness and death. Based on what we’ve learned from Chernobyl and Fukushima, the risk to public health from particulate pollution is orders of magnitude greater than the harm that would be caused by radiation released by a nuclear power plant accident.

Then there is perhaps the greatest threat to human health we have ever known, climate change. Radiophobia has contributed to decisions by several nations (among them Germany, France, Spain, Italy, Austria, Sweden, and Switzerland) to adopt policies that economically advantage renewable energy (solar, wind, and hydropower) over nuclear as a means of reducing greenhouse gas emissions, or in some cases to phase out nuclear energy altogether.

In the United States, the federal Clean Power Plan (shaped significantly by anti-nuclear environmental groups including the Natural Resources Defense Council) gives less support to nuclear than renewable energy. Several states have plans to reduce greenhouse gas emissions by using subsidies or other policies that encourage renewable power, but offer either less support or none at all for zero-emission nuclear energy. These policies change the economics of energy production, encouraging growth in renewables but making it increasingly uneconomical to operate nuclear plants.

Supporters of renewable energy say that solar, wind, and hydropower, along with conservation, will be enough to stave off the worst effects of climate change, but the evidence suggests this optimistic view is naïve. The closure of a nuclear plant in Vermont in 2014 has led to increased burning of fossil fuels by utilities that provide New England with electricity (Abel 2016). Energy experts expect similar outcomes from planned

or potential nuclear plant closures in Massachusetts, New York, Illinois, Ohio, Connecticut, and California.

After Fukushima, the Japanese government reversed a promise to reduce carbon dioxide emissions by 25 percent compared to 1990 levels, and now promises only a 20 percent reduction from 2005 levels. After Germany shut all its nuclear plants in 2011, nationwide greenhouse gas emissions rose 1.2 percent, the first increase in a decade. Germany will almost surely fail to keep its promise to cut greenhouse gas emissions by 40 percent from 1990 levels by the year 2020 (Deutsche Welle 2015).

In short, fear of nuclear power leads to policies that take a major source of clean energy off the table as a way to reduce the greatest threat to life on Earth humans have ever faced.

Moving past fear

Bertrand Russell, a leader in the global campaign against nuclear weapons, said in his acceptance speech for the Nobel Prize in Literature in 1950, “Fear, at present, overshadows the world... If matters are to improve, the first and essential step is to find a way of diminishing fear.” The same remains true today. We are worried about many things, but far more worried in some cases than the evidence says we need to be, and as Russell suggests, that excessive fear is dangerous, too.

How, though, do we diminish it? How do we reduce radiophobia and the perils it poses? Might we follow the prescription of Marie Curie? She said, “Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.”

The problem is, simply trying to educate the public won’t be enough. As much as we have learned about the surprisingly low biological risk of radiation, we also know from decades of research into the psychology of risk perception that, as pioneering researcher Paul Slovic puts it, “risk is a feeling.” We worry about some things more than the evidence says we need to, and less about some things than the evidence says we should, because risk perception is affective, a combination of how we consciously think about the facts and how we subconsciously feel about them. As Joseph LeDoux, Antonio Damasio, and other neuroscientists have learned, given the chemistry and wiring of the brain, feelings have as much – or more – of a say in how we see the world as facts alone.

This is neither right nor wrong, rational nor irrational. It is simply the reality of how our brain works to try to keep us safe. But it means that it won’t be enough

to merely educate the public about the low biological hazard of ionizing radiation. The excessive fear of nuclear radiation is a permanent feature of the modern zeitgeist.

However, recognizing the dangers of radiophobia might help us put things in perspective. Nuclear energy, along with all other forms of clean energy, can protect us from the huge danger of particulate air pollution, which annually sickens or kills millions more people worldwide than were – or may yet be – harmed from Chernobyl or Fukushima. As the effects of climate change become more dramatic and damaging, public concern and fear will increase, and the dangers of nuclear energy will more and more be weighed against its perceived environmental benefits. This is already happening as many people, including a growing number of environmentalists and climate change experts – former anti-nuclear radiophobes among them – are making the case for nuclear energy. Political leaders in several states where nuclear plants have closed (or will soon) are already searching for ways to subsidize nuclear energy, just as they do other forms of zero-emission power, in order to meet state goals for greenhouse gas emissions. Perception of the risk of radiation relative to much greater threats has shifted.

That is cause for hope, evidence that reason does play a role as we try to figure out what is dangerous and what is not. We're not entirely slaves to our emotions, lurching about ignorantly based only on what feels right. The shift demonstrates that we use our intellect as well as our instinct, the facts as well as our feelings, our reason as well as our gut reactions, to sort out what will best keep us safe. It suggests we might reach a balance between, on one hand, reasonable protection from the dangers of radiation, and, on the other, avoiding the dangers we face when our fear of radiation exceeds the evidence.

That is encouraging. If this shift toward a more balanced view of the risk of radiation spreads, we will be safer.

Disclosure statement

The author has done extensive work worldwide teaching the psychology of risk perception and its application to more effective risk communication to academic, non-profit, professional, government, and corporate organizations involved with nuclear energy.

Notes on contributor

David Ropeik is an instructor in the Environmental Studies Program of the Harvard Extension School, a consultant in

risk communication, and author of *How Risky Is It, Really? Why Our Fears Don't Always Match the Facts*.

References

- Abel, D. 2016. "Carbon Emissions Rising at New England Power Plants." *Boston Globe*, May 16. <https://www.bostonglobe.com/metro/2016/05/15/carbon-emissions-rising-new-england-power-plants/9WfbtQMJEBSzzxPzf2OLO/story.html>
- Andresen, T. 2014. "Coal Returns to German Utilities Replacing Lost Nuclear." *Bloomberg*, April 15. <http://www.bloomberg.com/news/articles/2014-04-14/coal-rises-vampire-like-as-german-utilities-look-for-survival>
- Brumfiel, G. 2013. "Fukushima: Fallout of Fear." *Nature*. January 17. 493: 290–293. doi:10.1038/493290a. http://www.nature.com/polopoly_fs/1.12194!/menu/main/topColumns/topLeftColumn/pdf/493290a.pdf
- European Energy Agency. 2013. *Air Pollution Fact Sheet 2013, Germany*. <http://glossary.eea.europa.eu/terminology/sitesearch?term=particulate+pollution+in+Germany>
- Federal Ministry for Economic Affairs and Energy. 2016. *Zeitreihen Zur Entwicklung Der Erneuerbaren Energie in Deutschland*. http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/zeitreihen-zur-entwicklung-der-erneuerbaren-energien-in-deutschland-1990-2015.pdf;jsessionid=244C1F90C34382CA8B36D886608ADF7B?__blob=publicationFile&v=6
- "German CO2 Emissions Targets at Risk." 2015. *Deutsche Welle*, November 19. <http://www.dw.com/en/german-co2-emissions-targets-at-risk/a-18862708>
- Hasegawa, A., T. Ohira, M. Maeda, S. Yasumura, and K. Tanigawa. 2016. "Emergency Responses and Health Consequences after the Fukushima Accident; Evacuation and Relocation." *Clinical Oncology* 28 (4): 237–244. doi:10.1016/j.clon.2016.01.002.
- IAEA. 2005. "Chernobyl: The True Scale of the Accident." Press release 2005/12. September 5. <https://www.iaea.org/PrinterFriendly/NewsCenter/PressReleases/2005/prn200512.html>
- IAEA. 2006. *Chernobyl's Legacy: Health, Environmental and Socio-Economic Impacts*. Vienna: IAEA Division of Public Information, https://www.iaea.org/sites/default/files/cher_nobyl.pdf
- Iwata, M. 2014. "Japan's Answer to Fukushima: Coal Power." *Wall Street Journal*, March 27. <http://www.wsj.com/articles/SB10001424052702304688104579464942892719528>
- McCurry, J. 2012. "Fukushima Radiation Fears are Linked to Increase in Obesity among Children." *Guardian*, December 27. <https://www.theguardian.com/environment/2012/dec/27/fukushima-radiation-child-obesity-fears>
- Normile, D. 2016. "Mystery Cancers are Cropping up in Children in Aftermath of Fukushima." *Science*, March 4. <http://www.sciencemag.org/news/2016/03/mystery-cancers-are-cropping-children-aftermath-fukushima> 10.1126/science.aaf4147
- Sapolsky, R. 2004. *Why Zebras Don't Get Ulcers*. Third Edition ed. New York: Holt Paperbacks.

US Energy Information Agency. 2015. *Japan, International Energy Data and Analysis*. https://www.eia.gov/beta/international/analysis_includes/countries_long/Japan/japan.pdf

Weart, S. 2012. *The Rise of Nuclear Fear*. Cambridge: Harvard University Press.

World Health Organization. 2005. "Chernobyl: The True Scale of the Accident." World Health Organization

Media Centre, <http://www.who.int/mediacentre/news/releases/2005/pr38/en/>

World Health Organization. 2013. *Health Risk Assessment from the Nuclear Accident after the 2011 Great East Japan Earthquake and Tsunami, Based on a Preliminary Dose Estimation*. Geneva: World Health Organization. http://www.who.int/ionizing_radiation/pub_meet/fukushima_risk_assessment_2013/en/