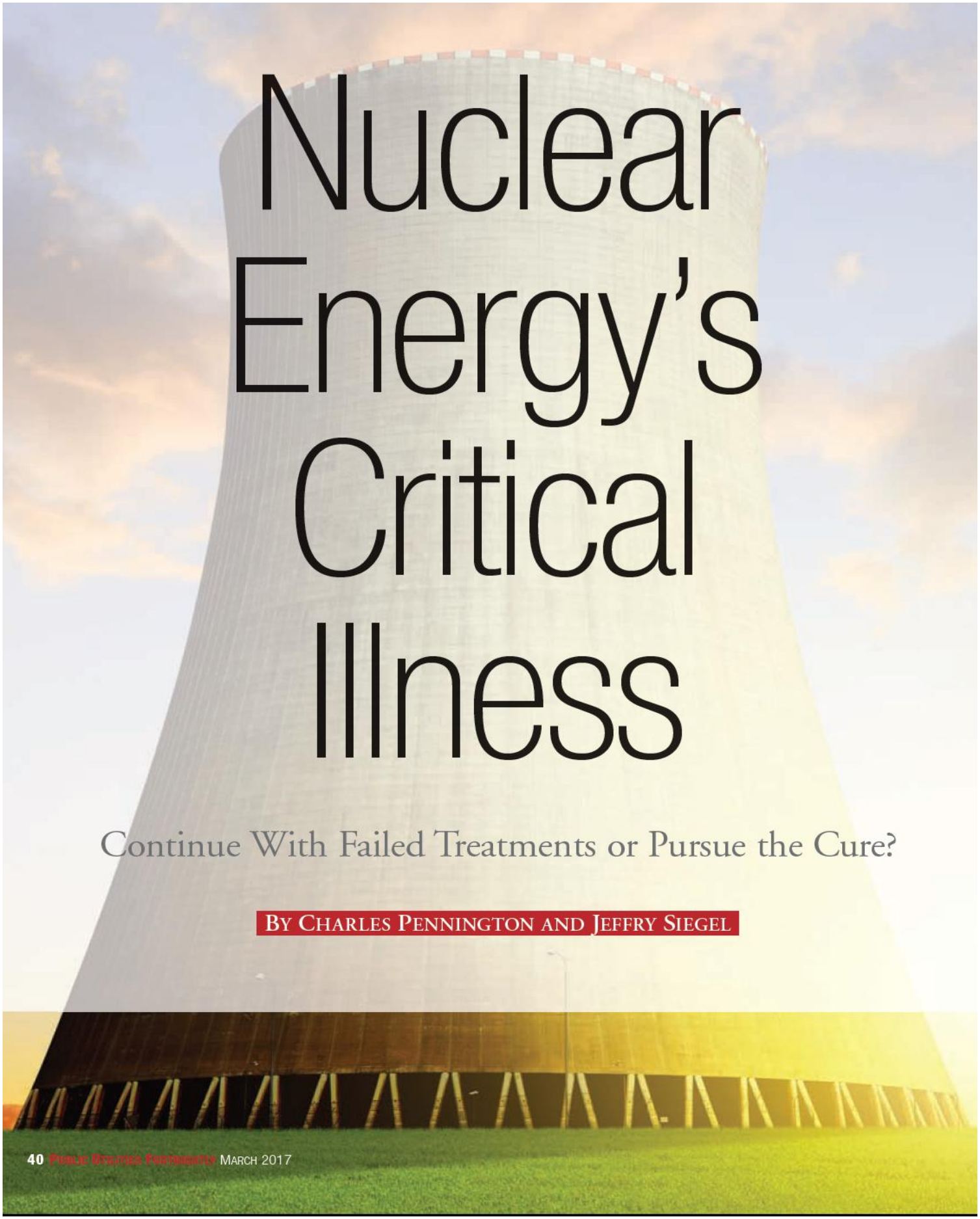

Nuclear Energy's Critical Illness

Continue With Failed Treatments or Pursue the Cure?

By Charles Pennington and Jeffry Siegel

Nuclear energy produces reliable electricity using a very compact, centralized design, with low fuel cost and throughput at a competitive price, stunningly low pollution, and demonstrated safety superiority compared to other technologies. Yet, it has remained competitively disadvantaged for decades, despite recent but now-failed hopes of a nuclear renaissance.

Many supporters of nuclear technology have tried to correct significant challenges on assorted issues from the public, the media, and the scientific, regulatory and political sectors.

But these efforts failed, owing to significant lack of understanding by scientists, educators, and regulators about the real problem. That is, they could not acknowledge the true illness and pursue the cure. The nuclear industry understood the problem, but lacked the science to pursue the cure.

This discussion focuses on what nuclear energy's critical illness is, how the industry has treated that illness, the cure for that illness, and one way to achieve a new political and regulatory environment that can save the patient. A partnership of the nuclear and medical communities is vital for assuring that desired outcome.

Background: The Illness

Nuclear energy has suffered from the illness of public and political fear of ionizing radiation. Regulators, government agencies and science advisors have supported the belief that it produces latent cancer from normal, accident, and waste-disposal conditions. This has created and sustained the global fear of nuclear energy. Societal fear of anything deemed a known cause of cancer at any dose by putative experts will always produce public opposition

The nuclear industry has known this for more than four decades. There are numerous authors whose writings show this, but in a recent, insightful discussion, Kidd states that public fear of nuclear energy's radiation could be terminal: "So nuclear gradually withers away from a viable technology to one that made a brief appearance in the twentieth century."[1]

The assertion of low-dose radiation harm is the foothold for fear. It arises from an erroneous, seventy-year-old assumption about radiation exposure from the nuclear energy and medical imaging businesses that is not settled science.

That assertion is known as the linear no-threshold model or LNT. It claims that all acute radiation exposures produce increased cancer incidence proportionally, down to zero dose; and that this effect is cumulative over a lifetime, regardless of the dose rate. Threshold means a dose/dose rate below which increased cancer incidence is zero.

No studies scientifically support low-dose/dose-rate radiation carcinogenesis (< ~200 milligray, or mGy, acute or chronic exposures), which are much higher than those likely resulting from nuclear power plant or radiological imaging doses. Nevertheless, all scientific advisory bodies and all radiation regulators use LNT.

Anything deemed a cause of cancer at any dose will always produce public opposition.

LNT only accounts for radiation damage, not for the cell, tissue, or organism biological damage response that has evolved from eons of living in higher natural background radiation. But where did this seventy-year-old assertion come from?

From the 1920s to 1946, scientists led by Nobel laureate Hermann Muller proposed the idea of LNT, based on genetic experiments using x-ray irradiation of fruit flies. Their research did not validate linearity to zero dose, but only down to doses far above zero. Nevertheless, Muller announced in his 1946 Nobel lecture that a dose threshold could not exist. Yet, within three years, his colleagues' research at lower dose and dose rates provided evidence for dose and dose-rate thresholds. These findings are scientifically irrefutable, but were overlooked or ignored by the scientific community until recently.[2]

Others applied LNT to radiation carcinogenesis in the 1950s. No valid evidence then supported LNT or the carcinogenicity of low-dose radiation exposure. In the years since, credible evidence of low-dose carcinogenic risk is nonexistent; it is a prediction of the demonstrably false LNT. Indeed, low-dose radiation does not cause, but more likely helps prevent, cancer.

What problems does LNT present? Clearly, claims that any radiation exposure is harmful, as formulated into nuclear energy and medical regulations and policies, will reinforce the understandable public fear of radiation due to decades of misinformation.

The policy implications produced by this fear are staggering. Public policy based on LNT's unproven threats to public health

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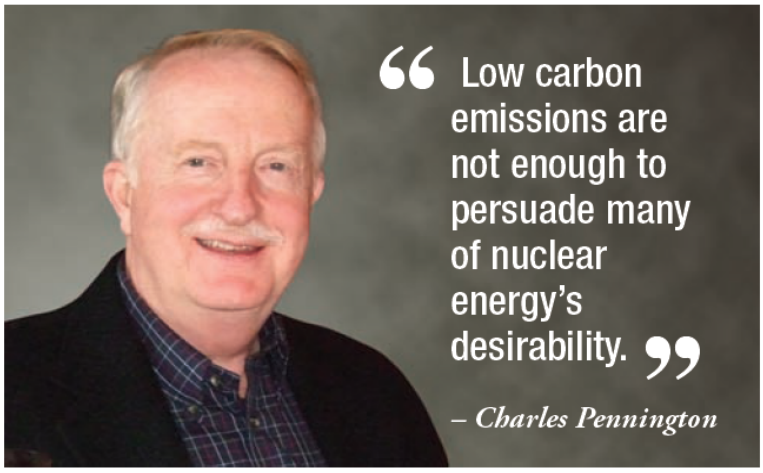
resulted in forced evacuations, suicides, and depression after the Fukushima and Chernobyl nuclear accidents.[3]

Fear of radiation after the Fukushima accident has been significantly more harmful than the radiation or the tsunami itself. Official figures indicate more than sixteen hundred fifty deaths in the Fukushima prefecture resulted from the forced evacuations.

The Chernobyl situation is far worse, with the accident's mental health impact being the largest public health problem. According to a 2006 UN/IAEA Report from the Chernobyl Forum on Chernobyl's Legacy, 2003 - 2005, seven million Chernobyl victims live on welfare, are psychologically incapable of being socially productive, and are suffering from groundless fear of radiation because of LNT-based policies.

Since LNT is fundamental guidance for regulatory policy, it propagates fear of radiation or radiophobia through various government entities and media into the public square. Today, LNT's illness also afflicts medical radiological imaging practices. Physicians fear using adequate medical imaging exposures, and patients fear receiving necessary imaging.

Radiological imaging has essentially replaced more risky exploratory surgery, contributing to reduced morbidity and mortality. Yet, medical imaging's consensus guidelines are based on LNT, believed to be a reasonable assumption about the radiation-associated risks of imaging. Concluding that LNT accurately assesses risk in the face of evidence to the contrary, however, cannot be called reasonable.



LNT also produced the as-low-as-reasonably-achievable or ALARA doctrine, which mandates radiation exposures be maintained as far below the arbitrary and already-low regulatory dose limits as is practical.

For nuclear energy and medical imaging, it is a mistake to reduce doses to mitigate purely hypothetical, scientifically unproven cancer risks without acknowledging the more likely benefit. For nuclear energy, this unnecessarily increases capital and operating costs. For medical imaging, reduced dose does not enhance patient safety and may unnecessarily increase patients' refusal of needed imaging studies or produce misdiagnoses due to non-diagnostic images.

LNT is philosophically more concerned with minimizing its theoretically predicted, low-dose-radiation cancer deaths than with reducing radiophobia's far larger number of actual deaths. LNT effectively produces a chronic poisoning, a metastatically spreading public radiophobia. LNT is a proven poison pill for nuclear energy, and eliminating LNT's radiophobia stops the active distribution to the public of that poison pill.

Nuclear Energy's Treatments and Why They Have Failed

The nuclear industry has worked to find treatments for the illness LNT causes. However, organized opposition to LNT itself has only formed recently, and the nuclear industry historically has not benefited from organized opposition to LNT.

The industry presently uses two major efforts to offset radiophobia. Reduce such fear through public outreach, and link nuclear energy to solving the problem of climate change, an issue the nuclear energy industry can use to showcase how its technology solves specific climate problems.

Public outreach regarding radiation has been focused on showing that low-dose radiation risk is very low (it is actually nonexistent and more likely beneficial), nuclear plants are very safe, and radiation releases are infrequent and result in doses too small to cause statistically detectable cancers.

But results have been disheartening because fear cripples reasoning, and fear arising from misinformation regarding Chernobyl and Fukushima that wasn't corrected has set back outreach efforts substantially.

Successful outreach efforts over several decades should produce visible results, but that has not occurred. Schools and colleges still teach that nuclear energy may have fearsome, radiological side effects. Medical schools still teach that any dose of radiation may cause cancer. Most doctors believe that low doses entail some cancer risk.

In short, regulators, oversight agencies, governments, the media, and the public accept LNT. We are led to believe that any radiation is harmful. Industry's outreach to reduce fear has been weak and insufficient, failing to eliminate the source of fear.

The other treatment for the illness involves implementing a strategy to gain endorsements for nuclear energy as a preferred source of baseload electricity generation because it produces virtually no carbon emissions. The reasoning is certainly sound, but it is clear that low carbon emissions are not enough to persuade many

Cartoon drawn by James Stevenson. Permission granted by The New Yorker and Condé Nast

"I think we're beginning to chip away at the stigma."

stakeholders of nuclear energy's desirability. Most environmental organizations believe the nuclear energy solution may be worse than the problem, with fear of radiation their major objection. This treatment may presently be viewed as wishful thinking and a failed strategy.

Our treatments, then, have been unable to allay the seemingly inextinguishable fear plaguing nuclear energy since they have shown little palliative and no curative effect.

The Source of Nuclear Energy's Cure: Evidence That LNT is False

If radiophobia is nuclear energy's critical illness, current treatments are neither curing the illness nor sustaining nuclear energy as a stable source of electricity supply. LNT, the source of the radiophobia, is a disproven assumption, and it is time to educate the public through a sustained effort to remove LNT from regulations and policies.

Experts have collected and analyzed the large quantity of extant data demonstrating that LNT is false non-science. Such studies are innumerable, predominantly generated by the global medical-science community. This section briefly summarizes a selection of such studies.

Radiation is a very weak carcinogen even at high doses/dose rates. The International Commission on Radiological Protection says that for an acute exposure of one Gy (Gray), defined as the absorption of one joule of radiation energy per kilogram of matter, at least ninety-five percent of exposed people would not get cancer. Further, carcinogenesis is a multistage, multi-mechanistic process involving many factors. Radiation may be a contributing factor at high doses/dose rates, but no single factor causes cancer.

LNT doesn't consider the body's radiation response. It focuses on unquestioned radiogenic cellular damage while ignoring

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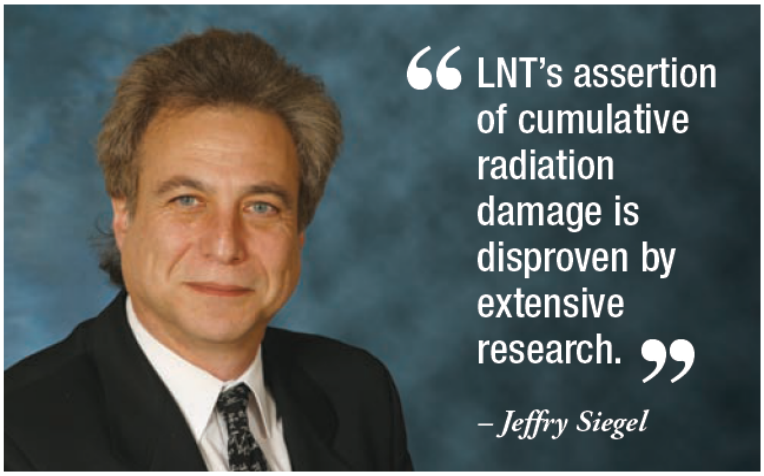
the organism's proven biological responses mitigating radiation damage by various repair mechanisms or, failing that, by various pathways that eliminate unrepaired damage from the body. It also ignores far greater non-radiogenic damage from naturally occurring oxygen metabolism in the body. Different mechanisms operate at high and low dose rates. At high dose rates, the body's restorative response is compromised; at low dose rates, the body mitigates any damage done. Therefore, a linear extrapolation from high-doses down to zero dose is not scientific.[4]

Mutations are necessary, but not sufficient, to produce cancer. Recent research shows models like the "one mutation = one cancer" or the "radiation-induced DNA double-strand breaks causing chromosome aberrations leading to cancer" are demonstrably false. Low-dose radiation stimulates the immune system, causing a reduction in cancer rates.[5]



LNT's assertion of cumulative radiation damage is disproven by extensive research showing the body's biological responses eliminate most low-dose radiation damage rather quickly.[6] Indeed, repair occurs even between fractions of much higher doses used in radiation therapy treatments. Therefore, much lower doses received from nuclear energy or medical imaging raise little concern.

The Radiation Effects Research Foundation in Japan has conducted its Life Span Study (LSS) of atomic-bomb survivors since 1950. The LSS is considered a most important dataset for estimating radiation effects in humans.[7]

Recent studies based on updated LSS data report the cancer mortality risk includes negative values for people exposed to low doses,[8] demonstrating cancer mortality rates less than the unexposed population rate, a radiation-induced benefit. This is consistent with experimental evidence for adaptive cancer protection after low-dose radiation exposure. These current data, therefore, do not support LNT. Other studies show similar results.

Epidemiological studies claiming to support LNT neglect, distort or dismiss experimental and/or observational discoveries at the cellular, tissue, and organism levels. These studies' conclusions are false due to circular reasoning, biased data selection, faulty experimental design, and/or incorrect inferences from weak statistical evidence.[9]

Basing regulatory revision and educational campaigns on these and other well-documented studies would be strong medicine, the antivenin for LNT's poisonous bite.

Elements of the Cure: How They May be Applied

We now require a strategy and process to initiate nuclear energy's cure. That would include the renunciation of LNT, coupled with a scientific approach to promote understanding of the benefits of radiation, so that regulations, standards, and policies are modified to reflect the available evidence. Several concepts are highlighted as suggestions for initiating such a process.

The medical community and its research must be involved. To develop the strategy and initiate this process, a working group comprised of medical and nuclear energy experts should be formed to plan the process to replace LNT and assemble accurate low-dose radiation information to allay public and political fear, an alliance for limiting LNT applicability. It can be called ALLAy.

While medical community leadership within ALLAy is important, the nuclear energy community must be involved in changing LNT's application to nuclear energy. Reducing LNT and ALARA impact on nuclear energy regulation is vital to improve nuclear plant economics, licensing, and schedules.

Approaching the NRC to effect regulatory change may bear more fruit as part of a docketed licensing process, where there is extensive input and technical exchange. Product developers and suppliers of nuclear facilities are best suited to lead efforts to replace LNT in the regulatory space.

Education of the medical and nuclear energy communities through the ALLAy plan should occur early, in parallel with regulatory reform efforts. Licensing interaction, resolution, and policy revision must take place before significant efforts to address public fears can achieve success.

Conclusion

LNT is the common, degenerative connection among man-made radiation, regulation, and public fear. While LNT is false, the disruptions arising from fixing the falsehood will be a great

impediment to changing the paradigm. Unfortunately, LNT has well-established interests dependent on its continued application.

Replacing LNT and the comatic atrophy it stimulates regarding nuclear energy expansion is vital to reducing radiophobia's destructive impact and achieving the survival and growth of nuclear energy.

Therefore, the nuclear energy and medical communities should move quickly to establish the ALLAy organization and begin its all-important, paradigm-shifting task. Eliminating LNT removes concerns about hypothetical harm and the fallacious fear of low-dose radiation exposure. It will establish nuclear energy as the key to a clean, reliable, and sufficient energy future. PUF

Endnotes:

1. Kidd S. Overcoming the paradigm of fear - part 2. Nuclear Engineering International, September 28, 2015. http://www.neimagazine.com/opinion/opinionovercoming-the-paradigm-of-fear-part-2-4680640/.
2. Siegel JA, Pennington CW, Sacks B, Welsh JS. The birth of the illegitimate linear no-threshold model: an invalid paradigm for estimating risk following low-dose radiation exposure. *Am J Clin Oncol.* November 3, 2015 [Epub ahead of print].
3. Siegel JA, Welsh JS. Does imaging technology cause cancer? Debunking the linear no-threshold model of radiation carcinogenesis. *Technol Cancer Res Treat.* 2016; 15:249-256.
4. Siegel JA, Pennington CW, Sacks B, Welsh JS.
5. Siegel JA, Welsh JS.
6. Siegel JA, Pennington CW, Sacks B, Welsh JS and Siegel JA, Welsh JS.
7. Ozasa K, Shimizu Y, Suyama A, et al. Studies of the mortality of atomic bomb survivors, report 14, 1950-2003: an overview of cancer and noncancer diseases (with ERRATA). *Radiat Res.* 2012; 177:229-243.
8. Doss M. Linear no-threshold model vs. radiation hormesis. *Dose-Response.* 2013; 11:480–497.
   Sasaki MS, Tachibana A, Takeda S. 2014. Cancer risk at low doses of ionizing radiation: artificial neural networks inference from atomic bomb survivors. *J Radiat Res.* 2014; 55:391-406.
   Furukawa K, Misumi M, Cologne JB, Cullings HM. A Bayesian semiparametric model for radiation dose-response estimation. *Risk Analysis.* 2016; 36(6):1211-1223.
9. Sacks B, Meyerson G, Siegel JA. Epidemiology without biology: false paradigms, unfounded assumptions, and specious statistics in radiation science (with commentaries by Inge Schmitz-Feuerhake and Christopher Busby and a reply by the authors). *Biol Theory.* 2016; 11:69-101.