

# Preserving the Anti-Scientific Linear No-Threshold Myth: Authority, Agnosticism, Transparency, and the Standard of Care

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## Abstract

The linear no-threshold (LNT) assumption is over 70 years old and holds that all ionizing radiation exposure leaves cumulative effects, all of which are harmful regardless of how low the dose or dose rate is. The claimed harm centers on the risk of future radiogenic cancer. This has been shown countless times to be fallacious, and hundreds of scientific studies—both experimental and observational/epidemiological—demonstrate that at low enough doses and dose rates, ionizing radiation stimulates an evolved adaptive response and therefore is beneficial to health, *lowering* rather than raising the risk of cancer. Yet the myth of uncorrected lifetime cumulative risk still pervades the field of radiation science and underlies the policies of virtually all regulatory agencies around the world. This article explores some of the motivations behind, and methods used to assure, the extreme durability of the LNT myth in the face of the preponderance of contrary evidence and the manifest harms of radiophobia. These include subservience to the voice of authority, tactics such as claiming agnosticism on behalf of the entire field, transparent references to contrary evidence while dismissing the findings without refutation, and seeking shelter behind the legally protective medical standard of care.

## Keywords

linear no-threshold (LNT), low-dose radiation, radiophobia, adaptive response

## Introduction

We have elsewhere recounted a sampling of the voluminous evidence of both the *falsity* of the linear no-threshold (LNT) assumption that underlies virtually all radiation protection policies in the world and of the *validity* of the human hormetic (beneficial) response to acute low-dose and chronic low-dose-rate radiation.<sup>1,2</sup> We have also refuted studies with the *appearance* of evidence in support of LNT,<sup>3,4</sup> exposing their circular reasoning and illegitimate statistics.<sup>5</sup> In these, we have documented the widespread and sometimes devastating harms of radiophobia consequent on LNT's claim that *all* ionizing radiation is harmful. Yet scientific argument, evidence, and refutation, by us and others over many years, have failed to move the radiation establishment; thus, here we discuss some meta-issues in an attempt to explain and overcome this ruinous anti-scientific stasis.

Through deceptive claims by official bodies, the LNT model for over 6 decades has been the bedrock both of regulatory policy and of a paradigm shared by an entire school of inquiry in radiation science.<sup>6</sup> These policies and its affirming paradigm constitute the voice of *authority* that defends LNT and its practical corollaries—as low as reasonably achievable (ALARA),

Image Gently, Image Wisely. Entailed in these is a one-sided attribution of radiogenic *risk*, while neglecting or denying radiogenic *benefit*. This one-sidedness is masked by explanations that diagnostic imaging, either with X-rays or with radionuclides, carries a favorable ratio of benefit to risk—that is, *diagnostic* benefit to radiogenic risk. Yet explanations to patients that excuse radiogenic risk by pointing only to *diagnostic* but not *radiogenic* benefit, and thereby lay claim to the virtue of “balance,” end up pairing falsity with validity and consequently disqualify themselves for the claim of “balance.”

The durability of this decades-old delusory justification demands explanation. Surely it rests on defense of career

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security, reputations, and funding sources, among other rewards. Rationalization of years of misguided publications encourages its authors to prolong the life of a scientific myth. Linear no-threshold proponents seek comfort and shelter in the voice of authority and in the custom-borne legal defense provided by the medical standard of care. They therefore blind themselves and others to the unintended radiophobic consequences of their advocacy. So powerful is this need for self-defense that, when its erroneous foundation comes to be realized, rejection of one's past advocacy requires rare courage and honesty.<sup>7</sup> But such rejection can also result in liberation and exhilaration.

### When the Voice of Authority Ignores the Preponderance of Scientific Evidence

Since the *origins* of the LNT mythology have been well covered elsewhere,<sup>2,5,6</sup> here we take aim at the very *persistence* of LNT advocacy, and the extreme difficulty of displacing any paradigm that is backed by the voices of authority. It is not for the lack of contrary evidence or published journal articles that LNT retains its domineering position in the radiation science literature, in regulatory policy, and in the popular media-driven public mind. It is because few scientists, physicians, and lay persons have, or at least take, the time to review conclusions critically, even with respect to the data presented in those very same papers. It is far easier and therefore far more common to simply hide behind the voices of authority. In this case, those voices are represented by the Biological Effects of Ionizing Radiation committee of the National Academy of Sciences, the National Council on Radiation Protection and Measurements, the International Commission on Radiological Protection, the US Nuclear Regulatory Commission, the US Environmental Protection Agency, and other widely recognized advisory groups and regulatory agencies around the world.

When multiple sources of information and/or evidence are *independent* of each other—linked solely through their assessments of the *same* reality—their very multiplicity is an important affirmation of the validity of their assertions. However, the point is that *the organizations named above are not independent* and are *not* linked solely through their assessment of the same reality. No, they consist of a certain number of rotating and overlapping memberships and, even were these convolutions absent, they generally reinforce each other's conclusions, each seeking sanctuary as a voice in the chorus singing in unison. Each thus acquires the legally defensible “justifiable reliance” on other voices of authority, should they someday be called upon to defend their anti-scientific stance. As such, rather than being *voices* (in the plural) of authority, they comprise a single *voice* of authority, rendering their authoritative value illusory.

Authority serves a most useful purpose when its voice propounds a position *supported by the preponderance of evidence*, along with a preponderance of concurrence. It can then propagate beneficial practices and support an entire school of scientific literature that expands the applications and horizons,

breathing into them vitality and valuable medical advances. But when the voice of authority, despite a preponderance of accord, propounds a position that, *even admittedly*, has no evidence in its favor and is opposed by the preponderance, if not totality, of the evidence (ie, the valid and irrefutable evidence), then that voice becomes a scourge. It produces widespread havoc, intensified illness, and premature death, as well as unwarranted fear and extensive and unnecessary suffering on all counts.

As we have discussed elsewhere,<sup>1,5</sup> (Sacks et al, 2016) these harms include, but are not confined to, the needless deaths resulting from the forced evacuations from Fukushima (more than 1600 according to the Japanese government's own accounting while the radiation has caused, and will cause, none), unfortunate fear-inspired and often physician-recommended refusals by patients and parents for medically indicated computed tomographic (CT) scans, obstacles to the erstwhile uses of low-dose radiation for relief of infections and pain, wholly inadequate funding for research into the salutary uses of low-dose radiation and, indeed, the ubiquitous media-driven radiophobia.

Mounting experimental and observational studies around the world provide evidence of an exposure threshold, with harm above but an evolved adaptive response with net health benefit below. Yet such studies are kept largely hidden – through ridicule, ritualistic dismissals, and error-ridden “proofs” of linearity<sup>3,4,5</sup> – from all but those who perform them or who avail themselves of their findings without preconceived prejudices. Favoring the mathematically convenient linear extrapolation from high- to low-dose effects, proponents *readily admit* that poor signal-to-noise ratios at low doses obscure evidence of LNT, or more specifically, of no threshold that distinguishes effects at high and low doses and doses rates, with inhibition of damage repair/removal above and promotion of same below. But their ready admission serves as a mere diversionary cover. Furthermore, when a study *claims* to find data unwarrantedly interpreted as confirming LNT,<sup>3,4</sup> its champions, inconsistency aside, applaud the “evidence” they had previously declared unobtainable.<sup>8</sup>

### Linear No-threshold only Accounts for Damage and Neglects Its Repair and/or Removal

Although LNT accurately enough describes *initial observable* radiogenic damage, it one-sidedly neglects the subsequent *equally observable* adaptive biological response that, over a matter of hours, repairs and/or removes that damage and necessarily further neglects the response's enhancement of defense against even *endogenous* damage, inflicted continually by reactive oxygen species (ROS) produced in the course of normal metabolism. The degree of endogenous damage is several orders of magnitude greater than that caused by levels of radiation from either natural background or medical imaging.

It should be noted that ionizing radiation-induced damage has a somewhat different spatial distribution than that caused by endogenous oxidative stress, depending on the linear energy

transfer (LET) of the radiation and its dose/dose rate. In cells, endogenous oxidative stress produces randomly distributed lesions; however, following exposure to radiation, formation of the lesions is localized around the particle track. Thus, radiation-induced damage contains more the so-called clustered DNA lesions, or multiply damaged sites, including complex double-strand breaks (DSBs). Clustered DNA damage sites, which are a signature of ionizing radiation, underlie its destructive potential, regardless of whether or not they are subsequently repaired or removed. Ionizing radiation, as used in radiation *therapy* (typically delivered in 2 Gy fractions, much higher dose and dose rates than would be encountered in radiological *imaging*), creates significant levels of clustered DNA damage, including complex DSBs, to kill tumor cells, as clustered damage sites are difficult to repair, but not difficult to *remove* in normal tissue. The complexity of the damage is dependent upon the absorbed dose/dose rate and the LET of the radiation, increasing with increasing LET (X- and  $\gamma$  rays associated with radiological imaging are low-LET radiations, whereas  $\alpha$  particles are high-LET). At low doses and low LET, most of the damage is caused by indirect action, that is, from the creation of ROS in the body's mostly aqueous composition, and not direct collisions with the DNA itself. The resulting radiogenic and endogenous DNA damage profiles are thus similar *qualitatively*, though *quantitatively* radiogenic damage is lower—*far* lower when delivered at low-dose rates.

### Evidence of Repair and/or Removal of Damage and the Agnostic Defense of LNT

According to a study by Löbrich et al.,<sup>9</sup> performed in individuals undergoing CT examinations, with their high dose *rate* but low dose and low-LET radiation, the body is capable of repairing or removing DSBs. The study showed that 30 minutes following exposure, there was an increase in DSBs compared with pre-CT levels, but the initial radiation-induced damage was repaired or eliminated by the body's adaptive responses and within hours. In fact, in all but 1 patient, the DSBs were repaired to, *and even below*, the initial (pre-CT) levels at some time between 5 and 24 hours (no data were obtained between these 2 time points). This suggests that the low-dose CT exposure not only repaired the radiogenic damage but *also induced repair of the preexisting and ongoing endogenous DNA damage*. Apparently, doses and dose rates associated with CT scans are able to stimulate, rather than inhibit, the DNA repair mechanisms; and these adaptive responses appear to be capable of repair without error or, at worst, removal of unrepaired cells, at least in normal individuals.

Of late, some LNT defenders have come to recognize the strength of the growing literature propounding hormesis but, instead of acceding to the evidence, have, as a tactic to preserve the dominance of LNT, shifted from categorical defense to *agnosticism*. That is, claiming to speak for the entire radiation science community, they assert that “*we just don't know*” whether low-dose radiation results in a net harm or benefit. Some even deny the *possibility* of obtaining evidence for

hormesis, claiming the same signal-to-noise problem that they admit obscures evidence for LNT in the low-dose range.<sup>10,11</sup> Thus, they permit themselves to ignore, and deny the existence of, the mountainous evidence for hormesis that does not, in fact, suffer from this statistical problem.

### The Deceptive Use of Transparency as a Surrogate for Fairness

In the face of widespread opposition to the practice of cherry picking and the growing condemnation of ignorance or neglect of an entire oppositional literature, some LNT proponents have sufficient confidence in the exculpatory *appearance* of fairness that they actually cite and acknowledge studies containing evidence against LNT. Yet, incredibly, in plain sight and without even a feint in the direction of refutation, they still conclude in favor of their preconceived mythology. In a stunning example of the latter, Dr David Brenner, a well-known and leading proponent of LNT, and others performed a study almost 10 years after that by Löbrich et al.,<sup>9</sup> in which they reported conclusions with respect to DSB induction in only 3 young children at 1 hour after undergoing CT examinations.<sup>12</sup> The stated objective of their study was to test whether CT examinations can *induce* DSBs, without any concern for the subsequent *repair* and/or *removal* of those DSBs induced, though they didn't refrain from implying that the damage was indeed permanent, which, in turn, required their complete neglect of the evidence for repair and/or removal.

Even acknowledging that Löbrich et al.<sup>9</sup> showed that repair or removal of initial damage occurs within 24 hours, they focused only on data obtained 1 hour after CT. The Brenner group even stated that the Löbrich results suggest that they “could have detected more foci in our samples had the blood been drawn 30 min post-CT,” and boldly called this failure to examine *earlier*, rather than later, results “a key limitation in our study” – missing completely the fact that more abundant foci at earlier times meant less abundant foci at later times. This oversight absolved the authors from having to consider that the number of foci is, in fact, not permanent but instead diminishes with time, and why this is true. Defying the credulity of any reader paying attention, they asserted in their conclusion that their findings in 3 children at only 1 early time point, when observable damage was indisputably expected, *supported LNT* and that even the low radiation of CT scans “can leave a mark in the somatic DNA,” unwarrantedly claiming *permanency* that would lead to subsequent cancer.<sup>12</sup> Based on this wholly unjustified and unjustifiable conclusion, they unconscionably recommended in their final sentence that “Unnecessary radiation-producing procedures should be eliminated when possible and, if appropriate, non-ionizing techniques such as US or MRI should be used.” Although the qualifiers “when possible” and “if appropriate” appear benign, the unmistakable message was that *CT scans are hazardous to your health*.

Brenner and his coauthors either suffer from a collective delusional state or they rely on the psychological phenomenon that drives people to rationalize their passive credulous

acceptance of such obvious inconsistency, thinking that, if it were as inconsistent as it appears, the authors could not possibly believe they would get away with it. Thus, readers may conclude that they themselves must have missed something and return instead to their own seemingly more important work.

As a side note, it is of further interest that even Löbrich et al<sup>9</sup> failed to point out that their data showed not only a return by 24 hours to pre-CT baseline concentrations of DSBs but also an apparent descent to *below* the pre-CT levels in all but 1 of their patients. This suggests that the exposure protects against even some of the endogenous and other damage and, if so, that hormesis is at work. One should always read with a critical eye even studies that happen to confirm one's hard-earned beliefs.

## Conclusion

Despite the preponderance of contrary evidence, the LNT myth has enjoyed extreme durability, in part for the reasons enumerated in this article. LNT-based a priori predictions of cancer risk are made with impunity but have never been validated by a posteriori observations. Instead such predictions are often justified with the excuse that possible exaggeration of harm at least errs on the side of caution. Fukushima was a game changer, invalidating that proffered justification once and for all. LNT-based public policy forced residents to evacuate and stay away, rather than shelter in place or return home in a timely fashion. More than 1600 people, according to the Japanese government, have died due to causes related to the unnecessary and prolonged evacuation, while it is likely that no one would have died as a result of the relatively low levels of radiation exposure. Unfortunately, there is no threshold for fear, but there *is* a threshold for radiation, a fact missing from the one-sided discussions concerning risk communication. Radiophobia, not low-dose radiation, is harmful, even deadly.

These are problems crying out for solution, but the first step is to acknowledge that the only secure pathway is through properly valorizing scientific evidence over the mutually reinforcing and self-serving concerns for career security, reputations, and funding opportunities, and accordingly being willing to change one's own mind – perhaps publicly admitting to such reconsideration, if appropriate – and to censure those who refuse to do so.

## Authors' Note

Lest anyone focus negatively on our forceful tone in this article, we assert that objectivity without passion, in the face of overwhelming and long-standing, concerted and organized anti-scientific opposition, only lends the *illusion* of objectivity while falling shy of its attainment.

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