**The LNT Model Is Wrong and Is Not Useful For Radiation Protection**

Jeffry A. Siegel, MS, MS, PhD, Charles W. Pennington, MS, MBA,

Bennett S. Greenspan, MD, MS

*In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual.*

– Galileo Galilei, 1632

We read with much interest the recent article, “Epidemiological Support of the Linear Nonthreshold Model in Radiological Protection: Implications of the National Council on Radiation Protection and Measurements Commentary 27 for the Radiologist” by Applegate, Shore and Dauer (1). This is an opinion piece in support of the LNT model and NCRP Commentary 27 (2), ignoring the data and science that refutes just about everything the authors claim. It is important to point out that the second and third authors were members of the scientific committee that authored NCRP Commentary 27, yet they did not so disclose. On the contrary, the authors stated “they have no conflict of interest related to the material discussed” in their article, rendering this “opinion” piece at the very least misleading and of questionable utility.

This article begins with the highlighted quote by George Box, "All models are wrong, but some are useful," foreshadowing the authors’ mindset and the article’s conclusion. At first glance, and after critical reading, the authors seem unaware or dismissive of all the scientific references refuting the LNT model (3-7) and also references refuting the conclusions of the NCRP commentary (8-11) supporting reliance on the LNT model for radiation protection purposes. These references, based on critical reviews of recent epidemiologic studies of populations exposed to radiation in the low dose and low dose-rate range, demonstrate that the LNT model is false, and even though Applegate et al. failed to acknowledge the existence of these works, these publications have never been refuted. This should come as no surprise since, as noted above, 2 of the 3 authors are responsible for NCRP 27.

Interestingly, the authors assert that many scientific bodies, including the NCRP (which include 2 of the authors), recognize that radiation delivered at low exposures or lower dose rates is likely less effective at producing biological outcomes by about a factor of 1.5 to 2 and, therefore, acknowledge that a dose and dose-rate effectiveness factor (DDREF) is probably appropriate. But all these advocates fail to recognize that the application of the DDREF negates the LNT model, i.e., the raison d’être of DDREF is to significantly adjust downward LNT’s putative and disproven low-dose risk. The authors claim that a threshold model for solid cancers is not supported, yet their acceptance of the appropriateness of the DDREF contradicts this claim. Indeed, the DDREF thoroughly corrupts the LNT model and converts it into a weak form of a linear threshold (LT) model.

The authors clearly ignore proven adaptive response science. Actual low-dose risk is less than that derived from linear extrapolation of high-dose effects because the body reacts differently to high and low doses and dose rates, as the data have demonstrated (4,5,7,10). Damage that may occur after exposure to low-dose radiation may happen in a linear fashion, but the net dose-response in the low-dose range (0 to 100 mSv) is not linear because the body’s response to mitigate or eliminate this damage is nonlinear. The DDREF derivation depends on low-dose linearity, but such positive-slope linearity does not exist, thereby rendering the DDREF scientifically meaningless (3,11). Linearity has only been demonstrated at doses well above 100 mSv, not in the low-dose range down to zero dose, and the absence of a threshold – the "NT" in LNT – has only been assumed, never demonstrated.

The article concludes that the LNT model is not proved or disproved, but it is a pragmatic and prudent basis for radiation protection. The authors acknowledge that the NCRP, like other international bodies, concludes that the cancer risk below 100 mGy is uncertain but small. This assertion defies logical credulity since the authors admit that while the risk at small doses is uncertain, it is nevertheless expected (albeit small). Illogically, no consideration is given to equally likely possibilities that the risk is non-existent or even negative (i.e., beneficial). The LNT model does not allow for either of these two other outcomes – the slope of the dose-response relationship in the low-dose region is forced to be everywhere positive. Negative risk is, by definition, thereby excluded. But as we have previously shown, the data actually indicate this slope is indeed either 0 or negative (4,11).

The LNT model is wrong, but it is nevertheless considered to be useful for radiation protection. But is it? Radiation protection involves the *management* of risks from low-dose radiation exposure. To properly manage this risk, the complete spectrum of possible health outcomes must be acknowledged, including the potential for beneficial effects and dose-and-dose-rate thresholds, below which the biological effect cannot exist. Use of the LNT model effectively excludes these considerations in policy and rulemaking and, therefore, in addition to being wrong, cannot be considered to be useful for radiation protection, or anything else for that matter. As we previously reported (10), the NCRP’s assessment that the updated analysis of the Japanese Life Span Study data provided strong support for the LNT model for radiation protection (2) was contradicted by this study’s major conclusion (12):

“At this time, uncertainties in the shape of the dose response preclude definitive conclusions to confidently guide radiation protection policies.”

The article by Applegate et al. is not simply a "me, too" piece, rather it’s a “me, me” piece, stating agreement with the organizational oligarchy of gatekeepers (and themselves) for radiation risk reasoning. They ignore contrary findings and modern science, supporting each other to rigorously enforce the status quo by adopting the ostrich fright pose. However, the LNT model is wrong and is neither pragmatic nor prudent, so we need to think outside the “Box,” *The LNT model is wrong, and is not useful for radiation protection*. It is way past time for the reinforcing and singular LNT-based mantra of the various scientific bodies (13) to be challenged and ultimately silenced.

REFERENCES

1. Applegate KE, Shore RE, Dauer LT. Epidemiological support of the linear nonthreshold model in radiological protection: implications of the national council on radiation protection and measurements commentary 27 for the radiologist *JACR*. 2020; in press.

2. NCRP, 2018. *Implications of Recent Epidemiologic Studies for the Linear Nonthreshold Model and Radiation Protection, Commentary No. 27* (Bethesda, MD: National Council on RadiationProtection and Measurements).

3. Siegel JA, Sacks B, Stabin MG. LNT 999. *Health Phys News*. 2015;XLIII:23-24.

4. 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.

5. 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.

6. Siegel JA, Pennington CW, Sacks B. Subjecting radiological imaging to the linear no-threshold hypothesis: a non sequitur of non-trivial proportion. *J Nucl* *Med*. 2017;58:1–6.

7. Siegel JA, Greenspan BS, Maurer AH, et al. The BEIR VII estimates of low-dose radiation health risks are based on faulty assumptions and data analyses: a call for reassessment. *J Nucl Med*. 2018;59(7):1017-1019.

8. Siegel JA, Sacks B, Pennington CW, Welsh JS. Dose optimization to minimize radiation risk for children undergoing CT and nuclear medicine imaging is misguided and detrimental. *J Nucl Med*. 2017;58(6):865-868.

9. Ulsh BA. A critical evaluation of the NCRP COMMENTARY 27 endorsement of the linear no-threshold model of radiation effects. *Environ Res*. 2018;167:472–487.

10. Siegel JA, Brooks AL, Fisher DR, et al. A critical assessment of the linear no-threshold hypothesis: its validity and applicability for use in risk assessment and radiation protection. *Clin Nucl Med*. 2019;44(7):521-525.

11. Pennington CW, Siegel JA. The linear no-threshold model of low-dose radiogenic cancer: a failed fiction. *Dose-Response*. January-March 2019;1-10 (doi: 10.1177/1559325818824200).

12. Grant EJ, Brenner A, Sugiyama H, et al. Solid cancer incidence among the Life Span Study of atomic bomb survivors:1958-2009. *Radiat Res*. 2017;187:513-537.

13. Sacks B, Siegel JA. Preserving the anti-scientific linear no-threshold myth: authority, agnosticism, transparency, and the standard of care. *Dose-Response*. 2017;15(3):1-4.

**Jeffry A. Siegel, PhD**

President & CEO

Nuclear Physics Enterprises

Orlando, FL

E-mail: [nukephysics@comcast.net](about:blank)

**Charles W. Pennington, MS, MBA**

NAC International (retired)

Norcross, GA

E-mail: [cwpenn@comcast.net](about:blank)

**Bennett S. Greenspan, MD, MS**

150 River Club Lane

North Augusta, SC

E-mail: [bengreenspan0708@gmail.com](about:blank)