

Ethics of Adoption and Use of the Linear No-Threshold Model

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Abstract

The linear no-threshold (LNT) model of ionizing radiation-induced cancer assumes that every increment of radiation dose, no matter how small, constitutes an increased cancer risk for humans. Linear no-threshold is presently the most widely applied model for radiation risk assessment. As such, it imposes very heavy burden on the society in both economic and human terms. This model, which was adopted in late 1950s in the wake of massive government investments in science, is controversial and raises important ethical issues. This article identifies 2 issues often missed: scientists usurping the role of policy makers and seeking funding and power. These issues should be considered together with the scientific controversy raging over the validity of the LNT model and the multiple other ethical issues regarding its ongoing use.

Keywords

professional ethics, conflict of interests, ionizing radiation, LNT dose-response model, nuclear safety, health and environmental protection regulations

Introduction

Every scientist is human and therefore cannot be an interest-free intellectual machine; even a remote potential conflict of interests should be declared. Research conclusions benefiting the funding agency, for example, are subject to increased scrutiny because of probable bias which may well be unintentional. Discussion of bias due to conflicts of interests can be traced to the Pentateuch (Exodus 23:8, Deuteronomy 16:19).

Just as scientists are humans and cannot be ideal interest-free intellectual machines, government officials are also humans and cannot be ideal interest-free decision-making machines always seeking for public welfare—even on account of their own personal interests. This fact is stressed by another obvious observation that, while personal interests are usually more or less clear to the person, “public welfare” is rarely obvious and is usually a subject of hot debate. Most humans (including government officials) want to have stable salaries and many are interested in career promotion—so they are interested in widening their authority and in increasing their department’s budget. In the economical literature, this is called the Niskanen model.¹ These interests can lead to bias in research results and even yield consensus that does not coincide with the truth (the analysis of the above processes will be reported separately). Below we consider ethical issues with the linear no-threshold (LNT) model of radiation carcinogenesis, which is likely a result of such bias.

The LNT Model, Its Controversy, and Ethical Issues Regarding Its Use

The LNT model of ionizing radiation-induced cancer assumes that every radiation dose increment, no matter how small, constitutes an increased cancer risk of humans. The risk is hypothesized to increase linearly as the total accumulated radiation dose increases. Linear no-threshold is presently the most widely applied model for radiation risk assessment; its use is recommended by such advisory bodies as the US National Academies of Sciences,² International Commission on Radiological Protection,³ and International Atomic Energy Agency.⁴ Linear no-threshold has become a dogma in many radioprotection circles⁵ and—in spite of increasing criticism⁵⁻⁸—is still probably the sole model used by official bodies.⁹ As such, LNT is the basis for nuclear and radiation regulation. There are even claims for a scientific consensus

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with respect to the LNT.³ However, in 2018 the US Environmental Protection Agency began discussing moving away from LNT.⁸

Continuous use of LNT raises many ethical issues, including but not limited to the following:

- The present LNT-based regulations impose excessive costs to the society, effectively leading to loss, rather than saving, of life.
- Linear no-threshold-inspired fear of low-dose radiation adversely affects use of medical imaging.
- Policy based on LNT significantly dissuades the study of low-dose radiation therapies in medicine, including cancer and Alzheimer disease.
- Radiophobia contributes to motivating radiological terrorism and promoting nuclear proliferation.

These issues have been reported earlier.¹⁰ Here, we consider additional ethical issues regarding the LNT adoption.

Additional Ethical Issues Regarding LNT Adoption

Fear of Nuclear War: From Plato to Muller and Beyond

The LNT origin should be traced to 1927, when radiation-induced mutations were discovered (in the study by Muller 1927).¹¹ Many geneticists believed then that no mechanism for gene repair existed and, therefore, that mutagenic damage was cumulative and proportional to the radiation dose just like the total number of ionized atoms.⁶ After the atomic bombing of Japan and the start of the nuclear arms race, many scientists became concerned about the very survival of the civilization. Actually, before the first atomic bomb was dropped and even tested, an official report suggested that “civilization would have the means to commit suicide at will.”^{12(p224)} Probably at least partly because of these concerns, Muller was awarded the Nobel Prize in 1946 for his discovery. In his Nobel Prize lecture, he stated that the dose–response for radiation-induced damage was undoubtedly linear with no threshold dose—while already aware of evidence against LNT. This statement, as well many other actions of Muller, raise serious ethical questions—see the article of Calabrese and references thereof.¹³

During the following decade, there was great controversy regarding LNT. The scientific debate has been summarized by Calabrese that among scientists “the data to support the linearity at low dose perspective was generally viewed as lacking but the fear that it may be true was a motivating factor.”^{6(p214)}

Taking into account the risks of nuclear warfare, one can emotionally support the scientists’ promotion of the LNT model (in spite of lacking scientific evidence) in the altruistic hope to stop the nuclear arms race. However, promoting scientific theory on political grounds (even altruistic) should be ethically questioned since by doing so scientists essentially usurp the role of policy makers. In a democratic society, the scientific community, which is professional and self-elected, must provide politicians and other policy makers with accurate

scientific information. It is the task of democratically elected representatives and duly-appointed government officials to translate the accurate scientific information, including the level of maturity of each theory or concept, into policy.¹⁴

It should be mentioned in this context that the idea of scientists ruling the society is not new. Already Plato wrote about “philosopher kings,” followed by Thomas More, J. J. Rousseau, and, more recently, by Karl Marx and some of his followers—see the review of Pei¹⁵ and references thereof. Discussion of the above idea, contradicting the accepted democratic norms, is beyond the scope of this article.

Economical Incentives

However, we would like to point out an additional kind of reasoning to promote LNT, which is less altruistic: getting funds and getting power—that is, participation in decision-making.

From the beginning of the 20th century, our society relies more and more on ionizing radiation. X-ray diagnostics and nuclear medicine, nuclear power, radiation therapy, and (later) security screening are an important part of our lives. If there is some threshold (tolerance) dose, then below-threshold-dose applications (eg, medical imaging) do not demand public control. However, if LNT is true or may be true, every ionizing radiation application is hazardous and much more resources should be spent on the study of radiation side effects. In addition, since there is no safe radiation dose—scientists should be actively involved in any policy decision related to radiation. And the area of issues related to radiation is wide namely energy (not necessarily nuclear), medical diagnostics, security (X-ray screening), and more.

Another economic reason is that LNT optimally meets government officials’ demands. First, it is useful for extending public spending as just mentioned above. Second, the model is extremely simple (and soon became rather famous) and therefore provides officials with simple and defensible basis for decision-making. So, according to the abovementioned Niskanen model, there is no wonder that LNT was promptly adopted by official bodies and that studies promoting LNT were better accepted by governmental funding agencies.

It is impossible to estimate quantitatively to what extent the actual reasons for LNT adoption by the radiation-research scientific community were altruistic (stopping the nuclear arms race) and to what extent—economic. There is a hint, however, in the timing of the LNT adoption. After the launch of the Soviet “Sputnik” in October 1957, the West became really troubled with assumed Soviet technology leadership. As a result, governmental funding of science was rapidly expanded, for example, the U.S. National Scientific Foundation appropriation was more than doubled in financial year 1958.¹⁶ In September 1958 (about a year after “Sputnik”) the International Commission on Radiological Protection officially adopted LNT.⁶ Is such timing a mere coincidence?

Linear no-threshold was adopted not in the wake of fresh postwar fears of nuclear apocalypses, but rather in the wake of

massive governmental investment in science in the United States and later in Europe. We suggest that this timing was not accidental and that in the process of LNT adoption the economic incentives (funding and power) were at least as important as the altruistic (stopping the nuclear arms race). The ethics of the LNT adoption should be anyway questioned.

Conclusions

Adoption of the linear no-threshold (LNT) model of radiation carcinogenesis, generally in late 1950s in the wake of massive governmental investment in science, is controversial and raises important ethical issues. These issues should be taken into account together with scientific controversy over LNT and multiple ethical issues regarding its continuous use.

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