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Overt Scientific Bias and Clandestine Acts by Trusted Scientists: The Flawed Application of the Linear No-threshold Model

John J. Cardarelli, II[1]

Abstract—**The Health Physics Society (HPS) released a video documentary on the history of the linear no-threshold (LNT) model in April 2022. It exposed many scientific and ethical failings of many leaders, influential scientists, and organizations that have resulted in the current system of radiological protection. Since then, the society received many comments; most were supportive, while a few criticized the video documentary as delivering an anti-LNT message. Shortly thereafter, many emails discovered via an independent Freedom of Information Act request revealed multiple layers of coordination between prominent people in the field of radiation protection to coopt the leadership within the HPS and suppress information they perceived or assumed to be contrary to a pro-LNT message. Many of these emails were published by JunkScience.com, an independent organization that exposes faulty scientific data and analyses used to advance special interests and hidden agendas. This Forum article is intended to document in the peer-reviewed literature the JunkScience.com findings of clandestine acts by trusted scientists within the radiation protection community. The emails exposed strong personal biases, actions taken by leaders within the National Commission on Radiation Protection and Measurements (NCRP) to "save the Society" from its "downward spiral," and actions taken by NCRP and HPS members serving on a National Academies of Sciences committee to suppress scientific information relevant to the debate about health effects in low-dose environments. These anti-science actions harm our entire profession and the trust that Congress bestows on our scientific organizations expecting to receive objective recommendations based on sound science. It is important that these events are recorded in the scientific literature from a historical perspective. The radiation protection community will be judged not by what is revealed in this article but by what actions are taken from here.**

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Key words: analysis, risk; ethics; linear hypothesis; public information

INTRODUCTION

NOTE TO READERS: For ease of reading, links to supplementary material are shown throughout as "Supplementary Digital Content"; to access the material, simply click on the link. Footnotes are listed in numerical order in the Acknowledgments section.

The International Commission on Radiological Protection (ICRP) is reviewing the entire system of radiation protection to ensure the current recommendations remain fit for purpose (Clement et al. 2021). Therefore, it is necessary to know the evolution of the radiation protection philosophy and the science that supports it. As the scientific community discovers new information and gains a deeper understanding of radiation exposures and associated health effects, especially in low-dose environments, it should adapt and evolve accordingly. In April 2022, the HPS released a series of videos (https://hps.org/hpspublications/historylnt/episodeguide.html) documenting the history of the linear no-threshold (LNT) model applied to risk assessment (Cardarelli et al. 2023). The release of the HPS History of the LNT Model documentary contributes to a better understanding of its history (it exposed a dark history based on highly questionable, if not intentionally inaccurate, scientific decisions). **Since it has been released, no significant information has been presented by critics that counters the documentation supporting that message.**

Robley Evans, 1972–1973 President of the Health Physics Society, wrote: "The linear nonthreshold model was specifically chosen on a basis of **mathematical simplicity** and **prudence** to represent the **upper limit** of risk in the low-dose domain, for somatic radiobiological effect which had been observed only in a higher dose domain. **The linear nonthreshold model was not based on radiobiological data for somatic effects in the low-dose domain**" (Evans and Shanahan 1972).

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Forum

Editor's Note: Dr. Brant Ulsh serves as the Editor-in-Chief of Health Physics. He has published several papers and presentations on the topic of the linear no-threshold (LNT) regulatory model. He has also co-authored several papers, one with Dr. Cardarelli, that are cited in the current paper. Because of his publication history regarding LNT, Dr. Ulsh has for the past several years recused himself from any papers on LNT submitted to *Health Physics* and asked me to supervise those submissions, which I have done. I served as the editor of the current paper, which went through the normal process of review and revision (revisions were multiple in this case). Dr. Ulsh has not seen the paper nor had any input into it. The publication is the product of the author and is his response to myriad review comments.

Craig A. Little
Editor-in-chief
Operational Radiation Safety

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The abandonment of the threshold model for the purposes of radiation protection began in the late 1940s. Andrew McLean, Director of the Health and Safety Branch of the United Kingdom in the early 1960s, prophesied that reliance on the LNT model would become "...the new testament of radiological priestcraft, the comfortable and insidious worship of the straight line. After a while the mathematics becomes more important than the biology; the dogma more important than those in whose service it has been enunciated" (McLean 1963).

These statements stand true today, and this "worship of the straight line" has ultimately caused unwarranted crippling fear of low-level radiation exposures (Brooks et al. 2023).

Three months after the release of the HPS documentary, Edward Calabrese, PhD,[2] received about 1,200 pages from an activist who conducted a Freedom of Information Act (FOIA)[3] request on Armin Ansari, PhD, CHP, a Past-President of the Health Physics Society (2012–2013) and 2024 President of the American Academy of Health Physics (AAHP). [Supplemental Digital Content 01, **http://links.lww.com/HP/A288**] The subject of the request focused on Centers for Disease Control and Prevention (CDC) guidance associated with health effects from non-ionizing radiation exposure, but the document contained email correspondence relevant to the HPS and the LNT video series. The contents motivated the requester to share it with Calabrese unsolicited. To be clear, the requester and Calabrese had no previous professional or personal connections.

After receiving this information, Calabrese submitted FOIA requests on several members of the 2022–2023 HPS Board of Directors and elected leadership that were subject to FOIA regulations (e.g., public institutions), myself included. I asked him why, and he explained that he was curious to understand the interactions between the HPS Board after he realized that some had been involved in exchanges with prominent, influential, and trusted scientists in the radiation protection field who were not pleased with the LNT video series. His action was consistent with his research methods as presented in Episode 4 of the documentary, where he explained why he purchased personal letters of several key players on the first Biological Effects of Atomic Radiation (BEAR) Committee. He wanted to better understand their motives and relationships that resulted in recommending the LNT model for cancer risk assessment.

The information in the FOIA emails revealed a covert and coordinated campaign by leaders in the National Council on Radiation Protection and Measurements (NCRP), namely John Boice, PhD, and other NCRP or HPS members, Ansari and Larry Dauer, PhD, CHP, to "save the Society" by electing HPS members with views consistent with a pro-LNT bias to leadership positions in the HPS. Many of these emails are digitally available as a supplement to this article and were published in the JunkScience article (Milloy 2022). Nothing prevents those actions, but it leads to group-think, not diversity of thought, and thwarts scientific progress. JunkScience exposed many other prominent figures in the radiation protection field who took action to protect the continued use of the LNT model for radiation protection purposes by suppressing relevant scientific information that contradicts it. Their personal actions and decisions impact national policies and the future direction of radiation protection. Individuals in such positions should be held to a higher standard of transparency and welcome diverse scientific opinions and debate.

This commentary is intended to document in peer-reviewed literature the JunkScience.com findings of clandestine acts by trusted scientists in the radiation protection community. Documenting these actions also is consistent with the position of the International Commission on Radiological Protection (ICRP) on the ethical foundations of radiation protection (ICRP 2018).

ETHICAL EXPECTATIONS OF SCIENTISTS

It is an accepted notion that scientists have a moral responsibility to benefit society as a whole (Elliott 2006). Society generally bestows authority and respect to scientists, so there should be a reciprocal responsibility expected from scientists. A way they achieve this is by providing unbiased, objective information to promote the public good and taking steps to prevent potential harms. Examples include maintaining transparency on all aspects of policy development and educating the public on the science behind the regulations or policies meant to protect them. These actions build trust and credibility so that the scientifically based message is more likely to be accepted by a skeptical public. Trust is one of the hardest things to earn and one of the easiest things to lose. Transparency and objective assessment act to maintain trust in times of doubt. Solberg argues that empowerment is better than any other value and can serve as the ethical foundation for enabling people to increase control over their decisions (Solberg 2021). Therefore, the radiation protection community has a moral obligation to provide truthful information to the public so they can make their own decisions regarding personal or political decisions affecting their well-being.

I believe the scientific community should disseminate information in such a way that members of society with diverse beliefs and values can use it to make and support decisions that accord with their own perspectives. It demands that scientists render their scientific conclusions and supporting evidence apart from their value judgments, so that each component and their justifications are separable and distinct in order to clarify the issues for the public. In other words, scientists have an ethical responsibility to provide information in a way that enables people to make their own decisions. When they make a decision, it should be based on unbiased and truthful information including all uncertainties (Wieder et al. 2022). Hence, it would be unethical to hinder the sharing of

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information that helps the public to make an autonomous decision based on a basic understanding of the scientific information shared with them.

The following sections provide a summary of the actions taken by trusted scientists serving in leadership or influential positions that impact the radiation protection community. A fair question to ask is this: Is all the knowledge we've learned regarding potential health effects (detrimental, nondetectable, or beneficial) associated with low-level exposures to radiation being included in the scientific exchange?

NCRP EFFORTS TO "MOVE THE NEEDLE"

Within days of the announcement of my election as the next President of the HPS in January 2020, Boice, the Past-President (2012–2018) and Director of Science (2019 to present; 2024) for the NCRP, sent an email to Ansari, the 2024 AAHP President, making him aware of the election results [Supplemental Digital Content 02, **http://links.lww.com/HP/A289**].[4] This announcement prompted a series of activities. For example, Boice and others held a meeting to discuss HPS issues where they expressed concern about the "downward spiral"[5] [Supplemental Digital Content 03, **http://links.lww.com/HP/A290**] of the HPS and initiated a campaign that was referred to as "moving the needle" defined as "incremental steps for a healthy Health Physics Society & renew the past excellence."[6] [Supplemental Digital Content 04, **http://links.lww.com/HP/A291**] During that meeting, several NCRP and HPS members discussed (1) HPS position statements (specifically the HPS Radiation Risk in Perspective), (2) potential future nominees to run for HPS President or Board of Director (BOD) positions, (3) concerns on how to "save the Society," and (4) names of HPS members with gravitas, name recognition, and institutional credentials who might support NCRP efforts to "move the needle." These types of conversations are not unexpected and reflect diverse views within a healthy scientific community as a whole. It also demonstrates group-think within a specific group of leaders in the NCRP. One of those members, Dauer, served on the HPS nominating committee at the time [Supplemental Digital Content 05, **http://links.lww.com/HP/A292**] [7] and helped NCRP in these clandestine efforts by supporting NCRP-endorsed nominees to be placed on the HPS 2020 Ballot. Ansari responds, "It feels good to be on the offensive for a change"[8] [Supplemental Digital Content 06, **http://links.lww.com/HP/A293**] while Boice opines [Supplemental Digital Content 07, **http://links.lww.com/HP/A294**], "I think you moved the needle at least 3 clicks!"[9] By June 2020, Dauer confidentially[10,11,12] [Supplemental Digital Content 08, **http://links.lww.com/HP/A295**, 09, **http://links.lww.com/HP/A296**, 10, **http://links.lww.com/HP/A297**] shares the 2020 HPS final ballot with Boice and Ansari stating, "Of course, all unofficial at this point…but we already are over the first hurdle. Now folks will need to vote for them!!"[13] [Supplemental Digital Content 11, **http://links.lww.com/HP/A298**]. Two HPS members on their list, supported by the "move the needle" effort, were successfully voted in as HPS Board members later that year. Let me be clear. There is no animus towards these individuals. They were duly elected by the HPS membership, of which less than 25% typically vote. It's how the process works. As pointed out by Kendall and Carey, a low turn-out historically benefits a motivated group (Kendall and Carey 1968). It's also worth noting that one of them, Mike Boyd, MSPH, worked for the US Environmental Protection Agency (US EPA), which has a policy that "literally applies" the LNT model for radiation protection purposes. The other worked for the Centers for Disease Control and Prevention (CDC) in the same office as Ansari, who recently left CDC to take Boyd's position at US EPA after his retirement. For clarity, there is no rule in the HPS by-laws preventing Nominating Committee members from sharing the ballot before it is released, but there is certainly an expectation of confidentiality in the deliberations of the HPS Nominating Committee. Boice, Dauer, and Ansari continued NCRP meetings through 2021 seeking candidates that represented their pro-LNT views to serve in HPS leadership positions, which involved sharing ballot information from HPS Nominating Committee members.[14,15,16] [Supplemental Digital Content 12, **http://links.lww.com/HP/A299**, 13, **http://links.lww.com/HP/A300**, 14, **http://links.lww.com/HP/A301**] Boice later shares his opinion with the 2022 HPS Secretary, Nicole Martinez, PhD, CHP, that the HPS turned to the "dark side" 4 y earlier with "non-scientific zealots" and his efforts to counter the HPS position statements he claims received non-scientific reviews with help from Ansari, Boyd, and others through AAHP and elections [Supplemental Digital Content 15, **http://links.lww.com/HP/A302**].[17]

HPS RELEASES THE HISTORY OF THE LNT DOCUMENTARY TRIGGERING A FLURRY OF NCRP ACTIONS

On 14 April 2022, the HPS released a 22-video series on the history of the LNT (Cardarelli et al. 2023). The HPS received numerous emails expressing strong support for this effort. It's been viewed by more than 20,000 unique IP addresses, in more than 700 cities and more than 70 countries world-wide. Around the time the documentary was released, a flurry of activities started within the NCRP. Boice, who served as the NCRP President for 7 y (2012–2018) and is its current Director of Science wrote: "Despite my best efforts, after stepping down from President I was unable to prevent NCRP contamination with anti-LNTers."[18] [Supplemental Digital Content 16, **http://links.lww.com/HP/A303**].

This statement conveys animus toward anyone holding a different view on the scientific validity of LNT for

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radiological protection purposes. It raises a series of questions: Did his long-term leadership create a culture at NCRP in which only pro-LNT views were welcomed? Were any nominees excluded from NCRP membership over the past 10 y because of his bias or influence? We may never know the answers.

To be clear, the LNT video series does not explicitly address the suitability (or not) of the LNT model for use in radiation protection but rather explores how the US came to adopt the LNT model for cancer risk assessment. It is not an anti-LNT message. However, some members of NCRP and HPS leadership erroneously label it as such and express their disdain for the messenger, Calabrese. They characterize him as "extreme," [18] [Supplemental Digital Content 16, **http://links.lww.com/HP/A303**], a "joke",[19] [Supplemental Digital Content 17, **http://links.lww.com/HP/A304**] a "cultic character",[20] [Supplemental Digital Content 18, **http://links.lww.com/HP/A305**], a "corporate hack"[21] [Supplemental Digital Content 19, **http://links.lww.com/HP/A306**] who spreads "conspiracy theories"[21] [Supplemental Digital Content 20, **http://links.lww.com/HP/A307**] and their response has generally been to ignore his work—a tactic which will be discussed later. Boice stated, "The inmates are in charge of the asylum" [Supplemental Digital Content 17, **http://links.lww.com/HP/A304**] and suspected many will quit the society.[19] For the record, at the end of my term as HPS President in July 2023, the Society ended years of membership attrition and actually increased its membership.

The HPS documentary drew international attention from prominent leaders in the field of radiation risk assessment. Richard Wakeford, PhD, expressed pleasure that NCRP was taking the HPS documentary seriously, "...because when HPS starts promulgating Calabrese's views (10 hours worth of videos!) it becomes necessary."[23] [Supplemental Digital Content 21, **http://links.lww.com/HP/A308**] As a result, the Chair of NCRP PAC 1: Basic Criteria, Epidemiology, Radiobiology, and Risk, Gayle Woloschak, PhD, called for a meeting to specifically discuss a recent publication by Calabrese and the HPS video documentary.[24] [Supplemental Digital Content 22, **http://links.lww.com/HP/A309**] A newly elected 2023 HPS Director and NCRP member, Derek Jokisch, PhD, CHP, "...couldn't make it through a single one in their entirety" yet labeled them as "low quality junk."[25] [Supplemental Digital Content 23, **http://links.lww.com/HP/A310**] The 2022 HPS Secretary and newly-elected NCRP member, Nicole Martinez, PhD, CHP, [Supplemental Digital Content 24, **http://links.lww.com/HP/A311**] stated, "I can't even make myself sit through a video."[26]

It's clear that individuals in leadership positions within NCRP took interest in the HPS documentary and acted to "move the needle" in a direction that aligns with their personal views on LNT as described in NCRP Commentary 27 (NCRP 2018a). It's worth noting that the AAHP provided a critical review of a draft of Commentary 27. In this review, 117 comments were submitted to the NCRP, of which 108 were apparently disregarded even though AAHP requested a written disposition of these comments (Ulsh 2018). It is also worth noting that NCRP Commentaries differ from NCRP Reports in that they are generally produced quickly in response to policy questions (Saenger 2000). As a result, they lack the intensive scholarship that marks each report. Approval is achieved by a margin of at least 11 of 13 board members, even though they are subject to review by the full Council (100 members). This subtlety can cause them to be confused with official NCRP Reports.

Boice lists his concerns for the HPS in a letter to the 2022 HPS Secretary, Martinez.[19] (see Supplemental Digital Content 17, **http://links.lww.com/HP/A304**). He states the corruption of HPS started or was accelerated in 2017 when Brant Ulsh, PhD, CHP was chosen as Editor-in-Chief of the Health Physics Journal. Following Ulsh's 2017 Plenary talk on LNT, he expressed outrage and considered resigning from the Society. Instead, Boice led an effort to "turn things around"[19] (see Supplemental Digital Content 17, **http://links.lww.com/HP/A304**) by working with the AAHP to counter "false science with good scientific sessions."[19] (see Supplemental Digital Content 17, **http://links.lww.com/HP/A304**) For example, during the 2018 HPS annual meeting in Cleveland, OH, he participated in the AAHP special session in which Calabrese was initially invited to be a speaker and then disinvited by the 2018 AAHP President, Kyle Kleinhans, CHP.[27] [Supplemental Digital Content 25, **http://links.lww.com/HP/A264**] He reassured Calabrese the disinvitation was neither personal nor political and stated to another AAHP member who questioned the decision that he decided to change the focus of his special session and Calabrese didn't fit with the new focus.[28] [Supplemental Digital Content 26, **http://links.lww.com/HP/A265**] Later, Kleinhans co-authored a publication summarizing the session stating that it "was structured to describe the current state of science, from molecular biology to human epidemiology, as well as to explain how that science is translated to radiation protection policy and regulations for low levels of radiation" (Ansari et al. 2019). This focus is very consistent with Calabrese's publications. That 2018 AAHP Special Session was led by Kleinhans and Ansari with Boice filling the Calabrese speaker slot. Calabrese mentioned this history during his 2022 Morgan Lecture as a Plenary speaker at the HPS Annual Meeting in Spokane, WA. It was clear that he felt the actions of the 2018 AAHP leadership in this matter were unprofessional, disrespectful, self-serving, and deceitful. Calabrese's lecture made for a dynamic session many will remember. After watching the HPS Documentary on the History of the LNT, Kleinhans, who disinvited Calabrese, later shared his impression of the documentary with me by stating, "I'm a bit embarrassed at my naivete expecting scientists to do the right thing and report

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all of the relevant data. I wasn't aware of the bad science and cherry-picking of data done by some of the scientist [sic] to point to their predisposed outcome. I guess I shouldn't have been too surprised to see a number of the scientist [sic]'following the money.'"[29] [Supplemental Digital Content 27, **http://links.lww.com/HP/A266**] More of this type of exchange is needed within our field.

Under Boice's leadership, from 2017 to the present, several NCRP members turned their focus on electing "balanced scientists to the HPS leadership roles" (see Supplemental Digital Content 17, **http://links.lww.com/HP/A304**) to make a difference with the help of a few HPS members.[19] He characterized HPS as extreme and NCRP and ICRP as "balanced professional organizations"[19] (see Supplemental Digital Content 17, **http://links.lww.com/HP/A304**) by providing learned commentary such as NCRP Commentary 27. I believe HPS, NCRP, and many other scientific organizations are balanced organizations. The acts of a few individuals with extreme views should not tarnish the reputations of an entire organization. However, if they hold leadership or influential positions, it can be viewed as if the whole organization subscribes to their personal views. Boice asserts that HPS has turned to the dark side of "non-scientific zealots,"[17] (see Supplemental Digital Content 15, **http://links.lww.com/HP/A302**) and he has continued a pursuit to counter the current HPS position statement on risk with support from specific 2022–2023 HPS Board members and others within AAHP leadership. It appears that his efforts have generally been successful, since nearly half of the 2022–2023 HPS Board are NCRP council members or actively serving on NCRP committees. Do these actions promote a healthy exchange of scientific discourse or lead to group think?

POTENTIAL SOLUTION TO THE LNT DEBATE EMERGES

Other correspondence shares a more balanced opinion. Graham Smith wrote: "…If you take a holistic view of the issues affecting, say, management of radioactively contaminated land, waste disposal, but also use of ionising radiation in medicine, then below about 5 mSv y^{-1} you are wasting your time looking at small risks when there are clear bigger risks to be concerned about that deserve anyone's attention first. And this is true whether you agree with applying LNT, or disagree."[30] [Supplemental Digital Content 28, **http://links.lww.com/HP/A267**].

Additionally, an HPS Board member, Boyd, quotes a paragraph by Pamela Sykes: "The pro-LNT/anti-LNT debate has led to much unnecessary division between scientists and regulators. The important question is 'Are the public and radiation workers protected using our current radiation limits?' It is very likely that the answer is 'Yes.' Can the public/workers be protected in a more efficient and sensible manner? The answer is 'Yes.' The latter question is gradually being addressed based on the graded approach to regulation of radiation. Basically, the current dose limits will not change until it is demonstrated that the regulations are no longer protective of public health and the environment. In the short term, if LNT is left out of the argument, and replaced with suggestions for sensible approaches to improve the ways to reduce financial and administrative burden based on acceptable risk using a graded approach within the current regulatory system, then there will be a clearer path forward toward more sensible regulation of ionizing radiation" (Sykes 2020).

He says "I couldn't have said it better myself!"[31] [Supplemental Digital Content 29, **http://links.lww.com/HP/A268**]

I agree with these sentiments and would like to point out they are consistent with the HPS Position Statement on Risk. I believe the root cause for much of this debate is the literal application of the LNT model by the US Environmental Protection Agency (EPA) to determine environmental cleanup values based on a policy decision that relies on a risk-based vs. dose-based philosophy. The HPS commented that the US EPA should not adopt a risk-based philosophy[32] [Supplementary Digital Content 30; **http://links.lww.com/HP/A269**] and testified to Congress that continued use of the LNT leads to public health policies that are not conservative and lead to misappropriation of public money with a net harm to public health.[33] [Supplementary Digital Content 31, **http://links.lww.com/HP/A270**], [34][Supplementary Digital Content 32, **http://links.lww.com/HP/A271**] It's the EPA's literal application of a risk-based approach relying on the LNT model that results in absurdly low cleanup values entailing enormous cleanup costs and promotes the false belief that any exposure comes with some risk. The US EPA Director of the Radiation Protection Division, Jonathan Edwards, defended this approach by stating that the application of the LNT model is a "set in stone policy."[35] [Supplementary Digital Content 33, **http://links.lww.com/HP/A272**)] This position conflicts with the EPA Scientific Integrity policy that states "Science is the backbone of the EPA's decision-making" (US EPA 2022). No science or scientific organization supports the use of the LNT model in the way it is built into the current EPA policy.

For example, the US EPA states that any exposure above 0.12 mSv y^{-1} is not protective (US EPA 2023), a statement that I believe would not be echoed by the world's radiation protection community. US EPA derived this value by using the LNT model. An upper estimate of acceptable risk of 3×10^{-4} excess cancers is divided by an excess cancer risk of 8×10^{-5} mSv^{-1} (3.75 mSv). This value is then divided by a 30-y lifetime exposure resulting in an estimated annual dose of 0.12 mSv y^{-1} above background. This is the upper limit of acceptable risk typically applied by the EPA. The default excess cancer risk value is 1 in a million excess cancers, which would result in an annual dose of 0.0004 mSv y^{-1} above background.

The views expressed above appear to agree that estimating risks at these levels is inappropriate. While the

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international community continues to endorse the LNT model for radiation protection purposes, it does not literally apply it to determine environmental cleanup levels as is done by the US EPA. There are many examples that can illustrate this, but I'll only mention one. The ^{210}Po cleanup levels following the 2006 murder of Alexander Litvinenko in London were decided by the City of Westminster via the United Kingdom (UK) Health Protection Agency (HPA) recommended cleanup level for fixed contamination of 10 Bq per square centimeter. HPA stated that this level was roughly equivalent to annual dose of 1 mSv. This is a dose-based criterion and was not derived from the LNT model. It essentially represents a threshold or tolerance dose. The UK authorities stated, "Levels of contamination below this value do not need remediation on health grounds, although it is good practice to remove contamination where this is easily achievable." In contrast, the US EPA cleanup policy requires a literal application of the LNT model resulting in a ^{210}Po cleanup value of 0.000011 Bq per square centimeter using the Preliminary Remedial Goal for Radionuclides on Surfaces (SPRG) calculator (e.g., default values for residents and ingestion model). There is at least a 900,000-fold difference between the UK and US cleanup numbers, and the only reason for it is due to an EPA policy that literally applies the LNT model and uses it in a manner that is inappropriate and is recognized as such by the international radiation protection community.

The ICRP recommends a band or dose range of 1 mSv y^{-1} to 20 mSv y^{-1} for existing exposures, taking into account the actual distribution of doses in the population and the societal, environmental, and economic factors influencing the exposure situation (Kai et al. 2020). These values were not derived by using the LNT model. If the international community were to expand the statement, "The LNT model is used for radiation protection purposes" to include a key qualifier like "The LNT model is used for radiation purposes down to an acceptable dose of 1 mSv y^{-1}," it would help to harmonize the application of the LNT model for radiation protection purposes. It would also bring clarity, simplicity, and consistency for environmental cleanup decisions, emergency response decisions, constructing less expensive nuclear power plants, improving risk communication for people fearful of medical imaging risks, and educating the population as to where the measurable risks to radiation exposure reside. A statement like this should prevent the literal application of LNT to levels where the uncertainties are too great to have any scientific validity. I believe this is a reasonable approach toward harmonizing radiation protection policies in the low dose region while accommodating those who believe the LNT model has merit.

NATIONAL ACADEMY OF SCIENCES COMMITTEE'S VIEW OF CALABRESE AND THE HPS DOCUMENTARY

In May 2021, the HPS submitted four names for consideration by the National Academies of Science (NAS) to serve as potential members of a committee titled "Leveraging Advances in Modern Science to Revitalize Low-dose Radiation Research in the United States" (NAS 2022). Not one of the HPS nominees was selected, but NAS chose two other HPS members, one of whom was also an NCRP member (Woloschak) and the other a recently elected member to the 2022–2023 HPS Board (Dewji). The NAS report was released in April 2022 and provided nine findings and two recommendations, which were summarized in an American Nuclear Society webinar titled "High Expectation for the Future of Low-dose Radiation Research" (ANS 2022; NAS 2022).

Calabrese's FOIA requests on HPS Board members captured email correspondences on a few members of the NAS Committee deliberating this topic and the HPS video documentary. Dewji was made aware of the video series during an International Radiation Protection Association (IRPA) meeting and expressed hope that NCRP PAC-1 committee would consider drafting a response. Woloschak, NCRP PAC-1 Chair, responded that NCRP would discuss whether a response was appropriate or not.[35] [Supplemental Digital Content 34, **http://links.lww.com/HP/A273**] To date, no response has been delivered. During these exchanges, the NAS Committee Chair, Joe Gray, PhD, questioned whether they should include one of Calabrese's articles "as a reference to the checkered history of Department of Energy (DOE) as a sponsor."[37] [Supplementary Digital Content 35, **http://links.lww.com/HP/A274**] Gray's response could be interpreted differently. If he intended to imply DOE was a sponsor of Calabrese's work, that would be incorrect. For the record, DOE has not sponsored Calabrese's research associated with his publications on the history of the LNT model, and attempts to link DOE with Calabrese's work would be inaccurate.[38] [Supplemental Digital Content 36, **http://links.lww.com/HP/A275**] If he intended to infer that Calabrese had published an article exposing the "checkered history of DOE as a sponsor" to whatever he may have been thinking, that would also be incorrect. Calabrese has not published an article that exposed a checkered history of DOE.[39]

The NAS Study Director, Ourania Kosti, PhD, stated that at least 2 to 3 committee members did not want the report to even reference Calabrese's work because it is controversial.[40] [Supplementary Digital Content 37, **http://links.lww.com/HP/A276**] She expressed concern that citing Calabrese to make the Committee Chair's point would risk credibility of the report. She stated that the entire committee had this discussion when another member on the committee proposed referencing one of his papers and that the "committee pushed back."[41] [Supplemental Digital Content 38, **http://links.lww.com/HP/A277**] Woloschak followed with "I do not think weshould [sic] cite Calabrese…" and "No one complained that they weren't there…as far as I can tell. My concern is more broadly for the community."[42] [Supplemental Digital Content 39, **http://links.lww.com/HP/A278**] These actions show a conscious decision

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by the NAS Committee to effectively ignore the most published author on this topic. Calabrese is ranked #3 in the world by ScholarGPS for his lifetime work in environmental health sciences.[43] He has a long history of directing conferences that were designed to explore leading edge scientific issues, typically with the inclusion of diverse and opposing views. Is it ethical to hinder sharing of information that helps "the community" make an autonomous decision based on examining all serious sides of a controversial topic?

Gray's response to Woloschak is significant from a transparency and ethical perspective, so I'm including it in the text of this article.[44] [Supplemental Digital Content 40, **http://links.lww.com/HP/A279**] It's worth noting that this email was not included in the FOIA response from his employer, Oregon Health and Science University.[44] However, it was discovered in the response from Dewji's employer, Georgia Institute of Technology.

Gray wrote: "Sorry to be difficult… but what I see is a Society backing Calabrisi [sic] and a lot of PUBLISHED papers articulating his positions that are critical of some of the institutions with which we are associated including the NAS. I know we have discussed this and that you have asserted that there are issues with his positions. However, we as a committee have not done a thorough review of the evidence behind your assertions. Selfishly, I also think it is very likely that I as a defender of this document will be asked about the lack of attention to these publications by unfriendly questioners. As it sits, I would be left to say that the committee did not find them credible but I would not be able to point to documents that back up the lack of credibility. So while you say that that [sic] citing them might be a problem, I can certainly see downsides to not citing them — namely that the NAS could be accused of suppressing 'uncomfortable truths' as other agencies have done in the past. Perception is important. 99% of our readers will have access only to the published literature. The fact that the reviewers did not pick up on it does not mean that our detractors won't. I am not going to push this any farther but I will appreciate a suggestion about how to respond to questions about why we did not cite, should those questions arise."

Woloschak responds by stating there's a large body of literature that is opposed to Calabrese's work, which she was not inclined to search for unless he found it necessary.[46] [Supplemental Digital Content 41, **http://links.lww.com/HP/A280**] However, she did provide him with a recent Calabrese publication characterizing it as having "alot [sic] of inaccuracies (perhaps downright lies)" based on her conversations with colleagues who knew the players in the paper and indicated that there are many problems with the article (Calabrese and Selby 2022).[46] [Supplemental Digital Content 42, **http://links.lww.com/HP/A281**] Paul Selby, the co-author on this paper, shared his response to her characterization with Calabrese.[47] [Supplemental Digital Content 43, **http://links.lww.com/HP/A282**] He indicated that her colleagues had no first-hand knowledge of the cancer study cover-up study details, raising serious questions with the factual basis of her assertions.

She further explained why the NAS report neglected to mention the word "hormesis," a criticism raised by the ANS Executive Director during the July 15, 2022, webinar. She stated: "Our committee decided not to take on the word 'hormesis' (which is the one Calabrese uses) because of both the controversy and the vast literature that do not support the overall hormesis model."[49] [Supplemental Digital Content 44, **http://links.lww.com/HP/A283**] She opines that it would be better not to deal with Calabrese; in essence, ignore his work. Instead, the NAS report used the term "adaptive response." It's worth noting that nearly 150,000 citations exist in the Web of Science based on the terms "hormesis" or "hormetic." There were about 400 peer-reviewed publications in 2022 on hormesis and that number has increased by about 10–15% per year over the past two decades. A vast majority are not authored by Calabrese. I also encourage readers to read the May 1987 special issue on hormesis published in Health Physics. Her guidance to the committee demonstrates how a single member can influence the direction of an entire committee.

Ironically, Calabrese was invited to give a seminar to the BEIR VII Committee on hormesis, yet two decades later, this new NAS committee showed disdain for the messenger and the message despite the tremendous growth of this topic. Kosti responded that the committee was not tasked to review the history of the LNT or to make policy recommendations. She states "The use of the LNT is a policy decision"[50] [Supplementary Digital Content 45, **http://links.lww.com/HP/A284**]—another reference to acceptance of the LNT model based on an EPA policy decision instead of its scientific validity at low doses. Gray accepted these responses but expressed his hope that someone publishes a counter to Calabrese sometime soon.

In 1999, HPS President Raymond Johnson wrote to the NAS expressing the Society's dismay and disappointment for removing HPS nominee, Kenneth Mossman, PhD, from membership on the BEIR VII Committee.[51] [Supplemental Digital Content 46, **http://links.lww.com/HP/A285**]. The letter also expressed dismay over the removal of HPS members Dade Moeller PhD, CHP, and David Hoel, PhD, from the committee; they could have provided similar perspectives on radiation safety. Mossman was a primary author of the HPS Radiation Risk Perspective position statement, which did not fully endorse the LNT model. Since that time, this position statement has been revised and was criticized by Boice as the current NCRP Director of Science.

RATIONAL REASONING OR LOGICAL FALLACIES

Ethical leadership means that individuals behave according to a set of principles and values that are recognized by the

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majority as a sound basis for the common good. These include integrity, respect, trust, fairness, transparency, and honesty. Were the actions taken by these influential people within authoritative organizations consistent with these values? Ersdal and Aven argue that no ethical theory prescribes answers to what is the right action in a risk management context (Ersdal and Aven 2022). Instead, ethical theories provide a tool for creating a rational reasoning for a decision. JunkScience exposed the hidden agendas and rationale of leaders within the NCRP, EPA, and the NAS to maintain the LNT model. This commentary documents it in the scientific literature for future scholars to assess.

Informed consent or the ability for one to make a rational, ethical, or moral decision requires knowledge. Any action that suppresses information and access to this knowledge can arguably be described as unethical. Uncertainty is part of any field, especially for health effects associated with low-dose exposures. The scientific community has a responsibility to acknowledge these uncertainties, not to suppress or ignore information that could help to understand them. It is accepted and widely acknowledged that the risks for radiation exposures at low levels **may be** non-existent, and there is strong evidence that it **may even be** beneficial. Labeling a group of scientists as "anti-LNT contamination" presupposes that there is only one answer to the question and that there are only adverse health effects in low-dose environments.

Further, suggesting that an opinion that is not consistent with an "authority" represents a form of misinformation or dis-information that challenges the very essence of scientific debate. It also promotes a logical fallacy where non-experts appeal to authority in making their conclusions, when in fact the authority can be wrong. Here are two examples: US EPA enforces its regulatory authority based on a policy decision to literally apply the LNT model to estimate cleanup levels despite the fact that this approach (1) conflicts with guidance from the international community and (2) conflicts with EPA Scientific Integrity policy. The US Nuclear Regulatory Commission (NRC) largely relied on the NAS BEIR VII report and the NCRP Commentary 27 to support their 2021 decision to continue use of the LNT model in its policies (US NRC 2021). The US NRC failed to address the peer-reviewed literature, which noted serious scientific issues with these documents yet made its decision without accounting for them (Cardarelli and Ulsh 2018; Ulsh 2018). Bottom line: policy decisions should not be conflated with scientific validity or integrity.

IMPACT ON SOCIETY

Reliance on the LNT policy affects other facets of society as well. It foments fear by suggesting there is no safe level of radiation exposure, causing some people to refuse life-saving medical treatments that use radiation for diagnostic or therapeutic purposes (Brooks et al. 2023). It results in unnecessary and tremendous costs to build or decommission nuclear power plants; a safe, reliable, and low-carbon emission form of energy.[52] [Supplemental Digital Content 47, **http://links.lww.com/HP/A286**] It effectively diverts economic resources that could be used to address other public health threats (e.g., infectious/contagious diseases) or build more economical nuclear power plants.[34] [Supplemental Digital Content 32, **http://links.lww.com/HP/A271**]

Transparent pursuit of the truth is a necessary part of science. The issues presented here are bigger than a question about the validity of the LNT model for risk assessment application in low dose environments. Without full transparency and equal access to debate the scientific issues, science cannot advance. Ignoring a segment of the scientific community, labeling them as "anti-LNTers" and "anti-science zealots" hardens the divide between groups. One side wants a transparent exchange of the scientific foundation, while the other does not because they believe the science is settled (or perhaps the policy of using the LNT for radiation protection is settled). That divide makes it difficult for scientists to engage for fear of being shunned by their peers or losing opportunities to support their jobs and family. I experienced these fears in my own career, and similar ones have been expressed by others.[53] [Supplemental Digital Content 48, **http://links.lww.com/HP/A287**] This creates an environment in which one must go along to get along and one should not cross the line.

Those who dismiss Calabrese and discourage reading any of his research or watching the LNT history videos may believe they are "saving the society." Although the videos are about the history of the LNT, history has shown that dismissing or ignoring theories deemed "unacceptable" or questioning of "settled" science status quo can lead to human tragedies. A recent example of a scientific community rejecting research is the case of Barry Marshall, MD. Marshall is credited with the discovery that ulcers are not caused by stress but by a bacterial infection, Helicobacter pylori (Marshall 2016). Marshall submitted his findings to the Gastroenterological Society of Australia in 1983 with this groundbreaking news. His presentation was rejected. The scientific community was not convinced that stress was not a factor, so Marshall voluntarily ingested a broth containing H. pylori to demonstrate the causation of ulcers. Although he states, "Needless to say, reports that I was alone in the promotion of HP as a pathogen are somewhat exaggerated," it is no exaggeration to state that the majority of scientists dismissed his findings. He went on to state, "There was interest and support from a few but most of my work was rejected for publication and even accepted papers were significantly delayed" and "When the work was presented, my results were disputed and disbelieved, not on the basis of science but because they simply could

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not be true." Barry Marshall was a recipient of the Nobel Prize in Physiology in 2005 for his work.

OPEN VS. CLOSED ORGANIZATIONS

The HPS was formed in 1956, and NCRP was chartered by Congress in 1964. Both are non-profit organizations with similar missions but have different purposes. The HPS has a long history of working collaboratively to promote the field of radiation protection. I've proudly served on a couple of NCRP Committees as a consultant. One area where these organizations differ is in their membership. To become an HPS member, an applicant only needs to meet academic standards or obtain professional experience set forth by its rules and be willing to pay the annual membership dues. This is an open-society model and the HPS has over 2,200 voting members today. NCRP is a closed-society model made up of only 100 Council voting members that go through a selective nomination process. This is the type of process in which Boice, during his seven years as NCRP President "...failed to prevent the contamination of anti-LNTers" but may have made progress in doing so along the way.

Naturally, diverse scientific opinions exist among both groups, probably more so in the HPS due to its larger size. Part of the scientific process is to vigorously debate the scientific issues, especially in areas with large uncertainties (e.g., risks at low levels). This should be celebrated in both organizations, not vilified. Unfortunately, members who are open to scientific debate on the LNT model may rightfully be concerned that they will be discriminated against. For example, Boice used his position to obstruct potential career opportunities for NCRP nominees to serve on the NCRP Council if they had expressed views he believed were inconsistent with LNT doctrine. NCRP 180 states, "NCRP now adopts the use of the ethical principles of providing good, preventing harm, respecting an individual's autonomy, and acting fairly in making decisions on radiation protection, particularly in circumstances and situations that present inherent conflicts in interests" (NCRP 2018b). These various statements about acceptance of diverse thoughts seem to encourage the communication of all scientific viewpoints in the HPS and NCRP. However, it appears that these principles have not always been followed if the topic is about the applicability of the LNT model in low dose environments.

Another area where HPS and NCRP differ is the ability to exert influence in the other's organization. Specific leaders within NCRP started an effort in 2017 to "move the needle" by seeking, nominating, and electing HPS members to serve in HPS leadership positions that are supportive of a pro-LNT position consistent with the NCRP doctrine. HPS cannot reciprocate due to the closed-society model, and I would not support any effort to do so. The independent FOIA request shared with Calabrese and the JunkScience article exposed their hidden agenda. The following statements can be made about their acts:

1. Leaders within NCRP used their position of power to limit debate by attempting to exclude people with "anti-LNT" views from becoming council members or presenting at conferences;
2. Influential NCRP members on the NAS Committee chose not to cite key references relevant to the scientific discussion. They even chose to censor specific words (e.g., "hormesis") because they label them as controversial; and
3. Critics of the documentary, including many from the NCRP leadership, choose to ignore the scientific failings used to support the LNT model in low-dose environments and instead attacked the messenger but not the message.

I encourage members of the HPS and the radiation protection community to consider everything that has been presented here and for HPS members to share their opinions with the HPS Board. A Past-President once told me that HPS members are the "practitioners of radiation safety." Our profession has to implement the guidance, policies, and regulations in the field of radiation protection. The video documentary on the history of the LNT model was intended to educate professionals in this field. I believe it has done that. To my surprise, the FOIA information shared with me uncovered multiple layers of coordination that can be reasonably interpreted as being harmful to the scientific community and the public we are expected to protect. So, I ask you: Is the radiation protection community repeating history? It will be judged by the actions the NCRP, HPS, and the entire radiation protection community take today, not by the scientific failings of the past.

Acknowledgments—The views expressed in this paper are those of the author.

FOOTNOTES

[1]HPS videos - https://hps.org/hpspublications/historylnt/episodeguide.html

[2]Individuals named throughout this article are initially introduced with their professional credentials and afterward, only their last name is used. There is no intention to diminish their professional accomplishments in any way.

[3]Scarato, Theodora. "Re: We did a CDC Foia [sic] and found information you might be interested regarding your work at Health Physics." Received by Edward Calabrese, 28 July 2022.

[4]Boice, John. "Re: Call tomorrow re HPS (and NCRP, re nominations perhaps)." Received by Armin Ansari, 06 Jan 2020.

[5]Boice, John. "IRPA and HPS." Received by anonymous, Armin Ansari, and Lawrence Dauer, 07 Feb 2020.

[6]Boice, John. "Notes from last Society call." Received by Armin Ansari and Lawrence Dauer, 5 Feb 2020 (including the attached notes).

[7]Dauer, Lawrence. "Re: RE: A Needle Update!" Received by Armin Ansari, 9 Jan 2020.

[8]Ansari, Armin. "[EXTERNAL] RE: A Needle Update!" Received by John Boice and Lawrence Dauer, 9 Jan 2020.

[9]Boice, John. "Re: A Needle Update!" Received by Armin Ansari and Lawrence Dauer, 9 Jan 2020.

[10]Dauer, Lawrence. "HPS Info" Received by Armin Ansari, 26 May 2020.

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[11]Boice, John. "Re: confidentially" Received by Lawrence Dauer and Armin Ansari, 10 Jun 2020.
[12]Ansari, Armin. "RE: confidentially" Received by Lawrence Dauer and John Boice, 11 Jun 2020.
[13]Dauer, Larry. No subject. Received by Armin Ansari and John Boice, 10 Jun 2020.
[14]Dauer, Lawrence. No Subject. Received by Armin Ansari, 4 Feb 2021.
[15]Ansari, Armin. "RE: RE: Need Names for HPS by today/tomorrow!" Received by John Boice, Lawrence Dauer, 20 Feb 2021.
[16]Boice, John. "Re: RE: Need Names for HPS by today/tomorrow!" Received by Armin Ansari and Lawrence Dauer, 4 Feb 2021.
[17]Boice, John. "Re: Great presentation/s" Received by Nicole Martinez, 4 Mar 2022.
[18]Boice, John. "Re: PAC 1 Meeting." Received by Armin Ansari, Lawrence Dauer, and Nicole Elizabeth Martinez, 24 Apr 2022.
[19]Boice, John. "Re: Great Presentation/s" Received by Nicole Martinez, 20 Apr 2022. Including the attachment "2022-03-10_Nicole Martinez" titled "War and Peace."
[20]Woloschak, Gayle. "RE: Follow-up from PAC-1 meeting" Received by Nicole Martinez, 05 May 2022.
[21]Egidi, Philip. "RE: John Cardarelli II shared a post: As…" Received by Jennifer Mosser, Mike Boyd, David Stuenkel, and paweld1511@protonmail.com, 22 Apr 2022.
[22]Boice, John. "Re: Great presentation/s" Received by Nicole Martinez, 28 Feb 2022.
[23]Wakeford, Richard. "Re: PAC 1Meeting" Received by John Boice, Lawrence Dauer, Nicole Martinez and Armin Ansari, 24 Apr 2022.
[24]Atwell, Laura. "PAC 1 Meeting." Received by Gayle Woloschak and at least 25 others, 21 Apr 2022.
[25]Jokisch, Derek "Calabrese videos" Received by Nicole Martinez, 13 Apr 2022.
[26]Martinez, Nicole "Re: Great Presentation/s" Received by John Boice, 14 Apr 2022.
[27]Kleinhans, Kyle. "RE: American Academy of Health Physics Society Special Session on LNT" Received by Edward Calabrese, 22 Dec 2017.
[28]Kleinhans, Kyle. "RE: American Academy of Health Physics Comments on NCRP/M/17/30, Implications of Recent Epidemiologic Studies for the Linear Nonthreshold Model and Radiation Protection" Received by Brant Ulsh, 21 Jan 2018.
[29]Kleinhans, Kyle. "Re: Calabrese LNT Series" Received by John Cardarelli, 30 Jan 2023.
[30]Smith, Graham. "RE: LNT (again)" Received by Neil Chapman and Nicole Martinez, 20 Apr 2022.
[31]Boyd, Michael. "My thoughts on the ENV/Rn Section Comments on the videos." Received by Kathryn Highley, Jaa VanHorne-Sealy, LathaVasudevan, Timothy Taulbee, Adela Salame-Alfie, Shaheen Dewji, Angela Leek, and Nicole Martinez, 06 June 2022.
[32]Barbara Hamrick to U.S. Environmental Protection Agency, 3 Aug 2014. Re: "Comments in response to advance notice of proposed rule making (40 cft 190) environmental radiation protection standards for nuclear power operations." Business letter.
[33]Paul S. Rohwer to Chairman Costello. 18 July 2000. Re: "Testimony of Paul S. Rohwer, HPS President, Hearing on "Reexamining the Scientific Basis for the Linear No-Threshold Model of Low-Dose Radiation" before the House Science Subcommittee on Energy and Environment.
[34]Paul S. Rohwer to Ken Calvert. 16 Nov 2000. Re: "Post-Hearing Questions Subitted by Chairman Ken Calvert." Business letter.
[35]Edwards, Jonathan. "Re: Agenda LNT Meeting with DOE AMS." Received by Dana Tulis, Reggie Cheatham, and Mike Flynn, 05 Aug 2015.
[36]Woloschak, Gayle. "RE: HPS and history of LNT by Calabrese." Received by Ourania Kosti, Joe Gray, and Shaheen Dewji, 18 Apr 2022.
[37]Gray, Joe. "RE: RE: HPS and history of the LNT by Calabrese." Received by Shaheen Dewji and Gayle Woloschak, 18 Apr 2022.
[38]Calabrese, Edward. No subject. Received by John Cardarelli II, 13 Feb 2023.
[39]Personal Communication. Cardarellli with Calabrese. 2 March 2024.
[40]Kosti, Ourania. "RE: HPS and history of the LNT by Calabrese." Received by Joe Gray, Shaheen Dewji, and Gayle Woloschak. 18 Apr 2022.
[41]Kosti, Ourania. "RE: re: HPS and history of LNT by Calabrese." Received by Shaheen Dewji and Gayle Woloschak. 19 Apr 2022.
[42]Woloschak, Gayle. "RE: HPS and history of the LNT by Calabrese." Received by Shaheen Dewji, Ourania Kosti, and Joe Gray, 19 Apr 2022.
[43]Available at https://scholargps.com/scholars/83094466738402/edward-j-calabrese. Accessed 20 December 2023.
[44]Gray, Joe. "Re: HPS and history of LNT by Calabrese." Received by Gayle Woloschak, Shaheen Dewji, and Ourania Kosti, 19 April 2022.
[45]The FOIA request to Joe Gray's institution was submitted but the response did not include this email. It was found within the emails he sent to Shaheen Dewji. Calabrese attempted to get this from his institution again but was not successful.
[46]Woloschak, Gayle. "Re: HPS and history of LNT by Calabrese." Received by Joe Gray, Ourania Kosti, and Shaheen Dewji, 19 April 2022.
[47]Selby, Paul. "Re: Curious short letter." Received by Edward Calabrese, 10 Dec 2022.
[48]Woloschak, Gayle. "Re: HPS and history of the LNT by Calabrese." Received by Joe Gray, Shaheen Dewji and Ourania Kosti, 19 Apr 2022.
[49]Kosti, Ourania. No subject. Received by Joe Gray, 19 Apr 2022.
[50]This email specifically references the lack of willingness to provide evidence.
[51]Johnson, R. Letter to National Academy of Sciences. Ed: E.W. Colglazier. Health Physics Society, 11 November 1999.
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