Protection and Measurements, the United Nations Scientific Committee on the Effects of Atomic Radiation, the UK National Radiological Protection Board, and other authoritative bodies have assembled committees of experts to review the available scientific data on health effects of low-level ionizing radiation and issued reports analyzing the scientific literature in which the LNT and other theories have been used in estimating risk.[5] Those expert organizations have long adhered to the LNT model as the basis for their recommendations.

Numerous scientific studies support the LNT model, and there is simply no statistically valid science at present that warrants changing the model.

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Letter writers Jeffry Siegel, Charles Pennington, and Bill Sacks state that modern-day concepts of a linear dose response to ionizing radiation are based on fruit-fly data collected 70 years ago. Actually, fruit-fly data haven't been important since William Russell's Oak Ridge mice data became available in the 1960s. Today, linearity is based on fits to data for cancer incidence or mortality as a function of dose received by individuals in large exposed populations, such as the atomic-bomb survivors (125 000), the Techa River cohort in Russia (17 000), and radiation workers (300 000–600 000). A linear fit is taken as the conservative starting point for dose response, with quadratic terms turning out to be modest.[1] Widespread consensus exists that linearity holds at least down to 100 millisieverts, and there is a broad but not unanimous view that it is likely to continue to apply at lower doses—that risk will continue to decrease in proportion to dose.

Arguments about repair and evolutionary protection are not sufficient. On occasion, repair systems can fail—for example, mismatched repairs of breaks in double-stranded DNA. Protective systems, such as tumor-suppression genes, can be damaged or turned off by ionizing radiation. Furthermore, ionizing radiation is a promoter, not just an initiator; it can affect cells already genetically damaged by other causes.

Siegel and coauthors cite a claim Siegel makes[2] that a graph of atomic-bomb-survivor data for cancer incidence suggests a threshold in the epidemiologic noise region of the dose response (below 100 mSv) where uncertainty of data points is great, but the comparable graph for mortality,[3] suggesting a supralinear response, is not shown. They also cite a 58-page review by the French Academy of Sciences and National Academy of Medicine,[4] but they do not mention the more comprehensive

500-page *BEIR VII* report by 17 experts and 16 reviewers assembled by the US National Academies.[1] That review concluded "that the risk would continue in a linear fashion at lower doses without a threshold and that the smallest dose has the potential to cause a small increase in risk to humans" (page 7).

In the decade since the French academies review, a wave of studies of protracted human exposure, as discussed in a 2009 meta-analysis,[5] has suggested that protracted exposures have dose responses similar to or greater than single exposures. It is hard to justify a threshold if a dose accumulated from a large number of small exposures has an impact the same as or larger than the same dose delivered in a single exposure.

The public-health and risk-assessment communities should ignore partisan views and assume the linear no-threshold (LNT) dose-response relationship at low doses, with uncertainty bands above and below the LNT that cover alternative hypotheses. Disputes over radiation dose-response models distract attention from the fact that the individual risks at the low-dose levels that are being debated are small, whether assessed using a linear, supralinear, or threshold model. However, for situations in which hundreds of thousands of people are irradiated, risk is spread over a huge population in a kind of reverse lottery. To estimate such social risks is considered inappropriate by some, but it is necessary for cost–benefit calculations in retrofit analysis of nuclear power plants or for seeing whether medical diagnostic procedures carry a net population benefit. Accounting for uncertainty should make such calculations more palatable. The concern that the public can't handle bad news about risk is misplaced. What destroys public trust is the idea of a cover-up, which is implied by an unwillingness to calculate possible risks.

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One of us is a radiologic educator, and the other a scientist. We do not support the linear-threshold (LT) radiation dose–response relationship that Jeffry Siegel and his coauthors do. The linear no-threshold (LNT) model has been extensively studied in numerous works that have established appropriate imaging with acceptably reduced patient radiation dose. Siegel and company correctly recognize that we do not know what the response is to medical radiation exposure below perhaps 100 mSv. However, many continue to subscribe to LNT, and we agree that it is the correct position.

To abandon LNT for LT would be another example of "normalization of deviance," a term coined by Diane Vaughan following the 1986 *Challenger* disaster and first applied to medicine in anesthesiology[1] in 2010. Normalization of deviance is the gradual shift in belief or behavior that strays from accepted safety standards because the belief or behavior has no adverse consequences—until it does. Andrew Woodward and Melissa Jackowski, in a presentation they gave at the Radiological Society of North America 2014 Scientific Assembly and Annual Meeting, explored normalization of deviance as the reason for radiologic technologists taking shortcuts that violate the concept of ALARA (as low as reasonably achievable).

Although the true dose–response relationship may well be nonlinear at low doses, assuming a threshold would be irresponsible. In medical imaging, low doses of radiation are viewed as acceptable given the diagnostic benefits. But radiologists must always strive to minimize radiation exposure to their patients and to themselves.

Abandoning LNT, in medical imaging at least, will result in another example of normalization of deviance and in an unknown but large number of unnecessary deaths. Consider, for example, the 80 million CT imaging studies performed annually in the US.[2] Estimates of lethality from radiation-induced cancer from such medical exposures approach 30 000 per year.[3]

Of course, the difficulty with such predictions is that radiation-induced cancer has no tag of any kind to identify it as such. Furthermore, whatever the true rate of radiation-induced fatalities is, it is hidden by the 20% normal cancer lethality in our total population.

At least for medical imaging, we recommend continuing to use LNT while accepting that a patient radiation dose less than approximately 100 mSv is well worth the benefit of the imaging and should be accepted as safe.

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A letter in the January 2016 issue of PHYSICS TODAY questioned the validity of the linear no-threshold (LNT) model of radiation damage. We would like to share the results of a study that shows a threshold effect in fruit flies.[1]

In our experiment, we gave fruit flies one dose of radiation shortly after they hatched. The incident radiation exposures ranged from 0.1 J/kg to 1000 J/kg (10–100 000 roentgen). We tracked life spans and gene expression at 2 days, 10 days, and 20 days after irradiation.

We found that there was no measurable effect on lifetimes below a radiation threshold of 50 J/kg. Above that threshold, lifetimes decreased. Below it, whatever gene expression changes occur at 2 days and 10 days are corrected at