The crippling fear of low-level radiation

By James Conca

Fear of radiation—termed "radiophobia"—has had some serious unintended consequences since its rise following World War II, particularly impeding the safe and beneficial uses of radiation and radioactive materials in medicine and in the production of electricity. It is even making it difficult to find and train nuclear and radiological workers.

A 2018 joint report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, *Measuring Employment Generated by the Nuclear Power Sector*, states that construction and operation of an average 1,000-MW nuclear reactor creates about 200,000 labor years of employment over a 40-year period. Double that number for the expected life cycle of 80 years. Since we need the equivalent of about 1,700 nuclear power plants, each capable of generating 1,000 MW, worldwide by 2050 to have any hope of reining in global warming, that is a lot of nuclear workers.[1]

It's even difficult to find a sufficient number of medical physicists. An article published recently in the *Journal of Applied Clinical Medical Physics* estimates that in the United States there are only 1,794 physicists supporting diagnostic X-ray (1,073 board-certified),

1. OECD Nuclear Energy Agency and International Atomic Energy Agency, *Measuring Employment Generated by the Nuclear Power Sector* (Paris: OECD, 2018).

934 supporting nuclear medicine (460 board-certified), and only 235 supporting nuclear medicine exclusively (150 board-certified)[2]—this few for the over 6,000 hospitals and imaging centers in America.

The causes of radiophobia are varied and complex and are not associated with any scientific knowledge or understanding—just the opposite.

To define this fear and address what may be contributing to and maintaining it, Antone L. Brooks, Wayne Glines, Alan Waltar, and I wrote a paper titled "How the Science of Radiation Biology Can Help Reduce the Crippling Fear of Low-Level Radiation."[3]

We present information in the article as a timeline to reveal how this fear developed over time and why. I will summarize this work in the following paragraphs, but check out the article in *Health Physics* once it is published for all the references and background.

Following the discovery of radioactivity in 1896, many radioactive materials were sold to the public in drinks and food supplements with the claim that these materials could cure almost any ailment. In the first decades of the 20th century, extensive applications of radiation were used to cure ringworm and inflammatory diseases like ankylosing spondylitis and arthritis. At that time, studies seemed to show beneficial effects from the treatment, especially for inflammation. Many of these studies, however, were not scientifically based and were carried out with high doses of radiation, which resulted not only in some evidence for curing disease but also an increased frequency of cancer. As time went on, it became apparent that high doses of radiation were also increasing the frequency of cancer and causing other adverse effects. Data were accumulating on the dangers of radiation due to occupational and medical exposure—the classic case being the increase in bone cancer among watch dial painters who worked with radioluminescent paint. After ingesting quantities of powdered radium from licking the brushes used to apply the paint, the frequency of bone cancer among the workers rose dramatically. However, there was a well-documented threshold dose below which no bone cancers were observed, and after workers stopped licking the brushes, the incidence of cancer fell to background levels.

Studies done in the 1920s by geneticist Hermann Joseph Muller on radiation-induced mutations in fruit flies demonstrated a linear response of mutations with dose—but only for high-radiation doses (millions of times higher than background doses). Even in the face of contrary data showing no effects at low doses, the linearity of the response was assumed to hold at low doses, resulting in the formation of the erroneous linear no-threshold (LNT) dose-response model for the induction of mutations. This was later used as the general model for cancer induction from radiation exposure, again in the face of contrary data, and has colored our global public perception and regulatory space ever since.

Our forthcoming article poses the following five questions, many of which have made front-page headlines at various times in the last 80 years and have stimulated radiophobia in the public.

1. Are the long-term risks for genetic damage and cancer from radiation almost equal? Does radiation exposure increase the genetic load and result in long-term genetic degeneration of the human genome?
2. What is the radiation-induced cancer risk as a function of dose following a single acute radiation exposure?
3. What are the risks from internally deposited radioactive material? This includes the risks from fallout produced by atmospheric nuclear weapons testing, the risk for bone cancer and other health effects because of exposure to strontium-90 and its daughter product yttrium-90, the risk for thyroid cancer from exposure to iodine-131, and the risk of liver cancer due to plutonium-239 exposure. Is Pu-239 really the most hazardous substance known to man?

Opinion continues

2. Sean D. Rose et al., "Estimated Size of the Clinical Medical Imaging Physics Workforce in the United States," *Journal of Applied Clinical Medical Physics* 23, no. 7 (2022): e13364. doi.org/10.1002/acm2.13664.

3. Antone L. Brooks et al., "How the Science of Radiation Biology Can Help Reduce the Crippling Fear of Low-Level Radiation," *Health Physics* (forthcoming).

4. Can molecular markers be used to help predict the risk of cancer? What can research at the cellular and molecular levels tell us about the risk of cancer and the mechanisms involved in low-dose radiation-induced cancer?
5. What are the costs to society—driven in a great part by the fear of radiation—and how does fear of radiation impact the economy, health, and well-being in exposed populations?

My coauthors and I reviewed scientific research addressing these questions, and in our paper, we concluded that fear of radiation is not founded in scientific knowledge and understanding. A few of our closing thoughts follow:

- It is critical to understand that cancer is actually a very complex set of diseases, and that the induction of a single mutation is not sufficient to cause one of these terrible diseases. Radiation is a very poor mutagen, just as almost all human carcinogens are not mutagens. This has been shown by research and has been adopted by the responsible regulatory bodies.
- We need to insist on regulatory changes that reflect current scientific knowledge and understanding and help the public understand the impact of radiation on their daily lives. Regulatory changes are needed to reflect and establish useful dose and dose-rate effectiveness factor, which demonstrates a decrease in risk when the radiation is delivered at a low dose rate or in small fractions. This has been used in medicine for many years with no outcry. The concept of ALARA (as low as reasonably achievable) should be replaced with "reasonableness in optimization of protection."
- It is essential to modify some of the basic regulatory standards, such as the current annual limit of exposure of the public to 1 mSv (100 mrem), which is much less than natural background radiation—even 10 to 100 times less than background in many areas of the world. This limit, based on the LNT model, assumes any amount of radiation can be hazardous. It is totally unrealistic and leads directly to the unnecessary and unproductive public fears of radiation that, in themselves, cause harm and death, as we saw after Fukushima.
- We need to recognize that a further problem is the implementation of the radiation standards where companies, cities, states, and local governments regulate to levels even below the accepted standards. These "conservative" actions are expensive and provide no benefit to public health or safety.
- Lastly, be engaged. As nuclear and radiological professionals we have a responsibility not only to minimize any potential detriments associated with the use of radioactivity and radiation but also to help maximize its beneficial uses. We believe that to not avail society of the beneficial uses of radioactivity and radiation is a detriment itself.

It's a fun read, if I do say so myself.

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