NCRP Commentary No. 27: Implications of Recent Epidemiologic Studies for the Linear-Nonthreshold Model and Radiation Protection

National Council on Radiation Protection and Measurements

Overview

In May 2018, the National Council on Radiation Protection and Measurements (NCRP) published Commentary No. 27, *Implications of Recent Epidemiologic Studies for the Linear-Nonthreshold Model and Radiation Protection*.

For over 40 years, the linear-nonthreshold (LNT) dose-response model has been used to develop practical and prudent guidance on ways to protect workers and members of the public from the potential for harmful effects of ionizing radiation, specifically, from low linear-energy transfer* (low-LET) radiation.

Commentary No. 27 was produced by an interdisciplinary group of radiation experts who critically assessed recent epidemiologic studies of populations exposed to low dose and low dose-rate ionizing radiation. The studies were then judged as to their strength of support for the LNT model as used in radiation protection.

NCRP concludes that the recent epidemiologic studies support the continued use of the LNT model for radiation protection. This is in accord with judgments by other national and international scientific committees, based on somewhat older data, that no alternative dose-response relationship appears more pragmatic or prudent for radiation protection purposes than the LNT model.

The Commentary provides a critical review of 29 high-quality epidemiologic studies of populations exposed to radiation in the low dose and low dose-rate range, mostly published within the last 10 years. Studies of total solid cancers and leukemia are emphasized, with briefer consideration of breast and thyroid cancer, heritable effects, and some noncancers, *e.g.*, cardiovascular disease and cataracts.

The epidemiologic methods, dosimetry and statistical approaches for each study were evaluated. These components of study quality were used to classify each study as to its support of the LNT model for use in radiation protection. The classifications were: strong, moderate, weak-to-moderate, no support, and inconclusive.

The 29 epidemiologic studies are listed below with literature references and the classification for support of the LNT model. Full references are provided in the Commentary.

*Linear energy transfer (LET) is a measure of the energy lost by ionizing radiation as it travels through matter. Low-LET radiations (*e.g.*, x rays, gamma rays, and electrons) transfer their energy at a low rate. High-LET radiations (*e.g.*, protons, alpha particles, and heavy ions) transfer their energy at a higher rate.

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Epidemiologic Study (or groups of studies)	Classification (support for LNT model)
Life Span Study, Japan atomic bombs (Grant et al., 2017)	Strong
INWORKS (French, United Kingdom, United States combined worker cohorts) (Richardson *et al*., 2015)	Strong
Tuberculosis fluoroscopic examinations, breast cancer (Little and Boice, 2003)	Strong
Childhood Japan atomic-bomb exposure (Preston *et al*., 2008)	Strong
Childhood thyroid cancer studies (Lubin *et al*., 2017)	Strong
Mayak nuclear workers (Sokolnikov *et al*., 2015)	Moderate
Chernobyl fallout, Ukraine and Belarus thyroid cancer (Brenner *et al*., 2011)	Moderate
Breast cancer studies, after childhood exposure (Eidemuller *et al*., 2015)	Moderate
In utero exposure, Japan atomic bombs (Preston *et al*., 2008)	Moderate
Techa River, nearby residents (Schonfeld *et al*., 2013)	Moderate
In utero exposure, medical x ray (Wakeford, 2008)	Moderate
Japan nuclear workers (Akiba and Mizuno, 2012)	Weak-to-moderate
Chernobyl cleanup workers, Russia (Kashcheev *et al*., 2015)	Weak-to-moderate
U.S. radiologic technologists (Liu *et al*., 2014; Preston *et al*., 2016)	Weak-to-moderate
Mound nuclear workers (Boice *et al*., 2014)	Weak-to-moderate
Rocketdyne nuclear workers (Boice *et al*., 2011)	Weak-to-moderate
French uranium processing workers (Zhivin *et al*., 2016)	Weak-to-moderate
Medical x-ray workers, China (Sun *et al*., 2016)	Weak-to-moderate
Taiwan radiocontaminated buildings, residents (Hsieh *et al*., 2017)	Weak-to-moderate
Background radiation levels and childhood leukemia (Kendall *et al*., 2013)	Weak-to-moderate
In utero exposures, Mayak and Techa River (Akleyev *et al*., 2016)	No support
Hanford ^{131}I fallout, thyroid cancer (Davis *et al*., 2004)	No support
Kerala, India, high background radiation area (Nair *et al*., 2009)	No support
Canadian worker study (Zablotska *et al*., 2014)	No support
U.S. nuclear weapons test participants (Caldwell *et al*., 2016)	No support
Yangjiang, China, high background radiation area (Tao *et al*., 2012)	Inconclusive
Computed-tomography examinations of young persons (Pearce *et al*., 2012)	Inconclusive
Childhood medical x rays and leukemia (aggregate of >10 studies) (Little, 1999; Wakeford, 2008)	Inconclusive
Nuclear weapons test fallout (aggregate of eight studies) (Lyon *et al*., 2006)	Inconclusive