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.

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*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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https://www.ncrppublications.org/Commentaries/27
<table>
<thead>
<tr>
<th>Epidemiologic Study (or groups of studies)</th>
<th>Classification (support for LNT model)</th>
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<tbody>
<tr>
<td>Life Span Study, Japan atomic bombs (Grant et al., 2017)</td>
<td>Strong</td>
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<tr>
<td>INWORKS (French, United Kingdom, United States combined worker cohorts) (Richardson et al., 2015)</td>
<td>Strong</td>
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<tr>
<td>Tuberculosis fluoroscopic examinations, breast cancer (Little and Boice, 2003)</td>
<td>Strong</td>
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<tr>
<td>Childhood Japan atomic-bomb exposure (Preston et al., 2008)</td>
<td>Strong</td>
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<tr>
<td>Childhood thyroid cancer studies (Lubin et al., 2017)</td>
<td>Strong</td>
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<tr>
<td>Mayak nuclear workers (Sokolnikov et al., 2015)</td>
<td>Moderate</td>
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<tr>
<td>Chernobyl fallout, Ukraine and Belarus thyroid cancer (Brenner et al., 2011)</td>
<td>Moderate</td>
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<tr>
<td>Breast cancer studies, after childhood exposure (Eidemuller et al., 2015)</td>
<td>Moderate</td>
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<tr>
<td>In utero exposure, Japan atomic bombs (Preston et al., 2008)</td>
<td>Moderate</td>
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<tr>
<td>Techa River, nearby residents (Schonfeld et al., 2013)</td>
<td>Moderate</td>
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<tr>
<td>In utero exposure, medical x ray (Wakeford, 2008)</td>
<td>Moderate</td>
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<tr>
<td>Japan nuclear workers (Akiba and Mizuno, 2012)</td>
<td>Weak-to-moderate</td>
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<td>Chernobyl cleanup workers, Russia (Kashcheev et al., 2015)</td>
<td>Weak-to-moderate</td>
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<tr>
<td>U.S. radiologic technologists (Liu et al., 2014; Preston et al., 2016)</td>
<td>Weak-to-moderate</td>
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<td>Mound nuclear workers (Boice et al., 2014)</td>
<td>Weak-to-moderate</td>
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<tr>
<td>Rocketdyne nuclear workers (Boice et al., 2011)</td>
<td>Weak-to-moderate</td>
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<tr>
<td>French uranium processing workers (Zhivin et al., 2016)</td>
<td>Weak-to-moderate</td>
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<tr>
<td>Medical x-ray workers, China (Sun et al., 2016)</td>
<td>Weak-to-moderate</td>
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<tr>
<td>Taiwan radiocontaminated buildings, residents (Hsieh et al., 2017)</td>
<td>Weak-to-moderate</td>
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<td>Background radiation levels and childhood leukemia (Kendall et al., 2013)</td>
<td>Weak-to-moderate</td>
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<tr>
<td>In utero exposures, Mayak and Techa River (Akleyev et al., 2016)</td>
<td>No support</td>
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<tr>
<td>Hanford $^{131}$I fallout, thyroid cancer (Davis et al., 2004)</td>
<td>No support</td>
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<td>Kerala, India, high background radiation area (Nair et al., 2009)</td>
<td>No support</td>
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<tr>
<td>Canadian worker study (Zablotska et al., 2014)</td>
<td>No support</td>
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<tr>
<td>U.S. nuclear weapons test participants (Caldwell et al., 2016)</td>
<td>No support</td>
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<tr>
<td>Yangjiang, China, high background radiation area (Tao et al., 2012)</td>
<td>Inconclusive</td>
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<tr>
<td>Computed-tomography examinations of young persons (Pearce et al., 2012)</td>
<td>Inconclusive</td>
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<tr>
<td>Childhood medical x rays and leukemia (aggregate of $&gt;$10 studies) (Little, 1999; Wakeford, 2008)</td>
<td>Inconclusive</td>
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<td>Nuclear weapons test fallout (aggregate of eight studies) (Lyon et al., 2006)</td>
<td>Inconclusive</td>
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