Evaluation of Updated Research on the Health Effects and Risks Associated with Low-Dose Ionizing Radiation

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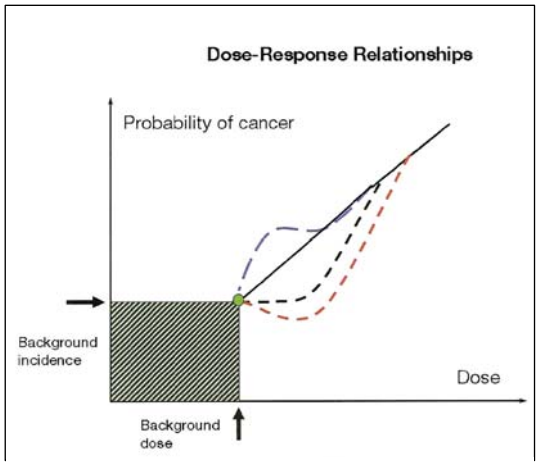
Executive Summary

Since 1983, the U.S. nuclear industry has monitored more than 100,000 radiation workers each year, and no workers have been exposed to more than 50 mSv (5 rem) in a year since 1989 [*U.S. Nuclear Regulatory Commission, 2007*]. The potential health effects of such low levels of radiation have predominantly been based on the health effects observed at high levels of radiation.

To minimize health risks at low doses, the cancer health risks from low-level radiation have historically been estimated assuming that the risk frequency observed at high doses is proportional to the risk frequency at low radiation doses. This approach, typically referred to as the "linear-no-threshold" model, implies that any level of radiation exposure results in a corresponding level of biological damage and health impacts. The EPRI analysis sought to determine whether this approach is directly applicable to the nuclear power plant environment, where doses are much lower, and dose rates are several times lower, than the high-dose atomic bomb studies on which the linear-no-threshold model is based.

The report evaluates current scientific literature on the health effects of low doses of radiation – with emphasis on new information – to determine how recent research results could enhance understanding of this issue and lead to operational or regulatory improvements.

The EPRI research team reviewed more than 200 peer-reviewed publications as part of this effort. The report summarizes background information related to the nature of radiation, sources of human radiation exposure and radiation standards, and occupational exposures in the nuclear industry. The report briefly summarizes the health effects of exposures to low levels of radiation based on the current scientific understanding of the mechanisms of risk, describes typical epidemiological approaches to assessing health effects, and discusses risk modeling applied to radiation epidemiological data.



Various models have been proposed to depict the relationship between radiation dose and health response, such as probability of cancer. Some evidence suggests the risks due to low dose-rate effects may be over-estimated.

Major advances are occurring in the use and understanding of radiobiological data for assessing low-level radiation health effects, and epidemiological advances continue at an incremental pace. Consequently, there is a continuing need to periodically re-evaluate radiation risk models. This understanding would make it possible to mitigate the uncertainty of the risk estimates associated with low doses and to develop models that are not dependent on the linear-no-threshold model. Such an understanding would also facilitate communication with

stakeholders, regulators, and the public, and provide confidence that radiation standards are protective, risk-based, and informed by science.

The analysis yielded a number of key conclusions:

- Recent radiobiological studies in the low-dose region demonstrate that the mechanisms of action for many biological impacts are different than those seen in the high-dose region. When radiation is delivered at a low dose-rate (i.e., over a longer time period), it is much less effective in producing biological changes than when the same dose is delivered in a short time period. Therefore, the risks due to low dose-rate effects may be over-estimated.

- From an epidemiological perspective, individual radiation doses of less than 10 rem in a single exposure are too small to allow detection of any statistically significant excess cancers in the presence of naturally occurring cancers. The doses received by nuclear power plant workers fall into this category because exposure is accumulated over many years, with an average annual dose about 100 times less than 10 rem.

- Research into the health effects of low-dose radiation should continue and should use holistic, systems-based approaches to develop models that define the shape of the dose-response relationships in the low-dose regions. Risk models should fuse the latest radiobiology and epidemiology results to produce a comprehensive understanding of radiation risk that addresses both damage (likely with a linear effect) and response (possibly with non-linear consequences).

While recent scientific advances have provided much new information in the low-dose region, they have also raised additional research questions. New research in areas such as systems biology can provide mechanistic understandings of low-dose and low dose-rate effects needed to estimate human cancer risks. Therefore, it is essential that research into low-dose radiation biology, dose reconstruction, and epidemiology continue in order to provide opportunities for continuous improvement in the scientific support of future regulatory and policy actions. Specific research needs in the areas of radiobiology, radiation epidemiology, and communication issues are described in the report.

The EPRI research team will continue monitoring radiobiology and epidemiological evidence to assess potential impacts on human risk management in the nuclear power industry and to ensure adequate radiological protection for workers, the public, and the environment.

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