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Health Risks from Exposure to Low Levels of Ionizing Radiation:
BEIR VII Phase 2 (2006)

Chapter: Public Summary & Executive Summary

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Public Summary

INTRODUCTION

The health effects of low levels of ionizing radiation are important to understand. Ionizing radiation—the sort found in X-rays or gamma rays¹—is defined as radiation that has sufficient energy to displace electrons from molecules. Free electrons, in turn, can damage human cells. One challenge to understanding the health effects of radiation is that there is no general property that makes the effects of man-made radiation different from those of naturally occurring radiation. Still another difficulty is that of distinguishing cancers that occur because of radiation exposure from cancers that occur due to other causes. These facts are just some of the many that make it difficult to characterize the effects of ionizing radiation at low levels.

Despite these challenges, a great deal about this topic is well understood. Specifically, substantial evidence exists that exposure to high levels of ionizing radiation can cause illness or death. Further, scientists have long known that in addition to cancer, ionizing radiation at high doses causes mental retardation in the children of mothers exposed to radiation during pregnancy. Recently, data from atomic bomb survivors suggest that high doses are also connected to other health effects such as heart disease and stroke.

Because ionizing radiation is a threat to health, it has been studied extensively. This report is the seventh in a series of publications from the Na-

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tional Academies concerning radiation health effects, referred to as the Biological Effects of Ionizing Radiation (BEIR) reports. This report, BEIR VII, focuses on the health effects of low levels of low linear energy transfer (LET) ionizing radiation. Low-LET radiation deposits less energy in the cell along the radiation path and is considered less destructive per radiation track than high-LET radiation. Examples of low-LET radiation, the subject of this report, include X-rays and γ -rays (gamma rays). Health effects of concern include cancer, hereditary diseases, and other effects, such as heart disease.

This summary describes:

- how ionizing radiation was discovered,
- how ionizing radiation is detected,
- units used to describe radiation dose,
- what is meant by low doses of ionizing radiation,
- exposure from natural “background” radiation,
- the contribution of man-made radiation to public exposure,
- scenarios illustrating how people might be exposed to ionizing radiation above background levels,
- evidence for adverse health effects such as cancer and hereditary disease,
- the BEIR VII risk models,
- what bodies of research the committee reviewed,
- why the committee has not accepted the view that low levels of radiation might be substantially more or less harmful than expected from the model used in this BEIR report, and
- the committee’s conclusions.

HOW IONIZING RADIATION WAS DISCOVERED

Why Has the Committee Not Accepted the View That Low Doses Are Substantially More Harmful Than Estimated by the Linear No-Threshold Model?

Some of the materials the committee reviewed included arguments that low doses of radiation are more harmful than a LNT model of effects would suggest. The BEIR VII committee has concluded that radiation health effects research, taken as a whole, does not support this view. In essence, the committee concludes that the higher the dose, the greater is the risk; the lower the dose, the lower is the likelihood of harm to human health. There are several intuitive ways to think about the reasons for this conclusion. First, any single track of ionizing radiation has the potential to cause cellular damage. However, if only one ionizing particle passes through a cell's DNA, the chances of damage to the cell's DNA are proportionately lower than if there are 10, 100, or 1000 such ionizing particles passing through it. There is no reason to expect a greater effect at lower doses from the physical interaction of the radiation with the cell's DNA.

New evidence from biology suggests that cells do not necessarily have to be hit directly by a radiation track for the cell to be affected. Some speculate that hit cells communicate with nonhit cells by chemical signals or other means. To some, this suggests that at very low radiation doses, where all of the cells in the body are not hit, "bystander" cells may be adversely affected, resulting in a greater health effect at low doses than would be predicted by extrapolating the observed response at high doses. Others believe that increased cell death caused by so-called bystander effects might lower the risk of cancer by eliminating cells at risk for cancer from the irradiated cell population. Although additional research on this subject is needed, it is unclear at this time whether the bystander effect would have a net positive or net negative effect on the health of an irradiated person.

In sum, the total body of relevant research for the assessment of radiation health effects provides compelling reasons to believe that the risks associated with low doses of low-LET radiation are no greater than expected on the basis of the LNT model.

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mates presented in this report have incorporated all of these advances. They show that at low or chronic doses of low-LET irradiation, the genetic risks are very small compared to the baseline frequencies of genetic diseases in the population. Additionally, they are consistent with the lack of significant adverse effects in the Japanese studies based on about 30,000 children of exposed survivors. In other words, given the BEIR VII estimates, one would not expect to see an excess of adverse hereditary effects in a sample of about 30,000 children (the number of children evaluated in Hiroshima and Nagasaki). One reason that genetic risks are low is that only those genetic changes compatible with embryonic development and viability will be recovered in live births.

RESEARCH REVIEWED BY THE COMMITTEE

The committee and staff ensured that the conclusions of this report were informed by a thorough review of published, peer-reviewed materials relevant to the committee's formal Statement of Task. Specifically, the sponsors of this study asked for a comprehensive review of all relevant epidemiologic data (*i.e.*, data from studies of disease in populations) related to health effects of low doses of ionizing radiation. In addition, the committee was asked to review all relevant biological information important to the understanding or modeling of those health effects. Along with the review of these bodies of literature and drawing on the accumulated knowledge of its members, the committee and staff also considered mailings, publications, and e-mails sent to them. Data on cancer mortality and incidence from the Life Span Study cohort of atomic bomb survivors in Hiroshima and Nagasaki, based on improved dose estimates, were used by the committee. The committee also considered radiation risk information from studies of persons exposed for medical, occupational, and environmental reasons. Models for breast and thyroid cancer drew directly on medical studies. Further information was gathered in open sessions of the committee held at meetings in Washington, D.C., and Irvine, California. Questions and concerns raised in open sessions were considered by committee members in writing this report.