Findings from the International Nuclear Workers Study (INWORKS): Ionizing Radiation and Leukemia, Lymphoma, and Multiple Myeloma

We studied deaths due to leukemia, lymphoma, and multiple myeloma in French, British and American nuclear workers who were exposed to ionizing radiation at work. Previous studies suggest exposure to high doses of ionizing radiation may cause leukemia. However, it is still unclear if low doses of ionizing radiation, which are common in some workplaces, may also cause leukemia.

What We Found

- There was significant evidence of a positive association between ionizing radiation exposure and death from leukemia (excluding chronic lymphocytic leukemia) among more than 300,000 nuclear workers.
- The excess leukemia risk increased with radiation dose.
- In our study, about one in eight workers received a total dose to the bone marrow of 50 millisieverts (mSv), (equal to 5 rem) or more. We found that the risk of leukemia increased by about 15% at 50 mSv. In the U.S., about 15 out of every 1000 people will get leukemia in their lifetime. Thus, in a population of 1000 people who were exposed to 50 mSv each, about two additional leukemia cases would be expected from their radiation exposure.
- The exposure-related risk differed by leukemia type.
  - The excess risk was greatest for chronic myeloid leukemia.
  - There was no evidence of increased risk for chronic lymphocytic leukemia.
- We found little evidence of associations between ionizing radiation exposure and death from multiple myeloma or lymphoma in the full study group. However, multiple myeloma was significantly elevated when the U.K. cohort was removed. This may be because the U.K. cohort was younger, on average, than the U.S. cohort. Myeloma rates are much higher at older ages.

What does this mean?

Exposure to ionizing radiation cannot be avoided completely. The United Nations Scientific Committee on the Effects of Atomic Radiation estimated in 2008 that the worldwide annual average effective dose people receive from natural and man-made radiation sources is about 3.0 mSv, or 0.003 Sieverts (Sv), and is increasing due to the use of radiation in health care.

The link between ionizing radiation exposure and some cancers is well known. However, much of this knowledge comes from studies of acutely exposed people, such as Japanese atomic bomb survivors and radiation therapy patients. Questions remain about using information from these studies to describe risks under much different (usually much lower) exposure conditions, such as those experienced by nuclear workers.

This study supports previous findings and strengthens the evidence of a relationship between leukemia and ionizing radiation. This relationship is observed not only at high doses following acute exposure, but also from prolonged, low exposures found in the workplace.

This information emphasizes the need

- for continued efforts to reduce ionizing radiation exposure to levels that are as low as reasonably achievable,
- and, in the case of patient exposures, to justify that the radiation exposure does more good than harm.

What should you do?

- If you currently work with radioactive materials contact your health and safety representative or employer if you have questions on how to best protect yourself from exposure.
- Share this information with your doctor if you are concerned about your health or have questions about these illnesses.

How the Study Was Done

Our approach is sometimes referred to as a retrospective cohort study, meaning that we followed the health experience of a group of people over a time period beginning at some point in the past. We followed a group (cohort) of nuclear workers from three countries over varying time periods ranging from 1944 to 2005.

We estimated these workers' excess relative risk, or ERR (that is, the relative risk minus 1) from exposure. The relative risk is the mortality rate in an exposed group compared to the mortality rate (for the same cause) in an unexposed group. For example, an ERR of 0.5 means that the risk of getting cancer among people with a given level of exposure was 50% higher than the risk among people without exposure. We were interested in the risk of certain cancers as it relates to the amount of radiation received during employment. To do this, our study had four general steps:

Step 1. We assembled the study cohort.
Employment records were used to identify 308,297 workers from France, the United Kingdom and the United States of America who worked in the nuclear industry for at least one year and were monitored for radiation exposure. The period of risk observation (sometimes referred to as follow-up) varied by country. The French, British, and American worker subgroups were followed between 1968-2004, 1946-2001, and 1944-2005, respectively.

Step 2. We evaluated each worker's potential job-related exposures.
Ionizing radiation received in the workplace was our exposure of interest. Historical records of personal monitoring data that were maintained by dose registries, government records, and employer records were thoroughly searched for information needed to estimate the absorbed dose to bone marrow from gamma radiation for each worker.

Step 3. We obtained death information.
We used national death databases and other record sources in each country to determine if a worker was alive or deceased and, if deceased, his or her underlying cause of death. For this study, we studied deaths from leukemia as a group (excluding chronic lymphocytic leukemia), as well as the subtypes acute myeloid leukemia, chronic myeloid leukemia, and chronic lymphocytic leukemia. We also looked at Hodgkin lymphoma, non-Hodgkin lymphoma.

Step 4. We examined the relationship between radiation dose and these cancers.
Using standard methods of statistical modeling, we assessed the dose-response relation between ionizing radiation exposure and each cancer outcome of interest. For consistency with other studies, the estimated risk was reported as an ERR per gray (Gy) of radiation exposure. However, typical occupational exposures are far less than that amount.

Study limitations
This study, like all observational studies, has a number of limitations. These include incomplete or imperfect information on radiation doses and other risk factors such as benzene exposure and tobacco use. The impact from these limitations is believed to be small and unlikely to change study conclusions.

For more information

Study Publication
Leuraud K , Richardson DB, Cardis E, Daniels RD, Gillies M, O'Hagan JA, Hamra GA, Haylock R, Laurier D, Moissonnier M, Schubauer-Berigan MK, Thierry-Chef I, Kesminiene A [2015]. *Ionising radiation and risk of death from leukaemia and lymphoma in radiation-monitored workers (INWORKS): An international cohort study.* Lancet Haematol DOI: http://dx.doi.org/10.1016/S2352-3026(15)00094-0

Other related papers
Hamra GB, Richardson DB, Cardis E, Daniels RD, Gillies M, O'Hagan J, Haylock R, Laurier D, Leuraud K, Moissonnier M, Schubauer-Berigan MK, Thierry-Chef I, Kesminiene A [2015]. *The International Nuclear Workers Study (INWORKS)*. Int J Epidemiol 2015, 1–7 doi: 10.1093/ije/dyv122

Thierry-Chef I, Richardson DB, Daniels RD, Gillies M, Hamra GB, Haylock R., Kesminiene A, Laurier D, Leuraud K, Moissonnier M, O'Hagan J, Schubauer-Berigan MK, Cardis, E [2015]. *Dose estimation for a study of nuclear workers in France, the United Kingdom and the United States of America: methods for the International Nuclear Workers Study (INWORKS)*, Radiat Res 183:632-642