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## "Long-Term Effects of the Rain Exposure Shortly after the Atomic Bombings in Hiroshima and Nagasaki"

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### Study Findings

Using a population of individuals responding to surveys from 1949 to 1961, we compared mortality and cancer incidence between those reporting rain exposure shortly after the atomic bombing and those reporting no such rain exposure. No increase in mortality or cancer incidence was observed in those reporting rain exposure.

### Explanation

1. Objectives

The objective of the study was to determine whether mortality or cancer incidence was higher among individuals reporting rain exposure shortly after the atomic bombing than individuals reporting no such rain exposure.

2. Methods

The study included 86,609 Life Span Study cohort members who had an estimated Dosimetry System 2002 (DS02) radiation dose. The Atomic Bomb Casualty Commission, the predecessor to the Radiation Effects Research Foundation, conducted surveys through personal interviews from 1949 to 1961. Based on these survey results, the respondents were categorized into three groups according to their response to the question on rain exposure (i.e., "Yes," "No," "Unknown"). The excess relative risks (ERRs) of mortality between 1950 and 2005 and cancer incidence between 1958 and 2005 were estimated among those reporting rain exposure relative to those reporting no rain exposure. The data were adjusted for city, sex, year of birth, attained age, and individual DS02 dose estimates from direct radiation exposure.

3. Results

- Of the individuals interviewed, 42,050 (72%) in Hiroshima and 25,064 (89%) in Nagasaki responded to the question on rain exposure. Of these, 11,661 (20%) in Hiroshima and 733 (2.6%) in Nagasaki reported rain exposure.
- The ERR of all-cause mortality from 1950 to 2005 among those who reported rain

exposure in Hiroshima was 0.01 (95% confidence interval (CI): -0.02, 0.04). The ERRs of mortality for solid cancer and leukemia for the same period were -0.02 (95% CI: -0.06, 0.04) and 0.06 (95% CI: -0.15, 0.32), respectively. No significant increase in risk was observed.

- A weak association was observed between all-cause mortality and rain exposure in Nagasaki (ERR = 0.08, 95% CI: 0.00006, 0.17) for the entire period of observation (1950 to 2005). However, the association was not statistically significant for the period after all surveys had been completed (1962 to 2005). The ERRs of mortality for solid cancer and leukemia between 1950 and 2005 were 0.14 (95% CI: -0.01, 0.33) and -0.03 (95% CI: -0.07, 0.02), respectively, suggesting no significant increase in risk.
- No increase in cancer incidence in those who reported rain exposure was observed in either city.

The individuals reporting rain exposure in Hiroshima were not at significantly higher risk of mortality from all cause, solid cancer, or leukemia or of developing solid cancer or leukemia. The findings, however, were inconsistent for those reporting rain exposure in Nagasaki; all-cause mortality risk was higher for certain observation periods and statistical models but not others. In addition, risk estimates for cancer mortality and incidence were inconsistent with each other. These inconsistencies could be attributable to the low number of individuals who reported rain exposure in Nagasaki (733), which is too small to provide reliable statistical inference. In addition, answers to the question on rain exposure would more likely be “unknown” when the 1949–1961 surveys, including the question on rain exposure, were conducted after individuals died and questions were answered by their proxies who had no knowledge regarding whether or not that individual had been caught in rain (outcome-dependent bias). It was also possible when the surveys were conducted after individuals had developed cancer or died that the respondents might have associated this health outcome with their rain-exposure experience (recall bias). For the observation period after completion of the surveys (i.e., starting in 1962), analysis results were probably less affected by these biases. For this observation period, therefore, no significant increase in risk was observed in Nagasaki. No increased risk was observed in either city for mortality from or the occurrence of leukemia, which is often taken to be a “sentinel” indicator of radiation effects. For these reasons, the association observed in Nagasaki is unlikely to be attributable to exposure to radiation from rain. In this study, a large percentage of individuals have missing data on rain exposure. In addition, we did not obtain any information on rain exposure from a considerable proportion of the subjects and no details were available on the circumstances surrounding the rainfall and how individuals experienced the rain from those providing the information on rain exposure. The results should thus be interpreted with caution.

**The Radiation Effects Research Foundation** has studied A-bomb survivors and their offspring in Hiroshima and Nagasaki for more than 60 years. RERF's research achievements are considered the principal scientific basis for radiation risk assessment by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and for recommendations regarding radiation protection standards by the International Commission on Radiological Protection (ICRP). RERF expresses its profound gratitude to the A-bomb survivors and survivors' offspring for their cooperation in our studies.

[§]***Radiation Research***, which is an official monthly journal of the Radiation Research Society, publishes original, peer-reviewed papers and review articles on radiation effects and related issues in the fields of physics, chemistry, biology, and medicine. (Impact factor in 2013: 2.445)