Paper published in *Health Physics*[§]

"DS02R1: IMPROVEMENTS TOATOMIC BOMB SURVIVORS' INPUT DATA AND IMPLEMENTATION OF DOSIMETRY SYSTEM 2002 (DS02) AND RESULTING CHANGES IN ESTIMATED DOSES"

Harry M. Cullings, Eric J. Grant, Stephen D. Egbert, Tadaaki Watanabe, Takao Oda, Fumiko Nakamura, Tomoaki Yamashita, Hiroshi Fuchi, Sachiyo Funamoto, Keiko Marumo, Ritsu Sakata, Yoshiaki Kodama, Kotaro Ozasa, and Kazunori Kodama

Health Phys 2017 (January); 112(1):56-97
(doi: 10.1097/HP.0000000000000598)

Study Findings

This study provided improved radiation dose estimates for members of the Life Span Study (LSS), based on vetting and prioritization of original source documents, restoration of the previously rounded-off digits from those documents, various cartographic and photogrammetric techniques, use of new digital terrain elevation data to estimate terrain shielding, and other improvements in various algorithms used to calculate doses from survivors' input data on location and shielding at the time of the bombings.

Explanation

We conducted a multi-year, interdepartmental program to improve survivors' dose estimates using resource materials available at RERF as well as new technologies.

1. Study purpose

Accurate evaluation of the radiation risk experienced by the atomic bomb survivors, in terms that are meaningful to other exposed populations, depends on accurate estimates of the radiation doses received by the survivors: those dose estimates constitute the divisors of the risk estimates. Starting about 2010, it became clear to investigators and staff members in the Epidemiology Department at the Radiation Effects Research Foundation (RERF) that a number of errors in survivors' map coordinates, which document the location information at the times of the bombings on which the survivors' dose estimates are based, had occurred over the years and should be corrected. In addition, it became known about that time that new technologies could be used to extract spatial information from old resources such as pre-bombing aerial photographs of Hiroshima and Nagasaki, which in turn could improve the accuracy of survivors' location estimates by specifying them in accurate new geographical coordinate systems. Another major improvement stemmed from the fact that accurate new digital terrain elevation data were available for estimating input data for terrain shielding, and advances in computer speed and memory allowed new terrain shielding to be estimated for what had previously been a patchwork of partial earlier estimates aimed at specific subsets of the LSS.

2. Study methods

All of the multiple original data collection instruments such as census and questionnaires that had been used at the Atomic Bomb Casualty Commission (ABCC) to collect survivor location data over the years from 1948 to 1963 were collated, vetted, prioritized, and used to select the most accurate location for each survivor. In addition, digits for tens of yards in map coordinates that had been truncated from many survivors' later records in the 1960s or 1970s were restored from the original records. Special technology was used to geometrically correct pre-bombing aerial photographs of the cities and assemble them into mosaics that function as photographic maps of high spatial fidelity to the locations of the original landmarks depicted on them. These "orthophotographic mosaics" were then used with Geographical Information System (GIS) software to 1) locate the neighborhood drawings of survivors with shielding histories and 2) perform "rubber-sheeting" mathematical transformations of the war-era U.S. Army maps on which survivors' coordinates were originally specified, to align them with the orthophotographic mosaics. Contemporary digital terrain elevation data on an approximately

10 m x 10 m grid were used to estimate terrain shielding input data universally for all members of the LSS, replacing far less accurate piecemeal data that dated back to 1966 in some cases. In addition, various other improvements were made to algorithms used at RERF to calculate survivors' doses, such as the calculation of average transmission factors and the truncation of implausibly high dose estimates, to minimize the effect of dose errors.

3. Study results

More accurate survivor locations and dose estimates were obtained for all members of the LSS. Differences from previous data were analyzed, depicted in plots, and summarized in tables. Systematic effects were relatively minor, but considerable random error was believed to have been removed from the dose estimates. In addition, the effects on risk estimates, compared to risk estimates obtained from the previous dose estimates, were evaluated and summarized. The effects on risk estimates were also minor.

Study Significance

In the present study a large number of errors and inaccuracies in survivors' dose estimates have been removed. The resulting improvement in dosimetric accuracy is expected to improve future risk estimates across the board for the LSS.

The Radiation Effects Research Foundation has studied A-bomb survivors and their offspring in Hiroshima and Nagasaki for around 70 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.

[§]*Health Physics*, the monthly journal of the Health Physics Society, publishes peer-reviewed original and review articles addressing radiation effects and related issues in the fields of physics, chemistry, biology, and medicine (Impact factor in 2015: 1.193).