How Reliable are the Risk Estimates Gained from the Japanese A-bomb Survivors in Cases of Chronical Low-Dose Exposures?

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Abstract
The Japanese A-bomb survivors studied by the RERF in Hiroshima are used world-wide as the reference collective to evaluate radiation risks in exposed workers and populations. For decades already, critics have doubted the compatibility of the data to other conditions of exposure for several reasons, which generally lead to an underestimation of risks. A special problem in A-bomb dosimetry by the RERF is the disregard of residual radioactivity.

The surviving victims of the Atomic bombing of the cities of Hiroshima and Nagasaki are certainly an important source of information about radiation effects. The compatibility to other conditions of exposure is, however, limited for several reasons and the ICRP risk estimates using the data of the Radiation Effects Research Foundation RERF generally lead to an underestimation for other populations, especially those affected by chronical low-dose exposures.

Critics have discussed and investigated the following items listed in Table 1.

Table 1 Problems in using the Japanese A-bomb survivors studied by the RERF as a reference for "normal" populations exposed by low-level radiations

Category	
Registration	Lack of the first 5 years after the bombardment
Epidemiology	„Survival of the fittest" Social discrimination Genetic differences
RERF-Dosimetry	ICRP: Overestimation of high dose-rate effects (DDREF) Lower effectiveness of high energetic gamma-rays Neglect of residual radiations

1) Lack of the first five years

The investigations in the research institute in Hiroshima (formerly the Atomic Bomb Casualty Commission ABCC) started not before 1950. This must be of influence for the registration of effects appearing early after the irradiation as inter alia leukaemia because of short latency periods; malformations, early deaths, and cancer after exposure in utero; genetic effects which lead to early death. The latter may be important if one considers the opinion that the last period of spermatogenesis before conception is the most sensitive one for induction of mutations. Therefore, genetic effects generated by the exposure of fathers my appear predominantly soon after the irradiation.

2) Survival of the fittest

When I visited the RERF institute for the first time in 1974, the U.S. investigator Beebee made the introduction and stated that the first period of 20 years oberservation had shown nearly no radiation effect except leukaemia, and that the mortality in the survivors was less than in the normal Japanese population. (As you know, this has then changed afterwards.)

The slogan in the title refers to the extraordinary situation for the survivors after the bombing, being in a catastrophe, wounded by physical and fire blasts, without water, food, houses and medical care. One must assume therefore that many people died who had overcome the direct power of explosion and immediate irradiation, and that the remaining survivors represent a selected population.

Alice Stewart and her coworker Kneale studied the pattern of mortality causes in the survivors and found that the non-cancer mortality was different to that in the unexposed population. They interpreted this as a consequence of damages of the bone marrow in the high-dose groups of the survivors which lead to a loss of immune competence (1).

They further investigated the age distribution for survivors being less than 5 years old at time of the bombing and those being older than 50 years, these groups must be suspected to be more sensitive because of a lower capacity for immune response (2). They found, indeed, a loss of persons in the high-dose survivors compared to the low-dose survivors showing the effect of enhanced mortality. They concluded that the findings in persons exposed in utero and being first generation descendants failed reliability.

2) Social discrimination

Some Japanese authors doubt that the informations about effects in the children of survivors are reliable, because the families were excluded by the society and parents feared that their children would not find partners for marriage (3). They therefore avoided the announcement of their origin and possible defects.

3) Genetic differences

This is an item for risk estimates for instance in European countries or other populations of caucasian or latin type etc.

4) Overestimation of high dose-rate effects

In former times of radiation research scientists believed that a radiation exposure of high dose-rate (dose per time) as valid in the case of the A-bomb explosion would be much more effective (up to a factor of 10) than a low dose-rate exposure of the same accumulated dose. That was an experience from radiation-therapy where the aim is to kill cells most effectively.

This is, however, not true in the case of induction of cell mutations. The results for the dose-response in the A-bomb survivors, showing the proportinate relation for cancer, was one of the reasons to leave the former assumption.

But the ICRP insisted up to now in a factor called DDREF to apply on the Japanese data for comparison, a dose and dose-rate effectiveness factor of 2, reducing the estimates of the RERF for other exposure conditions.

5) Lower effectiveness of high energetic gamma-rays

Straume has drawn attention to the fact that the gamma-rays following the atomic explosion are extremely high-energetic, up to 20 MeV (4). X-rays of 250-kVp (corresponding to an energy range of 15 to 250 keV) are normally taken as a reference source for the equivalent dose of low LET radiation (X-rays, gammas, betas). It is basic knowledge in radiation biology that the Relative Biological Effectiveness of these radiations also depends on the energy. The ICRP, however, uses a weighting factor w_R=1 for all photons and electrons to derive the dose equivalent in Sv from the energy dose in Gy (Joule/kg).

Occupational or environmental exposures by natural radioactivity or fission nuclides are normally of substantially lower energy than the Hiroshima radiations which lay predominantly between 2 and 5 MeV, with a mean of about 3 MeV. If the latter is used as a standard as done by the ICRP, the risk factors in other situations should be multiplied by 2-4, as is shown in the data compilation of Straume.

6) Neglect of residual radiations

As you know at least from the investigations of Prof. Sawada, a contribution of fission products delivered by the A-bomb explosions and of the radioactivity produced in materials by the neutron flux are not considered in the RERF dosimetry. This is certainly on the one hand a relic of the former opinion that low dose-rate exposures are much less effective than acute exposures. The dose estimates for the RERF about fallout and activation products - in the distances from the hypocenters of interest - have, moreover, lead to rather low values (about 5 mSv as far as I remember).

What I want to emphasize here is that the contribution must be much higher after our own considerations in the past, and that the recent results of Sawada must be taken serious and given support. The neglect of the residual component results in an underestimation of effects just as if one would work with exposed controls.

We made some studies at the university of Bremen, after I had visited an international congress of the IAEA (International Atomic Energy Agency) about radiation effects and somebody from the Eastern part of Europe, I think Yugoslavia, critized some interpretations of the Hiroshima results and the lack of fallout dose.

The ABCC-RERF used two low-dose cohorts as a control at that time. The one was the Not in City (NIC) group which consists of persons who had not been in the cities at time of the bombing, but came afterwards in order to seek for relatives or care for the victims etc. The other was the cohort with a dose below 10 mSv (1 rad) in the Life Span Study (LSS).

We studied effects which had been found in these cohorts. The dose in the LSS was estimated by the distance to the hypocentre of the bombing in every individual. Fig.1 shows the calculated doses in rad in dependence of the distance, the former estimation T65D, and the following correction by the Lawrence Livermore National Laboratory (LLNL). The actual estimation D02S would also go to zero after 2.5 km.

Additionally, the results of investigations of chromosome aberrations in survivors by Sasaki and Miyata are presented (5). These data gained by biological dosimetry show that there have been exposures up to 4 km, and generally higher ones in the low dose region than calculated by phyical reconstruction without considerung residual components.

Fig.2 shows relative risks for cancer and other causes in the NIC and the low dose group (6). We compared the rates in the LSS with data from tumour registries of Japan. You see that typical radiation effects are elevated (the relative risk=1 means equality with unexposed).

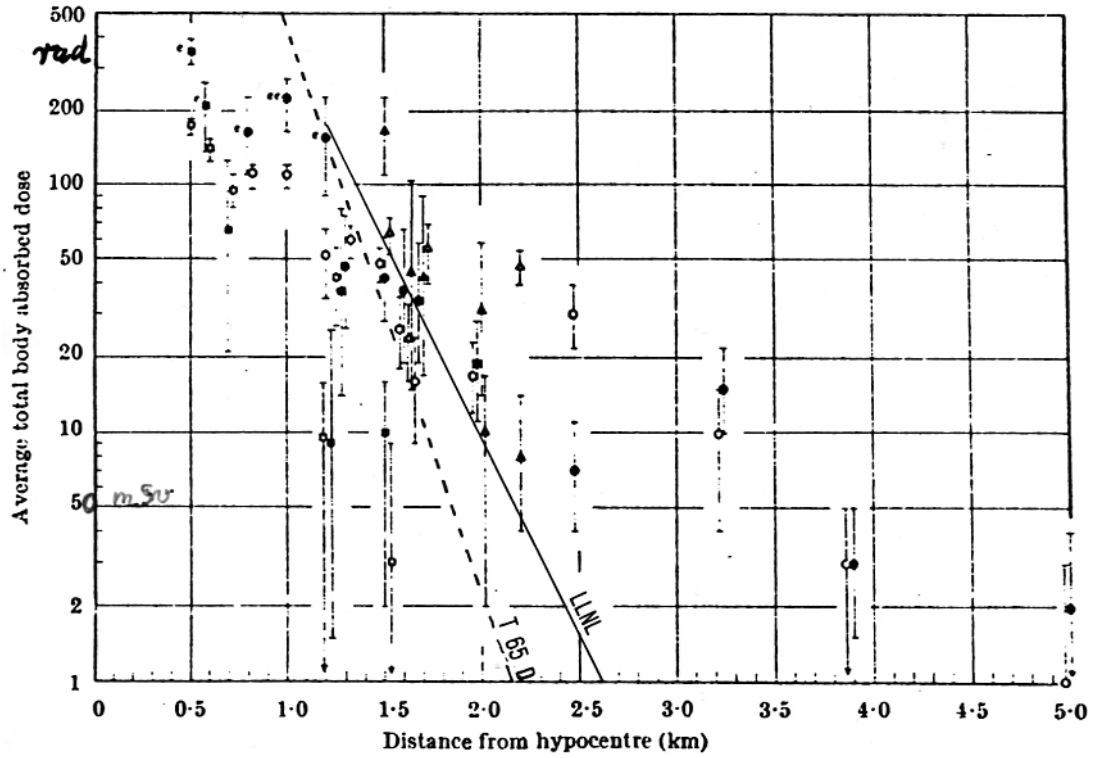

Fig.1 Whole body dose by chromosome aberrations in A-bomb survivors in relation to the distance from hypocentre in Hiroshima, from Sasaki Miyata 1968 (6). For comparison calculated doses for the ABCC-RERF Life Span Study
1 rad = 10 mSv.

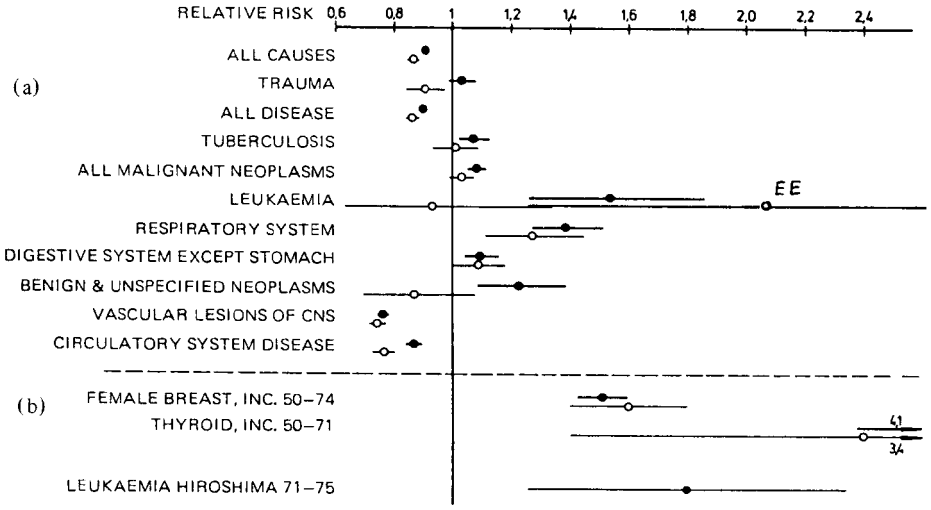

FIG.2. Standard mortality and incidence rates for cancer and other causes compared to national rates for controls in Hiroshima and Nagasaki:
—●— group 0–9 rad T65D; —○— group NIC.
taken from (6)
(a) mortality up to 1972 (and standard deviations) from ABCC [5], except EE;
(b) breast cancer incidence [6], thyroid cancer [7, 8], leukaemia 1971–75 [9];
EE = leukaemia in early entrants.

The mortality rates for diseases other than cancer are lower as in the normal population, showing the discussed selection bias.

Conclusions

The risk estimates of the ICRP for cancer induction are too low at least by a factor of 4, resulting from an unjustified dose-rate reduction factor DDREF of 2 and the higher biological effectiveness of usual gamma energies which should be also considered with a factor of 2 (at least). This is valid e.g. for exposures by environmental radioactivity as in Fukushima.

The other points are hardly to quantify, they are important in order to reject attempts of the authorities in cases when they deny radiation effects with the argument that these have not been found in the A-bomb survivors.

References

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