

RECONSIDERING HEALTH CONSEQUENCES OF THE CHERNOBYL ACCIDENT

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□ The Chernobyl accident led to major human suffering caused by the evacuation and other counter-measures. However, the direct health consequences of the accident-related radiation exposures, besides the acute effects and small number of thyroid cancers, have not been observed. This absence is challenged by some influential groups affecting public policies who claim that the true extent of radiogenic health consequences is covered up. We consider such claims. The most conservative (in this case – overestimating) linear no-threshold hypothesis was used to calculate excess cancer expectations for cleanup workers, the population of the contaminated areas and the global population. Statistical estimations were performed to verify whether such expected excess was detectable. The calculated cancer excess for each group is much less than uncertainties in number of cancer cases in epidemiological studies. Therefore the absence of detected radiation carcinogenesis is in full correspondence with the most conservative *a priori* expectations. Regarding the cover-up claims, rational choice analysis was performed. Such analysis shows that these claims are ill-founded. The present overcautious attitude to radiological hazards should be corrected in order to mitigate the present suffering and to avoid such suffering in the future.

Key words: Chernobyl, consequences, radiation carcinogenesis, cover-up

INTRODUCTION

The Chernobyl nuclear accident occurred on April 26, 1986. It killed two employees outright, and 28 more died within several weeks after receiving lethal doses of radiation (some of the fire fighters that died also had severe thermal burns). Many dire predictions were (and are still being) made. It was claimed, e.g., that over 50,000 people will die of Chernobyl-induced cancer.

In spite of the best efforts of statisticians and epidemiologists, the claimed Chernobyl-induced cancers and mutations have yet to manifest themselves.

In 2006, the US National Research Council published the extensive 424-page BEIR-VII report dedicated to the effects of low levels of low linear energy transfer (low-LET) ionizing radiation (NRC 2006). This report is one of several that review findings regarding Chernobyl – see also the

reports of Chernobyl Forum (2006), World Health Organization WHO (2006) and UNSCEAR (2008).

In most of the studies of the liquidators from Belarus, Russia, and Ukraine, increases (e.g., doubling or tripling) in the incidence of leukemia and thyroid cancer have been reported. However, “these results are difficult to interpret” (NRC 2006, p. 203) since the follow-up of the liquidators is much more active than that of the general population in the three countries, and since no increase in cancer or general mortality among the liquidators was reported. In a case-control study based on the limited dosimetric data, no significant association was seen between the risk of leukemia and radiation dose among the Russian liquidators (NRC 2006, p. 203) – namely, the liquidators had higher leukemia incidence as a group, but no dose-response within this group was observed. BEIR-VII (NRC 2006) summarizes:

“At this time [2006], no conclusion can be drawn concerning the presence or absence of a radiation-related excess of cancer—particularly leukemia—among Chernobyl accident recovery workers.”

Regarding the populations of the contaminated areas, the only traceable direct health effect of the radiation is the increase in the incidence of thyroid cancer in children. Those children consumed food contaminated by radioactive iodine just after the accident, and that consumption could easily have been avoided by issuing proper instructions. According to the Chernobyl Forum (2006), a total of about 4,000 thyroid cancers were observed; 15 died. The increase was first reported in 1990 (NRC 2006, p. 215), only 4 years after the exposure. There was immediate skepticism that such an increase was related directly to radiation exposure from Chernobyl since the latent period for radiation-related thyroid cancer was known to be much longer, about 10 years. The opinion was given that the apparent increase was largely the result of the widespread population screening (NRC 2006, p. 215). BEIR-VII considers nevertheless probable that the thyroid cancer were really caused by the radioiodine. However, the above number of 15 should be considered as the upper limit of the Chernobyl cancer death toll so far.

Regarding other types of cancer, BEIR-VII summarizes that

“there is no convincing evidence that the incidence of leukemia has increased in adult residents of the exposed populations that have been studied in Russia and Ukraine” (p. 227), and also that “there is no evidence of an increase in any solid cancer type to date” (p. 228).

There has in reality been a modest but steady increase in reported congenital malformations in Belarus since 1986. However, this increase occurred in both contaminated and uncontaminated areas! This is most probably the result of increased registration, rather than being radiation-related (Chernobyl Forum 2006, p. 20).

The direct health consequences of Chernobyl radiation, besides the acute effects, are therefore at most questionable. Unfortunately, the overall hysteria led to enormous human suffering, including that associated with the permanent relocation of more than 300,000 people. Evacuation for the majority was unjustified, and there was no justification for permanent relocation of even the closest locations (Jaworowski 2010). About 4,000,000 people living in the “contaminated” areas were officially declared victims (and many more felt so). And after being declared thus they became very real victims. Radiophobia—irrational fear of even small radiation doses—led to extremely traumatic decisions and results.

WHO (2006) mentioned:

“Evacuation and relocation proved a deeply traumatic experience to many people because of the disruption to social networks and having no possibility to return to their homes. For many there was a social stigma associated with being an ‘exposed’ person ...”

According to the Chernobyl Forum (2006),

“The most pressing health concerns for the affected areas thus lie in poor diet and lifestyle factors such as alcohol and tobacco use, as well as poverty and limited access to health care”. The Forum concludes that “the mental health impact of Chernobyl is the largest public health problem unleashed by the accident to date.”

It is often claimed that the direct health consequences of the exposure are much more severe than described above. Two kinds of arguments are made to support such claims.

- The medical data were and still are filtered by the governments of the USSR, Ukraine, Russia and Belarus to draw attention away from their misconduct and to reduce their responsibilities.
- The data are analyzed by agencies that are connected to nuclear energy and are therefore pro-nuclear biased and interested in diminishing the Chernobyl accident consequences.

Such claims deserve consideration since they are endorsed, among others, by persons and parties affecting public policies, e.g. in European Parliament (Fairlie and Sumner 2006).

METHOD

The most conservative (in this case – overestimating) linear no-threshold hypothesis (LNTH) of radiation carcinogenesis was used to predict excess cancer expectations for cleanup workers, population of the contaminated areas and global population. LNTH, widely accepted but seriously questioned and debated, assumes that radiogenic cancer risk is proportional to the radiation exposure; the proportionality coefficient is based on epidemiological studies of the atomic bomb survivors in Japan. The numbers of the expected excess cancers were quantitatively compared with the estimated uncertainties in epidemiological studies, both statistical and systematic, to verify whether such expected excess was detectable.

Regarding the cover-up claims, rational choice analysis was performed. Such analysis deals with incentives and agents' reactions on incentives. The basic assumption is that the agents (either persons or organizations) act in their best interests, given their information (Aumann 2005).

RESULTS

LNTH estimation of excess cancer deaths

First, let us consider the estimate of 50,000 deaths worldwide as a result of Chernobyl. This estimation was based on calculations of the collective total-body absorbed dose to the inhabitants of the Northern Hemisphere via the pathways of external exposure and ingestion of radionuclides with food (Anspaugh *et al.* 1987). The calculation yielded collective dose of 630,000 person-Gy for the 1-st year and 1,200,000 person-Gy for the 50-year period. The death toll calculation was derived by multiplying the above doses by the solid-cancer-mortality risk factor for mixed-aged population – about 5% per Gy (see e.g. NRC 2006, p. 281). The above risk factor is based on epidemiological studies of the atomic bomb survivors in Japan according to the widely accepted (but seriously questioned and debated) linear no-threshold hypothesis (LNTH) of radiation carcinogenesis. It should be noted here that probably all advisory bodies recommend against multiplying trivial doses by large populations to predict excess cancers – that is the official position of UNSCEAR (2012), International Commission on Radiological Protection (Gonzalez *et al.* 2013), Health Physics Society (HPS 1996) and Australasian Radiation Protection Society (Higson 2007). Not accounted for is the uncertainty in determining the doses over the Northern Hemisphere. Let us consider whether the above number of 50,000 excess cancer deaths is observable.

Mean rate of cancer mortality is about 110 per 100,000 persons per year in the developed countries (Jemal *et al.* 2011). Therefore, roughly speaking, of the 1 billion population of the developed countries, 1.1 million people die annually from cancer. Over 50 years, this yields about 50,000,000 cancer deaths (the approximation is extremely crude but gives the correct order of magnitude). The uncertainty of the above figure should be taken as about 5% or 2,500,000 since the cancer mortality rate differs within $\pm 5\%$ between different developed countries (e.g. 1.05 per 1000 in North America but 1.145 per 1000 in northern Europe). We must conclude that there is absolutely no way to detect the predicted 50 out of 50,000 ± 2500 (thousands cancer deaths).

Second, let us consider the “liquidators,” also referred to as “cleanup workers.” Approximately 200,000 of them labored in the 30 km zone in 1986–1987 according to BEIR-VII (NRC 2006, Table 8-9 at p. 202). Their exposures were monitored in real time and their average whole-body effective dose is estimated to be 100 mSv. The excess risk estimation below (assuming LNTH) is based on the model recommended by BEIR-VII. Taking into account that the liquidators were mainly males around 30 years of age (solid cancer incidence risk factor 0.06 Sv^{-1} – see NRC 2006, Table 12-6 at p. 281), 100 mSv should cause about a 0.6% life-time cancer incidence on top of the natural 42% (Fig. PS-4, p. 7). Namely, 1200 cancers should be diagnosed on top of 80,000 ± 300 (1σ) natural cancers. Such an excess, if not masked by systematic errors, could be statistically significant. However, the systematic errors are high. As mentioned just above, within the developed countries, the cancer mortality varies by $\pm 5\%$. The same uncertainty may be with reasonable justification applied to the cancer rate of the affected regions with their highly volatile socio-economic situation, making observation of cancer excess among liquidators a formidable task. Similar conclusions are probably valid for the population of the “strict control zone” – 270,000 people who received an average whole-body effective dose below 60 mSv (according to NRC 2006, Table 8-9, p. 202).

Finally, let us consider the general population. About 3,700,000 people lived in the territories that were officially declared as “contaminated.” The average whole body effective dose for this population was reported below 15 mSv (NRC 2006, Table 8-9, p. 202). The corresponding LNT estimation for cancer incidence excess ($0.015 \text{ Sv} \times 0.1 \text{ Sv}^{-1}$) is about 0.15% for mixed-aged population. As discussed above, such excess cannot be observed given the uncertainties of the natural cancer incidence rate.

We find therefore that the absence of detected radiation carcinogenesis is in correspondence with the LNTH which is the most conservative (overestimating) interpretation of the scientific knowledge.

Rational choice analysis of the cover-up claims

Cover-up of disaster consequences is not unusual in general. Let us consider reasonable incentives and their plausible outcome in the particular case of Chernobyl.

Regarding the filtering of data by the host countries—while such cover-up was certainly performed during the early years, the situation is just opposite since the collapse of the Soviet Union. The Ukrainian government, a bitter rival of Russia, has zero—or rather, negative—interest in covering up the misconduct of the Soviet authorities 25 years ago. The same is likely true, though probably to lesser extent, for Russia and Belarus. On the other hand, all the affected countries are keenly interested in *exaggerating* the health consequences, taking into account the extensive Western investment in the relief of Chernobyl victims and in dealing with the still-problematic damaged reactor.

Regarding the pro-nuclear bias of the international scientific bodies to under-estimate cancer mortality increase etc., two statements should be made.

- a) The data cited above is freely available to the scientific community. Profoundly anti-nuclear circles (including but not limited to Green parties, fossil fuel and renewable energy industries) have significant influence in many developed countries (including Germany with its considerable weight in the European Union)—and, therefore, a significant budget to fund independent analysis that would challenge any pro-nuclear bias, if it really existed.
- b) The pro-nuclear bias hypothesis is in contradiction with the simple fact that the above-mentioned respected organizations (including the BEIR-VII committee) promote the linear no-threshold hypothesis (LNTH) of radiation carcinogenesis, to the discomfort of the nuclear industry. In addition, some of the cited evidence (e.g. that cancer mortality of nuclear workers is generally lower than in reference populations) explicitly contradicts the LNTH, and the best that could be said by BEIR-VII (NRC 2006, p. 10), was: “...*there is no compelling evidence to indicate a dose threshold below which the risk of tumor induction is zero*”. BEIR-VII and other advisory bodies deny thresholds for radiation carcinogenesis despite the cited evidence. Therefore the evidence itself should be trusted.

It can be concluded that the claims regarding cover-up of the Chernobyl data are ill-founded also from the point of view of rational choice analysis.

DISCUSSION

The scale of the Chernobyl accident was unprecedented—and probably about the largest theoretically possible. As formulated by Jaworowski (2010),

Chernobyl was the worst possible catastrophe. It happened in a dangerously constructed nuclear power reactor with a total meltdown of the core and 10 days of free emission of radionuclides into the atmosphere. Probably nothing worse could happen.

Nevertheless, as shown in the previous section, even according to the officially-“conservative” (i.e. actually overestimating) LNTH model Chernobyl radiation consequences would be *a priori* undetectable. The *a posteriori* findings summarized in the Introduction are therefore fully consistent with highest expectations. Moreover, the principle of refutability demands that any scientific statement should contain information about how to disprove it. As formulated by Popper (1963),

“A theory which is not refutable by any conceivable event is non-scientific. Irrefutability is not a virtue of a theory (as people often think) but a vice.”

Therefore, the often-cited claim that the excess cancers are present but undetectable – is simply not scientific. More generally, the same can be probably said about the very use of LNTH: even largest-scale nuclear disasters cannot provide evidence that refutes this hypothesis; the same conclusion was reached by Socol and Dobrzyński (submitted) regarding the Japan atomic bomb survivors, as will be reported separately. Lauriston Taylor, the late president of the U.S. National Council on Radiological Protection and Measurements, deemed such LNTH-based estimates to be “*deeply immoral uses of our scientific heritage*” (Taylor 1980). Let us mention, by the way, that Taylor himself received a whole-body effective dose estimated to be more than 10,000 mSv – corresponding to 100% cancer risk according to the LNTH – when he was 27 years old (Taylor *et al.* 2004). Nevertheless, he died peacefully at the age of 102.

As for highly dreaded congenital malformations and popular myths of two-headed animals and children, it should be mentioned that mutants were born before the Chernobyl accident. For example, a 300-year-old child’s skeleton with two heads and three arms is exhibited in the Kunstkamera Museum (St. Petersburg, Russia, inventory number: No. 4070-914) and two-headed calf born in 1976 – in Beit Haim Sturman museum (Ein Harod, Israel).

It can be summarized thus: misconceptions and myths about the threat of radiation led to heightened anxiety and the tendency to associate every observed health effect with Chernobyl. These factors promoted increased suicides and paralyzing fatalism among residents. All the above, coupled with smoking and alcohol abuse, proved to be much greater problems than radiation.

Unfortunately, these lessons have not been learned. A recent memorandum of the International Commission on Radiological Protection (Gonzalez *et al.* 2013) admits that the LNT model yields “*speculative, unproven, undetectable and ‘phantom’ numbers,*” but nevertheless finds the model “*prudent for radiological protection.*” As a result of over-protection, the same kind of suffering is occurring in Fukushima (the accident, caused by an unprecedented natural disaster, with the total meltdown of three reactors, was of a lower order-of-magnitude than in Chernobyl). Here more than 50 patients of evacuated hospitals died within several days as a direct consequence of the unfounded evacuation (Tanigawa *et al.* 2012), and more than 1000 people died within two years owing to various evacuation-related non-radiogenic (mainly psychosomatic) problems (Saji 2013). Additional ethical issues of radiation health over-protection are considered in a recent paper (Socol *et al.* 2014). Historical and economical analysis of such policies is provided in (Socol *et al.* 2013).

CONCLUSIONS

It is concluded that, unlike the widespread myths and misperceptions, there is little scientific evidence for carcinogenic, mutagenic or other detrimental health effects caused by the radiation in the Chernobyl-affected area, besides the acute effects and small number of thyroid cancers. On the other hand, it should be stressed that the above-mentioned myths and misperceptions about the threat of radiation caused, by themselves, enormous human suffering. The authorities did not learn this lesson from Chernobyl, and the same kind of suffering is occurring in Fukushima. The lessons should finally be learned and the present overcautious attitude to radiological hazards should be corrected in order to mitigate the present suffering and to avoid such suffering in the future..

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