

## ORIGINAL RESEARCH ARTICLE

# Exaggeration of consequences of low-dose radiation exposures with special reference to cataracts

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### ABSTRACT

Publications overestimating the medical and ecological sequels of a slight anthropogenic increase in the radiation background have been reviewed recently with examples of different organs and pathological conditions. The overestimation contributed to the strangulation of atomic energy. The use of nuclear energy for electricity production is on the agenda today due to the increasing energy needs of humankind. Apparently, certain scientific writers acted in the interests of fossil fuel producers. Health risks and environmental damage are maximal for coal and oil, lower for natural gas, and much lower for atomic energy. This letter is an addition to previously published materials, this time focused on studies of cataracts in radiation-exposed populations in Russia. Selection and self-selection bias are of particular significance. Apparently, the self-reporting rate correlates with dose estimates and/or with professional awareness about radiation-related risks among nuclear workers or radiologic technologists, the latter being associated with their work experience/duration and hence with the accumulated dose. Individuals informed of their higher doses would more often seek medical advice and receive more attention from medics. As a result, lens opacities are diagnosed in exposed people earlier than in the general population. This explains dose-effect correlations proven for the incidence of cataracts but not for the frequency of cataract surgeries. Along the same lines, various pathological conditions are more often detected in exposed people. Ideological bias and the trimming of statistics have not been unusual in the Russian medical sciences. It is known that ionizing radiation causes cataracts; however, threshold levels associated with risks are understudied. In particular, thresholds for chronic and fractionated exposures are uncertain and may be underestimated.

**Keywords:** ionizing radiation; cataract; lens opacity; East Urals radioactive trace

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## 1. Introduction

The fossil fuel supply is not endless. External supplies of energy, e.g., for agriculture, will probably not last long, especially for countries that will not be able to afford the next leap in oil prices<sup>[1]</sup>. The exaggeration of the medical and environmental side effects of nuclear energy contributes to its strangulation<sup>[2,3]</sup>. The Chernobyl disaster has been used to discredit nuclear power<sup>[4]</sup> in order to maintain higher prices for fossil fuels. The escalation of conflicts contributes to the elevation of prices for oil and natural gas. By analogy with Chernobyl, the shutdown of the Zaporozhie nuclear power plant (the largest in Europe) has enhanced demands for fossil fuels. The weightiest consideration against nuclear facilities is that they are potential war targets. Some green initiatives, including campaigns to dismantle nuclear power stations<sup>[5]</sup> are self-damaging activities partly sponsored from abroad. The environmental movement is founded on new economic realities; it rested largely on a foundation of economic prosperity and complacency. When prosperity is threatened, the attitude must change<sup>[6]</sup>. It is obviously

unfavorable for the economy to redesign technologies, in which billions have been invested, in order to conform to ecological requirements. As a result, some industries and modern technologies flee to countries with less stringent standards and less legalistic traditions<sup>[7]</sup>. Nuclear power is a sustainable energy source devoid of the unpredictability of wind and solar energy; it uses fuels with high energy density, which facilitates transportation<sup>[8]</sup>. Hopefully, nuclear fission will be replaced in the future by fusion, which is intrinsically safer. The fusion should offer a source of safe, clean power generation with a plentiful supply of raw materials<sup>[9,10]</sup>. Durable peace and international cooperation are needed for this and other large-scale projects.

The exaggeration of harm from a slight-to-moderate anthropogenic increase in the radiation background has been discussed previously with regard to different organs and pathological conditions<sup>[2,3,11]</sup>. This letter, focused on lens opacities, is an addition to previously published materials. The topic is discussed here mainly on the basis of radiation-exposed populations in the former Soviet Union (SU). Sequels of radioactive contamination in the Urals have been, taken together, more severe than in the territories contaminated after the Chernobyl accident. The Mayak Production Association (hereafter Mayak) near Chelyabinsk has been the first plutonium production site in SU, built in 1948. The contamination in the Urals has continued since the forties, while there have been accidents in the meantime: the Kyshtym disaster, the dispersion of radioactive materials from the waste depository lake Karachai, and the contamination of the river Techa and its valley.

## 2. Materials and methods

The purpose of this letter was evaluation of potential bias in certain studies taking into account preceding analyses of works by the same research groups. It is important to include into reviews and meta-analyses only reliable reports. The author agrees that “certain studies<sup>[12–15]</sup> should probably not be used for epidemiologic analysis, particularly... the Russian worker studies”<sup>[16]</sup>. The search of international literature was performed using PubMed. Russian-language professional publications were searched on the Internet, in libraries and the electronic database Elibrary.ru. Of note, this letter is not a review on the cataractogenic effects of low radiation doses; it does not aim at determining of risks or thresholds.

## 3. Results

Results and conclusions of the research reporting associations between individual doses  $\geq 250$  mSv and the risk of cataracts among Mayak employees<sup>[17–19]</sup> have been doubted<sup>[20,21]</sup>. One of the reasons for doubts was the fact that a significant association between lens opacities and radiation doses was reported but the well-known correlation between cataracts and diabetes was not demonstrable<sup>[17,19,21]</sup>. After publication of the comments<sup>[21]</sup>, the topic of diabetes mellitus was excluded from the subsequent paper<sup>[22]</sup>. Another study that provided grounds for the threshold lowering down to  $\leq 500$  mGy of protracted exposure was performed among Chernobyl liquidators, where the authors noticed uncertainties of dosimetry<sup>[23]</sup>. Chernobyl cleanup workers (liquidators) underwent regular medical checkups so that detection rates of various diseases were higher among them compared to the general population<sup>[24]</sup>. Other reports on enhanced risks of non-malignant conditions under the impact of low-dose irradiation<sup>[12,13,25–30]</sup> have been discussed previously<sup>[2,3,11]</sup>.

The most important argument in favor of the selection and self-selection bias was the absence of significant correlation between radiation doses and surgical treatments of cataracts<sup>[31]</sup>. It can be reasonably assumed that lens opacities were averagely diagnosed earlier in exposed people, at a stage when surgery was not yet indicated. Analogous results were obtained in studies of radiologic technologists, who are, similarly to employees of nuclear industry, generally informed about radiation-related risks and possess “medical literacy”<sup>[32]</sup>. Technologists with a longer work experience and correspondingly higher accumulated doses had an increased risk of lens opacity but no increase in the risk of cataract surgery<sup>[32]</sup>. The dose-related frequency elevation of the surgical cataract treatment was found only in victims of atomic bombardments of Hiroshima

and Nagasaki (Life Span Study—LSS)<sup>[33]</sup>, where the dose rate was much higher than in professional workers and residents of contaminated territories.

Until recently, the threshold for detectable opacities was assumed to be on the order of 2 Gy for acute exposures and 5 Gy if the dose was highly fractionated or protracted. For vision-impairing cataracts, these thresholds were regarded to be 5 Gy and >8 Gy, respectively<sup>[34]</sup>. According to UNSCEAR 1982 Report, the dose of at least 3–5 Gy was needed to cause a significant lens opacification in animals with a similar to human susceptibility to cataracts. Minimal persistent opacities were observed after an acute exposure with a dose of 1–2 Gy<sup>[35]</sup>. Only a small number of studies provided explicit biological and mechanistic evidence at doses < 2 Gy<sup>[33,34]</sup>. Later on, the International Commission on Radiological Protection (ICRP) [36] has proposed a lower threshold: the recommended dose threshold for the lens was reduced from ~2 Gy for acute exposures to 0.5 Gy. The basis for the revision was mainly the study<sup>[23]</sup>, which reported the occurrence of cataracts 12–14 years after irradiation among liquidators (clean-up workers) of the Chernobyl nuclear power plant accident<sup>[37]</sup>. The authors of the article noted the possibility of “underestimation of uncertainties” in dosimetry<sup>[23]</sup>. The information about mechanisms of how radiation might cause or contribute to the development of cataracts at this dose level is regarded to be insufficient<sup>[33]</sup>. Not all epidemiological studies support such a low threshold<sup>[36]</sup>. Nakashima and colleagues observed the threshold point estimate to be 0.6–0.7 Sv, with a lower confidence limit including zero, for cataracts in A-bomb survivors<sup>[38]</sup>; but the acute exposure is not the same as that protracted over years in professional workers or residents of contaminated areas. Earlier assessments of the LSS data produced higher threshold values. A threshold for chronic exposures was judged as uncertain due to a lack of evidence<sup>[37]</sup>.

Of particular interest are the gender-related data about the frequency of supposedly radiogenic cataracts in Mayak employees and residents of the Techa River valley, namely the significantly higher excess relative risk in women than in men<sup>[22,31,39,40]</sup>. The reason is obvious for an inside observer, being unrelated to radiation. It is known and seen that aged women visit medical institutions more frequently than men in Russia. Some males encounter a less attentive attitude if assumed to be alcohol abusers. Many chronically ill male patients don't receive regular care. Apparently, this is one of the reasons for the worldwide largest gender differences in life duration/expectancy in some ex-Soviet countries<sup>[41]</sup>.

## 4. Discussion

The tendency to overestimate health-related risks from low-dose low-rate exposures to ionizing radiation in publications from the former SU has been noticed in Chernobyl-related studies since the 1990<sup>[42–44]</sup> and in those from the Urals since the mid-2000s<sup>[12,13,25–30]</sup>; commented previously<sup>[2,3,11,45–47]</sup>. Earlier data by the same and other Russian researchers did not confirm associations of cataracts with doses  $\leq 2\text{--}4$  Gy<sup>[48–51]</sup>. Neither cancer nor other health risks were exaggerated in earlier works<sup>[52–56]</sup>. According to the insider's observations, behind the changed attitude was an unofficial directive to overestimate low-dose radiation effects. The motives included fostering radiophobia, stirring anti-nuclear protests in other countries, and strangulation of nuclear energy aimed at boosting of fossil fuel prices<sup>[2,3,11]</sup>. In particular, risk estimates by Azizova et al.<sup>[29]</sup> were found to be significantly higher than those by other researchers<sup>[57]</sup>.

Radiation dose reconstructions in human populations are often imprecise. Screening effect, selection, self-selection, recall, and other biases in epidemiological research may lead to the appearance in the future of new reports on enhanced health risks associated with a slight anthropogenic increase in the radiation background. Such reports will prove no causality. In experiments, the doses and dose rates leading to lens opacities have been generally higher than the averages in human populations discussed above (apart from LSS), being dependent on hereditary predisposition<sup>[33,58–61]</sup>. Some recent studies used genetically manipulated or mutant animals. Such data are not directly extrapolatable to humans.

It is essential for radiation protection to determine threshold doses. Large-scale animal experiments involving different species are a reliable tool to determine thresholds. Admittedly, studies with primates, which might be similar enough to humans to extrapolate the results directly, are expensive, while conclusions based on data from laboratory animals are associated with uncertainties. Experiments with low radiation doses are feasible in animal breeding facilities. The use of various species would enable more precise extrapolations to humans. The monitoring of exposed populations and epidemiological studies are necessary, but potential biases and confounding factors should be taken into account<sup>[62]</sup>. Of particular importance is the selection and self-selection bias. In general, the higher the dose estimate, the greater the chance to undergo a medical examination. Accordingly, various diseases are diagnosed a priori more often in people receiving higher doses of ionizing radiation. A reasonable approach has been proposed: to determine threshold doses and dose rates on the basis of extensive experimental and also epidemiological research, shielded from bias and conflicts of interest, and to formulate safety regulations to ensure that radiation doses are kept well below the thresholds<sup>[63]</sup>.

## 5. Conclusion

The evidence in favor of a cause-effect relationship between low-dose, low-rate exposures to ionizing radiation and cataracts is unconvincing, and further studies are needed. Currently used thresholds and occupational dose limits are chiefly based on epidemiological studies that are potentially loaded with bias. Only a small number of studies provide explicit biological and mechanistic evidence at doses  $<2$  Gy<sup>[33,34]</sup>. In particular, thresholds for chronic and fractionated exposures are uncertain and seem to be underestimated. Trimming of statistics has not been infrequent in the Russian medical sciences<sup>[64]</sup>. It is important to include in reviews and meta-analyses only reliable reports; otherwise, excessive precautions might be recommended, which is harmful to the national economy. Tendentiousness is recognizable in some reports, apparently aimed at boosting fossil fuel prices by means of the strangulation of nuclear energy. A safe implementation of nuclear power must be managed by an authority based in developed countries. The economy should become more independent from politically unstable regions of the world<sup>[1]</sup>, including those producing fossil fuels. Unfortunately, current international tensions are not contributing to this development.

## Conflict of interest

The author declares that there is no conflict of interest.

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