Cataracts

§2.3.2 in the draft report of ICRP Task Group 111
"Factors Governing the Individual Response of Humans to Ionising Radiation"

Consultation webinar
20:30-20:40 JST, 9 April 2026

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Non-cancer effects on the eye

- ICRP has listed cataracts as a radiation health hazard since 1950, and has recommended dose limits for the ocular lens to prevent vision-impairing cataracts since 1954.
- Since 1959 (*Publication 1*), ICRP has considered that the lens, bone marrow and gonads are among the most radiosensitive organs/tissues.
- In 2011 (*Publication 118*), ICRP recommended a threshold of 0.5 Gy: at a higher dose, there is emerging evidence for an elevated risk of normal-tension glaucoma in the AHS of Japanese atomic bomb survivors (Kiuchi et al. 2013) and Russian Mayak nuclear workers (Azizova et al. 2022).
- A conclusion in 1984 (*Publication 41*) remains unchanged that the lens is the most radiosensitive ocular structure, so a focus shall be placed on cataracts.

¶167,209 & 210 in the TG 111 draft report

Evidence base

- A systematic review was conducted (Barnard and Hamada 2023).
- Table 2.9 lists 17 human epidemiological studies in AHS, USRT, Mayak workers, Chinese HNBRA residents, and astronauts.
- Table 2.10 lists 22 experimental studies: 17 in vivo studies using rodents (mice, rats, moles), 5 in vitro studies using LECs of human or bovine origin.
- There is no consensus about potential effect modifiers, but a brief outline is given for heritability, potential roles of age, biological sex, lifestyle, comorbidity, co-exposure, hormonal factors, immune cells and genetics/epigenetics, and approaches for predictions.

¶211–220 in the TG 111 draft report

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Heritability

- Evidence within the human population is limited.
- Germline mutations of certain genes (e.g., crystallins, connexins) underlie congenital cataracts, but the relevance to radiation is unknown.
- White skin tone is associated with higher radiation risk than other tones in USRT (Little et al. 2020).
- Certain SNPs of ATM and p53 increase radiation risks in Chinese HNBRA residents (Gao et al. 2022).

¶221 in the TG 111 draft report

Potential effect modifiers (1)

Age

- Higher radiation risk at younger age at exposure in AHS and higher attained age in Mayak workers.
- Younger age at exposure tends to cause higher incidence in animals, although the age response varies unintuitively: e.g., rats exposed at older age had a higher progression rate, but those at younger age had a shorter latency and a higher incidence (Dynlacht et al. 2012).

Biological sex

- Higher radiation risk in Mayak females and in AHS males.
- Higher incidence in male rats after low-LET radiation, but in females after high-LET radiation (Dynlacht et al. 2008; Henderson et al. 2012).

¶222–224 in the TG 111 draft report

Potential effect modifiers (2)

Lifestyle, comorbidity, co-exposure

- Higher radiation risk in diabetics in USRT and Mayak workers, but not in AHS.
- Less evidence available for diets, smoking, alcohol consumption and UV.

Hormonal factors

- Cataractogenesis in ovariectomized rats was facilitated by pre-irradiation administration of estrogen, but spared by post-irradiation administration (Dynlacht et al. 2008).
- Radiation cataractogenesis did not occur in hypophysectomized frogs, but occurred in frogs with pituitary hormone replacement (von Sallmann et al. 1962).

¶224–229 in the TG 111 draft report

Potential effect modifiers (3)

Immune system

- The role of cell-mediated immunity should be limited, as the lens capsule takes immune cells from entering the lens.
- The role of persistent inflammation is unknown.

Genetics/epigenetics

- Mice haploinsufficient for Atm, Rad9, Brca1 and Ptch1 show increased sensitivity to radiation cataracts.
- Certain SNPs of ATM and p53 increase radiation risks in Chinese HNBRA residents (Gao et al. 2022).
- The role of epigenetic factors is unknown.

¶230–233 in the TG 111 draft report

Conclusions and toward prediction

Conclusions

- Potential effect modifiers include sex, age and genetics, along with important roles of comorbidity (e.g., diabetes) and co-exposures; however, no firm conclusions can yet be reached.
- Further studies would be needed.

Predictions

- Radiation cataractogenesis is considered attributable to mechanisms other than cell killing.
- ATM, differentiation potential, and crystalline oxidation may be useful.
- Spatiotemporal cataractous changes can be monitored almost non-invasively.

¶234–237 in the TG 111 draft report

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