Epidemiology and Mechanistic Effects of Radiation on the Lens of the Eye

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Special Meeting on Dose to the Lens of the Eye

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Ottawa, Canada

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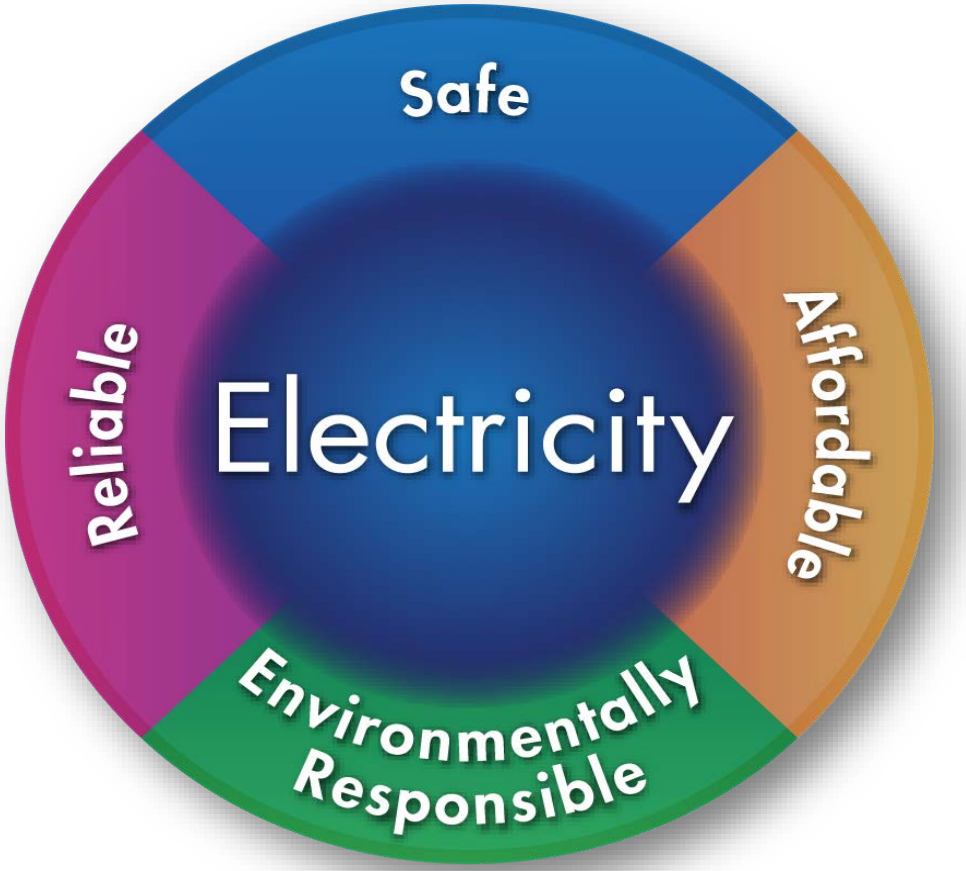
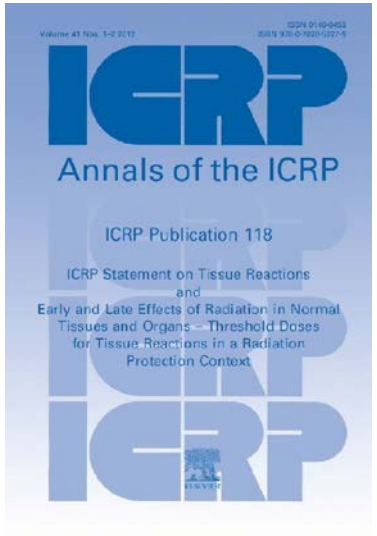
EPRI's Mission

Advancing ***safe***, ***reliable***, ***affordable*** and ***environmentally responsible*** electricity for society through global collaboration, thought leadership and science & technology innovation



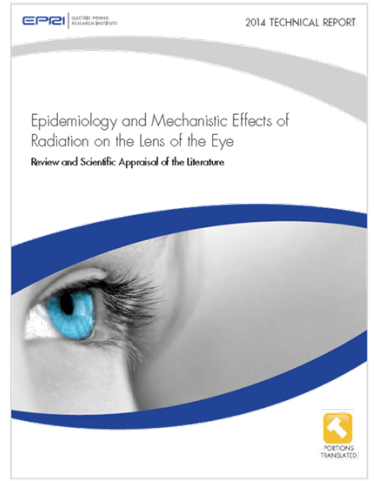
Independent, Collaborative, Nonprofit

EPRI Initiatives Following ICRP Statement on Tissue Reactions (ICRP Publication 118)



Fundamental Science

- Evaluation of epidemiology and mechanistic effects (3002003162)
- Analysis of monitoring practices (3002000486)



Plant Application

- Good practices and considerations for monitoring lens of the eye (3002010626)
- Protection factors for lens of the eye (2017+)

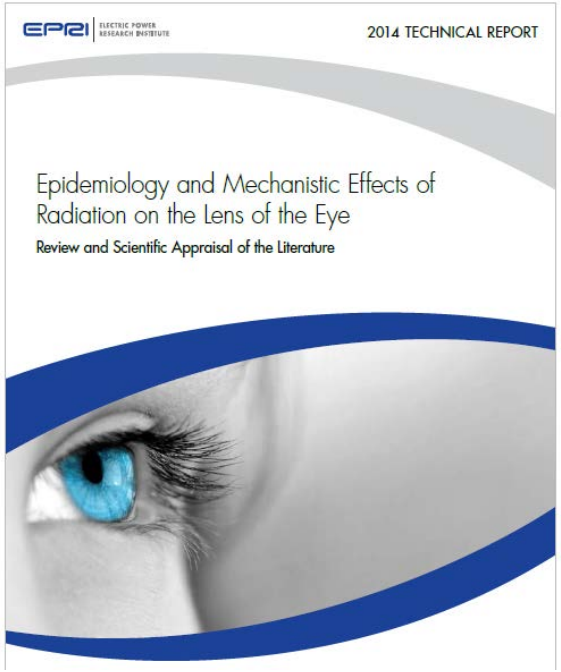
Communication

- Support of NCRP Commentary No. 26
- 2016 EPRI Workshop (3002009112)
- Ongoing industry discussions

Epidemiology and Mechanistic Effects on the Lens of the Eye (3002003162)

Objectives:

- Perform an independent “state of the science” evaluation to understand the technical basis for the ICRP recommendations.
  - Include studies post-ICRP publication
  - Assess relative strength of scientific studies

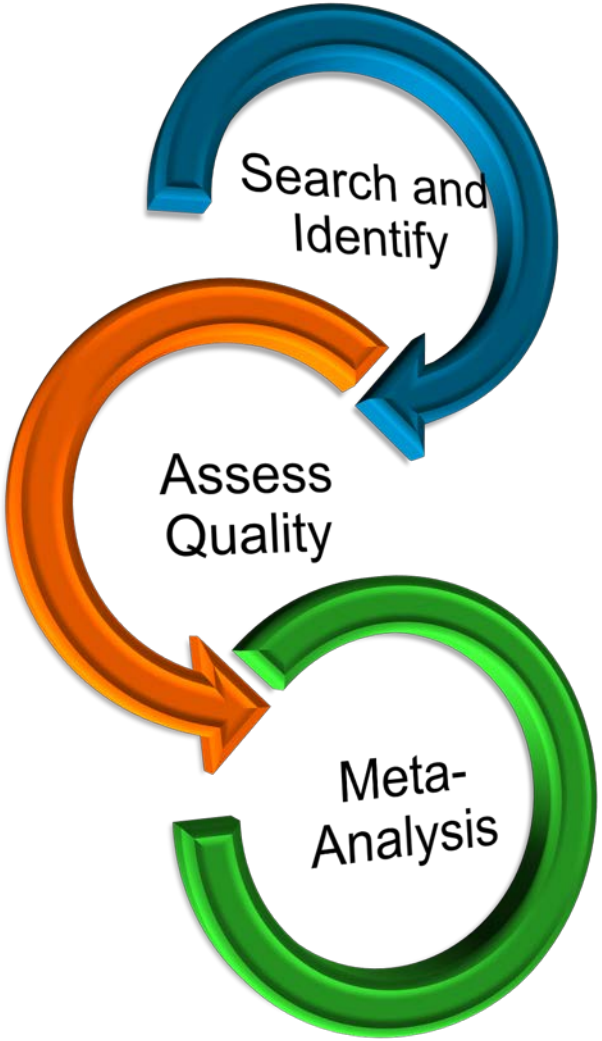


Evaluate Previous and Current ICRP Basis and Criteria → **Review Current Epidemiological and Mechanistic Study Results** → **Assess risk (probability) for cataracts** → **Publish EPRI Analysis and Communicate Findings**

EPRI Contribution: Quality Assessment Driven Results

Approach

- Rigorous, systematic approach to assess the methodological strengths and weaknesses/limitations
- Applied transparent criteria and classified studies by quality tiers
- Meta-analyses of reliable studies
  - Cataract Risks (odds ratio at 1 Gy)
  - Threshold Effects
- Review of molecular, cellular, and animal studies on the basic types and biology of cataract development



Methodology

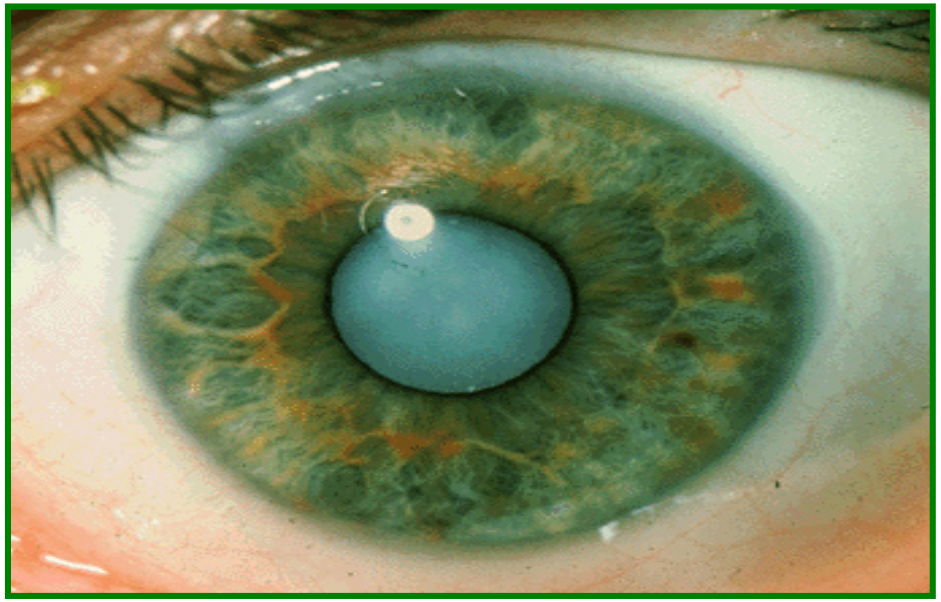
- **Literature Review:**
  - Evaluated > 300 studies, reviews, and other references
  - Larger number of studies than previous reviews
- **Evaluation Matrix:**
  - Established criteria based on EPA example*
  - Categorized human studies into 3 tiers:
    - Tier 1: Most informative
    - Tier 2: Less useful due to shortcomings
    - Tier 3: Unreliable for meta-analysis Mentioned for completeness and general trends

- **Epidemiology Review Criteria:**
  - Dosimetry
  - Pathology Method
  - Dose Response Analysis
  - Age Adjusted
  - Blinded Pathology
  - Cataract Scoring Type
  - Confounding
  - Latency
  - Numerical Risk Assessment
  - Selection Bias
  - Reporting Bias

*Wartenberg et al 2000

Cataract Epidemiology Study Evaluation

- 59 Epidemiology Studies Evaluated
  - 9 – Tier 1
  - 17 – Tier 2
  - 33 – Tier 3
- 4 of the Tier 1 or 2 studies provided risk ratios for a given dose.
  - A-Bomb (Nakashima)
  - US Radiology Techs (Chodick)
  - Infant Clinical Study (Hall)
  - Chernobyl Cleanup Workers (Worgul)



Limited, high quality, epidemiological studies

Key Conclusions – Associations with Various Types of Cataracts

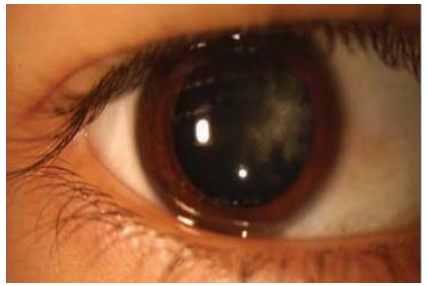
- **Science for radiogenic cataracts is evolving and uncertainties in radiation biology and epidemiology still exist.**
  - **Meta-analysis suggests an association exists with some types of cataracts (e.g. posterior subcapsular, cortical, and mixed cataracts) for a variety of exposure conditions and perhaps at doses lower than previously considered.**

Table 1
Results of Odds Ratio Meta-analysis at 1 Gy by Cataract Type

Cataract Type	Odds Ratio at 1 Gy	95% Confidence Interval	Relevant Studies with the Specific Cataract Type
Posterior subcapsular	1.45 *1.45	1.25-1.68 *1.15-1.85	Worgul 2007, Hall 1999 and Nakashima 2006
Cortical	1.37 *1.50	1.20-1.56 *1.21-1.87	Worgul 2007, Hall 1999 and Nakashima 2006
Nuclear	1.07 *1.07	0.89-1.28 *0.5-2.0	Worgul 2007, Nakashima 2006 (nuclear opacity)
Mixed	1.75	1.26-2.46	Worgul 2007, Chodick 2008

*Nakishima 2006 excluded

Cortical Cataract



Posterior Subcapsular Cataract

Key Conclusions – Dose Thresholds

- **Quantitative estimate of a specific dose threshold (adverse effect dose) is not yet possible**
  - Limited available studies that evaluated thresholds (A-Bomb and Chernobyl)
  - Uncertainties exist with the studies
    - Dose estimate uncertainties
    - Lens opacity/cataract detection not standardized

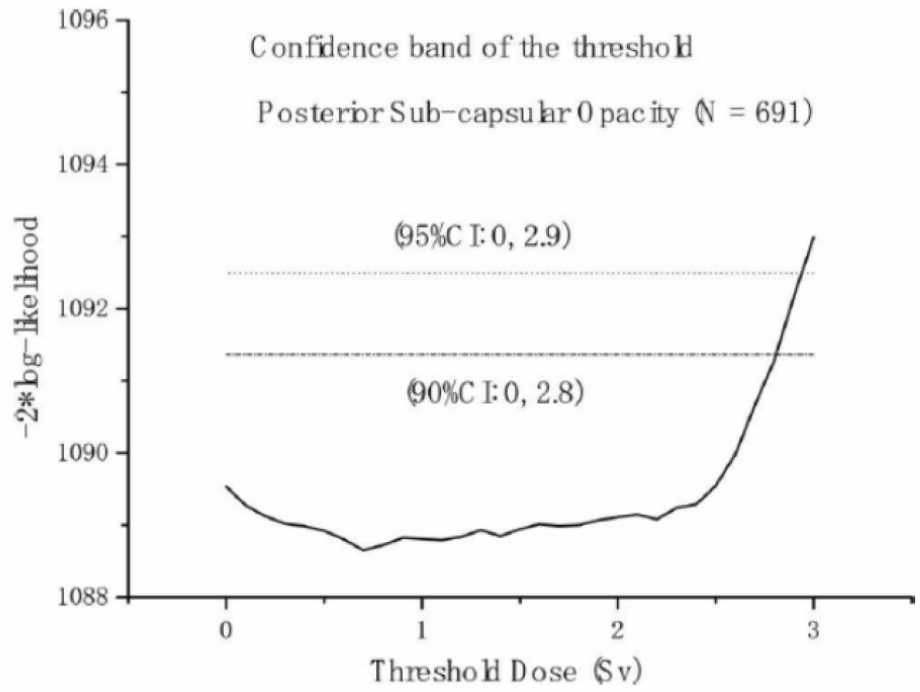


Figure 3-3
Estimation of Threshold Dose in A-bomb survivor study

(reproduced from Nakashima et al., 2006, Figure 2)

Presence or value of a dose threshold still unknown

Key Conclusions – Other Observations

- Shift in protection criteria by ICRP
  - Previous recommendations were based on visually-impairing cataracts but new criteria places more emphasis on minor lens opacifications
  - Belief that minor lens opacifications may progress to cataracts
- Biological studies are helpful but difficult to extrapolate to human exposures.

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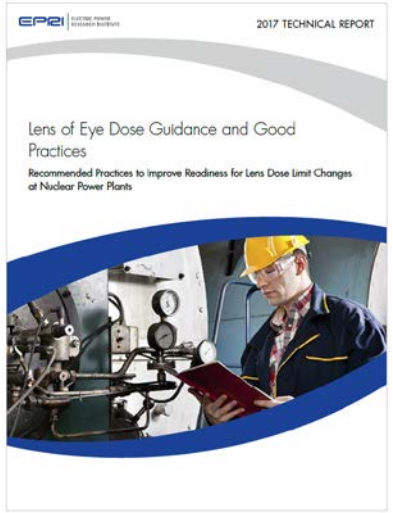

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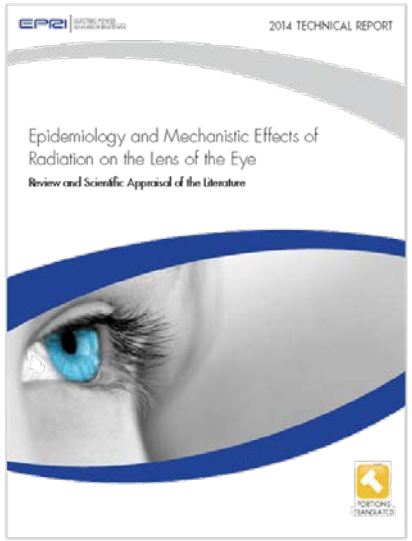

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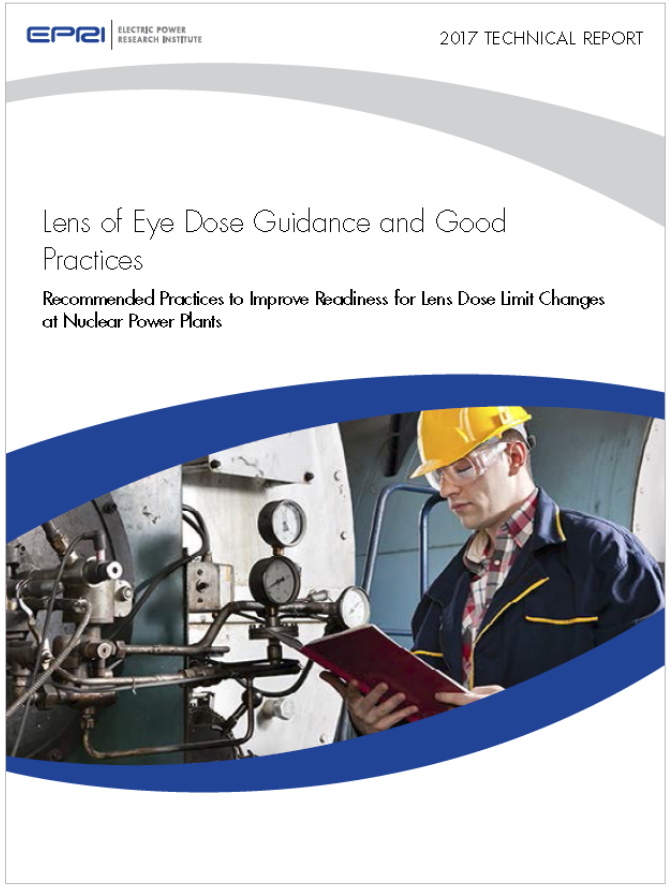
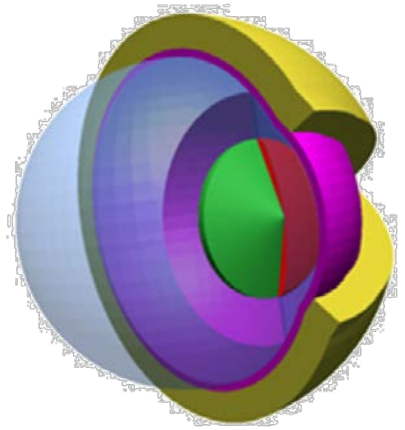
Lens of the Eye Guidance and Good Practices (3002010626)

- **Key Findings**
  - Lens dose should be considered separately in optimization
  - Radiation fields should be characterized in situations where lens dose will be significantly higher than effective dose
  - For high energy Beta, consider protective equipment
  - Utilize dosimetry capable of accurate measurement of lens dose (3 mm depth)
  - Provide information and training for workers on dose limits, biological effects, and changes to radiation protection program



In collaboration with Candu Owners Group and Sweden NPPs

Lens of the Eye Dosimetry and Shielding Factors of Protective Equipment



- **Purpose:**
  - Develop and document a consistent approach for testing of equipment for protection of the lens of the eye for use by industry and vendors.
  - Provide a generic set of protection factors for use in planning and implementing radiation protection for lens of the eye.
- **Research Value:**
  - Provide a consistent approach for testing of equipment for protection of the lens of the eye for use by industry and vendors, and for accreditation of dosimetry
  - Provide a set of factors for protection of the lens of the eye that can be used in a manner similar to the protection factors found in 10 CFR Part 20 for respiratory protection.
  - Inform consensus standards development, regulatory guidance and radiation protection practice, and provide mechanisms for ensuring compliance with requirements.
- **Status**
  - Ongoing. construction of phantoms for testing and analysis of results

Develop consistent approach to address Global Issue

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