Dose Rate Effectiveness Factor (DREF): Estimates from Epidemiologic Studies

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Overview: Procedure to Estimate the Dose Rate Effectiveness Factor (DREF)

- **Low dose and low dose-rate (LDR) studies: Obtain dose-response risk estimates for all solid cancer - studies of radiation workers or environmental radiation exposures.**
  - LDR: doses are accumulated over time at a slow rate, and cumulative doses are typically low.
- **Compare the LDR radiation risk estimates with corresponding risk estimates from the Japanese atomic bomb Lifespan Study (LSS)**
  - LSS: Doses largely received in under a minute
- **Estimate of DREF: Inverse of the overall ratio of the LDR risk to the corresponding LSS risk (LDR/LSS)**

LDLDR Study Selection

- **Avoid study-selection bias: include *all* LDR studies that reported solid cancer risk estimates based on dose-response analyses**
- **Result: Found 24 LDR studies of solid cancer mortality – occupational or environmental radiation exposures with dose-response analyses**
- **Found an additional 5 LDR studies with dose-response analyses of solid cancer incidence, no mortality analysis**
- **Combined total of 29 LDR studies**

Methodology to Compare LDR and Corresponding LSS Risk Estimates

- **For each LDR study, calculate an *adjusted* regression estimate of radiation risk in the LSS study.**
  - **Adjustment matched for: mean dose, percentage of females, average age at first exposure, average age at latest follow-up.**
- **For each LDR_i study we had its risk $estimate_i$ (and CI_i), and the corresponding risk $estimate_i$ (and CI_i) from the adjusted LSS_i study.**
- **So could calc for each LDR_i study a LDR_i/LSS_i ratio and CI_i on that ratio.**

Meta-analysis of the $LDLDR_i/LSS_i$ Ratios

- **Issue: Meta-analysis is weighted according to the inverse of the relative precision of each LDR_i/LSS_i ratio.**
  - Mayak worker study had large weight in meta-analysis, mainly because of the comparatively high cumulative doses of the workers.
- **Workers at the Mayak radiochemical and plutonium production facilities had high cumulative external doses (average of >400 mGy) and often, high plutonium exposures as well.**
- **Therefore, we conducted meta-analyses including:**

(1) All studies with all Mayak workers

(2) All studies, but excluding Mayak workers at the radiochemical or Pu-production facilities.

(3) Only studies with mean cumulative doses under 100 mGy –
(which excluded the Mayak and Chornobyl clean-up worker studies)

Estimates of the Dose Rate Effectiveness Factor (DREF) (with 95% CI) for All Solid Cancer from Meta-analyses of Low-Dose and Low-Dose-Rate (LDR) Studies

	DREF: Mortality Studies Only	DREF: Mortality and Incidence Studies
Including all Mayak workers	2.0 (1.4, 3.7)	1.9 (1.4, 3.0)
Mayak, except radiochemical or Pu-production facility workers	1.4 (0.9, 2.7)	1.5 (1.1, 2.5)
Only studies with mean cumulative doses under 100 mGy [a]	0.9 (0.6, 1.8)	1.3 (0.9, 2.3)

[a] All studies except Chornobyl clean-up workers and Mayak workers, whose mean doses were >100 mGy.

Tentative Conclusions from the Epidemiologic LDR Analyses

- **Results are not compatible with a high value of DREF (e.g., >3)**
- **Can't differentiate DREF of 1 versus 2. Too much heterogeneity among the LDR studies and among DREF estimates.**
- **Other sources of uncertainty:**
  - **Comparing risk estimates across populations (Japanese vs. western world nuclear workers)**
  - **Dosimetric (A-bomb several MeV vs. workers several hundred keV)**

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