National Cancer Institute

Epidemiologic Studies of the Mayak Worker and Techa River Cohorts

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Mayak Nuclear Facility

- First and largest nuclear weapons facility in the former Soviet Union
- Began operations in 1948
- Large exposures to both workers and surrounding populations, mostly during the late 1940's and 1950's
- Protracted low dose rate exposure similar to that of interest for radiation protection

Mayak nuclear facility

Background

Before 1990, Russian investigators established

- **Mayak worker registry**
  - **Currently includes 26,000 workers hired 1948-82**

- **Techa River cohort**
  - **Currently includes 30,000 people who lived in river bank villages downstream of Mayak facility 1950-61**

NCI, DOE, and the EC have supported research on these cohorts

- **Many US and European scientists involved**

Contributions of cohorts exposed from Mayak operations

- Large numbers of people exposed to a wide range of doses of low LET radiation at low dose rates
  - Both Mayak workers and Techa River cohort
- Persons exposed to internal sources
  - Plutonium (Mayak workers)
  - Strontium and cesium (Techa River cohort)
- Long term follow-up
  - Largest exposures occurred in early 1950's

Dosimetry

- International collaborative program for improving individual dose estimates
  - Supported by DOE and EC

- Since BEIR VII, many improvements in dose estimates for both Mayak worker and Techa River cohorts
  - Large number of publications on dosimetry.

Rest of this talk

- Overview of most important findings
- Mayak worker cohort (MWC): External dose
- Mayak worker cohort (MWC): Plutonium
- Techa River cohort (TRC)

Mayak Worker Cohort: External doses

Status at time of BEIR VII

- Shilnikova et al. Radiat Res 2003
- Dose-response analyses for solid cancer and leukemia mortality for the period 1948-1997
- Based on archive film badge doses
  - no adjustment for dosimeter limitations

Mayak Worker Cohort (MWC): External Doses

Current Status

- Many dosimetry improvements
- Updated solid cancer mortality analyses based on follow-up period 1948-2008.
- Solid cancer incidence analyses 1948-2004
- Cardiovascular disease mortality and incidence analyses

Mortality from solid cancers other than lung, liver, and bone: External Dose (MWC)

Dose (Gy)	Person-years	Observed deaths	Excess* deaths
<0.1	516,997	627	3.0
0.1-	248,626	558	22.9
0.5-	93,270	282	28.0
1-	72,944	271	48.9
2-	15,146	63	17.5
3+	3,913	24	7.7
Total	**950,894**	**1825**	**127.9 (7.1%)**

*Estimated excess due to external exposure based on the assumption of a linear dose-response.

Sokolnikov et al. 2014, in press

ERR/Gy: Solid cancers other than lung, liver and bone: External dose (MWC)

	Not adjusted for Pu dose	Adjusted for Pu dose
Mortality*	0.16 (0.07, 0.36)	0.11 (0.03, 0.21)
Colon dose	1825 deaths (1948-2008)	
Incidence*	0.07 (0.01, 0.15)	0.06 (−0.01, 0.14)
Hp(10)	1447 cases (1948-2004)	

A-bomb survivors: 0.35 (0.19-0.55)

*Sokolnikov et al 2014; **Hunter et al. 2013

ERR/Gy: Cardiovascular Disease External dose (MWC)

	Ischemic heart disease*	Cerebro-vascular disease**
Mortality	0.03 (−0.04, 0.10)	0.05 (-0.03, 0.16)
	2557 deaths	1578 deaths
Incidence	0.15 (0.08, 0.21)	0.46 (0.37, 0.57)
	6219 cases	8717 cases

*Moseeva et al. 2014 Radiat Environ Biophy; **Azizova et al. 2014 Radiat Res

Mayak Worker Cohort: Plutonium

- **Last BEIR report to address alpha emitters other than radon was BEIR IV (1988)**

Currently available

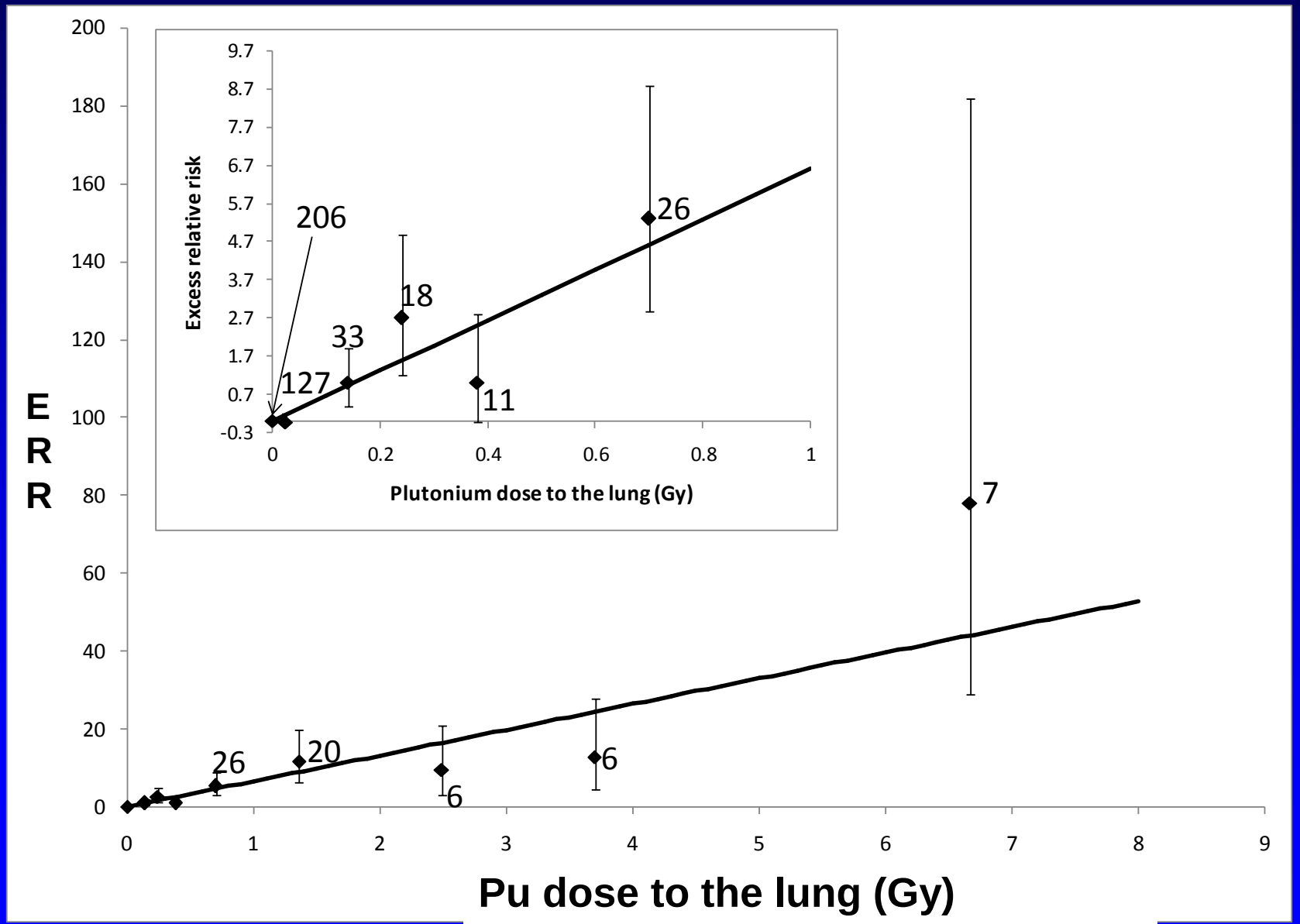
- **Lung, liver, and bone cancer mortality analyses**
  - **Clear evidence of dose-response for all three endpoints**
- **Lung, liver, and bone cancer incidence analyses**
- **Cardiovascular disease incidence and mortality analyses**

Lung cancer Pu dose-response (MWC)

- **Both mortality and incidence data indicate strong linear Pu dose response for lung cancer**
  - **Decrease in ERR/Gy with attained age**
  - **Interaction of Pu dose and smoking is intermediate between additive and multiplicative**
  - **ERR/Gy for adenocarcinomas was 11 times higher then the ERR/Gy squamous cell cancers**

Gilbert et al. 2013; Labutina et al. 2013

Lung cancer Pu dose-response (MWC)



Techa River Cohort

Techa River Cohort

- 30,000 people who lived in river bank villages downstream of Mayak facility in the 1950-61

- All ages and both sexes
  - 58% female
  - 40% under age 20 in 1950

Techa River Cohort

Status at time of BEIR VII:

- No individual dose estimates (grouped by village)
- Cancer mortality analyses only

Techa River Cohort

Current Status

- Many dosimetry improvements including individual dose estimates

- Published analyses on:
  - Solid cancer mortality and incidence
  - Leukemia mortality and incidence
  - Cardiovascular disease mortality

Solid Cancer Mortality: External Dose (TRC)

Dose (Gy)	Person-years	Observed deaths	Excess* deaths
< 0.01	519,473	1105	2.9
>0,<.1	336,733	969	17.0
0.1-	49,358	144	12.3
0.3-	21,074	80	16.1
0.5+	1,105	5	1.4
Total	927,743	2303	49.7 (2.2%)

*Estimated excess due to external exposure based on the assumption of a linear dose-response.

Schonfeld et al. 2013

ERR/Gy: Solid cancer and leukema External dose (TRC)

	Solid Cancer	Non-CLL Leukemia**
Mortality	0.61 (0.04 to 1.3)	~~6.5 (1.8 to 24)~~
	2303 deaths	
Incidence	1.0 (0.3 to 1.9)	2.2 (0.8 to 5.4)
	1836 cases	72 cases

Schonfeld et al. 2013; Krestinina et al. 2005, 2007, 2013

Cardiovascular Disease: External dose (TRC)

	Ischemic heart disease	Cerebro-vascular disease
Mortality	0.56 (0.02, 0.75)	p > 0.5
	3194 deaths	1933 deaths

Krestinina et al. 2012

Summary

- **Many publications since BEIR VII based on improved dose estimates**

- **New data on risks from low LET radiation from both MWC and TRC**
  - **Solid cancer and leukemia mortality and incidence**
  - **Cardiovascular disease mortality and incidence**
  - **Site-specific cancer risks: Not very informative**

- **New data on risks from plutonium from the MWC**
  - **Lung, liver and bone cancer mortality and incidence**
  - **Some data investigating risks of other cancers and cardiovascular disease**

What's coming?

- New Monte Carlo dosimetry systems for Mayak external doses, Mayak Pu doses, and Techa River doses
  - Dose-response analyses will make use of these systems to take account of dosimetry uncertainty
  - May be especially important for plutonium doses
- Updated analyses of MWC leukemia mortality data
- Pooled analyses of Pu effects in Mayak and Sellafield cohorts
- Pooled analyses of Mayak and Techa River *in utero* data

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