Federal Office for
Radiation Protection

# Aims and results of the German uranium miners cohort study

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# German uranium miners cohort study – *Kreuzer et al. 2010, 2023*

## Study aims

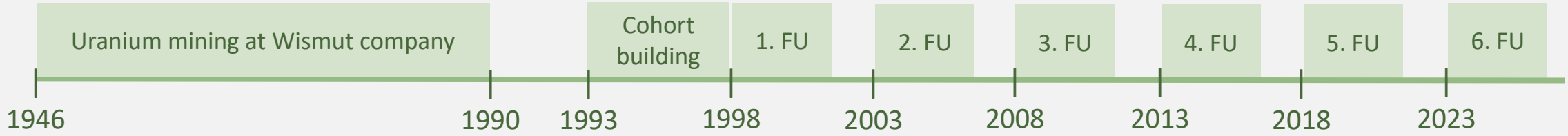
1. Investigating the health consequences of employment in German uranium mines
2. Assess health risks of occupational exposure to radiation and dust

## Study cohort

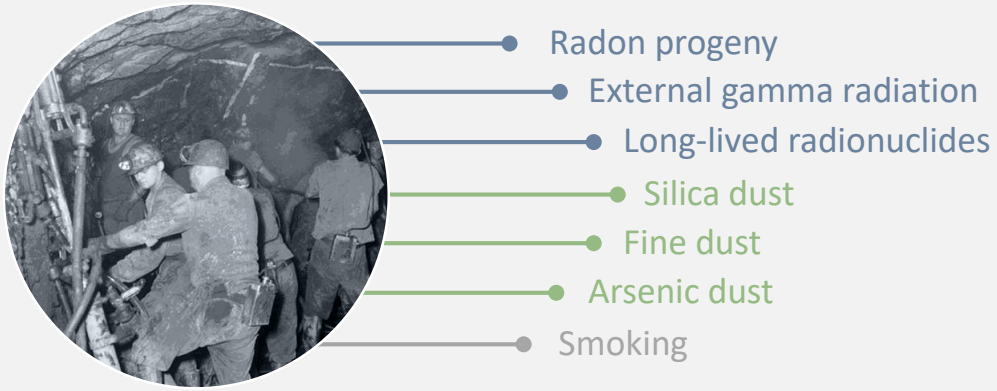
58,972 male former employees of the Wismut uranium mining company (operating from 1946 to 1990 in Saxony and Thuringia)

▶ Largest single cohort study of uranium miners

## Chronology of mining and mortality follow-ups



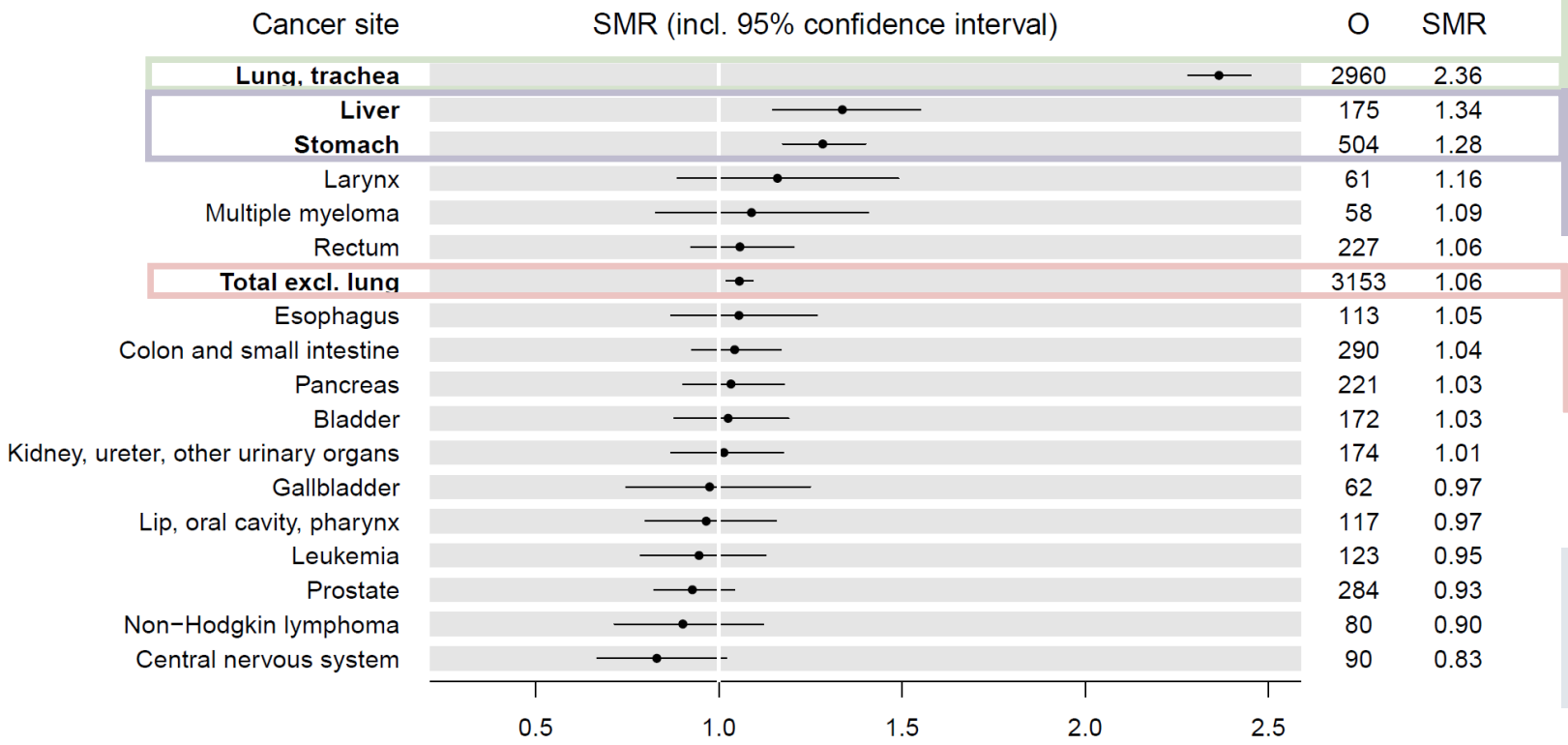

## Risk factors




## Vital status (by end of 2018)

| | |
|---|---|
| Alive: | 23,330 (39.6 %) |
| Deceased: | 33,794 (57.3 %) |
| Loss to follow-up: | 1,848 (3.1 %) |

# Mortality in comparison to the general population – *Kreuzer et al. 2021*




**Lung cancer** mortality in the cohort is 2.36-fold significantly higher than in the general population.

Of the 27 considered cancer sites other than lung, SMR was significantly increased for **liver and stomach cancer**.

The SMR **for cancer causes of death excluding lung cancer** is significantly increased.

→ **Explanation ?**
→ **Analysis of exposure-response relationships**

<u>Standardized mortality ratio (SMR)</u>

Observed number of deaths in the cohort (O)

vs.

Expected number of deaths in the cohort, if mortality rates are based on those of the general population

# Health risks of occupational exposure to radiation and dust

| | |
|---|---|
| **Radon & lung cancer** *Kreuzer et al. 2023* | • **Linear, positive relationship** between radon exposure and lung cancer risk<br>• The relative risk of lung cancer decreases with increasing<br>time since exposure,<br>attained age and<br>exposure rate.<br>• Increased lung cancer risk by radon for former miners even 20 to 30 years after the mines were closed<br>• Higher risk estimates at low exposures and exposure rates |
| **Radon & cancers other than lung cancer** *To appear* | • Linear, positive relationship between radon exposure and risk of cancers other than lung cancer<br>• Majority of relationships between radon exposure and cancer risk at individual sites are positive (not sign.)<br>• Excess risk is low, i.e. no substantial risk below 1,000 WLM |
| **Silica dust & respiratory diseases** *Kreuzer et al. 2013, Sogl et al. 2012* | • Linear, positive relationship between silica dust exposure and **lung cancer** for high cumulative silica dust exposures<br>• Strong, positive relationship between silica dust exposure and **silicosis**<br>• No relationship between silica dust exposure (or radon exposure) and COPD or other non-malignant respiratory diseases |

Working Level Months (WLM)

Unit for the measurement of occupational radon exposure

53 WLM corresponds to about 300 Bq/m³ of residential radon exposure over 40 years.

# PUMA: Pooled Uranium Miners Analysis

**Study aims** - *Rage et al. 2020*

1. Strengthen the basis for radiation protection
2. Address novel research questions that might not be feasible to address in any single cohort of uranium miners
3. Improve the understanding of radon and radon progeny-related diseases

**Study cohort** - *Rage et al. 2020, Kelly-Reif et al. 2023*

| Cohort (country) | Period of follow-up | Number miners | Number lung cancer deaths | Mean cum. radon exposure in WLM |
|---|---|---|---|---|
| Eldorado (Canada) | 1950-1999 | 13,574 | 517 | 122 |
| Ontario (Canada) | 1954-2007 | 28,546 | 1,246 | 31 |
| Czech (Czech Rep.) | 1952-2014 | 9,978 | 1,176 | 73 |
| France (France) | 1946-2007 | 5,086 | 213 | 37 |
| Wismut (Germany) | 1946-2013 | 54,919 | 3,759 | 304 |
| Colorado Plateau (USA) | 1960-2005 | 4,137 | 612 | 579 |
| New Mexico (USA) | 1957-2012 | 3,469 | 231 | 90 |
| PUMA | 1946-2014 | 119,709 | 7,754 | 119 |

**Radon & lung cancer**

*Richardson et al. 2022, Kelly-Reif et al. 2023, Kreuzer et al. (submitted)*

- Confirmation of a linear, positive relationship between radon exposure and lung cancer risk
- Support of the modification of the relationship by time since exposure, attained age and exposure rate
- Improved precision of risk estimates in comparison to previous results
- 5.7 % to 8.6 % of people exposed to 2 WLM from age 18 to 64 die on average of lung cancer due to this occupational radon exposure
  (based on models for more recent periods with chronic low exposures and exposure rates)

# Literature

Kelly-Reif K, Bertke SJ, Rage E, Demers PA, Fenske N, Deffner V, Kreuzer M, Samet J, Schubauer-Berigan MK, Tomasek L. 2023. Radon and lung cancer in the pooled uranium miners analysis (PUMA): highly exposed early miners and all miners. *Occupational and Environmental Medicine*, 80(7), 385-391.

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## Website

www.bfs.de/wismut-studie

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