

# United States Transuranium and Uranium Registries: Importance of human data



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## 1. How it Started: From National Concern to Scientific Registry – AEC's Legacy

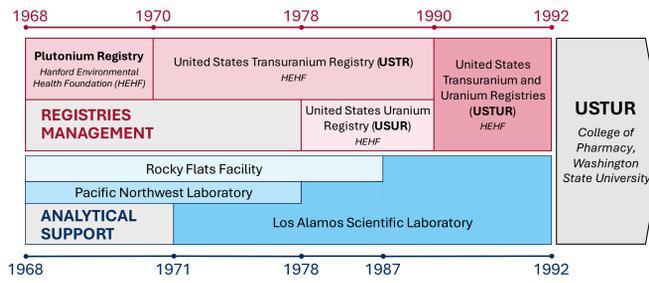


United States Atomic Energy Commission on August 16, 1968:

This is to announce that the Division of Biology and Medicine has authorized the establishment of a "Plutonium Registry" with the Hanford Environmental Health Foundation of Richland, Washington.



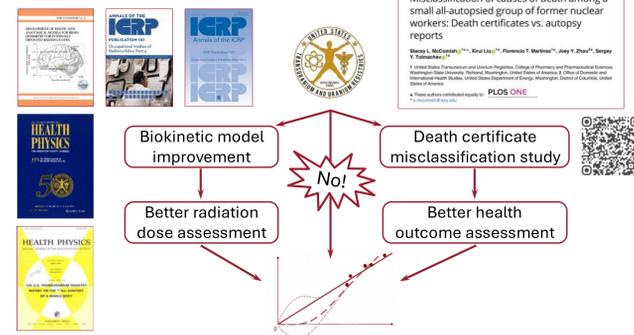
## 2. The Historical Development of the Registries



## 3. Mission of the Registries: Then and Now

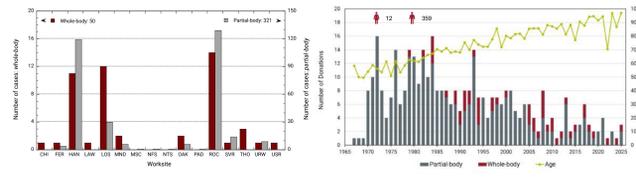
- Initial mission was "to protect the interests of workers, employees, and the public by ... the acquisition and provision of the latest and most precise information about the effects of the transuranic elements on man"
- By the end of 1970s, the mission of the Registries moved away from epidemiology
- Today's mission is to follow up occupationally exposed workers by studying the biokinetics and tissue dosimetry of the actinides to refine dose assessment methods in support of reliable epidemiological studies, radiation risk assessment, and regulatory standards for radiological protection of workers and general public

## 4. USTUR ≠ Epidemiological Study

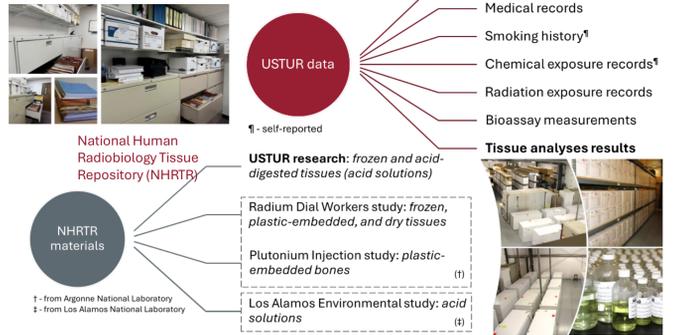


## 5. USTUR Registrants

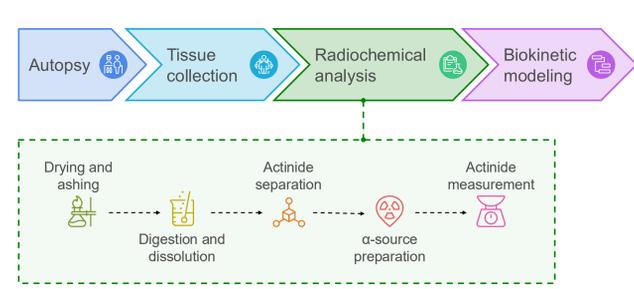
- Individuals with documented history of exposure to the actinides
- Primary exposure:  $^{239}\text{Pu}$ ,  $^{238}\text{Pu}$ ,  $^{241}\text{Am}$ ,  $\text{U}_{\text{nat}}$ ,  $\text{HEU}$ ,  $\text{DU}$ ,  $^{244}\text{Cm}$ ,  $^{237}\text{Np}$
- Criteria: 4 nCi (internal deposition) or 10 rem (external)
- Mainly former nuclear workers from U.S. Department of Energy sites
- Voluntary tissue donors (posthumous)
- Statistics and trends:



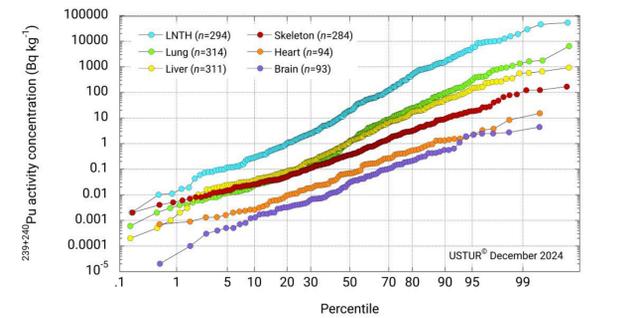
## 6. Unique Data Resource



## 7. Registries in Action: Schematic Overview



## 8. Radiochemical Analysis: $^{239}\text{Pu}$ in Human Tissues



## 9. Biokinetic Modeling: Importance of Human Data

Human study	Animal study
H1: element of interest	A1: element of interest
H2: chemical analog	A2: chemical analog

"In general, greater confidence can be placed in a biokinetic model based on H1 data than a model based on H2, A1, and/or A2."

USTUR: H1-type study!

## 10. Developing Site-specific Biokinetic Models

- Information on material type is critical

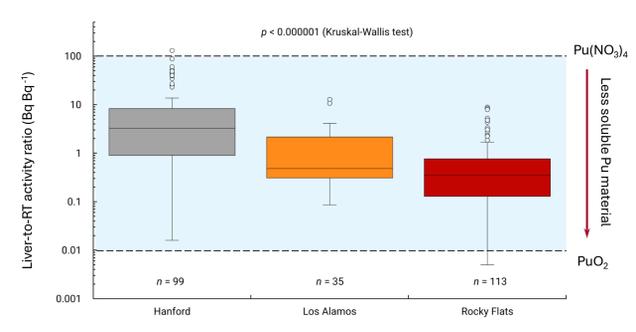
**LNTH-to-lung concentration ratio**

- Soluble [ $^{239}\text{Pu}(\text{NO}_3)_4$ ]: < 1
- Insoluble [ $^{239}\text{PuO}_2$ ]:  $\geq 27$

**Liver-to-respiratory tract activity ratio**

- Soluble [ $^{239}\text{Pu}(\text{NO}_3)_4$ ]:  $\geq 100$
- Insoluble [ $^{239}\text{PuO}_2$ ]: < 0.1

## 11. Inferring Pu Solubility from Liver-to-RT Activity Ratios



## 12. HRTM: Bound Fraction vs Scar Tissue

$f_b$  inferred from three studies:

- USTUR Case 0269:  $f_b = 0.037$
- Beagle dog study:  $f_b = 0.0023$
- 40 Mayak workers:  $f_b = 0.0014$

ICRP recommendation:  $f_b = 0.002$

## 13. Individual Organ Dosimetry: Brain

$^{226}\text{Ra}$  activity:  $5.7 \pm 0.2 \text{ Bq}$

GM = 0.175 (GSD = 2.2; n = 67)

## 14. Individual Organ Dosimetry: Heart

Systemic  $^{239}\text{Pu}$  (n=7): < 2 – 33 nCi

Systemic  $^{226}\text{Ra}$  (n=2): < 0.004 – 272.7  $\mu\text{Ci}$

## 15. Bayesian Approach to Uncertainty Modeling

Organ activity (surrogate of dose) predictions measured results for 20 plutonium workers

- The distributions do not cover the measured values in 15 (75%) cases for the liver and 18 (90%) cases for the skeleton<sup>1,2</sup>
- The model predictions are not conservative in 4 (20%) cases for the liver and in 2 (10%) cases for the skeleton

<sup>1</sup>Intake estimated using maximum likelihood fit of the urine bioassay for the set of parameters in a realization

<sup>2</sup>Forward calculations: activity predicted using the estimated intake and the same set of parameters

Antandilashvili M, Sefti M, Zhou JY, Tolmachev SY. Validation of Bayesian modeling approach of uncertainty in organ doses using post-mortem measurements. Scientific Reports 15: 20476; 2025



## Acknowledgment

The United States Transuranium and Uranium Registries is funded by U.S. Department of Energy, Office of Domestic and International Health Studies (EHSS-13), under grant award DE-HS0000073 to College of Pharmacy and Pharmaceutical Science at Washington State University.

