Examples of studies of Techa River populations and Mayak worker informing ICRP internal dose coefficients

Presented at ICRP Workshop

30 Years of Scientific Achievements for International Radiological Protection: Summary of the Southern Urals Health Studies Program

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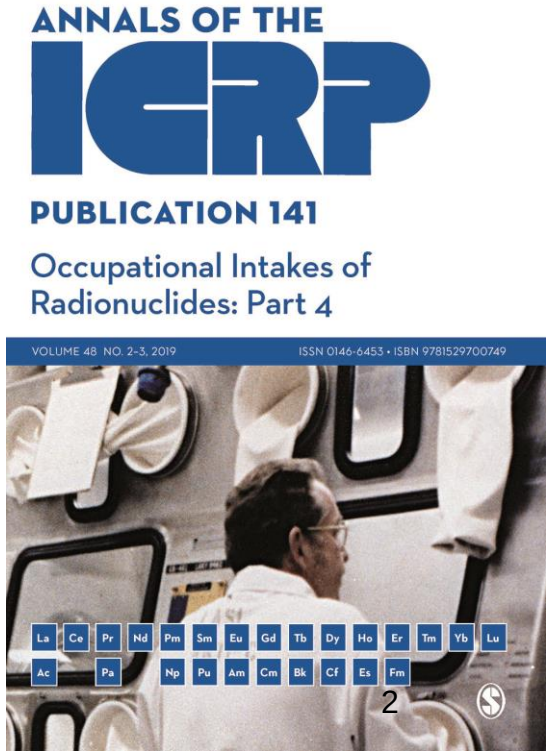
Derek Jokisch

ICRP

ICRP Internal Dose Coefficients

- **Provide effective dose to a reference person per unit activity ingested or inhaled.**
- **The most recent sets of internal dose coefficients are organized into two series:**
- **Workers – Occupational Intakes of Radionuclides (OIR)…5 parts**
  - Publication 130 – OIR Part 1
  - Publication 134 – OIR Part 2
  - Publication 137 – OIR Part 3
  - Publication 141 – OIR Part 4
  - Publication 151 – OIR Part 5
- **Public – Environmental Intakes of Radionuclides (EIR)**
  - Publication 159 (in press) – EIR Part 1
  - EIR Part 2 – currently available for public consultation



Impact on ICRP internal dose coefficients

- Internal dose coefficients found by multiplying a source term describing the time-dependent location of radioactive material and a physics term describing the energy absorption.
- The source term is determined by biokinetic modeling.
- Studies on Techa River populations and Mayak workers have impacted biokinetic models for strontium, plutonium, and americium.

Strontium biokinetics

Evaluation of Age and Gender Dependences of the Rate of Strontium Elimination 25-45 Years after Intake: Analysis of Data from Residents Living along the Techa River

N. B. Shagina, E. I. Tolstykh, V. I. Zalyapin, M. O. Degteva, V. P. Kozheurov, E. E. Tokareva, L. R. Anspaugh and B. A. Napier

Radiation Research
Vol. 159, No. 2 (Feb., 2003), pp. 239-246 (8 pages)

Age and gender specific biokinetic model for strontium in humans

N B Shagina[1], E I Tolstykh[1], M O Degteva[1], L R Anspaugh[2] and B A Napier[3]

Published 9 January 2015 • © 2015 IOP Publishing Ltd
Journal of Radiological Protection, Volume 35, Number 1
Citation N B Shagina *et al* 2015 *J. Radiol. Prot.* **35** 87
DOI 10.1088/0952-4746/35/1/87

Strontium biokinetic model for the pregnant woman and fetus: application to Techa River studies

N B Shagina[1], T P Fell[2], E I Tolstykh[1], J D Harrison[2] and M O Degteva[1]

Published 21 August 2015 • © 2015 IOP Publishing Ltd
Journal of Radiological Protection, Volume 35, Number 3
Citation N B Shagina *et al* 2015 *J. Radiol. Prot.* **35** 659
DOI 10.1088/0952-4746/35/3/659

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Strontium biokinetics

- **From OIR P2 (Pub. 134):**
  - "More recent human studies are described in articles by Shagina et al. (2003)…"
  - "The systemic biokinetic model for strontium given in *Publication 67* is reasonably consistent with later information on the biokinetics of strontium and related elements in humans (e.g. Shagina et al. 2003; Li et al. 2008). For example, the [ICRP] model predicts that 2.8-3.2 % of whole-body Sr-90 is eliminated each year at times 25-45y after uptake to blood, compared with average values of 2.7-3.2%, depending on age, in adult males of a Russian population exposed to high levels of ^{90}Sr (Shagina et al. 2003)."
  - OIR P2 also notes the Shagina et al. observed sex-dependency of strontium biokinetics but the ICRP model does not incorporate sex-dependency.

Strontium biokinetics

- **From EIR P1 (Pub. 159):**
  - "A number of age-specific biokinetic models for strontium have been developed (Shagina et al. 2003, 2015 [among several]). Although different conceptual frameworks have been used, the various models yield broadly consistent estimates with regard to accumulation and retention of ingested strontium in bone…"

Plutonium biokinetics

Radiation Protection Dosimetry (2017), Vol. 176, No. 1-2, pp. 62–70
Advance Access publication 9 September 2016
doi:10.1093/rpd/ncw121

THE MAYAK WORKER DOSIMETRY SYSTEM (MWDS-2013): PLUTONIUM BINDING IN THE LUNGS—AN ANALYSIS OF MAYAK WORKERS

Matthew Puncher[1], Alan Birchall[2,*], Alexandra B. Sokolova[3] and Klara G. Suslova[3]
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Radiation Protection Dosimetry (2017), Vol. 176, No. 1-2, pp. 83–89
Advance Access publication 13 August 2016
doi:10.1093/rpd/ncw190

THE MAYAK WORKER DOSIMETRY SYTEM (MWDS-2013): DETERMINATION OF THE INDIVIDUAL SCENARIO OF INHALED PLUTONIUM INTAKE IN THE MAYAK WORKERS

A. B. Sokolova[1,*], A. Birchall[2], A. V. Efimov[1], V. V. Vostrotin[1] and M-D. Dorrian[3]
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[2]Global Dosimetry Ltd., 1 Macdonald Close, Didcot, Oxon OX11 7BH, UK
[3]Department of Toxicology, Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Chilton, Didcot OX11 0RQ, UK

Mayak Worker Study: An Improved Biokinetic Model for Reconstructing Doses from Internally Deposited Plutonium

R. W. Leggett, K. F. Eckerman, V. F. Khokhryakov, K. G. Suslova, M. P. Krahenbuhl, S. C. Miller

Author Affiliations +

Radiation Research, 164(2):111-122 (2005). https://doi.org/10.1667/RR3371

Plutonium biokinetics

- **Mayak worker studies impacted the ICRP values for Pu:**
  - the bound fraction (f_b) and the slow dissolution rate (s_s) in the HRTM
- **From OIR P4 (Pub. 141) on plutonium nitrate absorption:**
  - "In conclusion, estimated values of the slow dissolution rate s_S from the human volunteer and long-term monkey and dog inhalation experiments are remarkably similar…Estimates from the USTUR and Mayak Production Association are considerably higher and lower, respectively."

Plutonium biokinetics

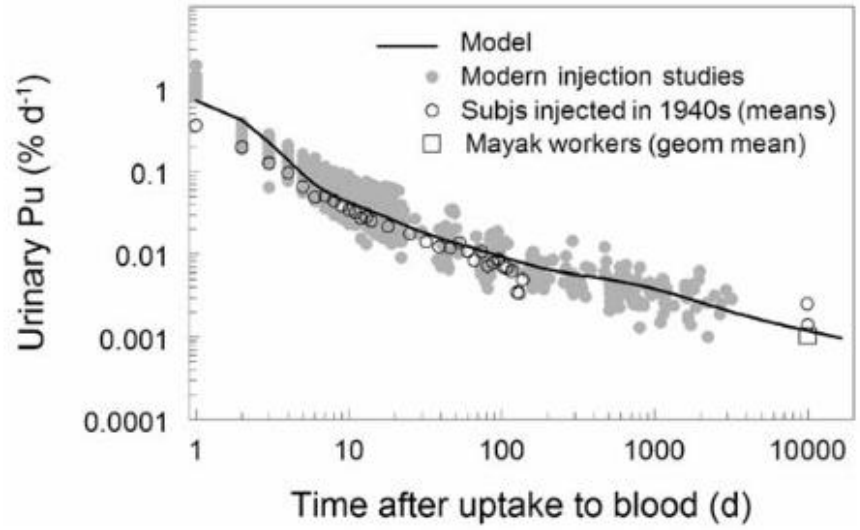

Fig. 22.3. Urinary excretion of plutonium predicted by the model used in this publication and measured in human injection studies and Mayak workers (Langham et al., 1950; Durbin, 1972; Rundo et al., 1976; Talbot et al., 1993, 1997; Khokhryakov et al., 1994, 2000; Popplewell et al., 1994a,b; Warner et al., 1994; Newton et al., 1998; Ham and Harrison, 2000).

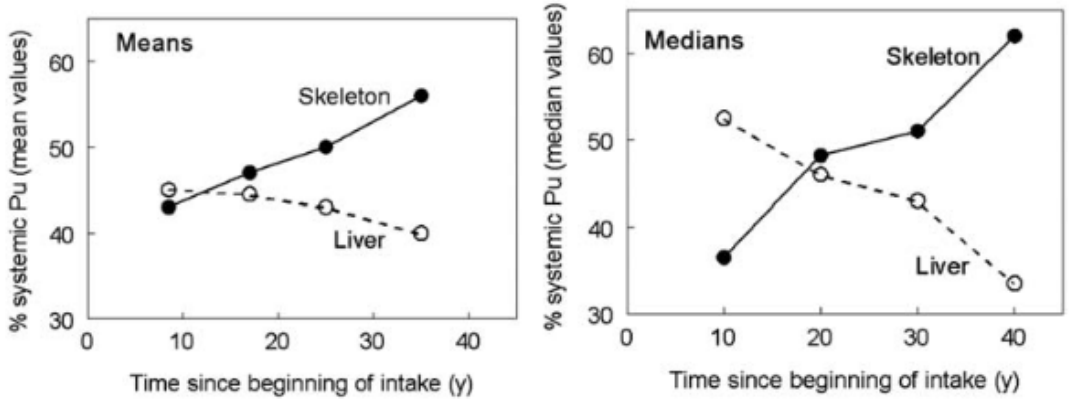

Fig. 22.7. Shift with time in the systemic distribution of plutonium as indicated by central estimates of skeleton and liver contents (% systemic plutonium), based on data reported by Suslova et al. (2002) for Mayak workers (after Leggett et al., 2005).

Americium biokinetics

Development of an Inhalation Intake Model for ^{241}Am Based on Mayak Production Association Worker Data

Sokolova, Alexandra B.*; Suslova, Klara G.*; Khokhryakov, Valentin F.*; Khokhryakov, Victor V.*; Vvendensky, Vladimir E.*; Miller, Scott C.†

Author Information

Health Physics 105(1):p 21-30, July 2013. | ***DOI:*** 10.1097/HP.0b013e3182891039

Use of In Vivo Counting Measurements to Estimate Internal Doses From ^{241}Am in Workers from the Mayak Production Association

Sokolova, Alexandra B.*; Suslova, Klara G.*; Efimov, Alexander V.*; Miller, Scott C.†

Author Information

Health Physics 107(2):p 135-142, August 2014. | ***DOI:*** 10.1097/HP.0000000000000081

Americium biokinetics

- **From OIR P4 (Pub. 141):**
  - "Sokolova et al. (2013) confirmed that applying the plutonium absorption parameters to americium resulted in overestimation of the americium lung burden by 48%, on average, over 456 autopsied cases, suggesting slightly faster lung clearance for americium than for plutonium."
  - "Sokolova et al. (2013, 2014) assessed the potential contributions of direct intake and in-vivo production of ^{241}Am to its total body content in a group of workers at the Mayak Production Association."

Conclusion

- Studies performed on data from Techa River populations and Mayak workers has had, and continues to have, a positive impact on ICRP reference individual dosimetry for strontium, plutonium, and americium.

- Thus…a great example of international science benefitting international populations.

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