USTUR - 0701-25

United States Transuranium and Uranium Registries

Annual Report

April 1, 2024 - March 31, 2025

WASHINGTON STATE UNIVERSITY
College of Pharmacy and Pharmaceutical Sciences

USTUR - 0701-25

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April 1, 2024 - March 31, 2025

Compiled and Edited

S.Y. Tolmachev, S.L. McComish, M. Avtandilashvili

May 2025

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United States Transuranium and Uranium Registries
College of Pharmacy, Washington State University
1845 Terminal Drive, Suite 201, Richland, WA 99354
800-375-9317 Toll Free
509-946-6870 Direct
509-946-7972 FAX
www.ustur.wsu.edu

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Faculty and Staff

Faculty

Sergey Y. Tolmachev	Director, Research Professor
Maia Avtandilashvili	Associate Research Professor
George Tabatadze	Associate Research Professor
Xirui Liu	Associate in Research
Stacey L. McComish	Associate in Research

Part-time Faculty

Florencio T. Martinez	Adjunct Faculty
Anthony E. Riddell	Adjunct Faculty
Teiying Shi	Adjunct Faculty
Daniel J. Strom	Adjunct Faculty

Classified Staff

Margo D. Bedell	Program Specialist II
Elizabeth M. Thomas	Laboratory Technician II

Part-time Employees

Mark Gorelco	Anatomic Pathology Technician
Seokyoung Kim	Laboratory Assistant I
Furtuna Moges	Laboratory Assistant I
Nicholas Tabatadze	Office Assistant I

Consultants

Eric Kiesel	Forensic Pathologist
Minh Pham	IT Support
Mariya Tolmachova	Technical Editor

Advisory Committee

Committee Chair

Thomas L. Rucker	Radiochemistry

Committee Members

Janet Benson	Toxicology
Luiz Bertelli	Health Physics
Elizabeth Ellis	Ethics
Kenn Inn (incoming)	Radiochemistry
David Pawel	Epidemiology and Biostatistics
Arthur W. Stange	Occupational Health

Contact Information

Address

U.S. Transuranium and Uranium Registries
College of Pharmacy and Pharmaceutical Sciences
Washington State University
1845 Terminal Drive, Suite 201
Richland, WA 99354–4959

Phone: 509–946–6870
Toll-Free: 800–375–9317
Fax: 509–946–7972
www.ustur.wsu.edu

E-mail

Sergey Y. Tolmachev	stolmachev@wsu.edu
Maia Avtandilashvili	m.avtandilashvili@wsu.edu
Margo D. Bedell	margo.bedell@wsu.edu
Xirui Liu	xirui.liu@wsu.edu
Stacey L. McComish	s.mccomish@wsu.edu
George Tabatadze	george.tabatadze@wsu.edu
Elizabeth M. Thomas	elizabeth.thomas@wsu.edu

Executive Summary

Sergey Y. Tolmachev, *Professor and Director*

This report summarizes organization, activities, and scientific accomplishments for the United States Transuranium and Uranium Registries (USTUR) and the associated National Human Radiobiology Tissue Repository (NHRTR) for the period of April 1, 2024 – March 31, 2025. This is the third fiscal year (FY) of the USTUR's five-year grant proposal (FY2023 – FY2027: April 1, 2022 – March 31, 2027).

Health Physics Database Completed!

On August 15, 2024, standardization of *all* available exposure and bioassay data for all USTUR Registrants was *completed*! The population of database started with *Case 0202* (Rocky Flats) on December 12, 2008. A total of 191,961 records from 395 Registrants was entered into the database.

FY2026 Grant Renewal

The FY2026 grant renewal proposal to manage and operate the USTUR and the associated NHRTR (DE-HS0000073), during April 1, 2025 – March 31, 2026, was submitted to DOE Office of Domestic and International Studies (EHSS-13). The requested FY2026 (Year 4) budget was $1,367,082. This includes $1,325,920 from the main operational grant and $41,162 from an infrastructure grant. On March 13, 2025, the FY2026 budget was approved by EHSS-13/DOE.

Organization and Personnel

A total of 7.7 full-time equivalent (FTE) positions, including 1.2 FTE for temporary workers, was supported by the available funding. The organizational structure of the USTUR Research Center during FY2025 is provided in Appendix A.

Registrant Donations

One whole-body tissue donation - *Case 0409* (Rocky Flats) - was received in FY2025. As of March 31, 2025, the USTUR had received 50 whole- and 319 partial-body tissue donations.

Radiochemistry Operation

Radiochemistry laboratory operation continued to be reduced due to infrastructure and equipment upgrades. Radiochemical analysis of one partial-body case was completed – *Case 0718* (Rocky Flats). As of March 31, 2025, the USTUR retains a backlog of 2,491 tissue samples from 22 whole- and seven partial-body cases.

HPS Board of Directors

The USTUR Assistant Director, Dr. George Tabatadze, was elected as a member of the Health Physics Society (HPS) Board of Directors (effective July 2025). This is a three-year appointment.

International Training

Dr. Avtandilashvili and Dr. Tabatadze were invited as International Commission on Radiological Protection (ICRP) experts to teach an internal dosimetry course for the United Arab Emirates Federal Authority for Nuclear Regulation (FANR). The week-long course was organized jointly by the FANR, ICRP, and the European Radiation Dosimetry Group (EURADOS). The detailed agenda is available as Appendix B.

Scientific Advisory Committee

The annual 2024 in-person meeting of the USTUR's Scientific Advisory Committee was held on April 25–26, 2024 in Richland, Washington. The Committee reviewed USTUR's progress since the previous meeting (April 20–

21, 2023) and provided seven recommendations for 2025.

Scholarly Activities

Three book chapters and four scientific papers were published by the Registries. Two papers were published ahead of print and one manuscript was accepted. Four invited talks, six podium presentations, and seven posters were delivered. In addition, five podium presentations and five posters were co-authored.

Institutional Review Board

The annual Institutional Review Board (IRB) review was completed and approved by the Central DOE IRB and is valid until July 28, 2025 (WASU-68-50181).

Registrant Communication

The annual USTUR Newsletter, Issue 30 (USTUR-0689-24) was sent to the Registrants and/or their next-of-kin.

Reporting Requirements Met

Four FY2025 quarterly progress reports for the USTUR federally funded grant (DE-HS0000073) were distributed to the sponsoring agency and university. The FY2024 annual report (USTUR-0682-24) was published and electronically distributed among scientific collaborators and posted on the USTUR's website.

Financial and Administrative Report

Margo D. Bedell, *Program Specialist II*

In FY2025, USTUR operations and research were supported by two grants from the U.S. Department of Energy (DOE) Office of Domestic and International Health Studies (EHSS-13). The EHSS-13 is a unit within the DOE Office of Health and Safety (EHSS-10).

On March 31, 2025, the USTUR completed the 3rd grant year of the USTUR's 5-year grant proposal (April 1, 2022 – March 31, 2027).

FY2025 Operating Budget

DOE cumulative funding of the USTUR in FY2025 was \$1,494,293. This included (i) \$1,324,783 to manage and operate the USTUR (Year 3) funded by the main five-year grant (DE-HS0000073) of \$6,500,000 (April 1, 2022 – March 31, 2027); (ii) \$169,510 funded by the infrastructure improvement (Year 3) four-year grant (amendment to DE-HS0000073) of \$765,527 (February 1, 2023 – March 31, 2027). Total expenses in FY2025 were \$1,521,120 (Fig. 1). The FY2025 overspending was balanced by positive carryovers from FY2024.

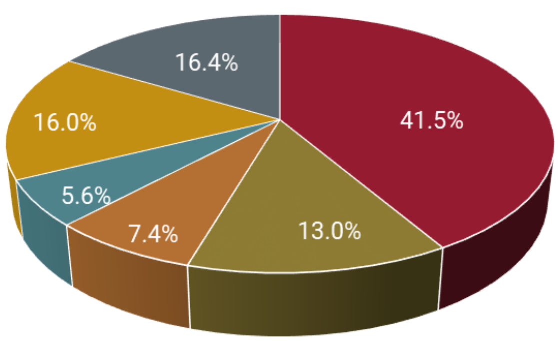

Fig. 1. FY2025 operating budget breakdown.

FY2026 Grant Renewal

On January 8, 2025, a grant renewal proposal (DE-HS0000073) to manage and operate the USTUR and the associated National Human Radiobiology Tissue Repository (NHRTR) during April 1, 2025 – March 31, 2026 (FY2026) was submitted EHSS-13/DOE via the Office of Research Support and Operations at WSU. The requested FY2026 (Year 4) budget was \$1,367,082. This includes \$1,325,920 from the main operational grant and \$41,162 from a supplemental (infrastructure) grant. On March 13, 2025, the FY2026 budget was approved by DOE.

Reporting

The FY2024 annual report (USTUR-0682-24) for the DE-HS0000073 grant was published online: https://ustur.wsu.edu/publications/annual-reports/ and electronically distributed within the scientific community. Four quarterly reports were electronically submitted to the funding agency and the university.

Registrant Statistics

Stacey L. McComish, *Associate in Research*

As of March 31, 2025, the Registries had 880 Registrants in all categories (Table 1). Of that number, 17 were living and 378 were deceased. The 17 living Registrants included two individuals who were registered for eventual whole-body donation, 13 for partial-body donation, and two for 'Special Studies,' i.e., a bioassay study with no permission for autopsy. There were also 485 Registrants in an inactive category, which includes those lost to follow-up and those whose voluntary agreements were not renewed.

Table 1. Registrant statistics as of March 31, 2025

Total living and deceased Registrants	395
Living Registrants	17
Potential partial-body donors	13
Potential whole-body donors	2
Special studies	2
Deceased Registrants	378
Partial-body donations	319
Whole-body donations	50
Special studies	9
Inactive Registrants	485
Total number of Registrants	880

Annual Newsletter

The annual Registrant newsletter was mailed in December (Appendix C). It included a note from the USTUR's director about the completion of a long-term project to enter data from health physics records into a database, as well as a summary of research on the accuracy of death certificates, the impact of death certificate misclassification on epidemiological studies, and the use of radiochemistry results to characterize plutonium solubility for worksite-specific dose assessments.

Registrant Deaths

During FY2025, the USTUR received one whole-body donation from an individual who worked with actinides for over 30 years. His primary intake appears to have been an inhalation. This was evidenced by a lung count that indicated he had a 1 nCi lung burden, though no incidents were associated with this measurement. He also had multiple wounds that were all monitored negative for plutonium. The worksite estimated that his systemic deposition was 5 nCi.

Registrant Status

The average age of living whole- and partial-body Registrants was 85.1±4.6 years and 84.3±14.4 years, respectively. The average age at death for the USTUR's deceased whole- and partial-body Registrants was 79.2±11.6 and 69.1±13.6 years, respectively.

The number of donations by calendar year, as well as the average age of donors by year, is shown in Fig. 2.

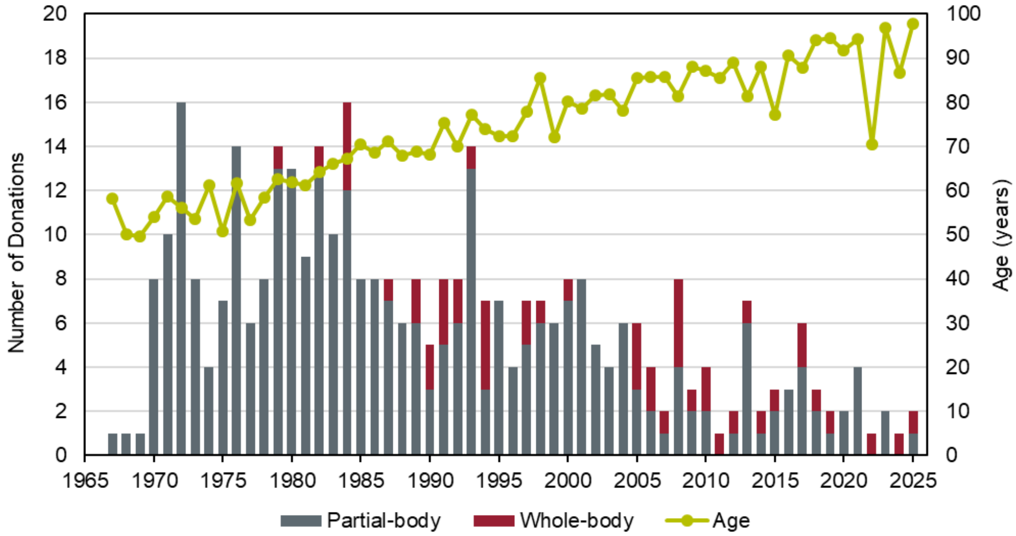

Fig. 2. Number of whole- and partial-body donations by calendar year and average age.

Health Physics Database Completed!

Maia Avtandilashvili, *Associate Professor*
Stacey L. McComish, *Associate in Research*

Health Physics Database Status

On August 15, 2024, Dr. Maia Avtandilashvili completed a 17-year-long project to standardize available copies of exposure and bioassay records from ***all*** USTUR Registrants. The USTUR houses tens of thousands of paper copies of these records, which were obtained from national laboratories and other nuclear worksites, after obtaining permission from Registrants.

The USTUR currently retains records from 49 whole-body and 319 partial-body tissue donors, as well as 16 living potential donors (three whole-body and 13 partial-body) and 11 special study cases (two living and nine deceased).

The USTUR Internal Health Physics Database was designed to standardize these extensive sets of health physics data from USTUR donors and provide access to detailed incident, contamination, in vitro and in vivo bioassay, air monitoring, work site assessment, external dosimetry, and treatment information for scientists who are interested in studying the distribution and dosimetry of actinides in the human body. Population of a database was initiated by Ms. Stacey McComish with entry of data from *Case 0202* – a nuclear defense worker who was involved in a plutonium fire – in December 2008. Starting in January 2012, Dr. Avtandilashvili took the lead role in database development and population and began to enter health physics data consistently. A total of 191,961 health physics records have been entered into the database. Figure 3 shows the FY2008–FY2025 progress and the overall status of the health physics database as of March 31, 2025.

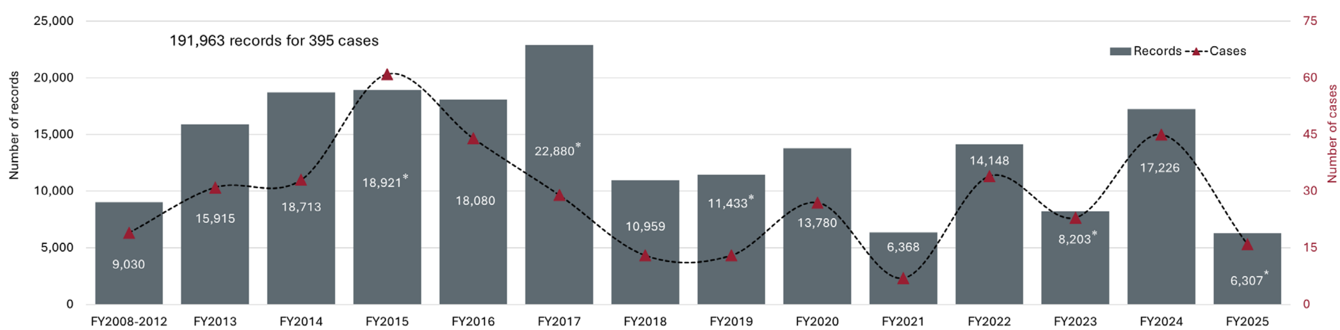

Fig. 3. FY2025 status of the USTUR health physics database. Includes special study cases completed in FY2015, FY2017, FY2019, FY2023, and FY2025 (*).

Missing Data Request

Next step was to identify all cases with incomplete health physics records and request missing data from the worksites. A total of 50 USTUR cases, including four special study Registrants, with missing records, were identified. Forty-three cases are from Hanford site.

On October 8, 2024, a records request for deceased Registrants from Hanford with missing data was sent to the U.S. DOE Hanford Field Office, Business and Industrial Relations (BIR). On February 27, 2025, the USTUR received an email from the Hanford Field Office confirming that the request had been processed, and the thumb drive with the requested records was to be delivered upon completion of data gathering. In the follow-up email on March 31, 2025, the USTUR was informed that the collection of the requested records was still in progress.

National Human Radiobiology Tissue Repository

Stacey L. McComish, *Associate in Research*

The National Human Radiobiology Tissue Repository (NHRTR) houses several collections of tissues and related materials from individuals with intakes of actinide elements and radium. These collections include tissues from USTUR donations, acid dissolved tissues from the Los Alamos Scientific Laboratory's (LASL) population studies, and tissues from the terminated radium worker and plutonium injection studies, which were received from Argonne National Laboratory (ANL).

Electronic Sample Inventory

The USTUR uses The Management Inventory System (THEMIS) to electronically inventory NHRTR samples. The USTUR's ultimate aim is to inventory all samples housed at the NHRTR facility. Most samples originating from USTUR tissue donations have already been inventoried. Projects to inventory USTUR tissues, acid solutions (acid-digested tissue samples), and histology slides were completed during FY2015 – FY2016. These projects are in a maintenance phase, where samples are inventoried as they are received and/or generated. This fiscal year, non-maintenance efforts focused on inventorying paraffin-embedded tissue blocks from the USTUR collection, and re-entering USTUR slides whose sample numbers did not conform to the current numbering system.

As of March 31, 2025, 28,406 parent samples and 12,256 subsamples had been inventoried using the THEMIS database (Table 2). During FY2025, laboratory staff inventoried 327 new USTUR tissues, 117 USTUR slides, and 69 USTUR paraffin embedded tissues blocks.

Table 2. Inventoried samples as of March 31, 2025

Tissue type	Samples		
	Parent	Sub-	Total
USTUR donations			
Soft tissue samples	5,658	462	6,120
Bone samples	5,135	84	5,219
Histology slides	2,053	1,876	3,929
Acid solutions	7,237	1,232	8,469
Planchets	0	6,924	6,924
Paraffin blocks	206	42	248
Plastic embedded	1	7	8
ANL tissues and slides			
Frozen tissues	2,011	457	2,468
Slides	482	0	482
Other	185	13	198
LASL solutions	4,456	192	4,648
Blank and QC			
Acids	466	56	522
Planchets	321	840	1,161
Miscellaneous	195	71	266
Total	28,406	12,256	40,662

Manual Inventory of ANL Samples

The NHRTR houses dried and plastic-embedded bones (resin blocks) from ANL's radium worker, plutonium injection, and other studies. These samples are stored in cardboard boxes and organized by case number.

A project was initiated this fiscal year to repackage all these materials into zip-sealed bags and conduct manual inventory of the samples. A new standard operating procedure (USTUR 820: *Radiation Survey Procedure for Radium Sample Packages*) was developed to enhance worker safety during repacking and inventory of radium-bearing samples. All workers were monitored for external radiation using chest and finger ring dosimeters. As of March 31, 2025, approximately 1,000 samples from 127 individuals have been repackaged and manually inventoried using a notebook. This is an ongoing project.

Inventory Progress Summary

Figure 4 shows the cumulative number of inventoried samples at the end of each calendar year from 2010 to 2024. Initial efforts focused on inventorying USTUR tissues and acids. From 2016 to 2019, laboratory personnel focused on LASL acid and USTUR planchet inventories. Resumption of efforts to inventory non-USTUR samples following the COVID-19 pandemic is reflected in the increase in ANL tissues and slides during 2023. In FY2025, the USTUR initiated the inventory of ANL dried bones and tissue blocks. This is a challenging task considering the conditions and radioactivity of the samples. The efforts were focused on repacking the samples and creating a paper inventory. This is not reflected in Fig. 4 which displays only progress toward electronically inventorying samples.

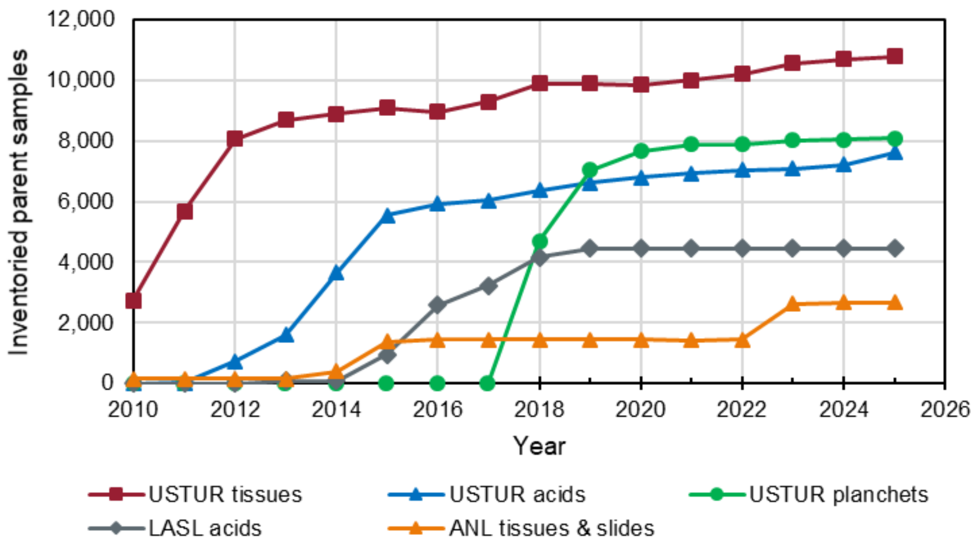

Fig. 4. Cumulative number of inventoried NHRTR samples at the end of each calendar year, and as of April 24 for year 2025.

Radiochemistry Operations

George Tabatadze, *Assistant Director*

This section describes specific activities and achievements of the Radiochemistry Group during FY2025.

Personnel

As of March 31, 2025, operation of the radiochemistry laboratory was supervised by Dr. Tolmachev (Principal Radiochemist) with two full-time personnel – Dr. Tabatadze (Laboratory Manager) and Ms. Thomas (Radiochemist).

Facility Upgrade

In FY2025, the USTUR completed the installation of a new make-up air unit (MAU) to resolve significant negative pressure in the radiochemistry laboratory caused by increased exhaust from five polypropylene fume hoods installed in FY2024. The MAU, located outside the laboratory building, regulates air supply and maintains pressure equilibrium.

New make-up air unit (MAU) system

This upgrade followed a lease amendment process initiated at the beginning of FY2025 to clarify responsibility for the installation. Because this process took longer than anticipated, the installation was delayed and not completed until December 2024.

New Equipment

The vacuum drying system, consisting of a drying oven (Yamato DP83C) equipped with a dry screw vacuum pump (Leybold Varodry 65), a -40 °C cold trap, and a SNAP vacuum controller, was purchased from DigiVac (Morganville, New Jersey, USA). The equipment was delivered in December 2024, and installation, along with training of USTUR staff on system operation, was completed in January 2025. The system is currently undergoing testing, and a standard operating procedure tailored to USTUR tissue samples is in development to ensure appropriate drying parameters.

The USTUR received an eight-detector modular α-spectrometry system (Alpha Ensemble®; AMETEK/ORTEC, Oak Ridge, Tennessee, USA). This increases USTUR's counting capacity to 48 detectors.

Vacuum-assisted drying oven Yamato DP83C (left) and eight-detector Alpha Ensemble® modular α-spectrometry system (right)

New Standard Operating Procedure

In Q4 FY2025, a new standard operating procedure, USTUR 820: *Radiation Survey Procedure for Radium Sample Packages,* was developed to enhance worker safety during inventory of boxes containing radium samples from the NHRTR. The protocol provides a step-by-step radiation survey process to ensure compliance with regulatory dose limits. It establishes conservative exposure thresholds, applies safety margins for close-contact assessments, and outlines clear actions if limits are exceeded. Equipment requirements, dosimetry practices, PPE standards, and ALARA principles help minimize exposure and avoid contamination, while thorough documentation ensures traceability and regulatory compliance.

Data Quality Assurance Plan

In FY2025, the USTUR advanced the implementation of the Data Quality Objectives (DQO) document by expanding the application of the URpy (USTUR Radiochemistry python) Python code. The DQO document was revised to function as the software specification for URpy, and the equations it contains were fully implemented in the code. Uncertainty propagation was extended across the entire USTUR radiochemistry process. Verification and validation of the software continued using previously analyzed USTUR cases. In the next phase, all existing cases will be reanalyzed using URpy, with a focus on comparing historical and newly generated results and integrating data QA/QC steps directly within the code.

Tissue Sample Analysis

Tissue sample analysis is a multi-step process. During the analysis, a tissue undergoes five different analytical steps: (i) drying and ashing, (ii) digestion and dissolution, (iii) radiochemical actinide separation, (iv) preparation of an α-counting source (planchet), and (v) measurement of individual actinides – plutonium (^{238}Pu and $^{239+240}$Pu), americium (^{241}Am), uranium (^{234}U, ^{235}U, and ^{238}U), and/or thorium (^{232}Th).

During FY2025, analyses of 51 tissue samples for ^{238}Pu, $^{239+240}$Pu, and ^{241}Am, including 13 bone and 38 soft tissue samples from a partial-body donation (*Case 0718*, died 2021) and a whole-body donation (*Case 0846*, 2008) were completed. Additionally, 192 tissue samples, including 45 bone and 147 soft tissue samples from five partial-body and five whole-body donations, were submitted for analysis.

Figure 5 shows FY2021–FY2025 tissue analysis progress.

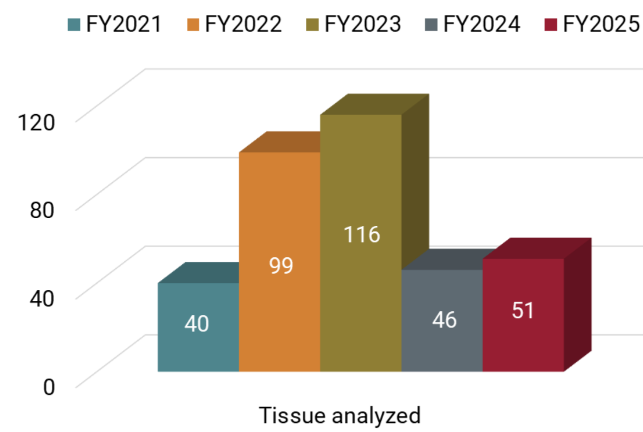

Fig. 5. USTUR tissue analysis progress in FY2021–FY2025.

Radiochemistry Case Analysis

As of March 31, 2025, the USTUR had received 50 whole- and 319 partial-body donations, including one whole-body donation, *Case 0409*, accepted during FY2025.

Cases are categorized as 'Intact,' 'Incomplete,' 'Surveyed', or 'Complete'. 'Intact' means that no tissue samples have been analyzed. 'Incomplete' typically denotes that analysis of a selected sub-set of tissues is in progress. 'Surveyed' denotes that only analysis of selected tissue samples that provide key scientific information to determine the level of exposure has been completed and can be used for biokinetic modeling. More tissue samples from 'Surveyed' cases are available for analysis. 'Complete' denotes that a full selection of tissue samples was analyzed, and results were reported.

In FY2025, radiochemical analyses of an 'incomplete' partial-body donation, (*Case 0718*), were completed. The radiochemistry status of this case was changed to 'complete'. Radiochemical analyses of a previously 'intact' partial-body donation (*Case 0398*, 2023), and two whole-body donations (*Case 0763*, 2024; *Case 0802*, 2022) began in FY2025. The radiochemistry status of these cases was changed to 'incomplete'. Figure 6 shows FY2021–FY2025 case analysis progress. The status change of case analyses during FY2025 is shown in Figure 7.

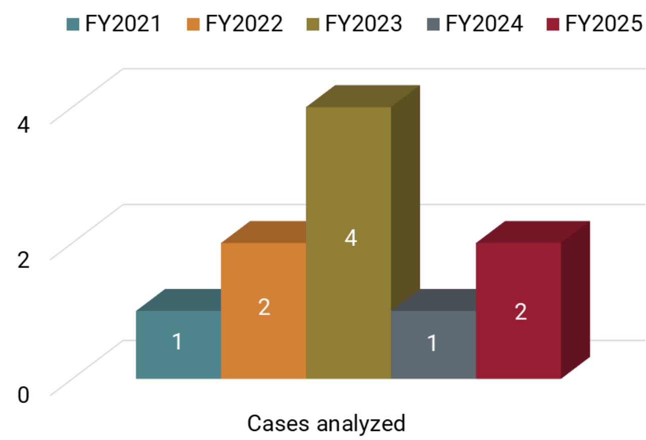

Fig. 6. USTUR case analysis progress in FY2021–FY2025.

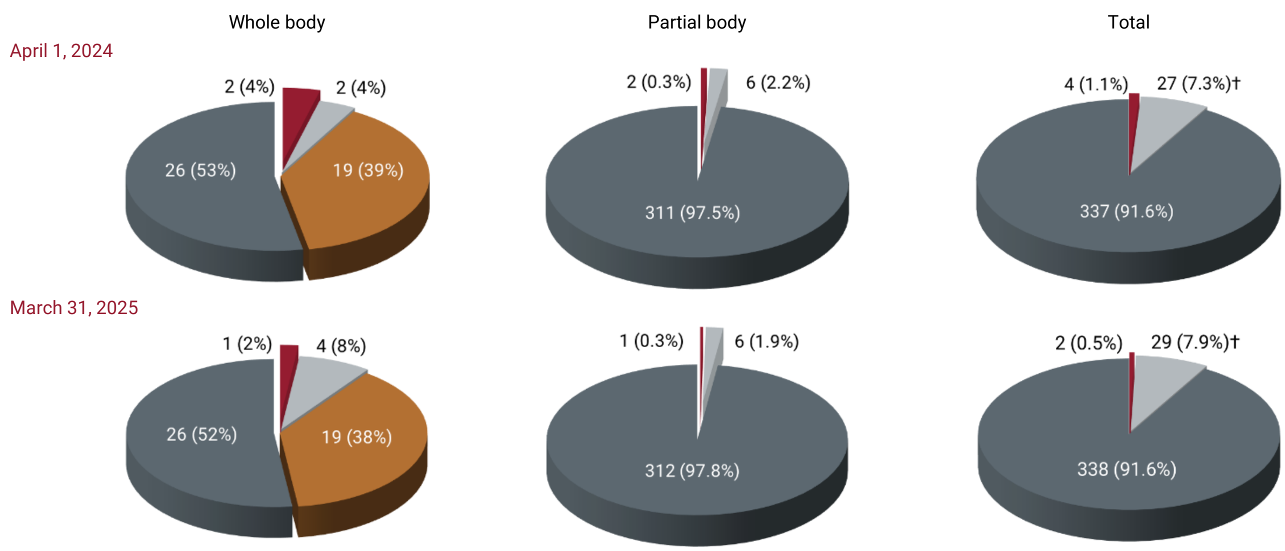

Fig. 7. Radiochemistry case analysis status: ■ Intact; ■ Incomplete; ■ Surveyed; ■ Complete. † Includes 'Surveyed' whole-body cases.

Tissue Sample Backlog

The USTUR/NHRTR retains a tissue backlog of 2,491 samples from 29 whole- and partial-body cases. They remain 'Incomplete' as of March 31, 2025. This includes 2,254 tissues from 22 whole-body cases, and 237 tissues from seven partial-body cases. Of 2,491 backlog tissue samples, 2,122 (85%) need to be analyzed for plutonium, 128 (5%) for americium, and 241 (10%) for uranium isotopes (Fig. 8).

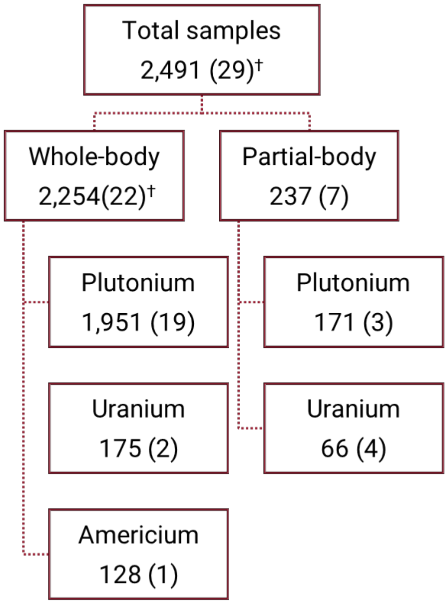

Fig. 8. USTUR tissue sample backlog at the end of FY2025.
† Excludes two Thorotrast cases.

2024 Advisory Committee Meeting Summary

Thomas L. Rucker, *Chair*

The 2024 annual meeting of the USTUR's Scientific Advisory Committee (SAC) was held April 25–26 in Richland, WA. This two-day meeting featured both operational and scientific presentations (Appendix D). It provided time for SAC members to discuss the USTUR's activities during the past year, and to make recommendations for the coming year.

Meeting Summary

The meeting opened with introductions and updates. The USTUR director, Sergei Tolmachev, welcomed meeting attendees, and the committee chair, Thomas Rucker, provided opening remarks. This was followed by an update on the Department of Energy (DOE) given by the USTUR program manager, Joey Zhou. WSU Tri-Cities vice chancellor, Kathleen McAteer, provided updates regarding the WSU Tri-Cities campus, and WSU College of Pharmacy and Pharmaceutical Sciences (CPPS) associate dean for undergraduate programs, Kathryn Meier, summarized research at the CPPS. Following updates, the USTUR's faculty and staff gave several presentations on the operational aspects of the Registries, including: administrative and financial developments, progress toward addressing recommendations from the 2023 SAC meeting, registrant statistics, laboratory information management system (LIMS) options, and radiochemistry operations.

This year's meeting included four scientific presentations on a variety of topics related to USTUR research. John Klumpp of Los Alamos National Laboratory discussed the unique behavior of ^{238}Pu and efforts to model its biokinetics. Michael Bellamy provided an overview of the Million Person Study, including several slides that highlighted ways that the USTUR has contributed to this project. Martin Šefl described uncertainties in estimated post-mortem organ activities that were calculated from urinary excretion of plutonium using Bayesian methodologies. The final scientific presentation was given by Xirui Liu, who described progress that she had made toward assessing the impact that death certificate misclassification errors on estimates risk in epidemiological studies.

To close the first day of the meeting, Dr. Tolmachev presented the USTUR's research and operational plan for the coming year, and opened the meeting for general discussion about the day's presentations. This included a Q&A session where SAC members and other attendees were invited to ask questions about the USTUR's operations and research.

The second day was administrative in nature and was open only to SAC members, the USTUR staff, and the DOE program manager. The day began with a brief discussion about SAC membership, and a session where the SAC and USTUR staff discussed topics presented during Day 1. This was followed by an executive session, where only SAC members remained in the meeting. After lunch, the USTUR staff and the DOE program manager rejoined the meeting, and the SAC shared several comments regarding progress during the past year as well as recommendations for the coming year.

Recommendations

1. We recommend developing a brochure for opportunities for research and use of the data and services of the USTUR. We recommend this include the vision for the USTUR and lab following completion of receipt and analysis of all Registrant samples.
2. We recommend the USTUR perform an informal literature review on impacts of over/under-ascertainment on risk estimates. Notable references are attached. If feasible, arrange for collaborations (e.g., with NCI) for these types of analyses/reviews.
3. We recommend the USTUR plan on sending staff to next year's (2025) NCI course on Epidemiology and Dosimetry and to the 2024 RRMC.
4. We recommend the USTUR send staff (e.g. Xirui) for training to the REAC/TS internal dosimetry training courses and other ORAU or MJW professional training courses.
5. We recommend Martin's research results be published.
6. We recommend inserting the Python code in the DQO document for documentation.
7. We recommend applying the DQO equations retroactively to some previous sample cases to explore the input to decisions.

SAC Membership

Luiz Bertelli's second term expired, and his participation on the advisory committee was renewed for a final three-year term. Additionally, Katherine Ertell resigned from the committee. She was replaced by Elizabeth Ellis, who attended the meeting as an incoming member.

Misclassification of Underlying Cause of Death

Stacey L. McComish, *Associate in Research*
Xirui Liu, *Associate in Research*

It is generally understood that when misclassification of causes of death is non-differential (i.e. independent of dose), the association between dose and measures of risk will bias epidemiological findings toward the null hypothesis. This heuristic is often used to state that if one could correct for misclassified causes of death, the findings would have been more significant. However, recent papers indicate that there are exceptions to the standard assumption that misclassifications biases risk estimates toward the null(1,2).

This study evaluated the impact of death certificate misclassification on radiation health risk models. Sixteen analyses were performed using different initial datasets and calculation methods (Table 3). Each initial dataset consisted of two variables: dose and outcome. Doses were either taken from real USTUR cumulative external dose data (*n*=229 cases) or were generated using a log-normal distribution to generate a larger dataset with the same geometric mean and geometric standard deviation as observed among USTUR Registrants (*n*=5,000). Outcomes were cancer deaths as identified from USTUR Registrants' death certificates (DC) or autopsy reports (AR), or they were generated using a logistic probability function.

Table 3. Analysis of impact with various methods and initial datasets

#	Method	Initial dataset					Percentage (min−max) of		
		Doses	Outcomes	Forced by	Odds ratio	*p*-value	OR moved away from null	Significant *p*-value	OR moved away from null with significant *p*-value
1	2×2 table	real USTUR (binary)	real USTUR (AR)	-	0.7092	0.2604	19.0−64.0	0.0−10.5	0.0−10.5
2	2×2 table	real USTUR (binary)	real USTUR (DC)	-	0.7003	0.2534	17.0−58.9	0.0−6.7	0.0−6.6
3	Logistic regression	real USTUR (continuous)	real USTUR (AR)	-	0.3598	0.3263	22.9−43.8	0.0−4.8	0.0−4.5
4	logistic regression	real USTUR (continuous)	real USTUR (DC)	-	0.5296	0.5398	31.5−46.8	0.0−3.6	0.0−2.7
5	2×2 table	real USTUR (binary)	generated	odds ratio	1.0112	1.0000	35.2−60.7	0.0−3.3	0.0−2.1
6	2×2 table	real USTUR (binary)	generated	*p*-value	1.7672	0.0501	5.7−54.3	9.3−54.3	5.7−54.3
7	2×2 table	real USTUR (binary)	generated	*p*-value	1.7810	0.0486	7.7−53.3	7.9−53.3	7.7−53.3
8	logistic regression	real USTUR (continuous)	generated	odds ratio	1.0001	0.9999	46.3−53.6	0.0−3.1	0.0−1.6
9	logistic regression	real USTUR (continuous)	generated	*p*-value	6.5016	0.0501	9.1−42.9	9.2−41.6	9.0−41.6
10	logistic regression	real USTUR (continuous)	generated	*p*-value	6.5991	0.0498	8.9−46.2	9.4−45.0	8.9−45.0
11	2×2 table	generated (similar to USTUR) (binary)	generated	odds ratio	1.0019	1.0000	46.9−51.2	0.0−3.4	0.0−1.6
12	2×2 table	generated (similar to USTUR) (binary)	generated	*p*-value	1.1291	0.0505	6.8−42.6	9.4−39.4	6.8−39.4
13	2×2 table	generated (similar to USTUR) (binary)	generated	*p*-value	1.1306	0.0493	6.6−44.1	9.3−44.1	6.6−44.1
14	logistic regression	generated (similar to USTUR) (continuous)	generated	odds ratio	1.0000	0.9999	49.0−51.7	0.0−3.5	0.0−1.9
15	logistic regression	generated (similar to USTUR) (continuous)	generated	*p*-value	1.4009	0.0505	7.7−44.5	9.5−40.4	7.7−40.4
16	logistic regression	generated (similar to USTUR) (continuous)	generated	*p*-value	1.4015	0.0492	7.7−44.9	9.5−42.6	7.7−42.6

AR – autopsy report; DC – death certificate; OR – odds ratio

In analyses with generated outcomes, the odds ratio was forced to approximately 1 or the *p*-value was forced as a preset value. When forcing *p*-values, both a maximum significant value lower than 0.05 and a minimum non-significant value just above 0.05 were chosen. For each initial dataset, the odds ratio and *p*-value were calculated using either a two-by-two table or a logistic regression. The study then started with the initial dataset, and simulated 20,000 possible misclassified datasets for various combinations of over- and under-misclassification rates ranging from 0 to 30%. The odds ratio and *p*-value were calculated for each of the 20,000 misclassified datasets and three summary statistics were calculated to evaluate how the odds ratio and corresponding *p*-value changed due to misclassification: (i) percentage of odds ratios that moved away from the null, (ii) percentage of *p*-values that were significant, and (iii) the percentage of odds ratios that moved away from the null and had a significant *p*-value.

A paper summarizing this work is being prepared for publication in a peer-reviewed journal.

Reference

1. Jurek AM, Greenland S and Maldonado G. How far from non-differential does exposure or disease misclassification have to be to bias measures of association away from the null? International Journal of Epidemiology; 37: 382–385; 2008.
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Vacuum Drying: Improving Tissue Sample Preparation

Sergey Y. Tolmachev, *Professor*
George Tabatadze, *Associate Professor*

Tissue ashing, the first step in radiochemical tissue analysis at the USTUR (Fig. 9), is critical for the complete dissolution of the entire sample. Historically, the USTUR tissue samples ashing procedure [(1)] was adopted from the method used by Los Alamos National Laboratory since 1950s[(2)]. With the advances in technologies, the USTUR tissue analysis protocol was updated by 2010[(3)] with the only exception of the sample ashing step.

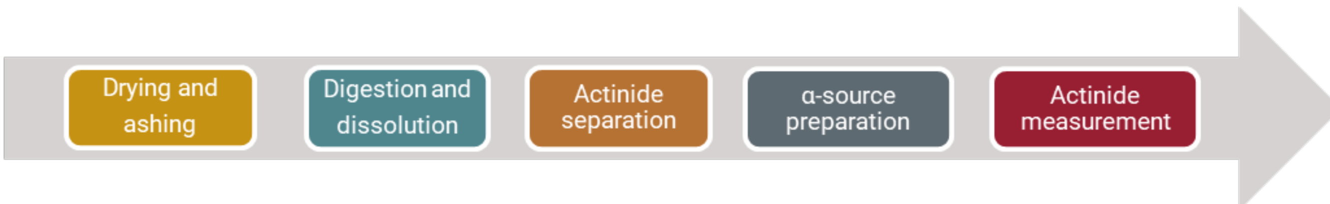

Fig. 9. USTUR tissue radiochemical analysis protocol

Ashing of large tissue samples is a challenging task, due to a large quantity of moisture and organic matter content in samples. To reduce moisture content, samples are conventionally dried in various-size glass beakers at 100 ˚C for several days prior to dry-ashing at 450 ˚C. Dry-ashed liver and brain samples typically require additional treatment with concentrated nitric acid (wet ashing).

During FY2025, the Radiochemistry Group tested a vacuum-drying technique to improve the quality of drying/ashing procedure. The key principle of vacuum drying is its ability to lower the boiling point of water by reducing pressure, thus accelerating evaporation. The objective of this test was to compare the effectiveness and quality of large-size (over 400 g) tissue sample drying with two techniques, in terms of moisture content removal and time. The comparison was conducted by DigiVac (Morganville, NJ) using a Yamato DP83C vacuum-drying oven equipped with a Leybold Varodry 65 dry screw vacuum pump, a -40 °C cold trap, and a vacuum controller. The system achieved a moisture removal rate of 1.8 kg h^{-1}, sufficient for processing of large sample batches.

Bovine heart, liver, and kidney samples with weights ranging from 420 to 560 g were purchased for the testing. To minimize sample size difference on the efficiency of drying, sample weights were closely matched for each individual organ.

For both drying procedures, the oven temperature was set to 99 °C. Once the drying cycle was complete, samples were reweighed to assess the amount of moisture removed.

In general, samples dried under vacuum had a better visual appearance, with a drier and more uniform texture compared to those dried in a conventional oven (Fig. 10). For example, the liver had a charred outer layer while the interior remained moist, most likely due to non-uniform moisture removal. The vacuum-dried liver sample had a jerky-like appearance. Heart samples were dried on aluminum foil in glass trays, while 1-L glass beakers were used for kidney and liver samples.

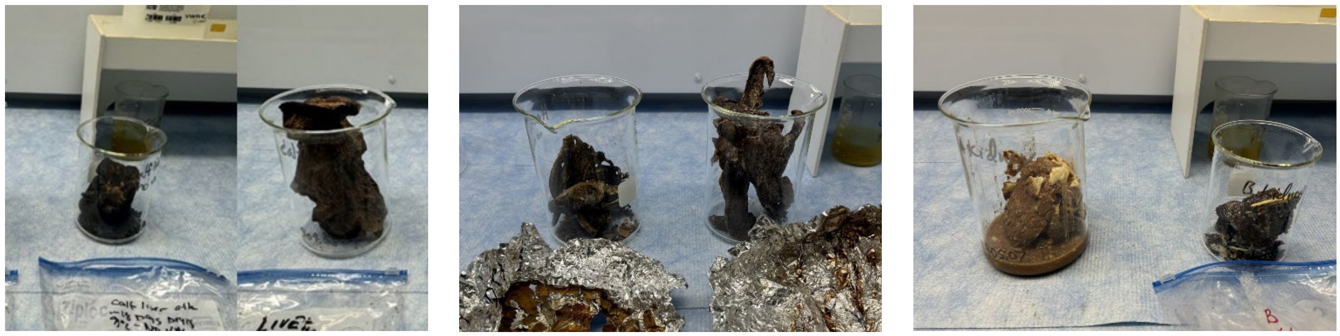

Fig. 10. Dried liver (left), heart (middle), and kidney (right) samples after conventional (left beakers) and vacuum drying (right beakers).

Using vacuum drying, tissue samples consistently reached maximum dryness (lowest dry fraction) in 24 hours (Figs. 11–12). For heart samples, no difference in drying time was observed for an open-tray drying geometry (Fig. 11). For kidney samples, after 72 hours, vacuum drying achieved a deeper level of moisture removal. (Fig. 11). For kidney and liver samples processed in glass beakers, vacuum drying significantly reduced the drying time (Figs. 11–12). However, using conventional drying, the same level of dryness can be achieved for the liver after 96 hours instead of 25 hours with vacuum drying (Fig. 12).

The next step was to evaluate the impact of the drying process on the quality of tissue ashing. The liver, heart, and kidney samples, dried using conventional and vacuum ovens, were received from the DigiVac research group (Fig. 10).

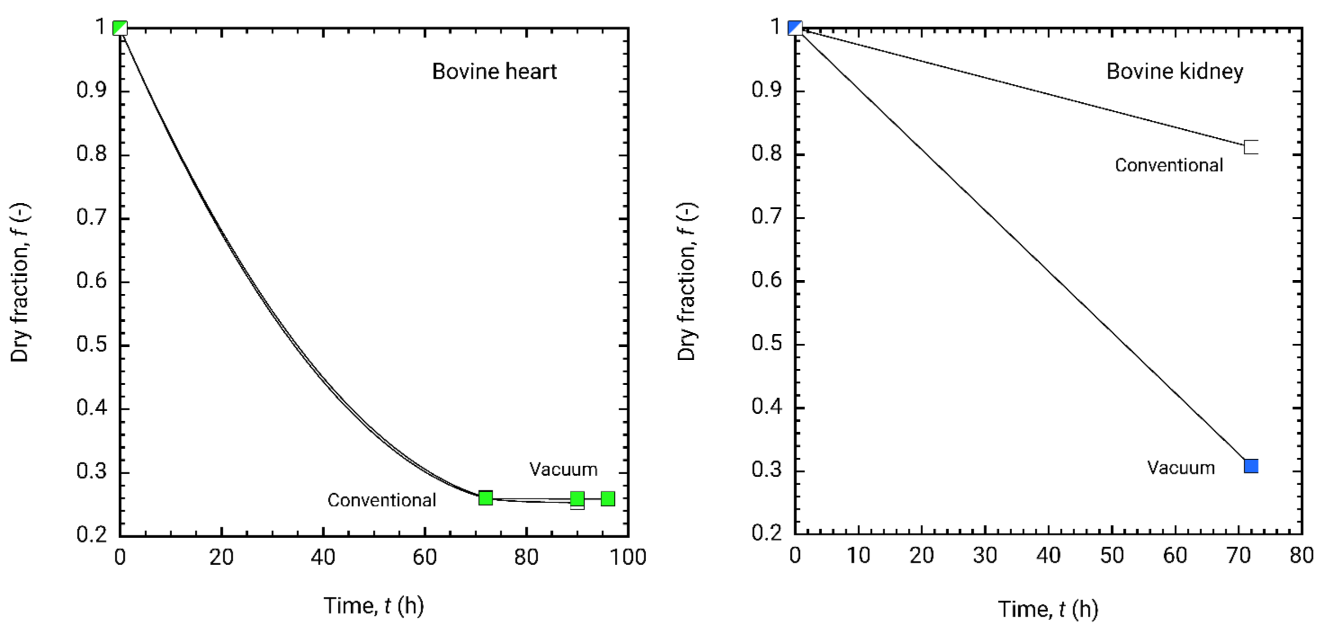

Fig. 11. Comparison of conventional and vacuum drying procedures for: bovine heart(left) and bovine kidney (right).

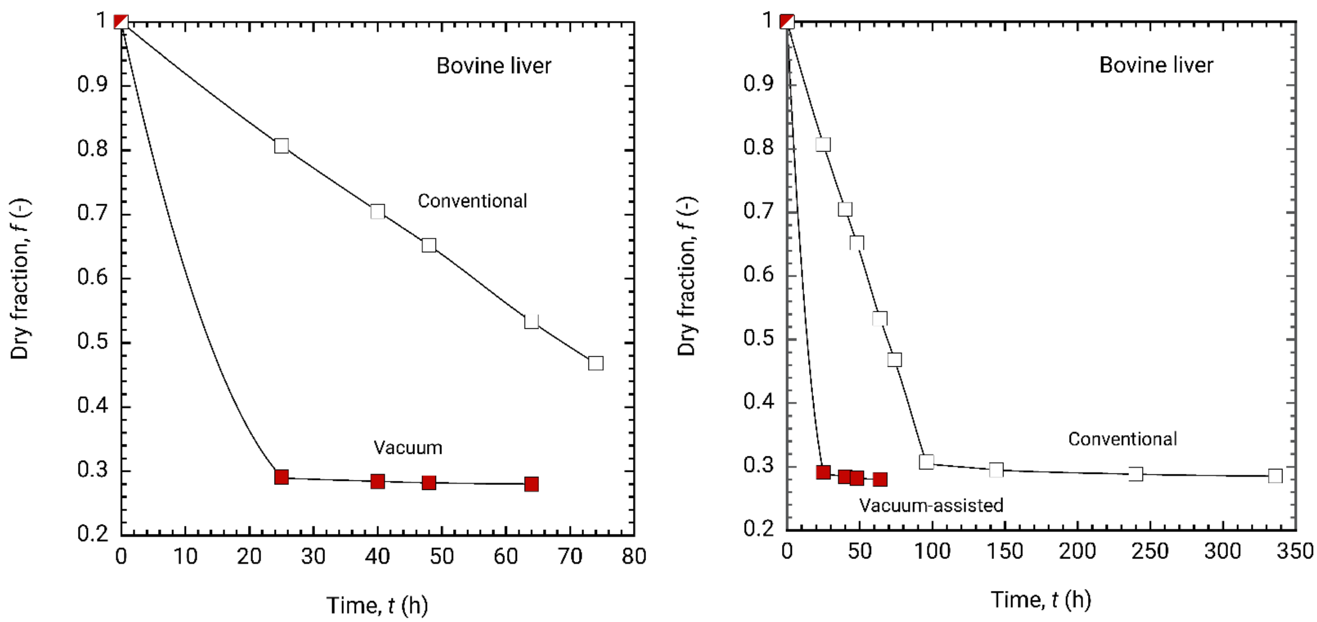

Fig. 12. Comparison of conventional and vacuum drying procedures for bovine liver: short (left) and long (right) time.

All samples were ashed in a single batch at 450 °C for 2 weeks. The visual appearance of the final ash residues and the ash fractions, the ratio of final ash weight to the initial wet sample weight, were compared.

Figure 13 shows ashed samples of the liver, heart, and kidney. Table 4 summarized weights and ash fractions for each tissue sample with respect to drying method used.

Fig. 13. Ashed liver (left), heart (middle), and kidney (right) samples after conventional (left beakers) and vacuum drying (right beakers).

Table 4. Weights and ash fractions for each tissue sample with respect to drying method used

Tissue	Wet weight (g)		Dry weight (g)		Ash weight (g)		Ash fraction (%)	
	conventional	vacuum	conventional	vacuum	conventional	vacuum	conventional	vacuum
Liver	561.6	560.9	160.0	157.1	24.48	7.46	4.36	1.33
Heart	427.8	422.3	108.4	109.4	3.83	4.38	0.90	1.04
Kidney	461.8	498.7	375.2	115.4	4.49	4.12	0.97	0.87

Ashing the liver sample dried in a conventional oven resulted in a charred-dense residue of 24.48 g with an ash fraction of 4.33%. This suggests that inadequate moisture removal during the drying process or smaller size beaker (500 mL *vs* 1000 mL) interfered with the combustion process. An additional wet-ashing step was required to complete sample ashing prior to its microwave acid-digestion. In contrast, ashing of the liver sample dried using the vacuum oven resulted in a 'fluffy'-gray residue of 7.46 g with an ash fraction of 1.33% (Table 4). The three-fold difference in ash fraction suggests incomplete ashing for the liver sample dried in a conventional oven. No difference in ash fractions was observed for the heart and kidney samples regardless of the drying process used. Visual inspection showed that, after ashing, the vacuum-dried samples of all three organs exhibited significantly fewer residue deposits on the walls of the beakers. Overall, vacuum drying produced a more uniform and cohesive sample texture resulting in a better efficiency of the ashing process.

Reference

1. USTUR-100. Tissue ashing, sample dissolution, sample aliquot Selection, and tracer addition for anion exchange Isolation of radionuclides; 1995.
2. Boyd HA, Eutsler BC, McInroy JF. Determination of americium and plutonium in autopsy tissue: Methods and problems. In: Wrenn ME (Ed). Actinides in Man and Animals. R. D. Press, Salt Lake City, Utah, 1981: 43–52.
3. Tolmachev SY, Ketterer ME, Hare D, Doble P, James AC. The US Transuranium and Uranium Registries: forty years' experience and new directions in the analysis of actinides in human tissues. Proceedings in Radiochemistry: A Supplement to Radiochimica Acta; 1: 173–181; 2011.

Curium-244 Case Study

Sergey Y Tolmachev, *Professor*
Maia Avtandilashvili, *Associate Professor*

Curium (Cm) is one of minor actinides presented in spent nuclear fuel. Due to its high specific activity, the radiotoxicity of ^{244}Cm predominates over the chemical toxicity. Information on curium distribution and biokinetics in the human body is limited. The USTUR has data on a single case with documented ^{244}Cm intake. Partial body *Case 0641* was exposed to airborne ^{244}Cm due to a glove-box failure. He died from hypertensive heart disease 52 years after the intake. A total of 35 soft tissue and 16 bone samples collected at autopsy were radiochemically analyzed for ^{244}Cm. Activity concentration in systemic organs followed the pattern: skeleton>liver>kidney>muscle. The total systemic ^{244}Cm activity was estimated to be 0.88±0.09 Bq with 91% retained in the skeleton. A total of 0.019±0.001 Bq was deposited in the respiratory tract. The activities in the respiratory tract, liver, and skeleton were used to estimate the intake and committed effective dose using Taurus internal dosimetry software (Fig. 14). The ICRP default biokinetic models, with the assumption of 84 % of type M compounds (e.g. oxide, nitrate, chloride) and 16 % of type S material described the data well (χ^2 = 0.763; p = 0.380). Total ^{244}Cm intake was estimated as 266±8 Bq and the corresponding committed effective dose was 1.77±0.07 mSv.

Using the estimated intake of 266 Bq, ^{244}Cm activities in the kidneys, heart, and stomach were predicted by the model (Fig. 15).

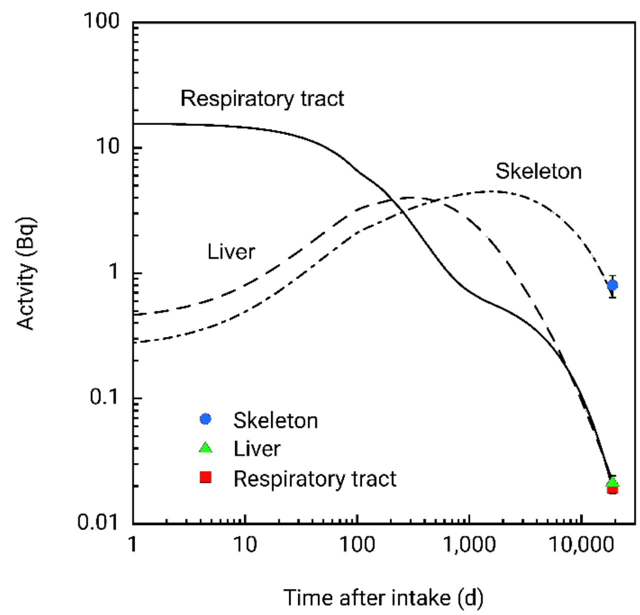

Fig. 14. Model fits (lines) and measured ^{244}Cm activities in the skeleton, liver, and respiratory tract.

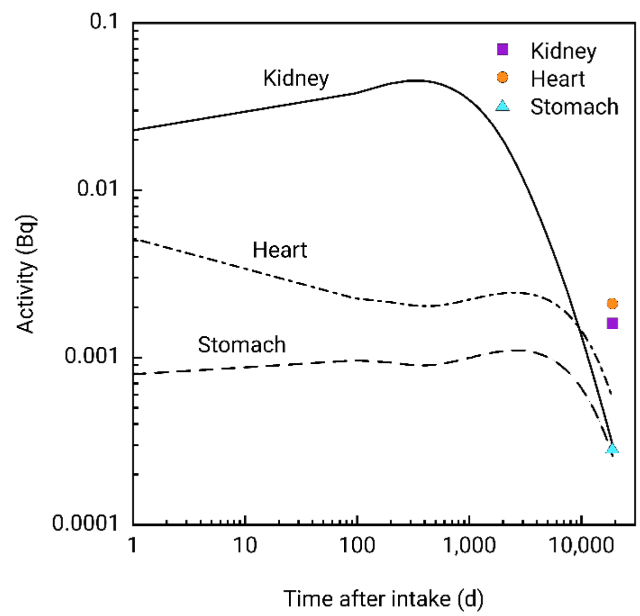

Fig. 15. Model predictions (lines) vs measured ^{244}Cm activities in the kidney, heart, and stomach.

Professional Activities and Services

During FY2025, the USTUR staff was actively involved in professional and academic activities nationally and internationally.

Professional Services

NCRP Council

Dr. Avtandilashvili and Dr. Tolmachev served as Council Members of the National Council on Radiation Protection and Measurements (NCRP) (2020–2026 and 2023–2029, respectively).

https://ncrponline.org/about/members/council-members/

NCRP Program Committee 6

Dr. Tolmachev served as a member of NCRP Program Committee 6 (PAC 6): Radiation Measurements and Dosimetry.

https://ncrponline.org/program-areas/pac-6-radiation-measurements-and-dosimetry/

NCRP Scientific Committee 6-13

Dr. Avtandilashvili served on the NCRP scientific committee (SC 6-13) on Methods and Models for Estimating Organ Doses from Intakes of Radium.

https://ncrponline.org/program-areas/sc-6-13-methods-and-models-for-estimating-organ-doses-from-intakes-of-radium/

EPA Science Advisory Board's Review Panel

Dr. Avtandilashvili and Dr. Strom served as members of the Radionuclide Cancer Risk Coefficients Review Panel of the Environmental Protection Agency's (EPA) Science Advisory Board (2022–2025).

https://sab.epa.gov/ords/sab/f?p=114:14:14616146437943:::14:P14_COMMITTEEON:Radionuclide%20Cancer%20Risk%20Coefficients%20Review%20Panel

U.S. DOE Russian Health Studies

Dr. Tolmachev served as an *ex-officio* member of the Scientific Review Group of the U.S. DOE Russian Health Studies Program. He is a reviewer for Project 2.8 "Mayak Worker Tissue Repository".

https://www.energy.gov/ehss/russian-health-studies-program

HPS/ANSI Standards Committee N13 Working Group

Dr. Avtandilashvili was appointed to serve as a member (2024–2027) of the Working Group of the Health Physics Society (HPS) Standards Committee N13 accredited by the American National Standards Institute (ANSI) to revise the National Standard ANSI/HPS N13.42-1997 "Internal Dosimetry for Mixed Fission and Activation Products".

Herbert M. Parker Foundation

Dr. Tolmachev and Dr. Tabatadze served as members of the Board of Trustees of the Herbert M. Parker Foundation (2016– present and 2019– present, respectively).

https://tricities.wsu.edu/parkerfoundation/

Hanford Advisory Board

Dr. Strom, a USTUR/CPPS adjunct faculty member, served as an alternate member of the Hanford Advisory Board (HAB) in a position representing the Benton-Franklin Public Health District. He also serves on the HAB's Public Involvement and Communication and Health Safety and Environment Protection committees.

https://www.hanford.gov/page.cfm/hab/

HPS Board of Directors

Dr. Tabatadze was elected to serve as a member of the Board of Directors of the Health Physics Society (2025–2028).

https://hps.org/membersonly/hpnews/society_news.html#Art1493

HPS Academic Education Committee

Dr. Tabatadze served as a member (2023–2025) of the Academic Education Committee of the Health Physics Society.

https://hps.org/aboutthesociety/organization/committees/committee1.html

HPS International Collaboration Committee

Dr. Tabatadze has served as a member (2016–2025) of the International Collaboration Committee of the Health Physics Society.

https://hps.org/aboutthesociety/organization/committees/committee9.html

HPS Science Support Committee

Dr. Tabatadze served as a member (2022–2025) of the Science Support Committee of the Health Physics Society.

http://hps.org/aboutthesociety/organization/committees/committee18.html

WSU Provost's Advisory Committee on Promotion and Tenure

Dr. Tolmachev served as a member (2022–2026) of the WSU Provost's Advisory Committee on Promotion and Tenure.

WSU Faculty Senate Graduate Studies Committee

Dr. Avtandilashvili and Dr. Tabatadze served as members (2023–2026) of the WSU Faculty Senate Graduate Studies Committee.

https://facsen.wsu.edu/graduate-studies-committee/

WSU Radiation Safety Committee

Dr. Tabatadze served as a member (2019–2025) of the WSU Radiation Safety Committee (RSC).

https://rso.wsu.edu/radiation-safety-committee/

WSU CPPS Graduate Steering Committee

Dr. Tolmachev was appointed to serve as a member (2024–2025) of the WSU College of Pharmacy and Pharmaceutical Sciences (CPPS) Graduate Steering Committee.

WSU CPPS Graduate Admissions Committee

Dr. Avtandilashvili and Dr. Tabatadze were appointed to serve as members (2024–2025) of the WSU/CPPS Graduate Admissions Committee.

WSU CPPS Faculty Meetings Secretary

Dr. Tabatadze served as a secretary (2023–2025) of the WSU/CPPS faculty meetings.

Kyushu Environmental Evaluation Association

Dr. Tolmachev served as a Technical Advisor (2016–2024) at the Kyushu Environmental Evaluation Association (Fukuoka, Japan). http://www.keea.or.jp/

Georgian Technical University

Dr. Avtandilashvili and Dr. Tabatadze served as members (2023–present) of the Internal Scientific Review Board of the Institute "Wave" at the Georgian Technical University (Tbilisi, Republic of Georgia). https://institutes.gtu.ge/en/Institute/3

Shota Rustaveli National Science Foundation

Dr. Tabatadze (PI) and Dr. Avtandilashvili (investigator) were awarded with three-year research grant (2025–2028), "*Protecting Public Health through Comprehensive Radon Monitoring and Dosimetry in Urban Tbilisi*" to Georgian Technical University from the Shota Rustaveli

National Science Foundation of Georgia. https://rustaveli.org.ge/eng

Japanese Journal of Health Physics

Dr. Tolmachev served as a member (2011–2025) of the Editorial Board for the *Japanese Journal of Health Physics*. https://www.jstage.jst.go.jp/browse/jhps

Austin Biometrics and Biostatistics

Dr. Avtandilashvili has served as a member (2016–present) of the Editorial Board for the journal of *Austin Biometrics and Biostatistics*.

Physical Science and Biophysics Journal

Dr. Tabatadze served as a member (2022–present) of the Editorial Board for the journal of *Physical Science and Biophysics Journal*.

Scientific Meetings

USTUR faculty attended and participated in the following scientific meetings:

- European Radiation Dosimetry Group (EURADOS) Annual Meeting 2024, Oxford, UK, April 8–11, 2024
- 3rd Public Meeting of the National Academies of Science, Engineering and Medicine's Committee on Feasibility of Assessing Veteran Health Effects of Manhattan Project (virtual), May 8, 2024
- International Commission on Radiological Protection's Workshop "30 Years of Scientific Achievements for International Radiological Protection: Summary of the Southern Urals Health Studies Program", Vienna, Austria, May 24–25, 2024
- 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, July 7–12, 2024
- 4th Public Meeting of the National Academies of Science, Engineering and Medicine's Committee on Feasibility of Assessing Veteran Health Effects of Manhattan Project, Richland, WA, July 18, 2024
- 70th Annual Meeting of the Radiation Research Society, Tucson, Arizona, September 15–18, 2024
- 2024 Annual American Public Health Association Meeting (APHA 2024), Minneapolis, Minnesota, October 27–30, 2024
- Virtual 16th Workshop of the Million Person Study on November 4, 2024
- NASA Human Research Program Investigators' Workshop, Galveston, Texas, USA, January 28–31, 2025
- 61st NCRP Annual Meeting "The Million Person Study: Current Results and Vision for Radiation Epidemiology and Protection", Bethesda, Maryland, March 24–25, 2025.

Professional Affiliations

USTUR personnel are active members of numerous national and international professional organizations:

- Radiation Research Society (USA)
- Health Physics Society (USA)
- EURADOS Working Group 7 (WG7) on Internal Dosimetry (EU)

Publications and Presentations

The following manuscripts and presentations were published or presented during the period of April 2024 to March 2025.

Previous manuscripts and abstracts are available on the USTUR website at:
ustur.wsu.edu/Publications/index.html

Abstracts of published peer-reviewed manuscripts and scientific presentations are included in Appendix E.

Published

USTUR-0697-24

Leggett RW, Tolmachev SY, Boice JD, Jr. Potential improvements in brain dose estimates for internal emitters. In: Boice JD, Jr, Bouville A, Dauer LT, Golden AP, Wakeford R (eds). The Million Person Study of low-dose radiation health effects. London, United Kingdom: CRC Press; 125–138; 2024.

USTUR-0698-24

Martinez NE, Jokisch DW, Dauer LT, Eckerman KF, Goans RE, Brockman JD, Tolmachev SY, Avtandilashvili M, Mumma MT, Boice JD, Jr., Leggett RW. Radium dial workers: back to the future. In: Boice JD, Jr, Bouville A, Dauer LT, Golden AP, Wakeford R (eds). The Million Person Study of low-dose radiation health effects. London, United Kingdom: CRC Press; 280–298; 2024.

USTUR-0699-24

Boice JD, Jr., Quinn B, Al-Nabulsi I, Ansari A, Blake PK, Blattnig SR, Caffrey EA, Cohen SS, Golden AP, Held KD, Jokisch DW, Leggett RW, Mumma MT, Samuels C, Till JE, Tolmachev SY, Yoder RC, Zhou JY, Dauer LT. A million persons, a million dreams: a vision for a national center of radiation epidemiology and biology. In: Boice JD, Jr, Bouville A, Dauer LT, Golden AP, Wakeford R (eds). The Million Person Study of low-dose radiation health effects. London, United Kingdom: CRC Press; 327–355; 2024.

USTUR-0602-22

McComish SL, Liu X, Martinez FT, Zhou JY, Tolmachev SY. Misclassification of causes of death among a small all-autopsied group of former nuclear workers: Death certificates vs. autopsy reports. PLoS One 19(5): e0302069; 2024.

USTUR-0618-22

Dauer LT, Mumma MT, Lima J, Cohen SS, Andresen D, Bahadori A, Bellamy M, Bierman D, Blattnig S, French B, Giunta E, Held K, Hertel N, Keohane L, Leggett R, Lipworth L, Miller K, Norman R, Samuels C, Thomas K, Tolmachev S, Walsh L, Boice Jr JD. A Million Person Study innovation: evaluating cognitive impairment and other morbidity outcomes from chronic radiation exposure through linkages with the centers for Medicaid and Medicare services big data. Radiation Research 202(6): 847–861; 2024.

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USTUR-0687-24

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USTUR-0651-23

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USTUR-0685-24

Martinez NE, Jokisch DW, Mumma MT, Tolmachev SY, Avtandilashvili M, Tabatadze G, Leggett RW, Samuels C, Golden A, Howard S, Dauer LT, Boice Jr JD. Archived historical records housed at USTUR support radium dial worker dosimetry. Journal of Radiological Protection; Published Ahead of Print; 2024. doi: 10.1088/1361-6498/ad8bcf.

USTUR-0655-23A

Dumit S, Avtandilashvili M, McComish SL, Miller G, Swanson J, Tolmachev SY. Modeling plutonium decorporation in female nuclear worker treated with Ca-DTPA. Health Physics 127(1): 223; 2024.

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Liu X, McComish SL, Zhou JY, Tolmachev SY. Impact of death certificate misclassifications on radiation health risk models. Health Physics 127(1): 210; 2024.

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Avtandilashvili M, Šefl M, Zhou JY, Tolmachev SY. Evaluation of Bayesian modeling of uncertainty in plutonium organ doses using post-mortem measurements. Health Physics 127(1): 56; 2024.

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Avtandilashvili M, Thomas EM, Tabatadze G, Tolmachev S. Learning from former nuclear workers: specifying plutonium material type for worksite-specific dose assessment. Health Physics 127(1): 216; 2024.

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USTUR-0664-23A

Martinez NE, Jokisch DW, Mumma MT, Tolmachev SY, Avtandilashvili M, Tabatadze G, Leggett RW, Samuels C, Dauer LT, Boice Jr JD. Million Person Study: review of archived historical records supporting radium dial worker dosimetry. Health Physics 127(1): 55; 2024.

USTUR-0665-23A

Goans RE, Dauer LT, Iddins CJ, Mumma M, McComish SL, Tolmachev SY. Chronic inflammation in a Radium Dial Painter cohort: elevated neutrophil to lymphocyte ratio and radiation-induced hearing loss. Health Physics 127(1): 229; 2024.

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Poudel D, Klumpp JA, Avtandilashvili M, Tolmachev SY. Mechanisms for long-term retention of plutonium in the respiratory tract: Inferences from animal and human studies. Health Physics 127(1): 58; 2024.

USTUR-0681-24A

Strom D. Beyond the system of radiation protection: the ten principles and ten commandments of radiation protection describe actions. Health Physics 127(1): 11–12; 2024.

USTUR-0682-24

Tolmachev SY, McComish SL, Avtandilashvili M. United States Transuranium and Uranium Registries Annual Report: April 1, 2023 – March 31, 2024. United States Transuranium and Uranium Registries; USTUR-0682-24, Richland, Washington, 2024.

USTUR-0689-24

McComish SL, Tolmachev SY. USTUR Registrant Newsletter 2024. Issue 30. United States Transuranium and Uranium Registries; USTUR-0689-24, Richland, Washington, 2024.

Presented

Invited

USTUR-0694-24P

McComish S. Military veterans at the USTUR. 4th Public Meeting of the National Academies of Science, Engineering and Medicine's Committee on Feasibility of Assessing Veteran Health Effects of Manhattan Project, Richland, Washington, USA, July 18, 2024.

USTUR-0696-24P

Tolmachev SY. The United States Transuranium and Uranium Registries: 55 years of experience in actinide research and radiochemical analysis. PNNL Radiochemistry Group's Colloquium, Richland, Washington, USA, December 12, 2024.

USTUR-0705-25P

Tolmachev SY. The United States Transuranium and Uranium Registries: resource for internal actinide dosimetry and biomolecular effects. National Nuclear Security Administration Bi-Monthly Operations and Safety Call (virtual), February 13, 2025.

USTUR-0706-25P

Tolmachev SY. Learning from plutonium and uranium workers. WSU Honors College Class Series "Science as a Way of Knowing: The Power of the Atom", Pullman, Washington, USA, February 25, 2025.

USTUR-0693-24A

Tolmachev SY. Importance of human data – U.S. Transuranium and Uranium Registries. 61st NCRP Annual Meeting "The Million Person Study: Current Results and Vision for Radiation Epidemiology and Protection", Bethesda, Maryland, USA, March 24–25, 2025.

Podium

USTUR-0667-24A

Avtandilashvili M, Tolmachev SY. Uranium content, distribution, and biokinetics in human body: USTUR studies. 43rd Annual Conference of the Canadian Radiation Protection Association (CRPA 2024), Edmonton, Alberta, Canada, June 3–7, 2024.

USTUR-0671-24A

Tabatadze G. From mapping to quantification: Digital autoradiography of ^{226}Ra in human skeleton. International Conference on Radiation Applications (RAP 2024), Granada, Spain, June 10–12, 2024.

USTUR-0655-23A

Dumit S, Avtandilashvili M, McComish SL, Miller G, Swanson J, Tolmachev SY. Modeling plutonium decorporation in female nuclear worker treated with Ca-DTPA. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0656-23A

Liu X, McComish SL, Zhou JY, Tolmachev SY. Impact of death certificate misclassifications on radiation health risk models. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0662-23A

Avtandilashvili M, Thomas EM, Tabatadze G, Tolmachev S. Learning from former nuclear workers: specifying plutonium material type for worksite-specific dose assessment. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0665-23A

Goans RE, Dauer LT, Iddins CJ, Mumma M, McComish SL, Tolmachev SY. Chronic inflammation in a Radium Dial Painter cohort: elevated neutrophil to lymphocyte ratio and radiation-induced hearing loss. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0686-24A

Liu X, McComish S, Tolmachev S, Zhou J. Impact of death certificate misclassifications on epidemiological risk models. WSU College of Pharmacy and Pharmaceutical Sciences Research Day, Spokane, Washington, USA, August 9, 2024.

USTUR-0675-24A

Liu X, McComish S, Zhou J, Tolmachev S. Can misclassification of disease change the conclusion of significant dose-response associations? 70th Annual Meeting of the Radiation Research Society, Tucson, Arizona, USA, September 15–18, 2024.

USTUR-0672-24A

Romanyukha A, Consani K, Tolmachev SY. Variability of radiation doses reconstructed by EPR in teeth of former United States nuclear workers. EPRBioDose 2024, Hirosaki, Japan, September 25–28, 2024.

USTUR-0688-24A

Beavers M, Blattnig S, Boice Jr JD, Cekanaviciute E, Costes S, Dauer L, Davis C, Iacono D, Miller K, Nelson G, O'Banion MK, Tolmachev S. Radiation-induced Parkinson disease: evaluating the level of evidence and recommending future work. NASA Human Research Program Investigators' Workshop, Galveston, Texas, USA, January 28–31, 2025.

Poster

USTUR-0657-23A

Avtandilashvili M, Šefl M, Zhou JY, Tolmachev SY. Evaluation of Bayesian modeling of uncertainty in plutonium organ doses using post-mortem measurements. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0658-23A

Tabatadze G, Strom D, Avtandilashvili M, McComish SL, Tolmachev SY. From deposition to detection: the USTUR approach to measurement quality. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0663-23A

Tolmachev SY, Martinez FT, Linson JE, Brockman JD, Thomas EM, Avtandilashvili M, Tabatadze G, Leggett RW, Samuels C, Martinez NE, Jokisch DW, Boice JD, Dauer LT. Distribution of plutonium and radium in the human heart. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0664-23A

Martinez NE, Jokisch DW, Mumma MT, Tolmachev SY, Avtandilashvili M, Tabatadze G, Leggett RW, Samuels C, Dauer LT, Boice Jr JD. Million Person Study: review of archived historical records supporting radium dial worker dosimetry. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0668-24A

Poudel D, Klumpp JA, Avtandilashvili M, Tolmachev SY. Mechanisms for long-term retention of plutonium in the respiratory tract: Inferences from animal and human studies. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0681-24A

Strom D. Beyond the system of radiation protection: the ten principles and ten commandments of radiation protection describe actions. 16th International Congress of the International Radiation Protection Association – 69th Annual Meeting of the Health Physics Society, Orlando, Florida, USA, July 7–12, 2024.

USTUR-0673-24A

Wilson LJ, Miller B, Tabatadze G, Mourtada F. Calibration of a novel microdosimetry system for in vitro applications of actinide radiopharmaceuticals. 70th Annual Meeting of the Radiation Research Society, Tucson, Arizona, USA, September 15–18, 2024.

USTUR-0670-24A

Liu X, McComish S, Zhou J, Tolmachev S. Quantification of likelihood that death certificate misclassification increases odds ratios of dose-response relationships. 2024 Annual American Public Health Association Meeting (APHA 2024), Minneapolis, Minnesota, USA, October 27–30, 2024.

USTUR-0702-25A

Liu X, McComish S, Howard S, Zhou JY, Tolmachev SY. Quantification of probability that death certificate misclassification increases measures of risk in epidemiology. 61st NCRP Annual Meeting "The Million Person Study: Current Results and Vision for Radiation Epidemiology and Protection", Bethesda, Maryland, USA, March 24–25, 2025.

USTUR-0704-25A

Linson JE, Tolmachev SY, Brockman JD. Quantifying Radium-226 in heart tissue using ICP-QQQ-MS: A study of Radium Watch Dial Painters. 61st NCRP Annual Meeting "The Million Person Study: Current Results and Vision for Radiation Epidemiology and Protection", Bethesda, Maryland, USA, March 24–25, 2025.

Bibliographic Metrics

Stacey L. McComish, *Associate in Research*

Since its inception in 1968, the USTUR has published 303 papers in conference proceedings and peer-reviewed journals, 34 books/book sections, 141 abstracts in journals, and 30 editorial journal publications such as letters to the editor. These publications were authored by USTUR staff, SAC members, and/or emeritus/adjunct faculty. As can be seen from the 'Publications and Presentations' section, the USTUR continues to make publication and presentation of research findings a priority.

Peer-reviewed papers by USTUR authors have appeared in 43 different journals, with impact factors ranging up to 12.5 (Cancer Research). Four journals account for 72% of these papers: Radiation Protection Dosimetry (1.8), Health Physics (1.0), the Journal of Radioanalytical and Nuclear Chemistry (1.5), and Radiation Research (2.5).

The USTUR has used a variety of bibliographic services to generate online publications profiles, the most recent of which was the Web of Science (WOS). Unfortunately, the WOS no longer allows us to track publications on an institutional level due to changes in the method use for verifying individual authorship for publications. As such, Google Scholar has been selected to track citation metrics associated with the USTUR. Google Scholar had citation data for 223 publications in peer-reviewed journals or conference proceedings. These articles were cited 5,250 times, and the USTUR has an h-index of 36. Of the 5,250 total citations, 1,073 came from articles that have been published since 2020. It is clear from these numbers that the USTUR's research continues to have an important impact on our understanding of actinides in humans. Figure 16 shows the number of publications and citations for years where data were available.

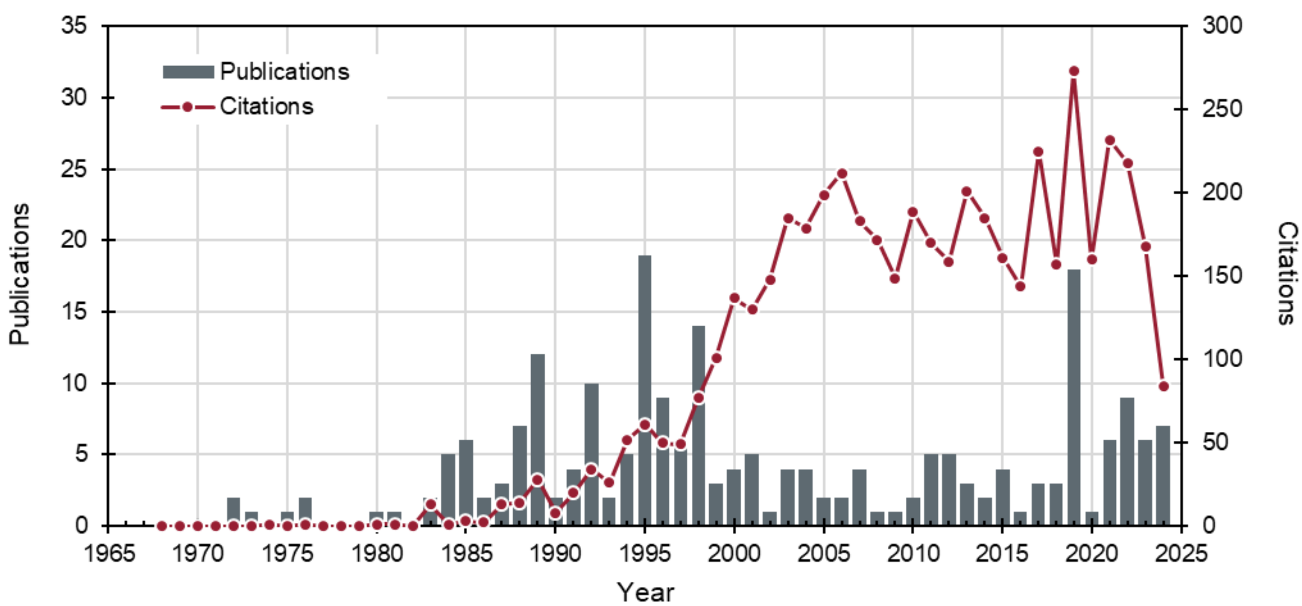
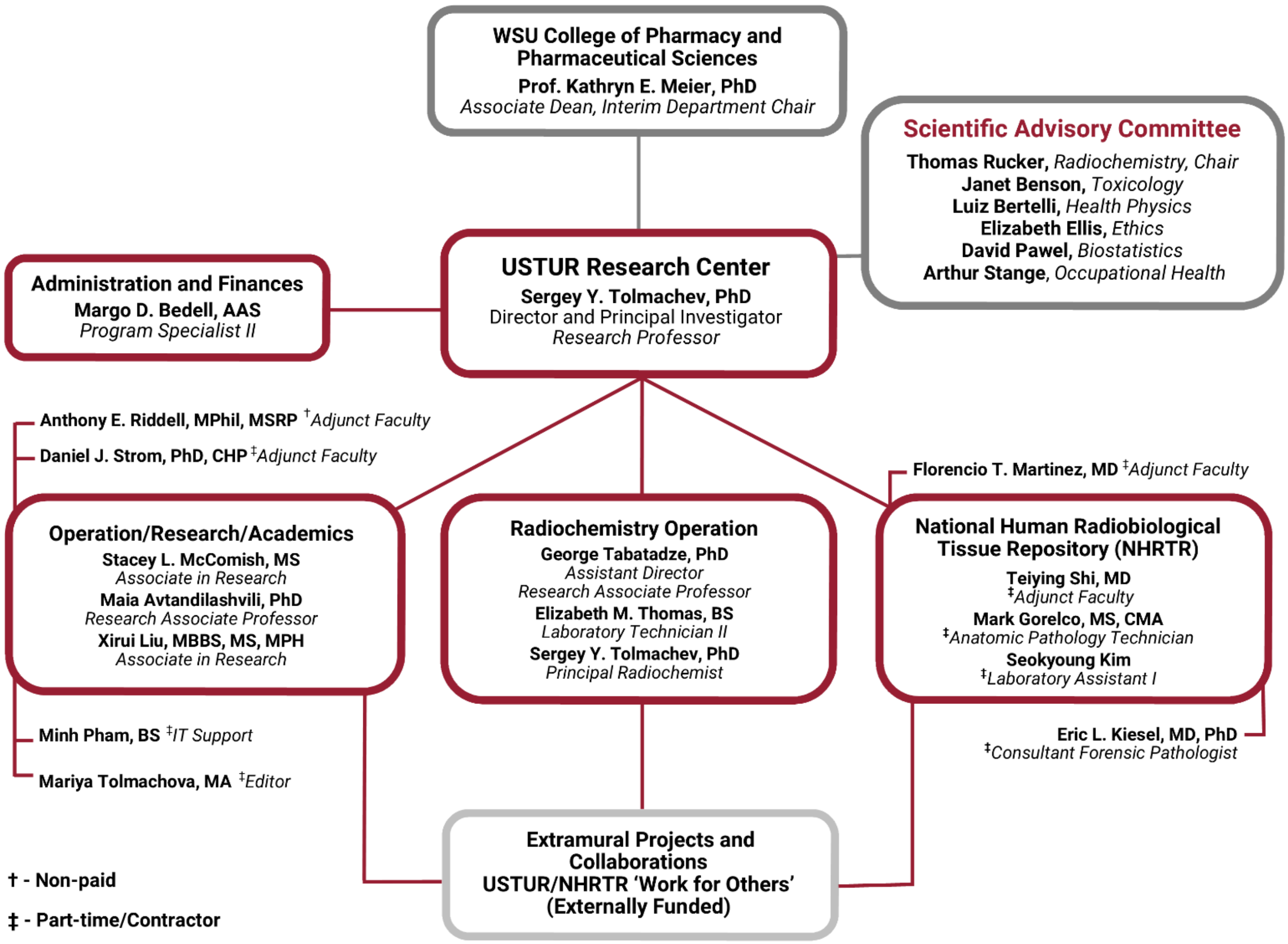


Fig. 16. The number of USTUR journal publications per year, and the number of times articles were cited in each year.

Appendix A



USTUR Research Center organization structure during FY2025 (April 1, 2024 – March 31, 2025).

Appendix B


International Training Course
BASIC INTERNAL DOSIMETRY
Hosted by FANR in collaboration with ICRP and EURADOS
14-18 OCTOBER 2024
Abu Dhabi, United Arab Emirates
FANR
الهيئة الاتحادية للرقابة النووية
Federal Authority for Nuclear Regulation
ICRP
EURADOS

Detailed Agenda

MONDAY 14 OCTOBER 2024

BIOKINETICS AND DOSIMETRY

8:30 - 9:30	**Welcome and Course Purpose** Aayda Al Shehhi (FANR), Christopher Clement (ICRP), and Juan Francisco Navarro Amaro (EURADOS)
9:30 - 10:20	**Introduction to Internal Dosimetry** Daniele Giuffrida (FANR)
10:30 - 11:20	**Biokinetics: Inhalation, Ingestion and Systemic Models** Bernard Landry (EURADOS)
11:20 - 11:50	Coffee Break
11:50- 12:40	**Dosimetric Models and Statistical Methods for Internal Dose Assessment** Maia Avtandilashvili (ICRP)
12:40 - 14:00	Prayer and Lunch Break
14:00 - 14:30	**Introduction to the Afternoon Exercise Session: Scope and Purpose** FANR-ICRP-EURADOS
14:30 - 15:20	**First Exercise** FANR-ICRP-EURADOS and Participants in Groups
15:20 - 15:40	Coffee Break
15:40 - 16:30	**Second Exercise** FANR-ICRP-EURADOS and Participants in Groups
16:30 - 17:00	**Q&A and Discussion** FANR-ICRP-EURADOS

TUESDAY 15 OCTOBER 2024

IN-VIVO MONITORING AND WBC

8:30 - 9:00	**Welcome and Recap** Daniele Giuffrida (FANR)
9:00 - 10:00	**Whole Body Counter Facilities: Organization and Operation; Techniques and Methods for Direct Bioassay Measurements** Juan Francisco Navarro Amaro (EURADOS)
10:00 - 11:00	**Intake Assessment by Direct Bioassay Measurement in a Whole Body Counter Facility** Juan Francisco Navarro Amaro (EURADOS)
11:00 - 11:30	Coffee Break
11:30- 12:30	**Accuracy Requirements and Uncertainty Analysis in Internal Dosimetry** Maia Avtandilashvili (ICRP) and George Tabadatze (ICRP)
12:30 - 14:00	Prayer and Lunch Break
14:00 - 14:30	**Introduction to the Afternoon Exercise Session: Scope and Purpose** FANR-ICRP-EURADOS

Basic Internal Dosimetry Training Course | 14-18 October 2024 2

TUESDAY 15 OCTOBER 2024 (CONT.)

IN-VIVO MONITORING AND WBC

14:30 - 15:20	**First Exercise** FANR-ICRP-EURADOS and Participants in Groups
15:20 - 15:40	Coffee Break
15:40 - 16:30	**Second Exercise** FANR-ICRP-EURADOS and Participants in Groups
16:30 - 17:00	**Q&A and Discussion** FANR-ICRP-EURADOS

WEDNESDAY 16 OCTOBER 2024

IN-VITRO MONITORING AND CODES FOR ID

8:30 - 9:00	**Welcome and Recap** Daniele Giuffrida (FANR)
9:00- 10:00	**Techniques and Methods Used in Excreta Analyses** Maria Inmaculada Sierra Bercedo (EURADOS)
10:00 - 11:00	**Intake Assessment by Indirect Bioassay Measurement of Excreta** Maria Inmaculada Sierra Bercedo (EURADOS)
11:00 - 11:30	Coffee Break
11:30 - 12:30	**Codes and Software for Internal Dosimetry (I)** Maria Inmaculada Sierra Bercedo (EURADOS) and Bernard Landry (EURADOS)
12:30 - 14:00	Prayer and Lunch Break
14:00 - 14:30	**Introduction to the Afternoon Exercise Session: Scope and Purpose** FANR-ICRP-EURADOS
14:30 - 15:20	**First Exercise** FANR-ICRP-EURADOS and Participants in Groups
15:20 - 15:40	Coffee Break
15:40 - 16:30	**Second Exercise** FANR-ICRP-EURADOS and Participants in Groups
16:30 - 17:00	**Q&A and Discussion** FANR-ICRP-EURADOS

THURSDAY 17 OCTOBER 2024

ICRP JOURNEY, RADON, AND PHANTOMS

8:30 - 9:00	**Welcome and Recap** Daniele Giuffrida (FANR)
9:00- 10:00	**The ICRP Journey in Internal Dosimetry: OIR Publications, EIR and the New ICRP Approach to Radon Exposure Calculations** Christopher Clement (ICRP)

THURSDAY 17 OCTOBER 2024 (CONT.)

ICRP JOURNEY, RADON, AND PHANTOMS

10:00 - 11:00	**Human Phantoms and Their Use in Internal Dosimetry** George Tabadatze (ICRP)
11:00 - 11:30	Coffee Break
11:30 - 12:00	**Decorporation Treatments** Bernard Landry (EURADOS)
12:00 - 12:30	**Codes and Software for Internal Dosimetry (II)** Maia Avtandilashvili (ICRP), George Tabadatze (ICRP), and Bernard Landry (EURADOS)
12:30 - 14:00	Prayer and Lunch Break
14:00 - 14:30	**Introduction to the Afternoon Exercise Session: Scope and Purpose** FANR-ICRP-EURADOS
14:30 - 15:20	**First Exercise** FANR-ICRP-EURADOS and Participants in Groups
15:20 - 15:40	Coffee Break
15:40 - 16:30	**Second Exercise** FANR-ICRP-EURADOS and Participants in Groups
16:30 - 17:00	**Q&A and Discussion** FANR-ICRP-EURADOS

FRIDAY 18 OCTOBER 2024

DOSE ASSESSMENTS AND INFRASTRUCTURE

8:30 - 9:00	**Welcome and Recap** Daniele Giuffrida (FANR)
9:00 - 9:30	**Internal Dosimetry Infrastructure Development Needs in the UAE** Aayda Al Shehhi (FANR)
9:30 - 10:00	**Internal Dosimetry as a Service in Radiation Protection in the UAE** Dejan Trifunovic (FANR)
10:00 - 11:00	**Round Table Discussion on the Requirements to Setup In-vivo and In-vitro Laboratories for Bioassay Intake Assessments in the UAE** Aayda Al Shehhi and Ali Alremeithi (FANR) Chrsitopher Clement, George Tabadatze, and Maia Avtandilashvili (ICRP) Bernard Landry, Maria Inmaculada Sierra Bercedo, and Juan Francisco Navarro Amaro (EURADOS) Moderated by Daniele Giuffrida (FANR)
11:00 - 11:30	Coffee Break
12:00- 12:15	**Open Discussion with the Participants and Course Feedback** FANR-ICRP-EURADOS and Participants
12:15 - 12:30	**Final Remarks and Closure of the IDTC** FANR-ICRP-EURADOS

Basic Internal Dosimetry Training Course | 14-18 October 2024 4

Appendix C

USTUR Newsletter

Issue 30 • December 2024
USTUR-0689-24

A sincere **Happy Holidays** from all of us at the USTUR!

Direct from the director

Dear Registrants and Families:

For the last three years, I have been updating you on progress we have made to bring our Radiochemistry laboratory to a new level. While radiochemical analyses are important, they are not the only thing that makes the USTUR a unique research program. Some of you probably are familiar with the term *health physics records*. It is a 'collection' of records that we received from the worksites for each of our Registrants. This typically includes occupational and exposure records, bioassay (urine and/or fecal) analyses results, in-vivo (whole-body) counting results, and information on medical procedures performed to reduce radiation dose (decorporation or surgical treatment). Knowledge about what happened, when it happened, and what has been done is as important as the final radiochemistry results for conducting high-quality research in radiation protection. *Two halves make a whole*. When I began working at the Registries in 2007, all health physics records were on paper. There was (and still is) an entire room full of file cabinets that are filled with hundreds of files, which are hundreds of pages each. Anthony James (USTUR director in 2005–2010) used to call this room a 'gold mine' – the scientific information in those paper files is highly valuable, but, at the time, it required a lot of effort to find out what information was there. The need for a health physics database – where records would be stored in a uniform, standardized, and searchable format – was rather obvious. On December 12, 2008, Stacey McCord (now McComish) completed standardization of Case 0202 from Rocky Flats. The health physics database was born! Since Stacey had many other duties and responsibilities, it was a slow process. On January 23, 2012, Maia Avtandilashvili joined the USTUR as a health physicist and took the lead role in database development and population. Case by case, file by file, page by page, and record by record, in punctilious detail, Maia went through the documents. On August 15, 2024, standardization of exposure and bioassay records for USTUR Registrants was completed! Over 16 years, a total of 191,961 records from 395 individuals was entered into the database. It was an excellent 'birthday present' to the Registries, which was established on August 16, 1968. More details about our progress in 2024 are included elsewhere in this newsletter. With this, I would like to thank all of you who have remained with the Registries for so many years and wish you and your families good health and joy in 2025. ~Sergey Tolmachev

THIS ISSUE

How accurate are death certificates?

The USTUR has both death certificates and autopsy reports for most of its Registrants. This has offered a unique opportunity to determine how accurate death certificates are among this population of former nuclear workers. It turns out that, for USTUR Registrants, the underlying causes of death on death certificates match the autopsy reports 75% of the time, at a broad disease level. This means that both the death certificate and the autopsy report agreed about the type of disease a person died from, such as cancer or circulatory disease; however, the two documents may not have agreed on the specific type of cancer or circulatory disease. While a misclassification rate of 25% is surprisingly high (at least it was to me!), it is consistent with the findings of other studies. The type of disease has a big impact on the likelihood that a death certificate will match the autopsy report. Cancer is most likely to agree with the autopsy report (90% of the time), while respiratory disease is least likely to match the autopsy report (39%). It seems likely that low rate of agreement for respiratory disease is due to the prevalence of multiple conditions at the time of death. For example, an individual may have had chronic obstructive pulmonary disease (COPD), diabetes, hypertension, and pneumonia at the time of death, all of which may have contributed to death, making it difficult to choose just one underlying cause of death.

Death certificates can list multiple diseases that contribute to death, but epidemiological studies often rely on a single **underlying cause of death** to look for associations between dose and disease. The underlying cause of death is the disease (or injury) that started the chain of events that led to death. So, if a person died from pneumonia as a consequence of another disease, such as cancer, the other disease would be considered the underlying cause.

Does this change epidemiology studies?

The next natural question is, how do these death certificate inaccuracies impact epidemiological studies, which often rely on death certificate data? The good news is that the rate of misclassification among USTUR Registrants was the same for those who were exposed to high doses of radiation as it was for those who were exposed to low doses of radiation. Traditionally, it is believed that this kind of misclassification adds noise to an epidemiological study, potentially making it more difficult to detect a true disease effect. It also implies that if a statistically significant association between dose and disease is observed, it would still have been observed if the researcher had been able to correct for misclassification. Often, this is the case; however, simulation studies suggest that it is possible for misclassification to have the opposite effect, such that the study concludes that there was a significant association between radiation and disease, when in fact there was none. The reason for this comes down to the nature of random chance. Just as it is possible, that one could toss six quarters and have more than three land heads up, it is also possible that proportionally more non-cancer cases could be misclassified as cancer in the high radiation dose group than in the low dose group. The chances that this will lead to incorrect conclusions in epidemiological studies is greatest for studies where the association between dose and disease is barely significant, and for misclassification rates that are low.

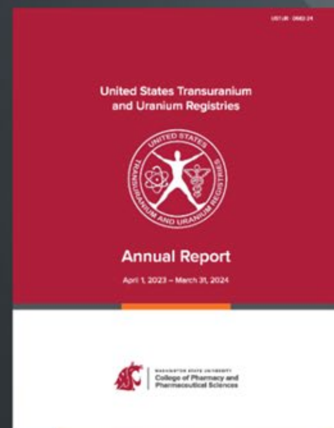
Download our Annual Report

Do you want to learn more about the work carried out at the USTUR? You may like to take a look at our annual reports. They provide summaries of both research and the more operational aspects of the Registries.

https://ustur.wsu.edu/publications/annual-reports/

Topics in our most recent report include:

- uncertainties in plutonium organ doses,
- distribution of plutonium and radium in the human heart, and
- operational topics such as: radiochemistry, finances, and standardization/digitization of health physics records.



Characterizing plutonium solubility for worksite-specific dose assessments

Information about the solubility of inhaled plutonium is critical to making accurate estimates of doses to workers. This is because soluble and insoluble plutonium behave differently in the human body. Soluble plutonium is dissolved in the lungs, absorbed into the bloodstream, and either excreted in urine or deposited in the liver and skeleton. Conversely, insoluble plutonium tends to stay in the lungs for long periods of time, where a portion of it is cleared to lymph nodes in much the same way that the lungs clear cigarette residues to the lymph nodes. Thus, inhaled insoluble plutonium results in higher lymph node-to-lung concentration ratios and lower liver-to-respiratory tract content ratios than would be seen with soluble plutonium, where the respiratory tract includes both lung tissue and respiratory tract lymph nodes. We recently compared these ratios for 291 Registrants who worked at Hanford, Los Alamos, and Rocky Flats - in order to characterize the solubility of plutonium at each of these worksites. The lymph node-to-lung ratios did not vary significantly among the three worksites; however, the lymph node-to-lung ratios were significantly lower for smokers than for non-smokers. This indicated that smoking impaired the lung's ability to clear plutonium to the lymph nodes. A comparison of liver-to-respiratory tract ratios indicated that Registrants were typically exposed to a mixture of soluble and insoluble materials. The material type at Hanford was most soluble, Rocky Flats material type was least soluble, and Los Alamos material type fell somewhere in between.


MEET THE TEAM
DIRECTOR
Sergey Tolmachev
Principal Investigator
Radiochemistry
ANSWERS PHONES – YOU'VE PROBABLY TALKED TO MARGO IF YOU'VE CALLED US
George Tabatadze
Associate Professor
Radiation Measurements
Margo Bedell
Program Specialist
Accounting
SAMPLE ANALYSIS
Elizabeth Thomas
Laboratory Technician
Radiochemistry
Maia Avtandilashvili
Associate Professor
Health Physics
RESEARCH
Stacey McComish
Associate in Research
Health Physics
Xirui Liu
Associate in Research
Public Health
WASHINGTON STATE UNIVERSITY
United States Transuranium and Uranium Registries
1845 Terminal Drive Suite 201, Richland, WA 99354
509-392-3749 • 1-800-375-9317 • ustur.wsu.edu

Appendix D

UNITED STATES TRANSURANIUM AND URANIUM REGISTRIES

College of Pharmacy and Pharmaceutical Sciences
Washington State University

2024 Scientific Advisory Committee Meeting, April 25–26, 2024
Hampton Inn, Riverview Room, Richland, WA

Thursday, April 25, 2024

07:00 – 08:00	*Breakfast*	
08:00 – 08:10	Welcome & Introductions	S. Tolmachev, *USTUR Director*
08:10 – 08:15	Opening Remarks	T. Rucker, *SAC Chair*
08:15 – 08:20	Updates from U.S. DOE	J. Zhou, *DOE USTUR Manager*
08:20 – 08:35	WSU/CPPS News	K. Meier, Associate Dean
08:35 – 08:50	Administrative & Financial Developments	M. Bedell, Program Specialist I
08:50 – 09:30	2023 SAC Recommendations & Overview	S. Tolmachev, Director
09:30 – 09:45	WSU Tri-Cities Updates	K. McAteer, WSU TC Vice Chancellor
09:45 – 10:00	*Coffee Break*	
10:00 – 10:20	USTUR Registrant Statistics and LIMS	S. McComish, *Associate in Research*
10:20 – 10:40	Radiochemistry Progress Report	G. Tabatadze, *Associate Professor*
10:40 – 11:00	^{238}Pu Biokinetic Modeling at LANL	J. Klumpp, *LANL Scientist*
11:00 – 11:20	Internal Dosimetry for MPS	M. Bellamy, *MSKCC Scientist*
11:20 – 11:40	Uncertainties in Internal Dose Estimation	M. Šefl, *USTUR Alumnus*
11:40 – 12:00	Death Certificate Misclassification and Risk Models	X. Liu, *Associate in Research*
12:00 – 13:00	*Lunch*	
13:00 – 13:30	Research & Operation: Plan for FY2025	S. Tolmachev, *Director*
13:30 – 13:45	Discussion and Q & A	USTUR, DOE, SAC, Guests

14:15 – 16:00 Tour to USTUR Laboratory Facility, 2340 Lindberg Loop, Richland, WA

18:00 Check in at Columbia Point Marina, Richland, WA (by Anthony's Restaurant)

18:30 – 21:00 - Dinner Water2Wine Cruise, Richland, WA (boat leave promptly at 6:30 pm)

Meetings, breakfast, and lunch will be held in the *Columbia Pointe* room at the Hampton Inn, 486 Bradley Blvd, Richland, WA

UNITED STATES TRANSURANIUM AND URANIUM REGISTRIES

College of Pharmacy and Pharmaceutical Sciences
Washington State University

2024 Scientific Advisory Committee Meeting, April 25–26, 2024

Hampton Inn, Riverview Room, Richland, WA

Friday, April 26, 2024 – SAC, DOE and USTUR Management

08:00 – 09:00	***Breakfast***	
09:00 – 09:10	SAC Membership	S. Tolmachev, *USTUR Director*
09:10– 09:30	SAC Q & A	T. Rucker, *SAC Chair*
09:30 – 13:00	SAC Executive Session	T. Rucker, *SAC Chair*
9:30 – 12:00	***Tour to USTUR Laboratory Facility, 2340 Lindberg Loop, Richland, WA (per request)***	
13:00 – 14:00	***Lunch***	
14:00 – 15:00	SAC Debriefing	T. Rucker, *SAC Chair*

Friday, April 26, 2024 – All

17:30 Social time

18:00 – 21:30 Buffet - Columbia Pointe Room, Hampton Inn

Appendix E

USTUR-0602-22

Misclassification of causes of death among a small all-autopsied group of former nuclear workers: Death certificates vs. autopsy reports

S. L. McComish[1], X. Liu[1], F. T. Martinez[1], J. Y. Zhou[2], S. Y. Tolmachev[1]

[1]*U.S. Transuranium and Uranium Registries, College of Pharmacy and Pharmaceutical Sciences, Washington State University, Richland, Washington, USA*
[2]*U.S. Department of Energy, Washington, District of Columbia, USA*

The U.S. Transuranium and Uranium Registries performs autopsies on each of its deceased Registrants as a part of its mission to follow up occupationally-exposed individuals. This provides a unique opportunity to explore death certificate misclassification errors, and the factors that influence them, among this small population of former nuclear workers. Underlying causes of death from death certificates and autopsy reports were coded using the 10th revision of the International Classification of Diseases (ICD-10). These codes were then used to quantify misclassification rates among 268 individuals for whom both full autopsy reports and death certificates with legible underlying causes of death were available. When underlying causes of death were compared between death certificates and autopsy reports, death certificates correctly identified the underlying cause of death's ICD-10 disease chapter in 74.6% of cases. The remaining 25.4% of misclassified cases resulted in over-classification rates that ranged from 1.2% for external causes of mortality to 12.2% for circulatory disease, and under-classification rates that ranged from 7.7% for external causes of mortality to 47.4% for respiratory disease. Neoplasms had generally lower misclassification rates with 4.3% over-classification and 13.3% under-classification. A logistic regression revealed that the odds of a match were 2.8 times higher when clinical history was mentioned on the autopsy report than when it was not. Similarly, the odds of a match were 3.4 times higher when death certificates were completed using autopsy findings than when autopsy findings were not used. This analysis excluded cases where it could not be determined if autopsy findings were used to complete death certificates. The findings of this study are useful to investigate the impact of death certificate misclassification errors on radiation risk estimates and, therefore, improve the reliability of epidemiological studies.

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USTUR-0618-22

A Million Person Study innovation: evaluating cognitive impairment and other morbidity outcomes from chronic radiation exposure through linkages with the centers for Medicaid and Medicare services big data

L. T. Dauer[1], M. T. Mumma[2], J. Lima[3], S. S. Cohen[4], D. Anderson[5], A. Bahadori[5], M. Bellamy[1], D. Bierman[1], S. Blattnig[6], B. Franklin[7], E. Giunta[5], K. Held[8], N. Hertel[9], L. Keohane[7], R. Leggett[10], L. Lipworth[7], K. B. Miller[11], R. Norman[6], C. Samuels[10], K. S. Thomas[13], S. Y. Tolmachev[14], L. Walsh[15], J. D. Boice Jr.[8,16]

[1]*Memorial Sloan Kettering Cancer Center, New York, New York, USA*
[2]*Vanderbilt University Medical Center's International Epidemiology Field Station, Rockville, Maryland, USA*
[3]*Brown University School of Public Health, Providence, Rhode Island, USA*
[4]*DLH, LLC, Bethesda, Maryland, USA*
[5]*Kansas State University, Manhattan, Kansas, USA*
[6]*NASA Langley Research Center, Hampton, Virginia, USA*
[7]*Vanderbilt University Medical Center, Nashville, Tennessee, USA*
[8]*National Council on Radiation Protection and Measurements, Bethesda, Maryland, USA*
[9]*Georgia Institute of Technology, Atlanta, Georgia, USA*
[10]*Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA*
[11]*National Institute of Aerospace, Hampton, Virginia, USA*
[12]*Morrison Family College of Health, University of St. Thomas, Saint Paul, Minnesota, USA*
[13]*Johns Hopkins University School of Nursing, Baltimore, Maryland, USA*
[14]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[15]*University of Zürich, Zürich, Switzerland*
[16]*Vanderbilt University School of Medicine, Nashville, Tennessee, USA*

The study of one million U.S. radiation workers and veterans, the Million Person Study (MPS), examines the health consequences, both cancer and non-cancer, of exposure to ionizing radiation received gradually over time. Recently the MPS has focused on mortality patterns from neurological and behavioral conditions, e.g., Parkinson's disease, Alzheimer's disease, dementia, and motor neuron disease such as amyotrophic lateral sclerosis. A fuller picture of radiation-related late effects comes from studying both mortality and the occurrence (incidence) of conditions not leading to death. Accordingly, the MPS is identifying neurocognitive diagnoses from fee-for-service insurance claims from the Centers for Medicare and Medicaid Services (CMS), among Medicare beneficiaries beginning in 1999 (the earliest date claims data are available). Linkages to date have identified ~540,000 workers with available health information. Such linkages provide individual information on important co-factor and confounding variables such as smoking, alcohol consumption, blood pressure, obesity, diabetes and many other health and demographic characteristics. The total person-level set of time-dependent variables, outcomes, organ-specific dose measures, co-factors, and demographics will be massive and much too large to be evaluated with standard software. Thus, development of specialized open-source software designed for large datasets (Colossus) is nearly complete. The wealth of information available from CMS claims data, coupled with individual dose reconstructions, will thus greatly enhance the quality and precision of health evaluations for this new field of low-dose radiation and neurocognitive effects.

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USTUR-0684-24

Distribution of plutonium and radium in the human heart

S. Y. Tolmachev[1], F. T. Martinez[1], J. E. Linson[2], J. D. Brockman[2], E. M. Thomas[1], M. Avtandilashvili[1], G. Tabatadze[1], R. W. Leggett[3], C. Samuels[3], N. E. Martinez[4], D. W. Jokisch[5], J. D. Boice Jr.[6], L. T. Dauer[7]

[1]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[2]*Department of Chemistry, University of Missouri, Columbia, Missouri, USA*
[3]*Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA*
[4]*Clemson University, Clemson, South Carolina, USA*
[5]*Francis Marion University, Florence, South Carolina, USA*
[6]*National Council on Radiation Protection and Measurements, Bethesda, Maryland, USA*
[7]*Memorial Sloan Kettering Cancer Center, New York, New York, USA*

Since 1968, the United States Transuranium and Uranium Registries (USTUR) has studied the biokinetics and tissue dosimetry of uranium and transuranium elements in nuclear workers. As part of the USTUR collaboration with the Million Person Study (MPS), radiation dose to different parts of the human heart is being estimated for workers with documented intakes of ^{239}Pu or ^{226}Ra. The study may be expanded for workers with intakes of ^{238}U and other radionuclides. The distribution of radionuclides, expressed in terms of concentration (Bq per kg of tissue) serves as an important parameter for estimating radiation dose. Based on available organs from workers who donated their bodies or tissues for research, nine undissected hearts were selected: seven from USTUR registrants with plutonium exposure (males) and two individuals with radium intakes (female and male). For the plutonium workers, estimated ^{239}Pu systemic deposition ranged from <74 Bq to 1765 Bq. Estimated ^{226}Ra 'initial systemic intakes' were 10.1 MBq and 14.8 kBq for the female patient and male worker, respectively. Organ dissection was based on a heart model published by Borrego et al (2019). This model includes nine cardiac substructures: aorta, left main coronary artery, left atrium, left anterior descending artery, left circumflex artery, left ventricle, right atrium, right coronary artery, and right ventricle. In addition, heart valves, fat attached to epicardium, fluids, and a coronary bypass graft were collected resulting in 111 samples for radiochemical analyses. These results are intended to support radiation worker health studies by improving associated dosimetric and epidemiological models.

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USTUR-0687-24

Chronic inflammation in a Radium Dial Painter cohort: elevated neutrophil to lymphocyte ratio and radiation-induced hearing loss

R. E. Goans[1], L. T. Dauer[2], C. J. Iddins[3], M. Mumma[4], S. L. McComish[5], S. Y. Tolmachev[5]

[1]MJW Corporation, Palm Beach, Florida, USA
[2]Departments of Medical Physics and Radiology, Memorial Sloan Kettering Cancer Center, New York, New York, USA
[3]Radiation Assistance Center/Training Site, Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee, USA
[4]International Epidemiology Institute, Rockville, Maryland, USA
[5]U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA

The radium dial painters (RDP) are a well-described group of predominantly young women who incidentally ingested ^{226}Ra and ^{228}Ra as they painted luminescent watch dials in the first part of the twentieth century. In 1974 pathologist Dr. William D. Sharpe published complete clinical and autopsy results for 42 former radium dial painters evaluated in the New Jersey Radium Research Project (NJRRP). This was an important paper due to the completeness of the observations. Surprisingly, in this study, clinicians noted a 35.5% incidence of hearing loss, both conductive and mixed etiologies. Since the 1974 publication, there has developed a considerable literature on radiation-induced hearing loss in patients undergoing radiotherapy for head and neck cancers. It is expected that hearing loss would also be associated with systemic inflammation. Recently, the neutrophil to lymphocyte ratio (NLR) has been shown in many cancer and non-cancer studies to be a nonspecific marker of inflammation. In prior collaborative efforts with the United States Transuranium and Uranium Registries (USTUR) and with the NCRP Million Person Study, it has been possible to evaluate NLR from medical records of a cohort of 166 former radium dial painters previously evaluated at Argonne National Laboratory. In addition, NLR was available in historic medical records of the sarcoma and nasopharyngeal cancer patients described in Rowland's summary of the Argonne studies. Using elevation of the neutrophil to lymphocyte ratio (NLR) as a non-specific marker of inflammation, chronic inflammation has been observed in all cohorts with significant dose. The RDP cohort has had a unique exposure to radium, but the incidence of radiation-induced hearing loss here is uncertain. Due to cosmic radiation dose to astronauts in space flight, there is a significant interest in high LET radiation dose to the brain, including the auditory system.

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USTUR-0651-23

Modeling plutonium biokinetics of female nuclear worker treated with chelation therapy after inhalation intake

S. Dumit[1], M. Avtandilashvili[2], S. L. McComish[2], G. Miller[3], J. Swanson[4], S. Y. Tolmachev[2]

[1]*Los Alamos National Laboratory, Los Alamos, New Mexico, USA*
[2]*U.S. Transuranium and Uranium Registries, College of Pharmacy and Pharmaceutical Sciences, Washington State University, Richland, Washington, USA*
[3]*Unaffiliated (retired from LANL), Santa Fe, New Mexico, USA*
[4]*U.S. Army, Tacoma, Washington, USA*

The present work models plutonium (Pu) biokinetics in a female former nuclear worker. Her bioassay measurements are available at the US Transuranium and Uranium Registries. The worker was internally exposed to a plutonium-americium mixture via acute inhalation at a nuclear weapons facility. She was medically treated with injections of 1 g Ca-DTPA on days 0, 5, and 14 after the intake. Between days 0 and 20, fecal and urine samples were collected and analyzed for ^{239}Pu and ^{241}Am. Subsequently, she was followed up for bioassay monitoring over 14 y, with additional post-treatment urine samples collected and analyzed for ^{239}Pu. The uniqueness of this dataset is due to the availability of: (1) both early and long-term bioassay data from a female with plutonium intake; (2) data on chelation therapy for a female; and (3) fecal measurement results. Chelation therapy with Ca- and/or Zn-salts of DTPA is known to aid in reducing the internal radiation dose by enhancing the excretion of plutonium and americium from the body. Such enhancement affects plutonium biokinetics in the human body, posing a challenge to the internal dose assessment. The current radiation dose assessment practice is to exclude the data affected by Ca-DTPA from the analysis. The present analysis is the first to explicitly model the chelation-affected bioassay data in a female by using a newly developed chelation model. Thus, the bioassay data collected during and after the Ca-DTPA administrations were used for biokinetic modeling and dose assessment. The Markov Chain Monte Carlo method was used to investigate model parameter uncertainty, based on the bioassay data and assumed prior probability distributions. A $\chi^2/nData$ (number of data points) ≈ 1 was observed in this study, which indicates self-consistency of the data with the model. Results of this study show that the worker's ^{239}Pu intake was 12 Bq, with a committed effective dose to the whole-body of 1.2 mSv and a committed equivalent dose to the bone surfaces, liver, and lungs of 37.8, 9.1, and 0.8 mSv, respectively. This study also discusses the worker's dose reduction due to chelation treatment.

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USTUR-0685-24

Archived historical records housed at USTUR support radium dial worker dosimetry

N. E. Martinez[1], D. W. Jokisch[2], M. Mumma[3], S. Y. Tolmachev[4], M. Avtandilashvili[4], G. Tabatadze[4], R. W. Leggett[5], C. Samuels[5], A. Golden[6], S. Howard[6], L. T. Dauer[7], J. D. Boice Jr.[8]

[1]*Clemson University, Clemson, South Carolina, USA*
[2]*Francis Marion University, Florence, South Carolina, USA*
[3]*International Epidemiology Institute, Rockville, Maryland, USA*
[4]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[5]*Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA*
[6]*Center for Radiation Protection Knowledge, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA*
[7]*Memorial Sloan Kettering Cancer Center, New York, New York, USA*
[8]*National Council on Radiation Protection and Measurements, Bethesda, Maryland, USA*

The American radium dial worker (RDW) cohort of over 3,200 persons is being revisited as part of the Million Person Study (MPS) to include a modern approach to RDW dosimetry. An exceptional source of data and contextualization in this project is an extensive collection of electronic records (requiring 43 gigabytes (GB) of storage) digitized from existing microfilm and microfiche housed at the United States Transuranium and Uranium Registries (USTUR). Although the type, extent, and quality (e.g., legibility) of record(s) varies between individuals, the remarkable occupational, medical and demographic data include in vivo radiation measurements (e.g., radon breath, whole body counts), autopsy results, medical records (including copies of radiographs), interviews over the years, and correspondence. Of particular dosimetric interest are the details of radiation measurements. For example, there are some instances where hand-written and transcribed values are both available, along with notes providing context for why a particular measurement in a time series of measurements was chosen to assign an intake, or if there were concerns about a particular measurement. Born prior to 1935, RDW have nearly all passed away. Thus, the updated dosimetry, especially for the bone, will allow the correlation of lifetime cumulative dose with radiation risk. Here we review typical information available in this collection of historical records, highlighting some interesting finds, and discuss the relevance to current and ongoing work related to updating the dosimetry of the RDW in the Million Person Study, including providing an example of the usefulness of information contained in these records.

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Modeling plutonium decorporation in female nuclear worker treated with Ca-DTPA

S. Dumit[1], M. Avtandilashvili[2], S. L. McComish[2], G. Miller[3], J. Swanson[4], S. Y. Tolmachev[2]

[1]*Radiation Protection Division, Los Alamos National Laboratory, Los Alamos, New Mexico, USA*
[2]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[3]*U.S. Army*

The present work models plutonium (Pu) biokinetics in a female former nuclear worker. Her bioassay measurements are available at the U.S. Transuranium and Uranium Registries. The worker was internally exposed to a plutonium-americium mixture via acute inhalation at a nuclear weapons facility. She was medically treated with injections of 1 g Ca-DTPA on days 0, 5, and 14 after the intake. Between days 0 and 20, 13 fecal and 24 urine samples were collected and analyzed for ^{239}Pu and americium (^{241}Am). Subsequently, she was followed-up for bioassay monitoring over 14 years, with 13 additional post-treatment urine samples collected and analyzed for Pu. The uniqueness of this dataset is due to the availability of: (i) both early and long-term bioassay data from a female with Pu intake; (ii) data on chelation therapy for a female; and (iii) fecal measurement results. Chelation therapy with DTPA is known to aid in reducing the internal radiation dose by enhancing the excretion of Pu from the body. Such enhancement affects Pu biokinetics in the human body, posing a challenge to the internal dose assessment. The current dose assessment practice is to exclude the data affected by DTPA from the analysis. Using this standard approach, i.e., only using data obtained 100 days after the last DTPA administration, the worksite's Radiation Protection personnel estimated the ^{239}Pu intake to be 73 Bq, with a committed effective dose equivalent to the whole-body of 16 mSv and a committed organ dose equivalent to the bone surfaces of 340 mSv. The present analysis is the first attempt to model explicitly the combined biokinetics of Pu and DTPA by using a newly developed chelation model. The bioassay data collected during and after the DTPA administrations were used for biokinetic modeling and dose assessment. The Markov Chain Monte Carlo method was used to investigate model parameter uncertainty, given the bioassay data and assumed prior probability distributions. Preliminary results of this study show that the worker's Pu intake was 21 Bq, with a committed effective dose to the whole-body of 2.31 mSv and a committed equivalent dose to the bone surfaces of 66.7 mSv. Differences in results are expected not only because of the different dosimetric systems used, but also because this analysis includes chelation-affected bioassay data and uses a biokinetic model that accounts for the effect of chelation therapy in removing Pu from the body.

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USTUR-0656-23A

Impact of death certificate misclassifications on radiation health risk models

X. Liu[1], S. L. McComish[1], J. Y. Zhou[2], S. Y. Tolmachev[1]

[1]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[2]*U.S. Department of Energy, Washington, District of Columbia, USA*

Death certificates are commonly used as a primary source of information in epidemiological studies investigating the relationship between radiation exposure and health outcomes. However, it is known that death certificates may misclassify the underlying cause of death. At the United States Transuranium and Uranium Registries, these misclassification errors have been observed at an overall rate of 25.5% for a group of 275 individuals with internal deposition of actinide elements. This simulation study aims to evaluate whether there is a statistically significant impact on risk estimates resulting from misclassifications. For the analysis, the logistic regression model was used as the risk model. Dose datasets were generated using a log-normal distribution with predefined values for the geometric mean and the geometric standard deviation. Subsequently, outcomes were randomly generated using a predefined odd ratio and baseline prevalence. Varied rates of over- and under-classification were evaluated to assess the impact of misclassification on the risk estimate results. With a predefined odd ratio of 1 (e.g. no statistical association), misclassification errors on death certificates can result in statistically significant odds ratios from 10% to 35% of the time. Further simulation studies will explore the impact of misclassification of outcome on risk estimates by various factors such as different risk levels, baseline prevalence, different types of dose distributions, and sample sizes.

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USTUR-0657-23A

Evaluation of Bayesian modeling of uncertainty in plutonium organ doses using post-mortem measurements

M. Avtandilashvili[1], M. Šefl[1], J. Y. Zhou[2], S. Y. Tolmachev[1]

[1]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[2]*U.S. Department of Energy, Washington, District of Columbia, USA*

Monitoring bioassay data, such as urinary excretion and in-vivo chest counts, is the primary source of information for radiation epidemiological studies of nuclear workers. Bayesian analysis provides a distribution of dose estimates rather than a single value that is commonly used in radiation epidemiology. Using distributions allows for more sophisticated uncertainty estimates of organ activities and associated doses. The United States Transuranium and Uranium Registries (USTUR) stores monitoring data with post-mortem radiochemical analyses of tissues. Uncertainties in organ activities and radiation dose estimates from internally deposited ^{239}Pu were evaluated using a group of 20 former nuclear workers. These individuals voluntarily donated their tissues to the USTUR. Ten workers were exposed to soluble Pu-nitrate and ten workers to 'high-fired' PuO_2 aerosols. Plutonium bioassay data for

everyone included at least five positive urine measurements. The measured ^{239}Pu activities ranged from 9.6 to 920 Bq in the liver, from 9.2 to 774 Bq in the skeleton, and from 7.2 to 6,550 Bq in the lungs. Latin hypercube sampling was employed to create priors of main absorption parameters (rapidly dissolved fraction and slow dissolution rate) and selected particle transport rates. Distributions of ^{239}Pu organ doses were generated. The distributions of doses based on ^{239}Pu bioassay measurements were compared to the point estimates based on the measured post-mortem ^{239}Pu activities in the lungs and liver+skeleton. Furthermore, the extent of distribution coverage of the post-mortem point estimate was evaluated.

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USTUR-0658-23A

From deposition to detection: the USTUR approach to measurement quality

G. Tabatadze, D. Strom, M. Avtandilashvili, S. L. McComish, S. Y. Tolmachev

U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA

The United States Transuranium and Uranium Registries (USTUR) is a U.S. Department of Energy funded research program at the Washington State University that studies deposition, biokinetics, and dosimetry of actinides such as plutonium, americium, and uranium. Other radionuclides of interest for analysis at the USTUR include ^{226}Ra, ^{232}Th, ^{237}Np, and ^{244}Cm. The USTUR radiochemical laboratory analyzes human tissues from deceased former nuclear workers who have donated selected organs/ tissues or entire bodies to the Registries. Plutonium and americium are radiochemically separated from digested tissues, electrodeposited onto a planchet, and measured by alpha spectrometry. Each sample is counted for 150,000 s with an associated background measurement of 300,000 s. This presentation is part of the development of Measurement Quality Objectives (MQOs) for the USTUR's Radiochemistry Program. It specifically addresses the minimum detectable activity (MDA) and the development of a measurement sensitivity MQO associated with the anticipated activity of a sample (i.e., expected activity on a planchet). Using this concept, the Registries characterizes its alpha spectrometry counting system based on an assumed actinide uptake of 74 Bq, 50 years prior to measurement, considering factors associated with the exposure scenario such as the chemical and physical form of the radioactive material, primary radionuclide, and route of intake. The resulting summary table highlights areas of technological limitations, prompting a subsequent discussion on potential measurement alternatives. Current radiochemical analysis procedures are more than adequate to detect activities of ^{239}Pu and ^{241}Am in the lungs, liver, and skeleton for most of the Registrants.

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USTUR-0662-23A

Learning from former nuclear workers: specifying plutonium material type for worksite-specific dose assessment

M. Avtandilashvili, E. M. Thomas, G. Tabatadze, S. Y. Tolmachev

U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA

The United States Transuranium and Uranium Registries (USTUR) studies actinide biokinetics and tissue dosimetry by following up occupationally exposed workers. At the USTUR, postmortem tissue radiochemical analysis data are used to improve biokinetic models for radiological protection. For accurate assessment of radiation doses from intakes of plutonium, information on material type is important. In occupational settings, inhalation is the most common route of intake. In this study, activity concentrations of plutonium isotopes were measured in the lungs, thoracic lymph nodes (LNTH), liver, and skeleton from 291 former nuclear workers from Hanford (116 individuals), Los Alamos (40), and Rocky Flats (135). To characterize plutonium material type (solubility), the LNTH-to-lung activity concentration ratios and liver-to-respiratory tract activity ratios were calculated. Since smoking affects plutonium material transport in the respiratory tract, LNTH-to-lung ratios for smokers and non-smokers were compared. With limited data analyzed, a significant statistical difference in the LNTH-to-lung concentration ratios was observed among three sites (p=0.0008) with median values of 21.1 (n=108), 31.5 (n=37), and 11.4 (n=121) for Hanford, Los Alamos, and Rocky Flats, respectively. The LNTH-to-lung ratios were significantly different between smokers and non-smokers (p=0.0066) with the corresponding median values of 19.7 (n=156) and 41.8 (n=41). Highly significant difference among three sites (p<0.00001) was observed for the liver-to-respiratory tract activity ratios with median values of 3.25 (n=99), 0.49 (n=34), and 0.35 (n=110) for Hanford, Los Alamos, and Rocky Flats, respectively, indicating that, among the three worksites, Hanford workers were exposed to the most soluble plutonium material. Information on plutonium material solubility can be used to improve worksite-specific dose assessment in support of radiation epidemiology.

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USTUR-0663-23A

Distribution of plutonium and radium in the human heart

S. Y. Tolmachev[1], F. T. Martinez[1], J. E. Linson[2], J. D. Brockman[2], E. M. Thomas[1], M. Avtandilashvili[1], G. Tabatadze[1], R. W. Leggett[3], C. Samuels[3], N. E. Martinez[4], D. W. Jokisch[5], J. D. Boice Jr.[6], L. T. Dauer[7,]

[1]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[2]*Department of Chemistry, University of Missouri, Columbia, Missouri, USA*
[3]*Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA*
[4]*Clemson University, Clemson, South Carolina, USA*
[5]*Francis Marion University, Florence, South Carolina, USA*
[6]*National Council on Radiation Protection and Measurements, Bethesda, Maryland, USA*
[7]*Memorial Sloan Kettering Cancer Center, New York, New York, USA*

Since 1968, the U.S. Transuranium and Uranium Registries (USTUR) has studied the biokinetics and tissue dosimetry of uranium and transuranium elements in nuclear workers. For 50 years, the mission of the USTUR has been "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." The Registries works closely with ICRP, NCRP, and Oak Ridge National Laboratory. In 1992, the National Human Radiobiology Tissue Repository (NHRTR) was established at the USTUR. The NHRTR holds biological specimens from USTUR tissue donors, as well as samples from U.S. Radium Studies acquired from Argonne National Laboratory in 1993. As part of the USTUR collaboration with the Million Person Study (MPS), radiation dose to different parts of the human heart was estimated for workers with documented intakes of ^{239}Pu or ^{226}Ra. The distribution of radionuclides, expressed in terms of concentration (Bq per kg of tissue) serves as a surrogate for radiation dose. Based on available organs from workers who donated their bodies or tissues for research, nine undissected hearts were identified: seven from USTUR Registrants with plutonium exposure (males) and two from radium workers (female and male). For the plutonium workers, estimated ^{239}Pu systemic deposition ranged from <74 Bq to 2,272 Bq. For the radium workers, estimated ^{226}Ra systemic deposition was 10.1 MBq for the female dial painter and 14.8 kBq for the male worker. Organ dissection was based on a heart model published by Borrego et al (2019). This model includes nine cardiac substructures: aorta, left main coronary artery, left atrium, left anterior descending artery, left circumflex artery, left ventricle, right atrium, right coronary artery, and right ventricle. A total of 102 cardiac tissue samples was collected from nine cases – 78 from the seven USTUR cases and 24 from the two radium cases. Besides 81 samples from nine cardiac substructures, the following tissues were also collected: mitral (left) valve (7), tricuspid (right) valve (7), epicardial fat (6), and coronary bypass (1). In addition to inductively coupled plasma mass spectrometry. These results are intended to support worker health studies by improving associated dosimetric and epidemiological models. The MPS has evaluated mortality from ischemic heart disease (IHD) for over 500,000 workers. Workers with intakes of plutonium and radium are unique in having heart tissue exposed to high-LET radiation, i.e., alpha particles. These dosimetric analyses will be generalized and incorporated into the dose-response analyses for IHD for workers at Los Alamos, Rocky Flats, Mallinckrodt and other facilities. These data are of special value to long-term space exploration where galactic cosmic rays will expose all tissues, including the heart, to high-LET radiation for long periods of time. These dose evaluations are relevant to the expanding field of theranostics that applies alpha-particle emitters in the diagnosis and treatment of tumors.

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USTUR-0664-23A

Million Person Study: review of archived historical records supporting radium dial worker dosimetry

N. E. Martinez[1], D. W. Jokisch[2], M. Mumma[3], S. Y. Tolmachev[4], M. Avtandilashvili[4], G. Tabatadze[4], R. W. Leggett[5], C. Samuels[5], L. T. Dauer[6], J. D. Boice Jr.[7]

[1]*Clemson University, Clemson, South Carolina, USA*
[2]*Francis Marion University, Florence, South Carolina, USA*
[3]*International Epidemiology Institute, Rockville, Maryland, USA*
[4]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[5]*Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA*
[6]*Memorial Sloan Kettering Cancer Center, New York, New York, USA*
[7]*National Council on Radiation Protection and Measurements, Bethesda, Maryland, USA*

The radium dial workers (RDW) comprise a well-known and influential cohort of primarily young women occupationally exposed to radium through the painting of dials and gauges with radioluminescent paint. The last epidemiological follow-up of this cohort was over 30 years ago, as the Radium Studies program at Argonne National Laboratory (ANL) was terminated in the early 1990s. The study of the RDW is being revisited to include updated dosimetric analyses as part of the Million Person Study (MPS) of low-dose health effects in healthy American workers and veterans. An informative and fairly unique source of data and data contextualization is the availability of extensive (>500 GB) electronic (i.e., scanned) records from existing microfilm (roll or reel of film) and microfiche (flat sheets/cards). When the radium program at ANL was canceled, tissue samples were transferred to the United States Transuranium and Uranium Registries (USTUR) at Washington State University to be stored at the National Human Radiobiology Tissue Repository. Surprisingly there was a lingering debate on whether the written records and radiographs would be scanned/copied and preserved. Advocates for archiving persevered, and the foresight and dedication of that team has provided our current team with incredible insight into the program and processes involved in the extensive prior work related to RDW. Although the type, extent, and quality (e.g., legibility) of record(s) varies between individuals, examples include in vivo radiation measurements (e.g., radon breath, whole body counts), autopsy results, medical records (including copies of radiographs), and various correspondence. Of particular dosimetric interest are details of radiation measurements. For example, there are some instances where hand-written and transcribed values are both available, along with notes providing context for why a particular measurement in a time series of measurements was chosen to assign an intake, or if there were concerns about a particular measurement. Taking care to preserve anonymity and dignity of the workers, we review herein typical information available in the aforementioned microfiche and microfilm, highlighting some historically interesting finds, and

discuss the relevance to current and ongoing work related to revisiting the dosimetry of the RDW in the MPS. The availability of tissues from RDWs at the USTUR will supplement the archival written record. This has been one of the seminal and influential epidemiological studies ever conducted and the current follow-up with modern dosimetry will provide new information on the lifetime risks associated with ingestion of radium.

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USTUR-0665-23A

Chronic inflammation in a Radium Dial Painter cohort: elevated neutrophil to lymphocyte ratio and radiation-induced hearing loss

R. E. Goans[1], L. T. Dauer[2], C. J. Iddins[1], M. Mumma[3], S. L. McComish[4], S. Y. Tolmachev[4]

[1]*MJW Corporation Inc., Buffalo, New York, USA*
[2]*Memorial Sloan Kettering Cancer Center, New York, New York, USA*
[3] *Vanderbilt University Medical Center's International Epidemiology Field Station, Rockville, Maryland, USA*
[4]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*

The radium dial painters (RDP) are a well-described group of predominantly young women who incidentally ingested ^{226}Ra and ^{228}Ra as they painted luminescent watch dials in the first part of the twentieth century. In 1976 pathologist Dr. William D. Sharpe published complete clinical and autopsy results for 42 former radium dial painters evaluated in the New Jersey Radium Research Project (NJRRP). This was an important paper due to the completeness of the observations. Surprisingly, in the NJRRP study, clinicians noted a 35.5% incidence of hearing loss, both conductive and mixed etiologies. Since the 1976 publication, there has developed a considerable literature on radiation-induced hearing loss in patients undergoing radiotherapy for head and neck cancers. Recently, the neutrophil to lymphocyte ratio (NLR) has been shown in many cancer and non-cancer studies to be a nonspecific marker of inflammation. In prior collaborative efforts with the United States Transuranium and Uranium Registries and with the NCRP Million Person Study, it has been possible to evaluate NLR from medical records of a cohort of 166 former radium dial painters previously evaluated at Argonne National Laboratory. These observations have suggested a possible state of chronic inflammation in those patients previously treated for radium-induced osteosarcoma. Revisiting the hematology profiles in the NJ cohort, we find the group NLR to be statistically elevated (3.05 ± 0.28, n=50; p=0.002; Mann-Whitney) from that for modern unirradiated controls (2.06 ± 0.06, n=125). These results are suggestive of chronic inflammation in the NJRRP cohort. The association of radiation-induced inflammation to hearing loss in the RDP cohort warrants additional investigation.

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USTUR-0668-24A

Mechanisms for long-term retention of plutonium in the respiratory tract: Inferences from animal and human studies

D. Poudel[1], J. A. Klumpp[1], M. Avtandilashvili[2], S. Y. Tolmachev[2]

[1]Radiation Protection Division, Los Alamos National Laboratory, Los Alamos, New Mexico, USA
[2]U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA

The radiation dose imparted by plutonium (Pu) to the respiratory tract, and consequently the risk from inhalation of Pu, depends on the residence time, location, and the mechanism of retention. One of the mechanisms for long term retention of Pu is 'binding,' by which a fraction of the dissolved material chemically binds to the tissue of the airway wall. The International Commission on Radiological Protection proposes a bound fraction of 0.2% for Pu, inferred from the findings of animal and human studies. A critical evaluation of these studies, along with other evidence in the literature and additional datasets from the United States Transuranium and Uranium Registries, strongly suggest that a mechanism other than chemical binding is responsible for the long-term retention of Pu in the respiratory tract. Analyses of historical animal datasets (rats and non-human primates injected with Pu) and a dataset on post-mortem retention in the respiratory tract of a wound case indicate some systemic uptake by the respiratory tract. However, this systemic uptake alone does not fully explain the observed post-mortem retention in an individual who had inhaled highly soluble Pu nitrate. A review of the literature review indicates the presence of – and a significant retention of – Pu in the scar tissues of the respiratory tract. Accordingly, an alternate model with scar-tissue compartments is proposed to explain the retention of plutonium in the respiratory tract compartments of four workers.

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USTUR-0681-24A

Beyond the system of radiation protection: the ten principles and ten commandments of radiation protection describe actions

D. Strom

U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA

For decades, the mantra of "time, distance, and shielding" has dominated worker training in radiation protection. While memorable, these 3 concepts are woefully incomplete and do not describe actions. To provide a much more complete menu of options that include actions outside of the ICRP's system of protection, the author published 10 principles and 10 commandments of radiation protection in 1996 (Health Phys 70(3): 388-393). The principles describe the variables that can be controlled (whether by an individual or an organization), followed by actions ("commandments") that can be taken for each variable, separated into external exposure situations and intake-of-radioactive-material situations. The commandments are expressed in both familiar terms and in technical terms. The principles are 1) time, 2) distance/direction, 3) dispersal, 4) source reduction, 5) source barrier (engineered controls),

6) personal barrier (PPE), 7) decorporation, 8) effect mitigation, 9) optimal technology, and 10) limitation of other exposures. The simple-language commandments are 1) hurry (but don't be hasty); 2) stay away from it or stay upwind of it; 3) disperse and dilute it; 4) make and use as little as possible; 5) keep it in; 6) keep it out; 7) get it out of you and off of you; 8) limit the damage; 9) choose the best technology; and 10) don't compound risks (don't smoke). Only a few items have been added in 28 years. Direction (stay upwind) has been added to the distance principle/ commandment. One commandment has been added to the personal barrier principle, "hold your breath." While no one should ask a worker to do this, but it could save an individual's life or dramatically reduce their intake under some emergency circumstances. Under the principle of source reduction, the prevention of attacks on nuclear power plants should be included with the prevention of the use of nuclear weapons.

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USTUR-0667-24A

Uranium content, distribution, and biokinetics in human body: USTUR studies

M. Avtandilashvili, S. Y. Tolmachev

U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA

Since 1968, the United States Transuranium and Uranium Registries (USTUR) has followed up occupationally-exposed individuals (volunteer tissue donors) by studying biokinetic and dosimetry of actinide elements. The USTUR currently holds data and tissue samples from six whole- and 38 partial-body donors with occupational uranium intakes. In this study, uranium tissue concentrations, body distribution, and biokinetics were compared between a group of individuals (two males and one female) with occupational exposure to uranium and a group with chronic environmental-only intakes (three males). Of three occupationally-exposed individuals, one had chronic inhalation intake of uranium oxide with natural composition, another had acute inhalation of slightly enriched UF_6, and the third (female) had both chronic and acute inhalation of highly enriched U_3O_8. For all six individuals, the skeleton was a major deposition site where 55±17% of systemic uranium was retained at the time of death. The geometric mean concentration in the skeleton was 4.1 μg kg^{-1} with a geometric standard deviation of 1.7. Systemic uranium was equally distributed between the skeleton and soft tissues. For five male cases, uranium content in systemic organs followed the pattern: skeleton >> spleen ≈ kidneys > liver ≈ brain > heart ≈ thyroid. For a single female case, the pattern was: skeleton >> brain ≈ kidneys > heart ≈ liver > thyroid ≈ spleen. For U_3O_8 inhalation, approximately 40% of occupational uranium was still retained in the skeleton, followed by the kidneys (~30%), and the brain and liver (~10%) 31 years after exposure. For UF_6 inhalation, 65 years post-intake, approximately 40% of occupational uranium was retained in the brain, followed by the liver (~26%), and the skeleton (~21%) and kidneys (~7%).

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USTUR-0640-24A

From mapping to quantification: Digital autoradiography of ^{226}Ra in human skeleton

G. Tabatadze

U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA

The United States Transuranium and Uranium Registries (USTUR) studies actinide biokinetics and tissue dosimetry by following up occupationally exposed individuals. Currently, the USTUR employs the ionizing radiation quantum imaging detector (iQID) to map the micro-distribution of alpha-emitting radionuclides in human tissues. This research aims to expand upon the capabilities of the iQID, primarily focusing on quantifying the activity concentrations of ^{226}Ra in bone samples. In this study, two plastic-embedded bone sections were selected from the middle shaft of a left femur and the left side of the thoracic vertebra of a radium dial painter (RDP). These samples were obtained from the National Human Radiobiology Tissue Repository (NHRTR), an integral component of the Registries. The NHRTR preserves an extensive collection of tissue materials from a variety of radium worker studies, including histological bone slides and tissue blocks from RDPs. In this study, the ^{226}Ra micro-distribution was mapped in bones of a female who had worked as a dial painter for 6 years, had an estimated ^{226}Ra uptake of 58.9 MBq, and passed away at age 24. Regions of interest for both cortical bone and trabecular bone were segmented. A computational model was developed to simulate the geometric efficiencies unique to the geometry of each sample, enabling the estimation of volumes and sample masses. This simulation utilized alpha particle transport models based on the particle interactions within the images of individual bone samples. The activity concentrations derived using iQID measurement were compared to results from the radiochemical analysis of these samples. The iQID imaging technique proves not only effective in studying micro-scale heterogeneous radionuclide distributions but also in accurately estimating activity concentrations of alpha-emitting radionuclides.

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USTUR-0675-24A

Can misclassification of disease change the conclusion of significant dose-response associations?

X. Liu[1], S. L. McComish[1], J. Y. Zhou[2], S. Y. Tolmachev[1]

[1]U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA
[2]U.S. Department of Energy, Washington, District of Columbia, USA

Objective: Misclassification of causes of death on death certificates can occur. This study aims to quantify the probability of death certificate misclassification errors changing the conclusion of dose-response associations.

Methods: This study utilizes a real dose distribution from Rocky Flats nuclear workers. A logistic function was used to generate outcome probabilities for each dose record, assuming an odds ratio of 1.85 with a baseline cancer rate of 26%. Health outcomes corresponding to each case were then generated based on these probabilities. This process was repeated 1,000 times to create 1,000 datasets. From these, a statistically non-significant dataset with a *p*-value

slightly exceeding 0.05 was selected. Over- and under-classification rates of 30% were randomly applied to this initially selected dataset to simulate a real-world misclassified dataset. This process was repeated 20,000 times. Subsequently, odds ratios and *p*-values of the misclassified datasets were calculated to evaluate the effect of misclassification.

Results: There is a 10.0% chance that misclassification errors cause the association to become statistically significant between the radiation dose and the outcome.

Conclusion: In general, it is believed that if misclassification of disease had been incorporated into epidemiological studies with significant dose-response associations, it would have resulted in findings that were more significant. However, these findings demonstrated that in a notable percentage of the time this belief is incorrect.

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USTUR-0673-24A

Calibration of a novel microdosimetry system for in vitro applications of actinide radiopharmaceuticals

L. J. Wilson[1], B. Miller[2], G. Tabatadze[3], F. Mourtada[1]

[1]*Department of Radiation Oncology, Thomas Jefferson University, Philadelphia, Pennsylvania, USA*
[2]*Department of Medical Imaging, University of Arizona, Tucson, Arizona, USA*
[3]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*

Alpha-emitting radionuclides show promise for targeted radiopharmaceutical therapy (TRT). The high linear energy transfer and short range of alphas result in highly localized DNA damage for effective cancer management. However, the distributions of radioactivity and absorbed dose on the cellular scale remain elusive, hindering progress toward understanding α-TRT radiobiologic response, evaluating novel α-TRT drug efficacy, and optimizing administration for personalized treatments. A novel real-time α camera, the ionizing radiation quantum imaging detector (iQID), has successfully mapped the micro-distribution of α-emitting radionuclides in mouse and human tissues. This study characterized the pixel size, spatial resolution, sensitivity, and background rate of the iQID for use in whole-animal α-TRT experiments.

The scintillator-based α detection system maps individual α emissions on a 10×10 cm^2 detector area. We measured pixel size using calibrated image templates. Line spread functions (LSF) measured with a 5 μm × 5 mm laser-drilled collimator and a 5 mCi ^{210}Po source (5.4 MeV α) quantified intrinsic spatial resolution. We measured the LSF at 5 locations on the detector surface: center and 4 edges in a × pattern to evaluate uniformity. Decays counted from a 50.2±1.1 Bq source (^{243}Am, ^{242}Pu, and ^{239}Pu; 5.16–5.43 MeV α) over 48 hours quantified detection efficiency. Finally, we evaluated the background rate over 60 hours.

Pixels measured 53.7 μm/pixel. The full width at half maximum of LSFs averaged 43.0±5.2 μm. The mean radioactivity over 48 h was 54.34±0.03 Bq, within 10% of the source-certificate value. The mean background rate over 60 hours revealed a lower limit of detection (LLD) of 4.04 mBq/cm^2.

Imaging results with a novel α camera for α-TRT experiments showed that it can image and identify α-emission events with nearly 100% efficiency, low LLD, and spatial resolution approaching the cellular scale. Future work will evaluate energy discrimination and build Artificial Intelligence tools to reconstruct whole-animal volumetric activity concentrations. The iQID is a promising tool for α-TRT experiments, filling a critical need in the field. With advanced microdosimetric understanding, novel applications of α-TRT can offer optimal cancer management to patients with previously intractable diseases.

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USTUR-0672-24A

Variability of radiation doses reconstructed by EPR in teeth of former United States nuclear workers analyses

A.Romanyukha[1], K. Consani[1], S. Y. Tolmachev[2]

[1]*Naval Dosimetry Center, Bethesda, Maryland, USA*
[2]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*

The United States Transuranium and Uranium Registries (USTUR) is a research program that studies actinide biokinetics in occupationally exposed individuals with known intakes of these elements [1]. This work is a continuation of our previous study “Electron paramagnetic resonance dose measurements in teeth of tissue donors to the United States Transuranium and Uranium Registries” [2] where EPR in tooth enamel was applied to reconstruct external doses of nine USTUR registrants. Our prior results showed that there was a reasonable agreement between the EPR-measured dose and the worksite external dose record only in two cases. For two Registrants, high EPR doses can be explained by possible cancer radiotherapy. For the remaining five cases, EPR doses significantly exceeded worksite reported doses with no plausible explanation for the observed discrepancy. In an effort to understand causes of this discrepancy, we carried out EPR dose measurements in additional tooth samples collected from the same donors as in the first study [2] to see if reconstructed doses are reproduceable. Powderized samples of tooth enamel were prepared using a standard technique and measured by EPR. In order to obtain radiation dose, peak-to-peak amplitude of a radiation-induced signal was related to a calibration curve. Radiation doses in enamel obtained in this study were compared with those reported by worksites and EPR reconstructed doses for the same individuals [2]. Additionally, tooth samples were counted using gamma spectrometry on a high purity germanium detector to measure any internally deposited radionuclides which can cause irradiation of tooth enamel.

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(Abstract) *Book of Abstracts EPRBioDose 2024*; 2024.

USTUR-0670-24A

Quantification of likelihood that death certificate misclassification increases odds ratios of dose-response relationships

X. Liu[1], S. L. McComish[1], J. Y. Zhou[2], S. Y. Tolmachev[1]

[1]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[2]*U.S. Department of Energy, Washington, District of Columbia, USA*

Objective: The general consensus is that death certificate misclassification is more likely to reduce measures of risk, such as the odds ratio, in epidemiological studies than to increase it. This study quantifies the probability that death certificate misclassification increases the odds ratio.

Methods: This study used a real distribution of dose data, originating from Rocky Flats workers. This dataset contained total cumulative colon doses (Gy) from 5,122 deceased individuals. The probability function associated with a logistic regression was used with an assumed baseline cancer rate of 24% to select an initial scenario for the simulation, which had an odds ratio of 1.85 and *p*-value of 0.049. Then the effect of over- and under-misclassifications were evaluated.

Results: On average, misclassifications indeed caused decreased odds ratios; however, a noteworthy percentage of simulations resulted in an increased odds ratio. When over- and under-misclassification rates were both 10%, the likelihood that the odds ratio would increase was 20%, and when over- and under-misclassification rates were both 20%, the likelihood that the odds ratio would increase was 11%.

(Abstract) *Book of Abstracts 2024 Annual American Public Health Association Meeting*; 2024.

USTUR-0688-24A

Radiation-induced Parkinson disease: evaluating the level of evidence and recommending future work

M. Beavers[1], S. Blattnig[2], J. D. Boice Jr[3], E. Cekanaviciute[4], S. Costes[4], L. Dauer[5], C. Davis[6], D. Iacono[6], K. Miler[7], G. Nelson[8,11], M. K. O'Banion[9], S. Y. Tolmachev[10]

[1]Tulane University, New Orleans, Louisiana, USA
[2]NASA Langley Research Center, Hampton, Virginia, USA
[3]Vanderbilt University Medical Center, Nashville, Tennessee, USA
[4]NASA Ames Research Center, Mountain View, California, USA
[5]Memorial Sloan Kettering Cancer Center, New York, New York, USA
[6]Uniformed Services University, Bethesda, Maryland, USA
[7]University of St. Thomas, St Paul, Minnesota, USA
[8]KBR Wyle Services, LLC, Houston, Texas, USA
[9]University of Rochester Medical Center, Rochester, New York, USA
[10]Washington State University, Richland, Washington, USA
[11]Loma Linda University, Loma Linda, California, USA

Recently, excess risks of Parkinson's disease (PD) have been seen in terrestrial occupational cohorts exposed to ionizing radiation. The result was initially observed in workers at the Mayak weapons facility [1] and then confirmed in six individual cohorts consisting of 517,000 workers within the Million Person Study (MPS) [2]. However, the subjects in these studies were exposed to primarily low Linear Energy Transfer (LET) chronic radiation, whereas space radiation is a more complex mixture of high and low LET radiation qualities. Based on the preliminary data from the MPS [2], an initial risk model was developed to project PD risks from space radiation exposure during exploration missions. The results suggest that PD risks may be high enough for concern. More specifically, for a two-year Mars flyby mission with an estimated brain radiation exposure of 0.33 Gy, the lifetime Risk of Exposure Induced Cases (REIC) of PD was estimated to be 8.75 (3.05-18.0) for 40 year-old men, and 2.44 (0.83-5.12) for 40 year-old women [3], where the confidence intervals only include statistical uncertainties from the epidemiological data. However, these estimates are highly uncertain, particularly when considering the unquantified uncertainties such as those associated with quality factor and dose rate effects. Nonetheless, the rather large REIC values strongly suggest a need for further evaluation. While the observational epidemiology is suggestive of a PD risk, it is currently difficult to establish causation using such data alone. Accordingly, to develop estimates of radiation quality and dose rate effects needed to scale risk estimates from the terrestrial circumstances to the space radiation environment, experimental neurobiology data are important. For example, preclinical rodent models of low and high LET exposure, including studies utilizing simulated Galactic Cosmic Rays (GCR), reveal evidence of neural injury, behavioral deficits, and microglia reactivation [4], all of which are commonly observed in neurodegenerative diseases, including PD. A recent study utilizing state-of-the-art spatial transcriptomics in the brains of female Balb/C mice flown on the International Space Station for ~40 days revealed neurodegenerative processes like PD, despite these mice not naturally developing the condition [5]. The most pronounced changes were observed in cortical neurons, suggesting potential parallels with PD involving protein misfolding and accumulation. However, while these findings are

promising, specific biological mechanisms for radiation-induced PD remain unclear, and there is a lack of data suitable to estimate how radiation quality or dose rate impact PD pathogenesis. To put this information into a broader context, an ad-hoc working group was convened to evaluate the level of evidence for a PD radiation risk following the criteria recommended by the NASA Human Systems Risk Board [6] and to make specific recommendations on what research is needed to confirm this risk and better enable quantitative risk projections for exploration missions. Some of the recommendations will be addressed by epidemiological research currently underway within the context of the MPS [7] including an effort specifically focused on multiple stressors and radiation exposure [8]. Recommendations for future studies from the ad-hoc group will focus on biology and epidemiology research beyond what is currently underway with a particular emphasis on integrating PD-related biological mechanisms with epidemiological evidence.

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(Abstract) *Book of Abstracts NASA Human Research Program Investigators' Workshop*; 2025.

USTUR-0693-24A

Importance of human data – U.S. Transuranium and Uranium Registries

S. Y. Tolmachev

U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA

Since 1968, the U.S. Transuranium and Uranium Registries (USTUR) has studied the biokinetics and tissue dosimetry of uranium and transuranium elements in nuclear workers. In 1992, the National Human Radiobiology Tissue Repository (NHRTR) was established at the USTUR. The NHRTR holds biological specimens from USTUR tissue donors, as well as samples from U.S. Radium Studies acquired from Argonne National Laboratory in 1993. The USTUR is not an epidemiology study, however, the materials and data available at the USTUR/NHRTR can be used to improve radiation dose assessment in support of radiation epidemiology. The uniqueness of the USTUR lies in its ability to link thoroughly documented exposure, work history, medical, industrial hygiene, and bioassay data with precise postmortem measurements of the content and distribution of radionuclides in the human body. The USTUR research focuses on: (1) modeling of actinide biokinetics, (2) study of actinide distribution in the human body, (3) quantification of uncertainties in radiation dose assessment and health outcomes, and (4) study of occupational exposure to nonradioactive materials associated with the nuclear industry. The USTUR maintains well-established collaborations with national and international scientists and institutions. As a part of collaboration with the Million Person Study, the USTUR provides tissue analyses results to develop worksite- specific biokinetic models for dose

reconstruction. Another topic of special interest, where tissues available at the USTUR/NHRTR can be used, is studying nonuniformity of radiation dose distribution from various radionuclides in individual organs. Data and tissue samples from individuals exposed to beryllium are also available at the USTUR. These can be used to improve the beryllium biokinetic model and investigate potential synergetic effects of beryllium and radiation on tissues.

(Abstract) *Book of Abstracts 61st Annual Meeting of the National Council on Radiation Protection and Measurements*; 2025.

USTUR-0702-25A

Quantifying radium-226 in heart tissue using ICP-QQQ-MS: A study of Radium Watch Dial Painters

J. E. Linson[1], S. Y. Tolmachev[2], J.D. Brockman[1]

[1]*Department of Chemistry, University of Missouri, Columbia, MO, USA*
[2]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, WA, USA*

This study investigates the bioaccumulation of radium-226 in heart tissue of Radium Watch Dial Painters. An Agilent 8900 ICP-QQQ-MS was employed to quantify radium-226 levels following acid digestion and strong cation exchange chromatography. The method achieved an instrumental detection limit of 3.4 fg Ra/g (0.12 mBq/g) and a sample limit of detection of 4.8 fg/g tissue (0.18 mBq/g tissue). Radium-226 concentrations in heart tissue samples ranged from 0.061 ± 0.021 pg Ra/g (2.2 ± 0.8 mBq/g) to 0.12 ± 0.04 pg Ra/g (4.6 ± 1.6 mBq/g). Analysis of bone material from a dial painter revealed significantly higher radium-226 concentrations: 2200 ± 250 pg Ra/g (81 ± 9 Bq/g) in the femur and 1700 ± 460 pg Ra/g (64 ± 17 Bq/g) in a vertebra.

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USTUR-0704-25A

Quantification of probability that death certificate misclassification increases measures of risk in epidemiology

X. Liu[1], S. L. McComish[1], J. Y. Zhou[2], S. Y. Tolmachev[1]

[1]*U.S. Transuranium and Uranium Registries, Washington State University, Richland, Washington, USA*
[2]*U.S. Department of Energy, Washington, District of Columbia, USA*

The general consensus is that death certificate misclassification is more likely to reduce measures of risk, such as the odds ratio, in epidemiological studies than to increase it. This study quantifies the probability that death certificate misclassification increases the odds ratio. This study used a real distribution of dose data, originating from Rocky Flats workers. This dataset contained total cumulative colon doses (gray) from 5,122 deceased individuals. The binomial probability function associated with a logistic regression was used with an assumed baseline cancer rate of 26% to select an initial scenario for the simulation, which had an odds ratio of 1.85 and *p*-value of 0.049. Then, the effects of over- and under-misclassifications were evaluated. On average, misclassifications

indeed caused decreased odds ratios; however, a noteworthy percentage of simulations resulted in an increased odds ratio. When over- and undermisclassification rates were both 10%, the likelihood that the odds ratio would increase was 20%, and when over- and under-misclassification rates were both 20%, the likelihood that the odds ratio would increase was 11.4%.

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