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2010 AAHP Special Session
Radiation Dose Reconstruction for Epidemiology

Richard J. Vetter, CHP, Past President, AAHP

Each year the American Academy of Health Physics (AAHP) sponsors a special session at the annual meeting of the Health Physics Society (HPS). The 2010 Special Session—"Radiation Dose Reconstruction for Epidemiology"—focused on dose-reconstruction science and uncertainty. Dan Strom suggested the topic to me and volunteered to serve as the principal organizer. Marina Degteva of the Urals Research Center for Radiation Medicine (URCRM) and I cochaired the morning session, and Dan and I cochaired the afternoon session. Marina worked for many years with Lynn Anspaugh and Bruce Napier on the Techa River dosimetry. Marina was selected by the HPS Awards Committee to receive a G. William Morgan lectureship (see September 2010 *Health Physics News*, page 16).


Richard J. Vetter


Daniel J. Strom

Dose reconstruction, a scientifically valid process for retrospectively estimating radiation dose, is often used in epidemiological studies to estimate the radiation received by a group of individuals exposed to a reasonably well characterized source of radiation. Dose reconstruction involves identifying the exposure pathway, using well-defined methods to estimate the dose, evaluating uncertainties, applying quality-control methods, and interpreting results. In this special session, presentations covered a range of dosimetry challenges including Japanese atomic bomb survivors, uranium miners, radium dial painters, Chernobyl public, Techa River public, and various occupational and medical studies. The first presentation, "The Needs of a 'Customer' of Dose Reconstruction," was given by Ethel Gilbert, a biostatistician at the National Cancer Institute. Dr. Gilbert was a member of both BEIR VI and BEIR VII committees. She described how radiation epidemiology quantifies dose-response relationships, evaluates risks in populations that have not been studied, and compares risk estimates (at a given dose) across subgroups and studies. Gilbert also explained why radiation dose estimates used in epidemiological studies are subject to many sources of uncertainty.

Dose reconstruction, a scientifically valid process for retrospectively estimating radiation dose ...

Bruce A. Napier, CHP, discussed "Radiation Dose Reconstruction: Principles and Practices - A New NCRP Report." Napier, an environmental health physicist at Pacific Northwest National Laboratory (PNNL), was the chief scientist for the Hanford Environmental Dose Reconstruction Project and has been associated with the Department of Energy's Joint Coordinating Committee for Radiation Effects Research Russian projects for over 15 years. Bruce chaired the National Council on Radiation Protection and Measurements (NCRP) Committee 6-4 on Principles of Dose Reconstruction. He explained that the scope of dose reconstruction includes estimates of absorbed dose to individual organs or tissues for specified exposure situations in support of epidemiological studies or compensation programs, to guide interventions in accidental or malevolent exposures, or for individual or public information. Dose reconstruction can be divided into the five essential steps in the dose-reconstruction process and the two foundation elements of the entire dose-reconstruction process that are integral to performing each step. The NCRP report discusses each element.

Daniel J. Strom, CHP, of PNNL discussed "Errors and

Uncertainties in Radiation Dose Reconstruction for Epidemiology: Approaches and Challenges." Dr. Strom received his PhD in radiological hygiene, is a member of the NCRP, and has worked at PNNL since 1991. He defined classical (measurement) vs. Berkson (grouping) errors that led to uncertainties in doses that are reconstructed for epidemiology. Strom explained that management of these uncertainties for radiation epidemiology differs from that for radiation protection dosimetry or for dose reconstruction done in support of compensation decisions. His presentation provided details of computational algorithms for "multiple dose history realizations" for occupational external dosimetry and medical x-ray dosimetry for the Mayak Worker Dosimetry System (MWDS) for use in radiation epidemiology studies.

Richard (Dick) Toohey, associate director of the Independent Environmental Assessment and Verification program at Oak Ridge Associated Universities and past president of the HPS, discussed "Skeletal Dose Estimates for Radium Dial Workers." In the follow-up studies of workers in the luminizing industry, only bone cancers and soft-tissue cancers of the sinuses and mastoids were unequivocally related to the ingestion of radium. Dr. Toohey described the history of how the measured body burden of radium was used as a surrogate for the skeletal dose, the conversion of body burden to intake, modification of the International Commission on Radiological Protection (ICRP)-20 model to allow for exchange with soft tissues, development of the parameter for endosteal dose, i.e, the dose to the 10-micron-thick layer of cells on endosteal surfaces (what ICRP now calls dose to bone surfaces), and opportunities to improve the bone surface dose estimates for radium workers and derive risk coefficients comparable to those derived from other studies.

Alan Birchall, speaking for Anthony (Tony) James, discussed "Radon and Uranium Miner Dosimetry: Current Status and Uncertainties." Dr. Birchall is leader of the Biomathematics Group at the U.K. Health Protection Agency and adjunct professor at Washington State University supporting the U.S. Transuranium and Uranium Registries (USTUR). Dr. James is the director of the USTUR. This presentation outlined developments in lung dosimetry for radon daughter progeny since the National Research Council's 1999 report "Health Effects of Exposure to Radon: BEIR VI." Bringing radon progeny dosimetry (and risk estimation) into congruence with lung dosimetry for all other radionuclides would enable the theoretical risks from all of these modes of occupational and population exposure to be compared on the same metric scales, i.e., absorbed target-tissue dose and dose rate.

Harry M. Cullings discussed "Uncertainty in Dose Reconstruction for the Atomic Bomb Survivors in Hiroshima and Nagasaki." Dr. Cullings has a PhD in biostatistics and is currently chief of the Statistics Department at the Radiation Effects Research Foundation (RERF). Previously he worked for the National Research Council's Committee on Dosimetry for the RERF and for the Dosimetry System DS02 working group. The main cohort followed by RERF, the Life Span Study (LSS), has 120,321 survivors of whom 93,741 were in the cities at the times of the bombings and the rest are an unexposed control group. Dose reconstruction to date has used a succession of dosimetry systems devised by scientific working groups to estimate doses received directly from neutrons and gamma rays produced by the bombs and debris in the fireballs during the first minute of the explosions. RERF has collected detailed data on the location and shielding for 22,787 persons (~75 percent of the cohort at <1.6 km in Hiroshima and 80 percent at <2 km in Nagasaki). Classical error due mainly to survivor recall of location and shielding is a major component of error, generally considered to have a coefficient of variation of ~35 percent to 40 percent. There are various Berkson errors due to grouping aspects of the shielding calculations, varying considerably among subsets of survivors classified by available shielding data and to a lesser extent precision of location data. Finally, there are systematic errors in the computational methods of the dosimetry system and its general inputs such as estimated hypocenter locations, heights of the explosions, atmospheric humidity, and interaction cross sections.

Isabelle Thierry-Chef of the International Agency for Research on Cancer received her PhD for her work on the study of errors in dosimetry conducted within the International Collaborative Study of Cancer Risk among radiation workers in the nuclear industry. She described "The 15-Country Nuclear Workers Study - Quantification of Errors in Doses," a large-scale epidemiological study of nuclear industry workers, which was designed to provide direct estimates of cancer risk following low-dose protracted exposure to ionizing photon radiation. The study of errors in dosimetry was designed to identify and quantify biases and uncertainties in historical recorded doses. Identification of errors was based on a review of dosimetric practices and technologies in participating facilities.

In his presentation "Radiation Organ Doses Received by U.S. Radiologic Technologists: Estimation Methods and Findings," Steven L. Simon summarized methods and strategies for historical reconstruction in a large cohort of U.S. radiologic technologists. Dr. Simon, who received his doctorate in radiological health sciences, currently conducts retrospective dose estimation in support of epidemiologic investigations at the National Cancer Institute. Annual and cumulative occupational film badge readings were obtained for about 110,000 technologists who worked during the period 1916 to 2006. Absorbed doses were estimated for 12 organs and tissues. Energy-dependent transmission factors were derived for protective aprons of different thicknesses and used to modify organ dose estimates according to individual survey responses about the use of protective aprons. Bone-marrow dose estimates were adjusted for body size by using an individual-specific body mass index correction factor.

André C. Bouville described the "Dosimetry for NCI Chornobyl Studies (Thyroid Diseases)." Dr. Bouville is a senior radiation physicist at the National Cancer Institute, where his work includes epidemiologic studies conducted in cooperation with the governments of Ukraine and Belarus. His previous work included estimation of the thyroid doses received by members of the public from ^{131}I released during nuclear weapons testing at the Nevada Test Site. The explosions at the Chornobyl nuclear power plant in Ukraine in 1986 led to a considerable release of radioiodines. Thus, much attention has been paid to the thyroid doses resulting from intakes of ^{131}I. Thyroid doses received by the inhabitants of contaminated areas of Belarus, Russia, and Ukraine varied widely based on age, level of ground contamination, milk consumption rate, and origin of the milk consumed. Thyroid uptake measurements, together with models of environmental transfer and metabolism and personal interviews on residence history and dietary habits, were used to estimate thyroid doses.

Alan Birchall provided a second presentation, "Bayesian Methods and Uncertainty for Internal Dose Reconstruction." He pointed out that Bayesian methods are used increasingly to quantify uncertainties in estimates of internal dose, but the methods are difficult and complex. He described a new method, Weighted Likelihood Monte Carlo Sampling (WeLMoS), which is simple both to understand and to apply. This methodology is currently being applied to analyze a large cohort of workers (2000) exposed to alpha-emitting radionuclides (plutonium, uranium, and radon) in a large multidisciplinary epidemiological study in Europe (EC Alpha Risk Study). There are plans to use this method on the Mayak workers cohort.

Victor Khokhryakov earned his PhD in radiation safety and dosimetry from the Moscow Biophysics Institute and worked for two decades at the Mayak Production Association, where he estimated environmental doses. He now heads the Dosimetry Department of the Southern Urals Biophysics Institute. He discussed "Plutonium Dose Reconstruction for Workers at the Mayak Production Association," a large industrial facility in the Russian Federation that began producing plutonium in the late 1940s. Workers were chronically exposed, and urine bioassays were done for unusual suspected intakes. In some cases, autopsy data were available, providing concentration measurements in skeleton, lung, and liver. Reconstruction of doses included use of results from research performed at the Southern Urals Biophysics Institute on particle size, particle solubility, radionuclide composition, in vivo monitoring, and microscopic studies of plutonium distribution. Dr. Khokhryakov described several challenges in reducing uncertainty in reconstructed doses.

Robert I. Scherpelz filled in for Evgeny Vasilenko, deputy chief engineer for radiation and labor safety at the Mayak Production Association, who was not able to attend. Scherpelz is the project manager for the U.S. researchers involved in Joint Coordinating Committee for Radiation Effects Research Project 2.4, Mayak Worker Dosimetry and principal investigator for external dosimetry. He described "Reconstruction of External Radiation Doses for Mayak PA Workers," including the stages of development of the dosimetry system of the Mayak Production Association and the basis for external dose estimates and their uncertainties for different production plants (reactor, radiochemical, and plutonium plants). He presented results of dose reconstruction for individual occupational radiation doses and dose of medical x-ray procedures received by the workers included in the cohort under study.

Marina Degteva earned her PhD in radiation protection from the Moscow Biophysics Institute and is currently head of the Biophysics Laboratory at the URCRM, Chelyabinsk, Russia. Her research interests include radiation dosimetry and risk assessment. We were delighted to welcome her as this year's G. William Morgan Lecturer. The topic of Dr. Degteva's lecture was "Dosimetry for the Extended Techa River Cohort." Degteva explained that the Techa River Dosimetry System (TRDS) deals specifically with dosimetry for the approximately 30,000 members of the Extended Techa River Cohort, exposed to radioactive releases from the Mayak Production Association. The TRDS is designed as a flexible system that uses various elements of system databases to provide dosimetric variables requested by the user. Degteva explained that the research will generate estimates of uncertainty for all doses calculated in a form that can be used by biostatisticians to estimate the uncertainty in calculated radiation risks.

The final paper was presented by James W. Neton, CHP, associate director for science in the Division of

Compensation Analysis and Support of the National Institute for Occupational Safety and Health (NIOSH). Dr. Neton received a PhD in environmental health sciences, with an emphasis in radiological health. For the last 30 years, his career has focused primarily on research and practice of radiation protection dosimetry. Neton explained that NIOSH has reconstructed individual organ doses for approximately 25,000 workers who are covered under the Energy Employees Occupational Illness Compensation Program Act. There are many similarities in the technical approaches to reconstruction of doses between epidemiological studies and those of a compensation program. For compensation program purposes, the need to produce an accurate estimate of exposure is offset by the need to produce a timely result that provides an unambiguous compensation decision for the claimant. To ensure that cases are expeditiously processed in a fair and scientifically defensible manner, NIOSH has developed over- and underestimating techniques that limit the amount of effort required to reach a compensation decision.

Dose reconstruction is a subject of intense interest in health physics. This special session was well attended, suggesting a high level of interest among attendees. I was especially gratified the Awards Committee awarded Marina Degteva the G. William Morgan lectureship. I would like to express my appreciation to the presenters, all of whom have established themselves as experts in the science of dose reconstruction and gave high-caliber presentations. I deeply appreciate the efforts of Dan Strom, who suggested this topic and worked with each author to organize this session.

A brief biography, abstract, and PowerPoint presentation for each presenter can be found on the academy Web site at http://www.hps1.org/aahp/public/wp_sessions.htm.

The State of AAHP Finances

Ray Johnson, CHP, Treasurer

Academy's Investments

Along with everyone else, the Academy has experienced another rough year in its investment portfolio. The good news is that after reaching a low point in February 2009, returns have generally been on a rebound.

The total value of the Academy's investments and short-term funds as of 31 May 2010 (the last full quarter of data available) was $681,694. This represents a net increase in investment funds of $47,774 since this same time a year ago.

The Academy's investment policy states that we should have securities (including short-term funds) equivalent to 2.5 times our annual budget. We continue to be well above this goal.

FY2010/2011 Budget

At the 26-27 June 2010 meeting in Salt Lake City, Utah, the Executive Committee adopted the FY2010/2011 operating budget as proposed by the Finance Committee. This budget has $228,235 for expenses of the Academy and the American Board of Health Physics (ABHP) and is essentially the same budget approved for the last three years.

This budget projects $171,100 in income for FY2010/2011, but this does not mean the Academy will experience an operating deficit. The projected income does not include revenue from the growth of assets. Also, the Finance Committee and Executive Committee have noted that historically the officers and committees of the Academy and the ABHP consistently spend less than is budgeted for them. The Finance Committee believes we will have no significant deficit in the coming year, although at some point the Academy may want to draw upon the increasing value of long-term and intermediate-term investments to support operating expenses.

The complete budget is posted on the Members Only section of the Academy's Web site (http://www.hps1.org/aahp/membersonly/). Should you have questions, don't hesitate to email me (ray.johnson@moellerinc.com).