

STANDARD PROCEDURES FOR POOLING HEALTH PHYSICS DATA FOR EPIDEMIOLOGIC STUDIES

Daniel J. Strom, William L. Beck, Paul S. Stansbury, William G. Tankersley,
and James E. Watson, Jr.

Department of Environmental Sciences and Engineering, University of North Carolina School of Public Health, Chapel Hill, NC 27514 (Mr. Strom, Dr. Watson, Dr. Stansbury).

Center for Epidemiologic Research, Oak Ridge Associated Universities, Oak Ridge, TN 37830 (Mr. Beck, Mr. Tankersley).

General Electric Company, P.O. Box 780 M/C J-26, Wilmington, NC 28405 (Dr. Stansbury - current address).

Bechtel National, Inc., P.O. Box 350, Oak Ridge, TN 37830 (Mr. Beck - current address).

ABSTRACT

Standard procedures are presented for pooling health physics data from multiple facilities for use in epidemiologic studies. Special effort is needed because health physics records ordinarily were made for radiation protection, not for epidemiology; because dosimetry practices and records are different at different facilities; and because the validity of epidemiologic study conclusions depends on the quality of the dose data used.

The objectives of this effort are: 1. to determine the availability of dosimetry data and supporting documentation at multiple facilities; 2. to develop criteria and methods for optimally retrieving data; 3. to evaluate and document the quality and completeness of data and dosimetry programs; 4. to put dosimetry data (e.g., external, whole body counting, and bioassay data) from various facilities in a single format for epidemiologic analysis; and 5. to document all work for peer review.

To achieve these objectives, a "Dosimetry Records and Radiation Hazards Questionnaire" was developed to send to the facilities under study. Responses to this questionnaire are used to develop data retrieval criteria and methods, and to retrieve data. Dose data are reformatted into Standard Intermediate Dosimetry Files for editing and characterization. Evaluations of dosimetry programs are performed concurrently. Results of these steps are brought together and analysis files created. Status of this work in the context of the Department of Energy 5-Rem Study is reported. The standard procedures are applicable to single- as well as multiple-facility studies.

Introduction

In occupational radiation epidemiology, the validity of study conclusions depends on the completeness and quality of both the biologic response data and the radiation dosimetry data. In this paper, we discuss the standard procedures that we have developed for pooling radiation dose data from multiple facilities for use in epidemiologic studies.

As used here, radiation dose assessment, or simply dose assessment, means the critical analysis and definitive judgment of the quality, appropriateness, and completeness of both radiation dosimetry programs and of the individual records that are the product of such programs. The goal of these analyses and judgments is to make usable the data recorded by occupational radiation monitoring programs as a measure of the exposure variable in an epidemiologic study. Obviously, biased or invalid measures of the exposure variable would lead to an invalid estimate of the risk-per-rem (or upper limit for the risk-per-rem). The procedures and methods described below were developed to increase the overall validity of the studies being performed by Oak Ridge Associated Universities with the collaboration of the University of North Carolina for the U.S. Department of Energy.

The Contribution of Dose Assessment to an Epidemiologic Study

In the context of an epidemiologic study, dose assessment is needed to determine what health physics data are available at a facility; and to develop facility-specific criteria and optimal methods to retrieve these data and supporting documentation. It is necessary to determine what measurements these health physics data represent, and what the units of these measurements are. It is important that edits be performed to detect errors in the health physics data, and to correct, flag, or eliminate records containing errors. It is necessary to determine which data are usable in an epidemiologic study. Dose assessment includes the evaluation of the quality and completeness of health physics data. It is necessary to convert the results of monitoring programs for internal radioactivity to either dose equivalents or dose categories, where possible. Dose assessment is needed to evaluate, and if possible, maximize the comparability of health physics data between facilities and over time. Dose assessment is required for presentation of health physics data in forms that give meaningful overviews, and to put health physics data into formats that are of use in epidemiologic analysis. Finally, it is important to document the work done in the course of dose assessment for peer review and for the use of future researchers.

In short, the dose assessment process is needed to interface epidemiology with health physics.

Methods of Dose Assessment

To determine what is available, a "Dosimetry Records and Radiation Hazards Questionnaire" (DRRHQ, see reference 1) has been developed and sent to the facilities under study. Some ideas for this questionnaire were derived from the work of Dreyer et al. (2) and the work of Fix et al. (3). However, most of the questions in the DRRHQ are adapted from the "Dosimetry Assessment Fact Sheet," developed by Beck, Stansbury and Watson, and included here as an appendix. The Dosimetry Assessment Fact Sheet is a checklist of information needed to evaluate an occupational dosimetry program in the context of an epidemiologic study.

The DRRHQ addresses the question of what is available in terms of dosimetry program information by requesting identification of health physics contacts at the facility, both current and retired or transferred; a list of dosimetry program documentation, and the location of such documentation; a breakdown of site operations by year; a determination of what years employees were exposed

externally to each of four types of radiation, as well as what years they were not monitored; a description of possible internal exposures and monitoring; a list of units and quality factors broken down by high-LET radiation type and year; and information on several miscellaneous topics.

The DRRHQ addresses the question of what is available in terms of dose data by requesting a breakdown of record form by monitoring method, year, and external radiation type; the locations of these records; identification of commercial dosimetry services, if applicable; a breakdown of record form by monitoring method and year for internal exposures; and the locations of these records.

Responses to the DRRHQ from each site are analyzed as a function of year. Radiation hazards are characterized by year from answers on the DRRHQ. This characterization permits a comparison of actual monitoring with monitoring which would have been desirable in light of today's standards. Monitoring programs and those records which are currently available are characterized.

The completeness and appropriateness of dosimetry programs are assessed by comparisons of the characterizations of the hazards and monitoring programs. Completeness is the degree to which there were no gaps in the program (e.g., a hazard existed since 1945, but was not monitored before 1950). Appropriateness is the degree to which the monitoring program addressed the hazards (e.g., was a beta-gamma badge used to monitor tritium exposures?). Availability of program documentation is also assessed, including references to commercial services. Preliminary assessment of dose data quality (i.e., how good were the measurements?) is made insofar as possible, based on references to known documents, processes, vendors, etc. It is recognized that this is possible only to a limited degree. It may be easier to identify low quality or flawed data than to identify high quality data. In the context of a multi-site epidemiologic study, usability of the dose data is assessed based on the criteria of data availability and completeness; machine-readability; appropriateness of monitoring programs; availability and adequacy of documentation; and data quality (if this can be determined without further information).

Analysis of DRRHQ data leads to the development of criteria and methods for data retrieval from each facility. These analyses prompt decisions regarding what additional dosimetry program data to request (e.g., specific documents relating to the dosimetry programs); what dose data to request for individuals; what forms and formats to get dose data in; what identifiers are needed for dose data; and what documentation is required to make dose data useful (e.g., units).

For facilities that are still in operation, a visit to the site to talk with the health physicists responsible for personnel dosimetry and records is the best way to retrieve most of the needed information. In some cases, time, money, or other factors will not permit on-site contact, and contacts by phone and mail must be used.

Once dose and dosimetry program data have been retrieved, they are processed according to our "Standard Assessment Procedures" (SAP, see reference 1). The SAP are a detailed prescription and checklist for assessing both dose and dosimetry program data.

In the "Dosimetry Program Evaluation" section of the SAP, dosimetry program and hazards data are analyzed to reveal temporal trends in monitoring and hazards, and to determine for what time periods the monitoring was appropriate for the hazards. Such topics as quality assurance programs, reconstruction of previous occupational histories, minimum detectable doses, quality factors, dosimetry initiation criteria, analysis of problem codes accompanying data, lost and damaged dosimeter procedures, recordkeeping (forms and formats), documentation and procedure manuals, etc., are addressed.

A detailed description of a "Standard Intermediate Dosimetry File" (SIDFile) for storage and processing of dose data is given in the SAP. SIDFiles are general, flexible computer files that can accommodate a variety of dose data from multiple facilities, including external radiation measurements, bioassays, and whole body counts. Information in a SIDFile grows and evolves as the dose assessment process proceeds. Data come from facility dose records, demographic and work history databases, assignments made by health physicists based on program evaluations, and results of logic and edit tests. SIDFiles contain annotation to indicate what has been learned about the data, what edits have been done, and which tests have been passed. Provision is made for judgment flags, uncertainties, and references to dose conversion algorithms on the SIDFiles. SIDFiles permit the merging of internal and external dose records so that complete dose histories for individuals at a given site can be compiled, and eventually merged with data from other sites.

The SAP contain data management considerations for handling, editing, characterizing, storing, and documenting dose data. Univariate and multivariate edit checks are performed both before and after the dose data are reformatted into SIDFiles. These checks serve to detect errors. In addition, characterizations done in the editing stage are useful in preliminary work in other parts of dose assessment. A random sample of data is listed to compare with original hardcopy records.

The edited SIDFiles are brought together with the results of the dosimetry program analysis in a five-part "Synthesis" section. This section includes the development and assignment of conversion algorithms, the assignment of uncertainties, the assignment of judgment flags, the final characterization of the data, and the generation of a final assessment report.

The conversion algorithms that are developed during the synthesis step of dose assessment convert dose data or bioassay data into a form usable in an epidemiologic analysis. For external exposures, these conversion algorithms usually are multiplicative constants to convert site measurements into millirems. An example of this is the assignment of a quality factor for neutron exposures. For internal exposures, the conversion algorithm generates ordinal variables in most cases. In some cases of internal exposures, however, the conversion algorithm generates dose numbers in millirems. Such conversion depends on the availability of large amounts of information about internal exposures. For example, a bioassay result in units of dpm of tritium in a 24-hour urine sample can be converted to a dose equivalent rate (mrem/hr) and integrated over the time between samples to achieve a dose equivalent (mrem). Of course, this can only be done in cases where several bioassay results are available in proper time sequence, with sufficient documentation. Even then, many assumptions and

judgments have to be made to do this (such as the mass of the worker in question), and these assumptions are documented in a final assessment report.

Dose data, once converted to millirems, are assigned either ordinal (e.g., A, B, C, D, or F) or interval (e.g., X or \div by 2) uncertainties. These uncertainties usually are assigned categorically, by monitoring type; however, given sufficient information, more detailed uncertainties may be assigned on the basis of the magnitude of the dose numbers (e.g., at 10 mrems, the uncertainty may be X or \div by 2, while at 100 mrems, it may be X or \div by 1.3).

Judgment flags also are set on each individual's dose history. Such flags represent the overall usefulness of the data for a particular individual in an epidemiologic study. Judgments are based on uncertainties in records, and additional information, such as omissions, that may bias the data in an individual's file.

Once data are converted to millirems, final characterization is done. Dose distributions by year and by dose range are examined. Summary statistics and other descriptors such as those described in UNSCEAR-77 (4) are computed.

A Final Assessment Report is prepared for the dose and program evaluation information and edited SIDFiles. This report summarizes program evaluation information, and contains references and data characterization. This report also documents what has been done to the data and why; what has not been or could not be done, and why; questions, concerns, problems, and limitations; and caveats for the use of the data in epidemiologic studies.

With the assignment of conversion algorithms, uncertainties, and judgment flags, and with the preparation of the final assessment report, the edited SIDFile is considered "assessed" and is ready for use in the creation of analysis files.

The results of the application of Standard Assessment Procedures to the dose and dosimetry program data from a facility are edited, assessed SIDFiles and a final assessment report.

Status and Conclusions

As of January 1983, responses to the Dosimetry Records and Radiation Hazards Questionnaire have been received from twenty-seven of the forty DOE and DOE contractor facilities where individuals have been identified for inclusion in the 5-Rem Study. The 5-Rem study includes nearly 3000 workers who received a whole body dose of 5 or more rems in one year between 1947 and 1978. The mortality and morbidity experience of this cohort of workers is currently being studied by the ORAU/UNC epidemiology group. Dose assessment is in progress for this study. Dosimetry program evaluations are well underway for two of the facilities in the 5-Rem Study (Argonne National Laboratory and the Y-12 Plant in Oak Ridge, Tennessee), and the dose data for workers at Y-12 are being analyzed.

Data from these two facilities are being used to refine and test the SAP. The final version of the Standard Assessment Procedures will be applicable to dose assessment for studies of workers at one or more facilities.

APPENDIX: DOSIMETRY ASSESSMENT FACT SHEET

William L. "Jack" Beck, Paul S. Stansbury, and James E. Watson, Jr.
Original version, 1979; Draft 4, 6/15/81

The following information is needed to evaluate the completeness and accuracy of dosimetry data required for the Department of Energy Health and Mortality Study.

I. History of "Hazards" to Assess Overall Monitoring Program

- A. What were the radiation hazards as a function of time?
- B. By present day standards, were there significant radiation hazards that were not monitored for or that were inadequately monitored?
- C. Describe in general the monitoring systems that have been used and the dates for each system.
- D. Are there other written documents such as research reports, technical memos, internal evaluation memos, procedure manuals, etc., that would provide additional information on your dosimetry systems? Where can these documents be found?

II. External Monitoring Data

- A. Personal Monitoring Badges
 1. What type of badge was used? (Film, TLD, etc.).
 2. If more than one type, please give data for each different type used.
 3. What different modes of measurement were made (skin, penetrating, photon, beta, etc.)?
 4. Were dosimeters evaluated by commercial processor(s) or "in house"? If by commercial, give names and addresses and dates used.
 5. If done in house, is there a procedure manual(s) available? If manual is not available, the following information is needed. Please give dates, etc.
 - a. Describe the calibration procedure and frequency.
 - b. Can the calibration be traced to NBS?
 - c. Describe the dosimeter evaluation process.
 - d. How often were "test" dosimeters evaluated and were they blind tests?

- e. For test dosimeters, how accurate and precise were the results?
 - f. What other quality assurance procedures were used?
 - g. Were there specific training requirements for the dosimetrist?
6. What is the consensus of personnel operating the dosimetry service as to the accuracy and precision of the monitoring measurements?
- B. Use of Badges
1. What part of the total worker population was badged?
 2. What were the criteria for badging?
 3. Were monitoring badges also security badges?
 4. What percentage of the time did workers probably wear their badges?
 5. Did workers tend to leave badges in desks, in cars, etc., often?
 6. What procedure was used to provide monitoring if worker left his badge at home or lost his badge?
 7. At what location did most workers wear their badge (shirt pocket, waist, collar)?
- C. Other External Monitoring Techniques
1. Were pocket ionization chambers used? If yes, describe the type of chambers, procedure, quality assurance program, testing, and give overall estimate of accuracy and precision of results if possible.
 2. Were other external personnel monitors such as NTA neutron film, activators, glass, or chemical dosimeters used? If yes, describe system as in part C-1 above.
 3. Were area monitoring devices used? If yes, describe devices, etc., as in C-1 and explain how data were used in personnel monitoring program.
- D. Administration and Recordkeeping
1. What units were used in reporting results? Describe any conversion calculations.
 2. Were quality factors (QF) or other modifying factors used to evaluate dose equivalent? If yes, describe procedure and QF's used, etc.

3. How were unusually high or low readings handled for determining if they were true readings or artifacts?
4. How were lost or obviously damaged dosimeters compensated for in dosimetry records of an individual worker?
5. Was there any compensation for natural background?
6. Are records known to be complete or are there known to be periods of lost data or records?
7. How were lost or unobtainable past personnel monitoring records compensated for in your record system?
8. Are monitoring data computerized? If yes, describe format of computer records. If no, describe or provide a copy of the form on which monitoring data are recorded.
9. What length of monitoring period(s) was used?
10. Are quarterly or yearly summaries available?

III. Internal Monitoring Data

A. Bioassay Program

1. What types of bioassays were used (urinalysis, fecal, breath, etc.)?
2. What were the criteria for requiring bioassays?
3. How was the frequency of bioassays determined?
4. What radionuclides were analyzed for each method of bioassay analysis?
5. Are there procedure manuals available? If not, the following information is needed about each different method.
 - a. Description of method of analysis.
 - b. Units and description of any calculations or conversions used in obtaining final answers in dose or dose equivalent.
 - c. Procedure for calibration of counting equipment.
 - d. NBS traceability.
 - e. Estimated accuracy and precision of measurement technique; and limits of detection.

B. Whole-Body Counting

1. Was whole-body counting (WBC) used?
2. What were the criteria for requiring a whole-body count?
3. Was WBC done in house or by a commercial company? If done by others, identify company and if possible, the person responsible for measurements.
4. If in house WBC, describe counter, limits of detection, calibration procedure, calibration traceability to NBS, estimated accuracy and precision of measurement.
5. What calculations or modifications were done to counting data to determine radionuclide content of worker?
6. Were any conversions to dose or dose equivalent done? If yes, describe procedure used for conversion.

C. Other internal Monitoring Techniques

1. Were air monitoring results used to estimate internal deposition? If yes, describe the equipment, usage procedures, calibration, and the method of interpreting measurements. Give results of accuracy or precision of monitoring, if available.
2. Were any other monitoring methods used to estimate internal deposition other than bioassay, whole-body counting or air monitoring? If yes, describe in detail as outlined in Part 1 above.

D. Administration and Recordkeeping

1. Are internal monitoring reports computerized? If yes, what is the format of the data? If no, what information is available, and are there quarterly or yearly summaries?
2. How were unusually high or low values validated?
3. If artifacts were discovered, how was individual worker's record corrected?
4. What procedure was used to merge internal and external dosimetry data?

Please make any other comments that you think are needed for a better understanding of the personnel monitoring programs at your facility.

References

- (1) Strom, D.J., "A Strategy for Assessing Radiation Dose Data from Many Sites for Use in Epidemiologic Studies", Doctoral Dissertation, Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina at Chapel Hill, in preparation.
- (2) Dreyer, N.A., Kohn, H.I., Clapp, R.W., Covino, Jr., S.J., Fahey, F.H., Friedlander, E.R., and Loughlin, J.E. The Feasibility of Epidemiologic Investigations of the Health Effects of Low Level Ionizing Radiation, Final Report, NUREG/CR-1728, National Technical Information Service, Springfield, Virginia 22151, 1980.
- (3) Fix, J.J., Selby, J.M., and Vallario, E.J. "Current Personnel Dosimetry Practices at DOE Facilities", PNL-3538, UC-41, Battelle Pacific Northwest Laboratory, Richland, Washington 99352, 1981.
- (4) United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and Effects of Ionizing Radiation", United Nations, New York, 1977.

Acknowledgements

This report concerns work undertaken as part of the Health and Mortality Study of Department of Energy workers being conducted by Oak Ridge Associated Universities with the collaboration of the School of Public Health, University of North Carolina at Chapel Hill under Contract No. DE-AC05-76OR00033 between the Department of Energy, Office of Energy Research and Oak Ridge Associated Universities.

Rec'd 7/7/83

CONF-830101

Distribution Category UC-41

EPIDEMIOLOGY APPLIED TO HEALTH PHYSICS

Proceedings
of the
Sixteenth Midyear Topical Meeting
of the
HEALTH PHYSICS SOCIETY

Albuquerque, New Mexico

January 9-13, 1983

Co-sponsored by

INHALATION TOXICOLOGY RESEARCH INSTITUTE
LOS ALAMOS NATIONAL LABORATORY
SANDIA NATIONAL LABORATORIES
U. S. DEPARTMENT OF ENERGY

Hosted by the

RIO GRANDE CHAPTER
of the
HEALTH PHYSICS SOCIETY

ON THE COVER:

The refreshingly high city of Albuquerque, New Mexico, stretches from the romantic Rio Grande to the cool Sandia Mountains. Set in the mountain sky is a Zia sun symbol, the state insignia. Originally found on a piece of pottery from the pre-Spanish Indian pueblo of Tsia, the entire symbol represents friendship, and the groups of rays represent the four directions of the compass, the four winds, the four seasons and the four stages of life. Artwork by Emerson Goff.

NOTICE: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government, any agency thereof or any of their contractors or subcontractors. The views and opinions expressed herein do not necessarily state or reflect those of the United States Government, any agency thereof or any of their contractors or subcontractors.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

NTIS price codes
Printed copy: A24
Microfiche copy: A01