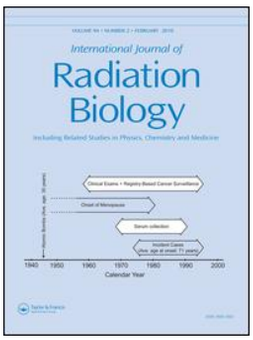

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REVIEW

50 Years of the Radiation Exposure Information and Reporting System

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ABSTRACT

Purpose: As the Radiation Exposure Information and Reporting System (REIRS) celebrates 50 years of existence, this is an appropriate time to reflect on the innovative and novel system and how it has shaped the study of occupational radiation exposure. It is also fitting to appreciate the vision and initiative of the individuals who recognized the future value of the collection and analysis of this information to better inform regulations, policies, and epidemiologic studies, and thus contribute to the protection of workers and the public from the adverse health effects of radiation exposure.

Conclusions: REIRS has evolved and expanded over its 50-year history and has played a central role in providing the radiation exposure monitoring records for the Million Person Study for individuals monitored as NRC licensees and at DOE facilities. REIRS has played two major functions in epidemiologic studies. First, it has provided dosimetry information on individual workers in occupational studies to ensure nearly complete ascertainment of career doses. Second, REIRS was used as the primary data source for large cohorts within the Million Person Study: nuclear power plant workers (n∼140,000) and industrial radiographers (n∼130,000). The legacy that REIRS continues to uphold is a model for creating and maintaining a successful tool throughout decades of political, technological, and demographic change.

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Introduction

In 1968, the U.S. Atomic Energy Commission (AEC) required the reporting of an annual summary regarding occupational radiation exposure information in a central repository. This was the catalyst for the creation of the Radiation Exposure Information and Reporting System (REIRS), which has become the gold standard in occupational radiation dose collection and reporting (REIRS 2018).

Over the past 50 years, REIRS has proven to be a reliable, continuously improving, and evolving system for the management and regulatory oversight of radiation exposure monitoring records and has contributed to numerous epidemiologic studies (Cardis et al. 2005; Schubauer-Berigan et al. 2015; Boice et al. 2019a). As REIRS celebrates 50 years of existence, this seems an appropriate time to reflect on the innovative and novel system and how it has shaped the collection and evaluation of occupational radiation exposure. It is also fitting to appreciate the vision and initiative of the individuals who recognized the future value of the collection and analysis of this information to better inform regulations, policies, and studies in order to protect workers and the public from the potential adverse health effects of radiation exposure.

Overview and history

In November 1968, the AEC amended 10 CFR Part 20 to require the reporting of a statistical summary of occupational radiation exposure information, thus creating REIRS. The records were submitted on paper and manually entered into the database, with a few facilities experimenting with reporting electronically on magnetic tapes as a pilot project. REIRS was initially located at the Oak Ridge National Laboratory (ORNL).

In January 1975, the AEC was separated into two agencies, the Energy Research and Development Administration (ERDA) and the U.S. Nuclear Regulatory Commission (NRC). Each agency assumed responsibility for collecting and maintaining occupational radiation exposure information reported by the facilities under its jurisdiction. A further federal reorganization in 1977 replaced ERDA with the Department of Energy (DOE).

Subsequently, the REIRS database was split into two systems, one located at the Oak Ridge K-25 facility containing the monitoring records for NRC licensees, and one located at the Idaho National Laboratory containing the monitoring records for DOE facilities. The basic systems and functional requirements did not change significantly during this period

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while advancements in database management software were advancing rapidly. The systems continued to provide information to the NRC and DOE for the compilation of annual reports on occupational exposure; however, the annual publications began falling behind schedule with the maintenance and operation of the systems insufficient to keep up with the increasing number of records and information requests.

NRC staff changed the technical specifications for operating nuclear power plants (NPPs) and required them to submit an annual report that indicated number of individuals exposed and the cumulative doses broken down by personnel, work function, and occupation in accordance with NRC Regulatory Guide 1.16 (AEC 1975). On 4 February 1974, 10 CFR Part 20.407 was amended, requiring licensed NPPs to submit an annual statistical report indicating the distribution of the whole-body doses of all individuals monitored at each facility, allowing an estimate to be made of the total collective dose, and of the number of workers receiving measurable doses (NCRP 2018).

Originally, REIRS only collected information on four types of licensees. However, in 1982–1983, 10 CFR 20.408(a) was amended to include three additional categories of licensees required to submit reports: geological repositories for high-level radioactive waste; independent spent fuel storage installations; and facilities for the land disposal of low-level radioactive waste.

In 1990, the NRC transferred the operation and management of REIRS to a company under contract to the NRC to modernize the system into a relational database management system. The system underwent a complete overhaul including the processes for collecting and entering data into the system and the annual reports. A website (which was a brand-new thing in those days) was created to exchange information on the collection and analysis of occupational exposure, as well as relevant regulations and guidance.

Although DOE had been maintaining a parallel system since the 1975 division, the two agencies (DOE and NRC) signed an interagency agreement in 1994–1996, which resulted in a new DOE system that benefited from the experience of the NRC called the Radiation Exposure Monitoring System or REMS. This agreement also established the share and transfer of technology used by NRC to support DOE programs, including REMS, and assisted in the development of a new DOE annual report of exposure. In some ways, after nearly 20 years had passed, the two systems had a sort of homecoming.

Utility of the system

Because of the volume and type of data contained in REIRS, it has become a key resource to any major study regarding human health related to occupational radiation exposure (NCRP 2018; Boice et al. 2019a). The demographic and dosimetric data in REIRS makes it not only a unique resource, but also an extremely valuable one for use by occupational health and safety professionals and regulators. REIRS data has applications in estimating exposure, as well as evaluating the data with health outcomes for epidemiological studies, and evaluating the relationship used to assess dose-response relationships. It also can be used to evaluate the impact on changes in regulation to occupational exposure and the distribution of radiation dose across the worker population (Anzenberg et al. 2010). In this sense, REIRS has the power to be used as a tool for guiding regulatory frameworks regarding radiation protection.

Other countries have similar databases that function as registries, and many of them have been used for health studies (Lee et al. 2010; Hill 2014; Mayer et al. 2016; Lim 2017; GOC 2018). REIRS is the closest dataset to a U.S. occupational radiation exposure registry in existence, particularly for NPP workers. Initially, NRC licensees were only required to submit radiation-monitoring records upon termination of employment; however, in 1994, as part of the implementation of the 1991 revisions of 10 CFR Part 20 (NRC et al. 1991; NRC 1992), the NRC began requiring annual radiation exposure records for every monitored worker. In addition, NRC Generic Letter 94-04 (NRC 1994) requested that licensed utilities report voluntarily the career doses of current employees for input into the REIRS system. Utilities responded favourably to this request. In the mid-1990s, Dr. John Boice, Branch Chief of the Radiation Epidemiology Branch of the National Cancer Institute (NCI) and his colleague, Dr. Gilbert Beebe, sent a letter to the NRC via the Director of the NCI requesting a change in reporting requirements and the addition of data fields to REIRS in order to create a better foundation for what could become a radiation exposure registry suitable for epidemiologic study (NRC et al. 1991, 1994; Muirhead et al. 1996; Boice 2015; Boice et al. 2019a). The NRC revisited the idea of using REIRS as a radiation work registry in 2011 (ORISE 2011).

The relevance and utility of REIRS has been shown time-and-time again as evidenced by its use in several studies and proposed studies. REIRS has played a supporting role in occupational health studies, including the International Agency for Research on Cancer (IARC) "15-country" study (Cardis et al. 2005) and in U.S. nuclear worker studies (Howe et al. 2004; Schubauer-Berigan et al. 2015). In 2001, the U.S. Department of Labor implemented a compensation program for former DOE workers who may have developed certain types of cancer from their time working at DOE facilities post-World War II. The Energy Employees Occupational Illness Compensation Program Act (EEOICPA) (Neton 2014) provides monetary and healthcare resources to certain individuals and utilizes data from REMS and REIRS.

One of the most important uses of REIRS data is its support of the Million Person Study of Low-Dose Health Effects (MPS), which is one of the largest of its kind (Boice 2015, 2017; NCRP 2018; Boice et al. 2018, 2019a). Over the years, REIRS has provided additional dose information for workers in the MPS to assure that nearly complete career doses are available for analysis. These cohorts include Rocketdyne (Boice et al. 2006a, 2006b, 2011), Mound (Boice et al. 2014), nuclear weapons test participants (Caldwell et al. 2016) and Mallinckrodt (Ellis et al. 2018; Golden et al. 2019). Further,

the REIRS database was used for the first time as the primary source of two large cohorts in the MPS: the study of nuclear power plant workers (NCRP 2018; Boice et al. 2019b) and the study of industrial radiographers (NCRP 2018; Boice et al. 2019c). These two cohorts alone comprise about 270,000 workers or approximately 27% of the MPS study populations.

Information and data architectures

One of the most unique things about REIRS is that it began before the digital revolution and is still in existence. Therefore, the rapid change in technology not only forced the REIRS system to evolve, but REIRS became better because of technology. REIRS initially began as paper records transferred to tapes. In the late 1980s, these tapes were converted to an Oracle relational database. As the Internet evolved, so did the power of REIRS, and in May of 1995, the NRC began disseminating radiation exposure information on the Internet. This was one of the first websites the NRC initiated and maintained.

Although information was reported online in 1995, dose records were submitted on compact discs (CDs) until the Anthrax attacks of 2001. In response to the biological threat, all U.S. mail was irradiated prior to delivery. While this killed anthrax spores, it ruined CDs, so data could no longer be submitted on electronic media. This led to the development of a web portal for the secure submittal of annual radiation exposure records. In 2006, DOE followed suit and issued a policy stating that the only acceptable method for submitting radiation exposure data was through web pages. The requirement for online submissions improved functionality, efficiency, and availability of records. Dose histories are now also requested online, saving time and reducing frustration from individuals and licensees. Responses to dose history reports, including NRC and DOE occupational exposure, are now provided within two days, with the vast majority of responses being the same day or the next business day. The process ensures the necessary protections under the Privacy Act of 1974 and related cyber-security requirements for personally identifiable information.

Summary

It is challenging for a program to survive 1 year, let alone 50. The legacy that REIRS continues to uphold is a model for creating and maintaining a successful tool throughout decades of political, technological, and demographic change. REIRS continues to be on the forefront in supporting epidemiologic studies of health effects, most importantly the ongoing Million Person Study of Low-Dose Health Effects.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Derek A. Hagemeyer is the Associate Director for Human Health & Environment at Oak Ridge Associated Universities. He is responsible for program operations associated with human subject health and protection surveillance as well as the independent environmental assessment and verification under the DOE Oak Ridge Institute for Science and Education (ORISE). He serves as the principal investigator for the DOE Radiation Exposure Monitoring System (REMS) and the U.S. Nuclear Regulatory Commission (NRC) Radiation Exposure Information and Reporting System (REIRS) projects. He is currently serving as Vice Chairman of the international Information System on Occupational Exposure (ISOE) Working Group on Data Analysis (WGDA) to provide support in the collection and analysis of ISOE's international database of radiation exposure information. ISOE is jointly sponsored by the Organisation for Economic Co-operation and Development (OECD) and the International Atomic Energy Agency (IAEA).

Gregory P. Nichols is the President of GP Nichols & Company, LLC. He has nearly 20 years of experience spanning clinical laboratory medicine, emergency medical care, and occupational/environmental health research. He has supported projects for a variety of government agencies including the Department of Energy and the Nuclear Regulatory Commission.

Terry A. Brock is the current NRC project manager for the Analysis of Cancer Risk in Populations near Nuclear Facilities study, the Radiation Exposure Information and Reporting System, and the agency's participation in the One Million U.S. Radiation Workers and Veterans health study. He has also served as the project manager for the State-of-the-Art Reactor Consequence Analyses study and on the Risk Task Group that explored risk-informing the radioactive materials arena.

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