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Where are the Radiation Professionals (WARP)?

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Since the discovery of x rays and radioactivity in the 1890s, sources of ionizing radiation have been employed in medicine, academia, industry, power generation, and national defense. To provide for the safe and beneficial use of these sources of radiation, the United States developed a cadre of professionals with the requisite education and experience. Unfortunately, their numbers have diminished alarmingly (AAAS, 2014; GAO, 2014; HPS, 2013; NA/NRC, 2012).

Methods

To study the decline in radiation professionals and potential national crisis, the National Council on Radiation Protection and Measurements (NCRP) sponsored a workshop in June 2013 in Arlington, Virginia to evaluate whether a sufficient number of radiation professionals exist now and into the future to support the various radiation disciplines essential to meet national needs. Attendance at this workshop included professionals from government, industry, academia, medicine, and professional societies. Presentations from over 30 groups (NCRP, 2013) resulted in the recommendations found in this Statement.

Findings

Evidence presented at the workshop revealed that the country is on the verge of a severe shortfall of radiation professionals such that urgent national needs will not be met. Factors contributing to the downturn include the economy, attrition, redirected national priorities, and decreased public funding. The magnitude of this shortfall varies with radiation disciplines and practice area. Radiation biology has already been critically depleted and other specialties are following the same downward spiral. All radiation professionals share the same goals to develop or implement scientific knowledge to protect workers, members of the public, and the environment from harmful effects of exposure to ionizing radiation. Accordingly, the workshop concluded that the current and projected shortfall will adversely affect the public health, radiation occupations, emergency preparedness, and the environment. Major shortfalls have already been observed in day-to-day operations, leaving policy development, regulatory compliance, research and development, environmental monitoring, emergency management, and military applications as unfunded and under-supported mandates.

The dwindling number of professionals will be of particular concern in mounting a response to a catastrophic nuclear or radiological incident, including terrorist attacks. The current concept of operations for response includes surge support from the existing body of radiation professionals to serve as technical subject matter experts to aid in the management of the consequences of such an event. However, as the number of radiation professionals decreases, the nation's resilience and ability to cope and manage a catastrophic nuclear or radiological event is severely degraded.

Deficit of Professionals

Federal, state and local governments employ radiation professionals in broad and diverse areas such as policy development, regulatory compliance, research and development, environmental monitoring and restoration, waste management, emergency preparedness and response, nuclear medicine, radiation therapy, diagnostic radiology, and nuclear forensics.

The U.S. Government Accountability Office (GAO, 2014) estimates that 31 % of the federal workforce will be eligible to retire by September 2017, and the percentage of engineering and technical professionals eligible to retire by September 2017 is even higher at 41 %. Similarly, a survey of the Conference of Radiation Control Program Directors (directors of state agencies that regulate the use of radioactive materials and radiation-producing devices within their states) predicted that over 50 % of the technical staff in the states' radiation control programs will need to be replaced in the next 10 y.

The National Academy of Sciences has expressed concern about the future supply of radiochemists (NA/NRC, 2012). The projected shortfall of skilled technical expertise within government will result in an inability to support day-to-day operations and will have a significant adverse effect on the ability to manage the consequences of a catastrophic nuclear detonation or nuclear power plant accident in the United States. The basic radiation sciences and their real world applications are part of a vast enterprise that directly and materially benefits the

U.S. population. This enterprise must be strategically managed to prevent atrophy of U.S. expertise and loss of world leadership in radiation sciences to Europe and East Asia.

Numerous professional societies represented at the workshop conclude that the current workforce demographics and expected retirements are such that the demand for replacement radiation professionals will substantially increase from 2015 to 2025 (Appendix A; NCRP, 2013).

Within the private sector (*e.g.*, nuclear power, uranium production, consulting services), adequate numbers of some but not all skilled workers are available in the short term (5 to 10 y). However, in the longer term (10 to 20 y), experienced workers will be retiring, and insufficient replacements are projected to be available. Consequently, even outsourcing of traditional government work to the private sector, especially in large-scale incident response and remediation will unlikely be a viable option to cope with the numerous retirements of government workers.

Only two areas appear to have adequate personnel in the short term: medical physics and nuclear power. In medical physics, where radiation and the practice of medicine intersect, there appears to be no current or anticipated deficit, despite the tremendous growth of the use of ionizing radiation in medicine (NCRP, 2009). Unlike most areas where radiation professionals work, the demand is highly visible and the salaries for practice are attractive. In nuclear power, some utilities have begun educational programs in cooperation with local colleges to "grow their own" future staff. Further, military retirees, especially from the nuclear Navy, frequently transition from shipboard to civilian nuclear power operations. Nonetheless a surge of retiring employees, combined with a waning interest in the field by young professionals and a deficit of training programs in general, have contributed to the industry's growing skills gap in the United States and in other countries.

Figures 1 and 2 demonstrate the long-term trends in the declining numbers of students enrolled in academic health physics programs (ORISE, 2015) and the declining number of members in the U.S. Health Physics Society.[1]

Deficit of Funding

Federal funding of student scholarships and postgraduate fellow programs have been disappearing. There are only 22 U.S. academic programs with students and staff involved with health physics education, including 12 small programs that graduate fewer than six students per year (ORISE, 2015). Only 12 U.S. programs have sufficient faculty and staff to train future students at B.S., M.S., and Ph.D. levels. Loss of research funding has decimated the ranks of university radiation biologists and other professionals (i.e., the professors needed to teach the next generation of radiation professionals).

The Biomedical Advanced Development and Research Authority (BARDA), the National Institute of Allergy and Infection Diseases, and the National Cancer Institute (all parts of the U.S. Department of Health and Human Services) sponsor research in radiological counter-measures, radiation oncology, and radiation epidemiology. The U.S. Department of Energy's (DOE) National Nuclear Security Administration established the Stewardship Science Academic Alliances Program in 2002, to fund academic research in the areas of materials under extreme conditions, low energy nuclear science, radiochemistry, and high energy density

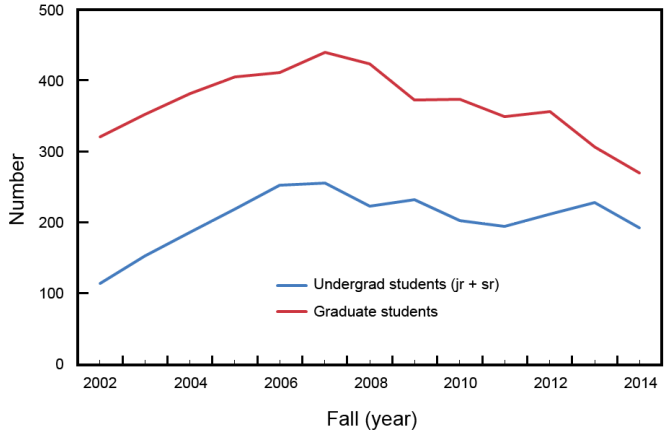

Fig. 1. Health physics enrollment trends, Fall 2002 to Fall 2014 (ORISE, 2015).

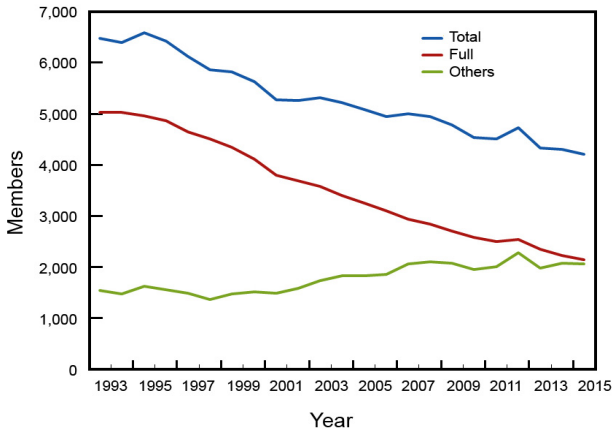

Fig. 2. Membership of the U.S. Health Physics Society, 1993 to 2015.

[1]Health Physics Society (2015). HPS Secretariat (McLean, Virginia).

physics. One of the goals of the program is to provide hands-on training and experience to students who will be the next generation of scientists and physicists in the areas of interest and potentially be employed at one of our national laboratories (NNSA, 2015). However, these highly focused programs alone cannot support the required faculty and students needed to replace retiring radiation professionals.

Total current federal funding of the radiation sciences (including salaries, grants, contracts) is estimated to be approximately $50 billion annually, including U.S. Nuclear Regulatory Commission training programs, the DOE low-dose radiation research program (before funding was significantly reduced last year), the Centers for Disease Control and Prevention Radiation Studies Branch, the NIOSH Division of Compensation Analysis and Support, the Armed Forces Radiobiology Research Institute, the National Cancer Institute Radiation Epidemiology Branch, and the National Nuclear Security Agency Office of Emergency Operations. NCRP considers it reasonable to provide funding to ensure a continued supply of radiation professionals for these and other programs at a level approaching 10 % of the annual operating costs (*i.e.*, $5 billion annually), judiciously spread across education, training, research, professional development, career management, and development of surge capacity to meet emergency response requirements.

Recommendations

Courses of action to preclude and mitigate the disastrous outcome of not having sufficient radiation professionals to handle the current and future needs of the nation include:

- **Education:** The federal government considers science, technology, engineering and mathematics (STEM) education programs in kindergarten through twelfth grade as vital to the future economic development of the United States (NA/NRC, 2011). Recently the administration published a *Federal STEM Education 5-year Strategic Plan*, with FY15 funding of almost $500 million requested. Support for education of radiation professionals should be considered equally as vital to the health and safety of the United States. University programs must be enlarged and adequately funded to build on STEM learning experiences. The opportunities for higher education in radiation science have been particularly threatened by double-digit budget cuts and higher tuition costs, both of which contribute to decreasing enrollment. Reduced faculty support affects basic research as well as the ability to educate the next generations of radiation professionals. As an example, DOE funds for low-dose radiation research have all but vanished; this hampers acquisition of fundamental knowledge for basic understanding of risk to human populations from low radiation doses needed for radiation protection and for risk management.
- **Research:** Research funding is a necessary condition for education in the radiological sciences. It supports student activities and the faculty who will teach the next generation of students. Without external research support, colleges and universities cannot maintain academic programs in the radiological sciences. Consequently research funding needs to be restored and in fact increased to answer the crucial questions that affect aspects of government operations and policy (*e.g.*, what are the health effects of low-dose radiation exposures comparable to those routinely received from medical procedures, environmental circumstances and occupational endeavors?). The House Committee on Science, Space, and Technology approved the Frontiers in Innovation, Research, Science and Technology (FIRST) Act to prioritize federal investments at the National Science Foundation and the National Institute of Standards and Technology by funding research and development to address national needs (HR, 2014). Maintaining an adequate and well-trained cadre of radiation professionals is one of those needs, as is determining the actual health effects, and magnitude, of low-dose radiation exposures. The importance of public support for radiation research is highlighted in the *Low-Dose Radiation Research Act of 2015* which was passed by the U.S. House of Representatives and awaits approval by the U.S. Senate (HR, 2015).
- **Training:** To provide a significant and guaranteed supply of replacements for radiation professionals lost to retirement, jobs with more opportunities, and death, new graduates will require months to years of practical, hands-on experience to replace senior professionals. Consequently support must be provided not only for formal academic education, but also for internships, practicums, post-doctoral positions, and similar post-graduate training programs. Such developmental positions at national laboratories and with federal agencies should be funded and guaranteed for the long-term, so that prospective employees can expect career stability. In addition, training grants should be made available to develop a surge capacity of radiation professionals in emergency response to augment the small number of federal and state radiological staff in the case of a potential large radiation emergency involving mass casualties. Competing for emergency response funds has been difficult because of the assumed low probability of such an event. While such events might be low probability, they are of high consequence, and the country cannot afford to be unprepared. Not only are more radiation professionals

required for day-to-day activities, but their expertise needs to be leveraged efficiently to train all other responders (*e.g.*, medical, security) about managing such incidents.

- **Joint Program Support Office (JPSO):** The federal government should create a (radiation) JPSO to more efficiently manage radiation professionals in the civil service. The JPSO would: centralize and provide better visibility for the function of radiation professionals; monitor federal staffing levels and needs; enhance mechanisms for interagency collaboration; diminish cross-organizational stovepipes; and centralize recruiting and development of future radiation professionals.
- **Continued monitoring and advocacy:** The status of the availability of radiation professionals, training programs, graduation rates, research opportunities, career opportunities, and professional development obviously needs continued monitoring and follow-up. Consequently, NCRP has established Council Committee 2 specifically to carry out this role and provide advice on this radiation issue to the federal government, consistent with NCRP's Congressional Charter.

Conclusion

The looming shortage of radiation professionals represents a serious threat to the United States: scientific leadership is being lost, competition in world markets is affected, and protection of our citizens and country diminished. NCRP advocates a sequence of activities in the areas of education, training, research, and personnel management to address this urgent national need:

- Restore significant federal and state funding for scholarships, fellowships, and faculty research to increase and sustain a credible workforce of radiation professionals.
- Reinvigorate partnerships among universities, government, and the private sector to ensure undergraduate and graduate programs are adequately resourced to support the training and qualification of radiation professionals, including those who will educate the next generation.
- Establish a Joint Program Support Office (JPSO) for radiation professionals in the federal civil service to manage utilization and career development of personnel more effectively.
- Monitor trends in the supply of and demand for radiation professionals.
- Establish basic and advanced competency profiles to serve as guidance upon which to base the education, training, qualification and appropriate use of radiation professionals.

Public health, radiation safety, emergency preparedness, and the environment are all at risk. The clarion call to act is now!

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