MILITARY MEDICINE, 182, 9/10:1677, 2017

Military Global Health Engagement and Low-Dose Ionizing Radiation

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U.S. Military Global Health Engagement is evolving toward more specifically military strategic objectives, as well as better coordination with U.S. diplomacy and international development.[1] The Department of Defense (DoD) issued policy guidance on global health engagement codifying these priorities for the first time in 2013, and is now developing the corresponding implementing instructions and a Joint Concept of Operations.[2] As concepts gel, the time is ripe for new ideas that can help round out military global health engagement's emerging triple aim of force health protection, partnership building, and threat reduction, and situate these activities effectively within Whole of Government global health efforts. One novel line of effort that is particularly well aligned and currently under-resourced is cooperative military engagement on the scientific problems of low-dose radiation health effects.

"Low dose" in the military context means ionizing radiation exposure in the dose range where there is no immediate performance decrement, but there is exposure-related risk of long-term health consequences. In numerical terms as defined by Joint Publication 3-11 (Operations in Chemical, Biological, Radiological, and Nuclear Environments), this range extends from a projected mission cumulative radiation dose of 0.5 milliGray (mGy), where focused monitoring begins, through 50 and 100 mGy as nonpriority tasks are progressively curtailed, to 250 mGy where monitoring for acute radiation effects begins. For comparison, annual cumulative exposure in the U.S. averages about 3 milliSievert (mSv), and the annual U.S. occupational dose limit for radiation workers is 50 mSv.[i] Peacetime radiation protection decisions are driven toward the low end of the occupationally allowable range by the fundamental strategy of keeping exposures As Low As Reasonably Achievable (ALARA), which is also explicitly adopted as overarching DoD policy in Joint Publication 3-11.

During Operation Tomodachi, USPACOM took a conservative approach to ALARA, limiting individual cumulative radiation exposure to the equivalent of 3 mGy. Radiation avoidance measures necessary to meet this target included mission-impacting constraints such as deferred maintenance to reduce crew exposures and increased ship standoff distances.[3] After-action analyses identified lack of consistent guidelines to translate detectable radionuclide levels to protective actions, and widespread lack of preparation to implement ALARA decision-making within an evolving emergency.[4] U.S. authorities set the evacuation zone in Japan at 80 km for U.S. nationals, conflicting with the Japanese government's 20 to 30 km zones despite the challenges for public trust and risk communication that this discrepancy created. Other nations' advice to their nationals was in some cases even more unilaterally conservative, including sheltering in place out to 250 km.[5]

Underlying these challenges is persisting scientific uncertainty about low-dose radiation effects, stemming from biological complexities that are only now becoming possible to address. For example, the study of radiation cancer risks has been limited because cancer arises also in people who have not received excess radiation. Epidemiologic studies of excess risk from radiation have therefore relied on population-level statistics to separate the "signal" of radiation-attributable cancers from the "noise" of biologically indistinguishable cancers occurring through a variety of other pathways. Progressively higher statistical power is needed for epidemiologic study of lower exposures. Thus, it has been estimated

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The opinions expressed are those of the authors and are not the opinions of the Armed Forces Radiobiology Research Institute, Uniformed Services University of the Health Sciences, Department of Defense, or the U.S. Government.

doi: 10.7205/MILMED-D-17-00142

[i] The Gray is a unit of absorbed dose, while the Sievert is a unit of effective dose in a living system. One Sievert is defined as that effective dose produced by one Gray of absorbed dose of x-rays or gamma rays; higher Sievert values are associated with one Gray of neutrons, alpha particles, or other higher energy-transfer radiation. In practice, DoD guidance uses Gray because field-deployed measurement technology may not include Sievert readouts.

that measuring the increased risk due to a 20 mGy exposure would require lifetime follow-up of roughly a million people.[6] However, within a defined population with a specific overall dose response rate, there are subpopulations and individuals with higher and lower risks.[7] Methodological advances such as genetic sequencing, gene expression profiling, bioinformatics, and single-cell irradiation are enabling new experimental and epidemiologic strategies that promise better ways of individualizing risk assessment and follow-up, as well as potentially leading to risk-modifying countermeasures.

Such scientific advances could provide commanders with nuanced alternatives to blanket avoidance when faced with operations in a contaminated environment. Readiness for operations in contaminated environments is important for DoD, not only for the worst-case scenario of an improvised or hostile state nuclear detonation and its aftermath, but for a broad range of radiological release scenarios. Particularly, overseas, as in Fukushima, DoD assets may be the first and largest component of U.S. Government assistance to a crisis of this kind. Such advances are also highly relevant in the global health community, as they relate both to international cooperation for emergency response and to lasting public health consequences for large numbers of people. National responsibilities for detection and response to radiological or nuclear hazards/events/emergencies are established within the framework of the 2006 International Health Regulations (IHR), and queried in the Joint External Evaluation (JEE) process by which nations assess their IHR compliance. Emergencies of this type can displace and negatively impact health for hundreds of thousands of people, due to decisions and concerns in the low-dose range.

For example, in the Fukushima disaster, about 150,000 residents were evacuated and another 20,000 relocated on their own. Radiation exposures from the disaster were low across the population: there were no cases of acute radiation injury even among emergency response personnel, and among the general population, there are only 14 people believed to have received more than 15 mGy, whereas 99.8% were under 5 mGy and the average additional exposure for all enrollees over the 4 months following the disaster was less than 1 mGy.[8] At the population level, these doses are too low to represent a measurably increased health risk. However, radiation stigma and distress among displaced persons remain substantial, and medical follow-up has provoked ethical debate.[9]

These challenges to public health following a radiological release may be exacerbated in poor, vulnerable, or underserved populations, and may also relate to efforts to establish nuclear power or nuclear fuel management. Of the 44 nations identified by the World Nuclear Association as having current or envisioned nuclear power generating capacity, 15 are at or below the $9,500 GNI threshold established by DoD as a first-level appropriateness screen for global health engagement.[2] Of these 15, 10 have also joined the Global Health Security Agenda (GHSA), a multilateral partnership supported by the United States and advised by the World Health Organization and other partners in the international health security enterprise. GHSA activities are focused on infectious disease threats, but since they use the JEE methodology for assessment of compliance with the IHR, they also engage radiological and nuclear emergency readiness, and available JEE reports indicate near-universal self-assessed room for improvement. The current GHSA countries include 5 of the 6 low-resource countries worldwide, which have no current nuclear power capability, but do have reactors in the planning or proposal stage: Bangladesh, Indonesia, Jordan, Thailand, and Vietnam.

Until recently, the U.S. Department of Energy's (DOE) Office of Science had taken the lead in low-dose radiation research. Aiming to leverage technical advances to improve the scientific basis of low-dose regulatory policy, the office began funding a Low Dose Radiation Research Program in 1999 at an initial level of more than $20M per year. Funding progressively dropped as priorities shifted, and the program closed out in fiscal year 2016. However, an expert review convened by DOE in 2015 identified a number of feasible and promising low-dose research directions going forward, such as molecular markers of the onset of carcinogenesis at low doses, molecular markers of radiation etiology in cancers, and drugs that interact with low-dose repair mechanisms and that could potentially lead to countermeasures. The panel also noted the relevance of low-dose research to other Federal agencies, including DoD.[10]

This nexus of scientific opportunity, military operational relevance, and global health significance suggests a role for DoD global health engagement in low-dose radiation science. The winding down of the DOE program, and the consequent Federal-wide under-resourcing of low-dose research, makes it timely. Programming could take the form initially of scientific conferences and exchange of experts, but should progress to competitive funding for international collaborative research in low-dose radiobiology, systems biology, and epidemiology, addressing a research agenda reflecting the mutual interests of DoD and the host nation contingency response authorities, both military and civilian, in better characterizing low-dose risks. Human capacity building of the host nation scientific workforce could be augmented by training agreements bringing outstanding candidates from the host country to the United States for advanced training before returning to sustain long-term projects. U.S. investment provided by, or catalyzed by, DoD could also include radiation laboratories or other infrastructure development in the host country that would support research and provide solid technical capabilities in radiation environmental survey and biological assay toward effective contingency response. Collaborative engagement of this type by DoD would also support State Department initiatives in science diplomacy, by providing an ongoing demonstration of productive links between science, policy, and preparedness, and between the military and national civilian authorities. In summary, better characterizing low-dose radiation effects through collaborative scientific engagement overseas appears to be an excellent fit for DoD's emerging paradigm of operationally focused, federally integrated military global health engagement.

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