EDITORIAL

Nuclear Preparedness

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It is with great pleasure and careful consideration that we present this special issue focused on addressing the medical and public health response to a nuclear detonation.

One of our aspirations in presenting this special issue is to counteract the all-too-prevalent notion that there is little utility in planning for a nuclear detonation because the event is so terrible that "there is nothing you can do." Such attitudes reflect perceptions of nuclear annihilation that are a legacy of the Cold War and the strategic posture of "mutually assured destruction," when the scenario of nuclear exchange entailed the detonation of thousands of warheads. This is not the scenario we face today. To quote President Obama from remarks made at the Nuclear Security Summit in April 2010, "Two decades after the end of the Cold War, we face a cruel irony of history—the risk of a nuclear confrontation between nations has gone down, but the risk of nuclear attack has gone up." What we also objectively know, thanks to survey efforts from Sharon Watkins and colleagues from the Council of State and Territorial Epidemiologists, is that 45% of states do not have a radiation plan, and for other measures (planning, resources, partnerships) as many as 85% of states reported an insufficient capability to respond to a radiation incident. Guidance for state and local planners is paramount and we believe that this special issue (particularly in contributions such as the state and local "playbook" presented by Murrain-Hill et al) begins to address the need for such guidance in a practical manner.

Preparing for the contingency of a 10-kiloton nuclear detonation in an urban center is daunting to contemplate. The staggering nature of such an event notwithstanding, we as medical and public health providers have a duty to our communities to attempt to address the challenges posed, just as we have done for virulent pandemics, large-scale earthquakes, and other significant disasters with long-term consequences. This special issue tackles those challenges head on. It confronts them in an objective manner, using the best available science and evidence, and provides practical recommendations and guidance that create a rational framework for grappling with almost inconceivable events. This will in no way prevent the significant population impact on mortality and morbidity, but it will greatly enhance our ability to mitigate this impact so that we can realistically think from a population perspective of mutually assured survival.

At the core of this issue is the dilemma of scarcity, one that cuts across all large-scale disasters and public health emergencies: scarcity in medical and public health personnel, scarcity in health care facilities, and scarcity in medical therapeutics and countermeasures. The mismatch between medical resources and medical need in the first days after the detonation of a nuclear device in a US city would be severe. It was with this stark reality in mind that the Working Group on Management of Scarce Resources for a Nuclear Detonation began its work more than 2 years ago. The core of this issue is provided by a series of detailed articles prepared by this working group that address the manifold complexities of responding to the detonation of an improvised nuclear device. These articles specifically address the medical and public health response during the period in which the mismatch of resources and needs will be greatest (up to 4 days after detonation). This is also, of course, the period in which the rational allocation of resources can save the greatest number of lives.

The commentaries provided by Coleman et al and Knebel and colleagues introduce the series, provide an overview of its content, define terms, and lay out critical assumptions. Among the other articles in the series are a state-of-the-science review article (DiCarlo et al) on the acute medical consequences of a nuclear detonation that details acute radiation syndrome, combined injury, traumatic injury, and thermal burns, and a review of the health systems response (Hick et al) that examines the integration of the radiation triage, treatment, and transport sites and system. This article is complemented by Murrain-Hill and colleagues' local playbook, a practical how-to planning guide for local radiation planners. The examination of triage and treatment tools by Coleman et al, and the modeling article by Rocco Casagrande's group make the case for the importance of appropriate triage. Ethical, behavioral, mental health, and legal reviews by Caro et al, Dodgen et al, and Sherman, respectively, further describe the complexity and challenges of delivering appropriate care to traumatized victims in a setting that will be characterized by profound scarcity.

The working group articles by Coleman et al, Knebel et al, and Casagrande et al suggest that with appropriate triage and resource allocation, the number of lives saved after a nuclear detonation could be increased 3-fold. The specific strategy they propose entails prioritizing moderately injured ahead of severely injured patients and trauma patients without combined injury ahead of those with combined injury. Although the specific numbers of lives that can be saved may be debated, the message is clear: appropriate triage saves a large number of lives. Effective triage is to a certain extent dependent upon an accurate quantification of an individual's radiation exposure (through a process known as biodosimetry), and it is important to underscore that at this time, rapid biodosimetry devices do not exist. To offset this current capability gap, Coleman et al offer practical guidance in generating a potential estimate of radiation exposure by combining clinical diagnosis with geographic

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location and proximity to detonation. A critical point to note is that traumatic injury does not necessarily indicate that the individual has been exposed to radiation.

These core contributions are supplemented by articles that we hope will better contexualize this topic for the reader. As noted earlier, Watkins et al provide a detailed national assessment of the state of radiation preparedness around the country, and the findings, although sobering, provide an objective benchmark against which to measure progress going forward. The article by Tan et al provides a practical case study of the implementation of a radiation preparedness plan in Baltimore, Maryland. Finally, Meit et al provide an illuminating modeling analysis that details evacuation and population displacement of urban centers into the rural community and elucidates the medical needs and resources that will be required in those rural communities. It is our hope that follow-up studies in 1 to 2 years will reveal marked improvements in preparedness and that the articles published in this special issue contribute directly to this process.

This issue presents 2 modeling papers that warrant special comment. Planning for unique events would be almost impossible without the use of models, but models must be used and interpreted with care. As part of the Department of Health and Human Services' Scarce Resources Project, Casagrande et al developed a model of resource and time-based triage to explore the impact of various prioritization schemes for victims requiring surgery on overall outcomes under varying conditions of resource scarcity. This model builds on the time task treater files developed by the Department of Defense to predict the resource requirements at different echelons of care for combat-related injuries in victims coded according to the type and severity of injury. Working independently and without knowledge of the Scarce Resources Project, Meit et al used studies of historical evacuations, surveys of citizens' evacuation intentions in hypothetical disasters, and semistructured interviews with emergency preparedness experts to estimate evacuation flow out of the borough of Manhattan and surrounding counties after the detonation of an improvised nuclear device in New York City. These models represent thoughtful attempts to grapple with scenarios of mind-boggling complexity.

The authors of both studies are candid about the limitations of their models. These limitations derive from the complexity of the events the models seek to represent and uncertainties about parameter values included in each model. Given these limitations and uncertainties, readers should not misconstrue the results and findings presented. It is an old saw among modelers that all models are wrong, but some are useful. The practical question, as George E.P. Box noted, is how wrong do they have to be to not be useful? Models, like maps, are synthetic approximations of reality and by their nature, they leave out a great deal. The advantage of using models, particularly in circumstances such as those under consideration, where relevant empirical data are limited or nonexistent, is that they require their authors to make their assumptions explicit. Careful readers can then judge for themselves the ways in which a given model is actually useful. A good rule of thumb is that in the realm of public health preparedness, models typically provide insights rather than answers. They are better at illustrating dynamic processes than making quantitative predictions.

Also included in this issue is a concise but comprehensive review article on the long-term effects of exposure to atomic radiation, prepared by the scientific staff of the Radiation Effects Research Foundation in Hiroshima, Japan. This joint Japan-US research center and its predecessor organization, the Atomic Bomb Casualty Commission, have monitored the ongoing health consequences of exposure to the atomic bombs in Hiroshima and Nagasaki for more than 60 years, documenting an increased incidence among survivors of leukemia, solid tumors, and noncancer health effects such as cataract formation, thyroid disease and hyperparathyroidism, and cardiovascular disease.

Readers may be surprised to learn that fewer than 1000 excess deaths due to leukemia and solid tumors have been attributed to the atomic bombings. In interpreting this finding, it is important to remember that the bombings at Hiroshima and Nagasaki were air bursts as opposed to ground bursts. The devices were deliberately detonated at an altitude of several hundred meters above each city to maximize the blast and thermal effects of the bombs while minimizing the amount of fallout that resulted. Many immediate survivors who experienced high doses of radiation also received burns or other blast injuries and perished in the first days or weeks after the bombings. Consequently, the vast majority of long-term survivors sustained comparatively low doses of radiation (typically much less than 1 Gy, with an average of around 0.2 Gy). A ground burst in a contemporary US city would churn up huge quantities of neutron-activated soil and other debris, generating a large quantity of fallout, and would likely result in a large number of individuals receiving high but survivable doses of radiation. What is important in the Hiroshima and Nagasaki data are not the absolute number of cancer cases attributed to the atomic bombings, but the excess relative risk per Gray exposure. Among the *hibakusha* (the preferred Japanese term for survivors of the bombings), the proportion of leukemia deaths attributable to atomic bomb radiation reaches 86% in those exposed to doses >1 Gy, whereas the attributable proportion of solid tumor deaths reaches 48%. These are sobering numbers. It is hoped that the lasting effects of Hiroshima and Nagasaki provide a stark reminder of the importance of nuclear disarmament and the value of preparedness.

As in so many challenging issues, gaps remain at the local community level. Knebel et al discuss the benefits of adequate shielding as a means to protect individuals and save lives. Indeed, it is hoped that resilience can be further garnered through preevent education and communication that

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detail this benefit to our communities. It is a crucial piece of the preparedness equation that cannot be neglected by planners. In every major catastrophic event for which empirical and survey data have been collected, the majority of victim rescues have been carried out by citizen survivors as opposed to trained responders.[1] In a nuclear event, with probable ingress restrictions to a contaminated environment, it can only be assumed that the citizen responder will play an even more critical relief role—a role that can only be effectively played by an educated and trained public and, hence, a more resilient one.

We conclude by commending the authors of the working group for the comprehensive analysis they have performed. The set of articles included in this issue represents a unique contribution to the literature of nuclear preparedness, assembling years of discussion and effort in a digestible synthesis. Taken together, these articles capture and convey the best current thinking of our most prominent thought leaders. We also want to thank our reviewers, who frequently reviewed more than 1 article at a time, to ensure that the issue we present to you remained coherent. We are hopeful that this issue will present frank and practical guidance to local and national planners and improve nuclear preparedness in our country.

REFERENCE

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