Exploring Medical and Public Health Preparedness for a Nuclear Incident: Proceedings of a Workshop (2019)

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Exploring Medical and Public Health Preparedness for a Nuclear Incident

PROCEEDINGS OF A WORKSHOP

Leslie Pray, Benjamin Kahn, and Scott Wollek, *Rapporteurs*

Forum on Medical and Public Health Preparedness for
Disasters and Emergencies

Board on Health Sciences Policy

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This Proceedings of a Workshop was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published proceedings as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

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Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the content of the proceedings nor did they see the final draft before its release. The review of this proceedings was overseen by **HELLEN GELBAND,** independent consultant. She was responsible for making certain that an independent examination of this proceedings was carried out in accordance with standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the rapporteurs and the National Academies.

Contents

Acronyms and Abbreviations

AACN	American Association of Colleges of Nursing
ABA	American Burn Association
ACS	American College of Surgeons
ALC	absolute lymphocyte count
AMS	Aerial Monitoring System
AO	alert originator
AP	advanced practice
ARC	American Red Cross
ARS	acute radiation sickness
ASPR	Office of the Assistant Secretary for Preparedness and Response, U.S. Department of Health and Human Services
ASTHO	Association of State and Territorial Health Officials
A-Team	Advisory Team for Environment, Food, and Health
BARDA	Biomedical Advanced Research and Development Authority
BMT	bone marrow transport
CBC	complete blood count
CBRN	chemical, biological, radiological, and nuclear
CDC	Centers for Disease Control and Prevention
CEMP	Comprehensive Emergency Management Program, U.S. Department of Veterans Affairs

CIP	Healthcare and Public Health Sector Critical Infrastructure Protection Program, Critical Infrastructure Protection, Office of the Assistant Secretary for Preparedness and Response, U.S. Department of Health and Human Services
CIR	critical information requirement
CMRT	Consequence Management Response Team
CMS	Centers for Medicare & Medicaid Services
CONOPS	continuity of operations
CRC	community reception center
DHS	U.S. Department of Homeland Security
DoD	U.S. Department of Defense
DoE	U.S. Department of Energy
DSNS	Division of Strategic National Stockpile
EMAC	Emergency Management Assistance Compact
EMP	electromagnetic pulse
EMS	emergency medical services
EOC	emergency operations center
EPA	Environmental Protection Agency
ESF#15	Emergency Support Function #15
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FRMAC	Federal Radiological Monitoring and Assessment Center
GAO	Government Accountability Office
HAP	The Hospital + Healthsystem Association of Pennsylvania
HHS	U.S. Department of Health and Human Services
HPP	Hospital Preparedness Program
ICBM	intercontinental ballistic missile
ICU	intensive care unit
IND	improvised nuclear device
IRB	institutional review board
kt	kiloton
MDP	Mobile Device Project
MERRT	Medical Emergency Radiological Response Team
MRC	Medical Reserve Corps

Mt	megaton
NACCHO	National Association of County & City Health Officials
NARAC	National Atmospheric Release Advisory Center, U.S. Department of Energy
NARR	National Alliance for Radiation Readiness
NCDMPH	National Center for Disaster Medicine and Public Health
NDMS	National Disaster Medical System
NEST	Nuclear Emergency Support Team, U.S. Department of Energy
NHSS	National Health Security Strategy
NIH	National Institutes of Health
NRF	National Response Framework
NRIA	Nuclear/Radiological Incident Annex
NRITF	Nuclear/Radiological Incident Task Force
NYC	New York City
OADN	Organization for Associate Degree Nursing
PA	physician assistant
PAHPA	Pandemic and All-Hazards Preparedness Act
PEMDP	Pre-Event Message Development Project
PHEP	public health emergency preparedness
PHIT	Public Health Infrastructure Training
PSA	public service announcement
PSI	pounds per square inch
RADM	rear admiral
RAP	Radiological Assistance Program
RCAC	Risk Communication Advisory Committee
RDD	radiological dispersal device
RDHRS	Regional Disaster Health Response System
REAC/TS	Radiation Emergency Assistance Center/Training Site
RED	radiation exposure device
RITN	Radiation Injury Treatment Network
RN	registered nurse
RSL	Remote Sensing Laboratory
SMS	short message service
SMS-CB	short message service-cellular broadcast
SNS	Strategic National Stockpile
START	Study on Terrorism and Responses to Terrorism

TNT	trinitrotoluene
USPHS	U.S. Public Health Service
VA	U.S. Department of Veterans Affairs
WEA	wireless emergency alert
WHO	World Health Organization
WMD	weapon of mass destruction

Dedication

This Proceedings of a Workshop is dedicated to
our science writer Leslie Pray (1964–2018).
Leslie worked for many years as a science writer with the
National Academies, and our staff will always remember
her kind nature, skillful writing, and sharp intellect.

1

Introduction

"These are interesting times. Concerns for the use of nuclear warfare against the United States, originally dating back to the Cold War, are now steadily increasing," Tener Veenema, professor, Johns Hopkins University School of Nursing and Bloomberg School of Public Health, stated in her welcoming remarks at Exploring Medical and Public Health Preparedness for a Nuclear Incident: A Workshop. The workshop, held on August 22–23, 2018, in Washington, DC, was hosted by the Forum on Medical and Public Health Preparedness for Disaster and Emergencies (the Forum) of the National Academies of Sciences, Engineering, and Medicine (the National Academies). The event brought together experts from government, nongovernmental organizations, academia, and the private sector to explore current assumptions behind the status of medical and public health preparedness for a nuclear incident, examine potential changes in these assumptions in light of increasing concerns about the use of nuclear warfare, and discuss challenges and opportunities for capacity building in the current threat environment (see Box 1-1 for the workshop's complete Statement of Task).[1]

[1] The role of the workshop planning committee was limited to planning the workshop. This Proceedings of a Workshop was prepared by the rapporteurs as a factual account of what occurred at the workshop. Statements, recommendations, and opinions expressed are those of individual presenters and participants and are not necessarily endorsed or verified by the National Academies of Sciences, Engineering, and Medicine. They should not be construed as reflecting consensus on the part of the planning committee, the forum, the National Academies, or any other group.

BOX 1-1
Workshop Statement of Task

Under the auspices of the Forum on Medical and Public Health Preparedness for Disasters and Emergencies, an ad hoc committee will organize and convene a 2-day public workshop in Washington, DC. Through this workshop, participants from government, nongovernmental, and private sector organizations will explore current assumptions behind and the status of medical and public health preparedness for a nuclear incident, examine potential changes in assumptions and approach, and discuss challenges and opportunities for capacity building in the current threat environment.

Specific topics that may be discussed in this workshop include

- the current state of medical and public health preparedness for a nuclear incident and how these relate to the prior assumptions about the threat environment;
- possible changes to planning assumptions for nuclear incidents, with particular attention to the (re)emergence of state actor threats, and the implications of those changes for nuclear incident prevention, planning, and response;
- implications for capacity building of potential communication, education and information challenges posed by a nuclear incident, and opportunities and approaches for addressing them; and
- challenges, opportunities, and implications for building capabilities to respond to and recover from a nuclear incident, including building capability for assessment, early treatment, monitoring, and long-term health surveillance among survivors.

The committee will develop the agenda for the workshop session, select and invite speakers and discussants, and moderate the discussions. Workshop proceedings will be prepared by a designated rapporteur in accordance with institutional guidelines, based on the presentations and discussions held during the workshop. The proceedings will be subject to appropriate review procedures before release.

During her opening remarks, Veenema laid the foundation for the rest of the workshop by discussing realities surrounding the present risk of nuclear attacks, beginning with the fact that there are five officially recognized nuclear weapons states in the world: China, France, Russia, the United Kingdom, and the United States. Of these, Russia and the United States possess approximately 90 percent of the weapons, and the weapons are not distributed equally between the two. In addition, four other countries are known to possess nuclear weapons: India, Israel, North Korea, and Pakistan. Altogether, Veenema said, the world's current collection of

15,000 nuclear weapons possesses enough power to destroy many cities and kill millions of people.

As far back as 2010, the first National Health Security Strategy (NHSS) stated that the American people face no greater or more urgent danger than a terrorist attack using a nuclear weapon (HHS, 2009), Veenema continued. More recently, in its annual announcement in January 2018, the Science and Security Board of the *Bulletin of the Atomic Scientists* warned that leaders are failing to act with the speed and scale required to protect citizens from the extreme dangers posed by both climate change and nuclear war (*Bulletin of the Atomic Scientists*, 2018). Now, in light of the current intensifying geopolitical tensions between countries in possession of nuclear weapons, the need for medical and public health systems with the capacity to accommodate a sudden, unanticipated surge of victims and a workforce capable of responding to a nuclear incident is of critical importance, Veenema stressed.

James Blumenstock, chief, health security, Association of State and Territorial Health Officials, provided some additional opening remarks. In addition to the NHSS document that Veenema mentioned (HHS, 2009), he called attention to another federal document, the *2018 National Defense Strategy* (DoD, 2018), where it is stated that it is now undeniable that the United States is no longer a sanctuary but a target of potential attacks. Clearly, Blumenstock said, a nuclear threat is one of the elements in the CBRN (chemical, biological, radiological, and nuclear) spectrum that is of critical concern and importance. This, in large part, is why this particular assembly of experts was convened, he said, referring to the many representatives of the health care and public health community responsible for preparing to manage the consequences of such acts of aggression.

Blumenstock noted that while the workshop was initially planned to include a focus on radiation in addition to nuclear incident preparedness, it did not take long for the planning committee to realize that the workshop needed to more narrowly focus on the current imminent threat. Because of their scientific similarity, radiation and nuclear threats are usually lumped together, but in this case the planning committee decided to split them. Notwithstanding the similarities between the two threat scenarios, there are substantial differences in planning assumptions, response, tactics and strategies, and the consequences of the disaster. Thus, the committee chose to focus on nuclear incidents, specifically the weapons of mass destruction that Veenema mentioned.

Both Veenema and Blumenstock encouraged active engagement of the audience over the course of the workshop. To foster interactivity, in addition to keynote and other speakers, there were several panel discussions and question-and-answer periods throughout the agenda (the workshop agenda is provided in Appendix A).

ORGANIZATION OF THE PROCEEDINGS

The organization of these proceedings largely parallels the organization of the workshop itself. Chapter 2 focuses on federal planning for nuclear incidents. Chapter 3 focuses on the current state of preparedness at the state and local levels. Chapter 4 addresses updating planning assumptions for nuclear incidents. Chapter 5 discusses communication, education, and information challenges of nuclear events. Chapter 6 addresses challenges for building capacity to respond to nuclear incidents across the health care system. Chapter 7 discusses building response and recovery capability following a nuclear incident. Chapter 8 focuses on workforce readiness for nuclear incidents. Chapter 9 discusses takeaways identified by workshop session moderators. Chapter 10 recounts the closing remarks.

2

Federal Planning for Nuclear Incidents

Key Points Made by Individual Speakers

- The U.S. Department of Homeland Security's (DHS's) preparedness and response planning for a nuclear incident began in the mid-2000s, with initial planning focused on a 10-kiloton yield; planning since then has evolved to acknowledge higher yield threats, and response strategies—including sheltering, communications, medical coordination, and mutual aid—are set up to serve broad objectives beyond only nuclear threats. (MacKinney)
- Current models for nuclear detonation incorporate sophisticated data on urban environments and are able to predict likely blast zones and fallout zones; the moderate blast zone is a focus of response planning because of the likelihood of survivors with injuries in that zone. Modeling has also shown that any form of sheltering is likely to save many lives during a nuclear event. (Buddemeier)
- The Office of the Assistant Secretary for Preparedness and Response (ASPR) takes an all-hazards approach to disaster planning; common challenges across threats, including nuclear threats, include lack of sufficient medical capacity and capability, jurisdictional disparities, lack of training and situational awareness, and resource allocation. ASPR is developing a Regional Disaster Health Response System to improve pre-

paredness and response through the strengthening of health care coalitions. (Yeskey)

- DHS's *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans* lays out a concept of operations for a response to a nuclear or radiological incident through the identification of primary authorities, coordination of jurisdictional planning efforts, and identification of federal response capabilities. The U.S. Department of Energy's National Atmospheric Release Advisory Center uses 3-D modeling to predict atmospheric dispersion of a release of radiological material from an explosive device and through its connections with meteorological centers can produce updatable models to support situational and planning efforts. (Crapo)

The opening session of the workshop, moderated by Blumenstock, served as an unclassified briefing on U.S. planning for nuclear incidents. It also provided an overview of the evolution of preparedness for a nuclear event over the past 10–15 years, a period of major change in the field; speakers were asked to consider the implications of these changes in the current nuclear threat environment. This chapter summarizes the four speaker presentations and the discussion that followed.

SETTING THE STAGE: NUCLEAR DETONATION RESPONSE PLANNING

The panel opened with John MacKinney, senior policy adviser, Countering Weapons of Mass Destruction Office, U.S. Department of Homeland Security (DHS), providing a brief history of federal nuclear attack response planning, the changing threat environment, and needs moving forward.

A Brief History of Federal Terrorist Nuclear Attack Response Planning

"The concern that somebody would sneak a nuclear weapon into the United States goes back to post-World War II, 1946," MacKinney began. After seeing the destruction in Hiroshima and Nagasaki, the federal government was very concerned that someone might be able to sneak a bomb into the United States, either by sea or land, because at the time bombs were small enough to go unnoticed. Even today, while the technology, techniques, and intelligence have improved, there are still significant limitations to actually detecting and discovering a weapon. A famous Senate testimony from Robert Oppenheimer during the post-World War II era raised alarms, and many reports and studies were conducted. But the warnings came and went until the 1970s, when a host of nuclear hoaxes raised alarms again and led to the establishment of the Nuclear Emergency Support Team (NEST) in the U.S. Department of Energy (DoE), which sent highly specialized teams into the field to look for, discover, and then render safe nuclear weapons. NEST still exists today, updated for the current threat environment.

Not until after 9/11 did the threat of a nuclear incident enter the forefront of national conversation again, when both improvised nuclear device (IND) and radiological dispersal device (RDD) terrorism became critical concerns for the federal government. By 2003, an interagency group had been formed to directly work on response planning for INDs and RDDs. The initial focus was largely on radiological impacts, but in the process of the interagency working group meetings, MacKinney recalled, it was fairly easily determined that a nuclear bomb was much more than a radiological incident—additional consequences would include a massive blast effect in addition to the initial pulse of radiation and fallout and potentially electromagnetic pulse effects. The damage to infrastructure, response organizations, and communications would be extensive, MacKinney said. Because of these other potential impacts and the greater scope of damage, a case was made to the relevant White House policy committee that a special planning effort was needed. The White House agreed unanimously, according to MacKinney.

By 2008, DHS was aggressively pursuing nuclear response planning. This led to the publication of *Planning Guidance for a Response to a Nuclear Detonation*, with a second edition issued in 2010 (FEMA/DHS, 2010). After release of the guidance, response planning was essentially turned over to the Federal Emergency Management Agency (FEMA). MacKinney described this guidance as "the bible" for how to approach nuclear attack planning.

DHS Roles and Responsibilities

According to MacKinney, Michael Chertoff, secretary of DHS from 2005 to 2009, once said, "The role of DHS is to keep bad people and bad things out of the country." Most DHS components, including Customs and Border Protection, the Transportation Security Administration, and the U.S. Coast Guard, are involved with the prevention of terrorists and transnational criminals, as well as weapons materials, from entering the country. Several offices, including the Office of Intelligence and Analysis, help determine threats, and Homeland Security Investigations, part of Immigration and Customs Enforcement, conducts counterproliferation investigations to track down people who are trying to export U.S. technologies for the development of nuclear weapons and other weapons of mass destruction (WMDs) capabilities. Finally, MacKinney's office, Countering Weapons of

Mass Destruction, coordinates counter-WMD planning and provides technical advice and support to operators in the field, MacKinney said. All of this work is conducted in concert with the Federal Bureau of Investigation, the U.S. Department of Defense (DoD), DoE, and others. "We really seem to be a deterrent, in the end analysis," MacKinney said. "It's extremely difficult to keep things out of the country, but we want to make sure that the adversary understands that the risk is high to them. So we seek to deter."

Operating through the National Response Framework (NRF) (DHS, 2013), FEMA has a unique role within DHS—the agency manages post-incident logistics. It leads and coordinates federal support and federal response to the state and local entities that are in charge on the ground and plans for every major kind of disaster, MacKinney said. In 2008, the DHS Office of Strategy, Policy, and Plans established a FEMA program that integrated CBRN (chemical, biological, radiological, and nuclear) into its WMD response capabilities. The NRF annex, *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans* (DHS, 2016b), describes the capabilities that federal departments bring to bear in a radiological or nuclear incident through task orders or mission assignments by FEMA (this will be addressed further in Chapter 7).

Changing Threats Since Preparedness Planning Was First Done

Threat levels have changed since nuclear preparedness planning first began in earnest around 2005–2006, MacKinney continued. At that time, the primary organizational threat was al-Qaida. Thus, the focus was on al-Qaida and similar organizations with the resources and ability to recruit scientists and technicians and the danger of their potential acquisition of a critical mass of plutonium or enriched uranium to construct a bomb, MacKinney said. If terrorists could construct a bomb, would they achieve nuclear yield, and how much? The nuclear response community zoomed in on a range of 1–10 kilotons (kt) of TNT (trinitrotoluene) and thus began planning for a 10 kt IND (meaning, MacKinney noted, not the same as a state weapon, although an IND could be a state weapon that has been partially dismantled and modified). Subsequently, there were murmurings that 10 kt was too low and that perhaps the response community ought to start considering weapons with 50 kt or greater yields. Nonetheless, even exercises conducted today assume a 10 kt range, MacKinney said.

"North Korea has changed this calculus substantially," MacKinney said, and has forced the issue around whether the nuclear preparedness community should consider larger bombs. There is no longer any question that they should be, he said. At the time of the workshop, North Korea had completed a total of six tests; one test, conducted in September 2017, achieved a yield estimated (by DoD), using seismic data, to be between 70 and 280 kt. Other estimates were in the 200–250 kt range. The possibility of a 1–10 kt device being snuck into the country and set off in a city without warning is still a threat, MacKinney clarified, but it has been amplified by this new additional threat of weapons with yields in the hundreds of kilotons.

In addition to the greater yield of this new threat, the method of delivery has also changed, MacKinney said. North Korea is primarily focused on missile development technologies, either an intercontinental ballistic missile (ICBM), with about a 20-minute warning time, or a short- or medium-range missile launched from a ship, with about a 5-minute warning time. MacKinney underscored the difference in warning time between a terrorist weapon and a missile launch. In a terror scenario, the experts' assumption is that the terrorists would notify the media that they were about to explode a bomb but would give no further warning. North Korea, in contrast, would likely offer a warning prior to a missile launch—unless North Korea were to smuggle a weapon into the United States and use it for distortion, in which case it is unknown whether there would be warning, MacKinney said.

Addressing the size of the larger yield weapons, MacKinney said that miniaturizing a bomb and moving it onto the tip of a warhead is quite a challenge, and it is unknown how far the North Koreans have progressed in that direction. Reentry is also a challenge, especially for an ICBM, as the reentry vehicle has to survive very high heat and energy. Targeting is difficult as well. Yet, MacKinney cautioned, it would be naive to dismiss North Korea's ability to solve such issues. In his opinion, because it has achieved substantial yield, there is a good likelihood that North Korea can also miniaturize and deliver the warhead.

Exploring Nuclear Preparedness Needs Going Forward

MacKinney identified several needs moving forward. The first is to continually refine the question. He emphasized that nuclear threats are constantly changing and that approaches to preparedness should continue to evolve as the threats evolve.

Second, he called for solutions that transcend the threat and serve broader objectives. Evacuation sheltering, improved methods of communication, fixing disrupted communications, medical response, and mutual aid all need to be designed to meet needs during and after any major disaster, not just a nuclear disaster. In fact, this is fundamentally how FEMA operates, MacKinney stated. While obviously there are complications unique to the nuclear arena, response plans cannot be so specific to a nuclear attack that they take away from preparedness for other, higher probability disasters, he said.

Next, he called for resilience: public resilience, technological resilience, rapid medical triage, rapid clearing of debris, rapid restoration of communications and global positioning system technology, and rapid repair of critical infrastructure. All of these, he said, will help the country rebuild after a disaster. But most importantly, in his opinion, is resilience of the American psyche. He stressed the role that government plays, including prior to a disaster, by preparing the population for the reality that major disasters occur. When a disaster does happen, in his opinion, it is critical that the president address it publicly to reassure those affected.

Finally, disaster exercises typically involve only federal resources and state and local planners, not the public. In MacKinney's opinion, given the importance of resilience and risk communication during a disaster, these exercises should also include the public.

UPDATED MODELING: NUCLEAR BLASTS AND FALLOUT IN AN URBAN ENVIRONMENT

As nuclear preparedness has changed since the early 2000s, so too has the modeling of nuclear blasts. Brooke Buddemeier, principal investigator, Global Security Directorate, Lawrence Livermore National Laboratory, explained how the early models, in 2005–2008, predicted a circular range of blast effects and a cigar-shaped fallout (IOM, 2009) (see Figure 2-1). However, an inherently problematic assumption of these early models was that everyone affected was standing outside in a "desert" (i.e., with no buildings or other forms of cover in the area). Today's models, in contrast, have more sophisticated capabilities because of the kinds of data that are available on urban environments, including the types of buildings and both daytime and nighttime populations for each city block. Unlike the simplified models of the mid-2000s, current models demonstrate a dynamic fallout pattern that moves in different directions and with significant variation in radiation levels across geography (see Figure 2-2), Buddemeier said.

Moreover, current models are able to account for distinct thermal effects of detonation at different altitudes. When compared to a near-ground detonation, a detonation at a height of 300 meters would result in reduced impact of thermal injuries and other line-of-sight effects due to the protection provided by the urban environment (Marrs et al., 2007). For prompt radiation compared to an open area, detonation in a high-rise area would result in a much curtailed range of effects from injurious levels of radiation exposure.

Buddemeier remarked that this updated modeling has helped to inform not only the federal *Planning Guidance for a Response to a Nuclear Detonation* (FEMA/DHS, 2010), as mentioned by MacKinney, but also a variety of additional guidance documents that followed (DHS, 2016a,c;

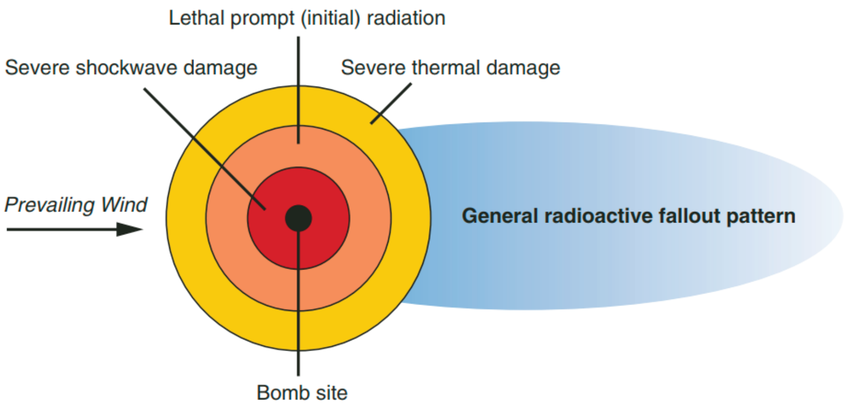

FIGURE 2-1 General radioactive fallout pattern.
NOTE: An illustration with circular prompt (initial) effects and a cigar-shaped fallout pattern.
SOURCES: Buddemeier presentation, August 22, 2018, and NAE and DHS, 2005.

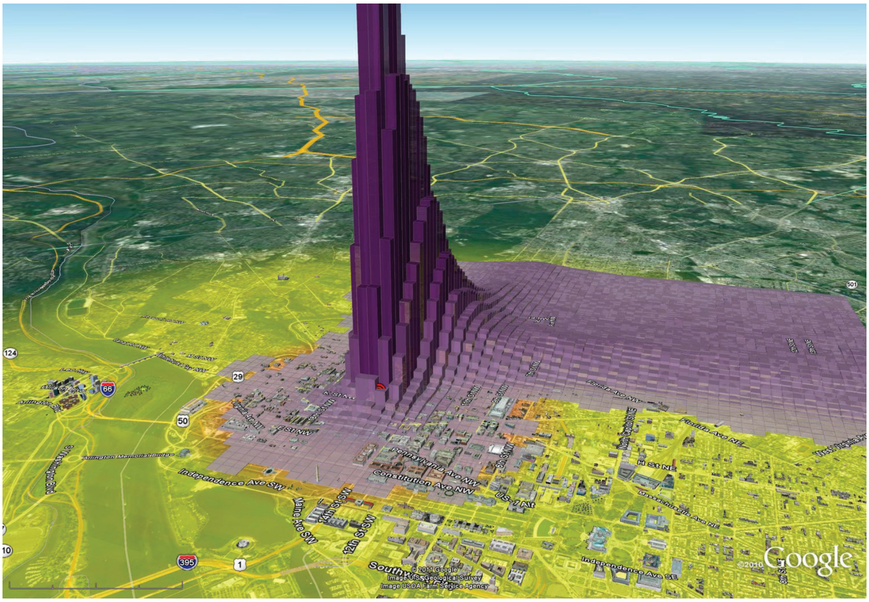

FIGURE 2-2 Illustration of detailed improvised nuclear device effects analysis.
NOTES: The dynamic fallout pattern of a 10 kt nuclear detonation in Washington, DC, based on a block-by-block assessment of prompt effects, overpressure, thermal effects, prompt radiation, and fallout dose and dose rate. The height of each block represents the radiation levels on that block.
SOURCE: Buddemeier presentation, August 22, 2018.

FEMA, 2013; NCRP, 2011), including *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans* (DHS, 2016b).

An Example: A 10 kt Detonation in New York City's Times Square

In order to contextualize the terminology and response zones defined in the guidance documents cited above, Buddemeier described an example of a 10 kt ground detonation in Times Square (New York City [NYC]) to demonstrate how the updated models predict varying effects across five key response zones: three blast zones (severe damage, moderate damage, light damage) and two fallout zones (dangerous fallout zone, hot zone). He described a 10 kt detonation as a bright flash of light that is the equivalent of 1,000 suns seen a mile away. In terms of yield, it is the equivalent of about 5,000 Oklahoma City bombs. This particular example was based on a real weekday population and real weather (from noon on August 14, 2009).

Blast Zones

The severe damage blast zone from a 10 kt detonation would extend approximately 0.5 miles from the blast site, and there would not be many survivors in this area, Buddemeier said. There would be some very severe building damage, and many buildings close to the detonation site would collapse. The moderate damage blast zone would extend from about 0.5 miles to about 1 mile, Buddemeier said. This zone would include significant structural damage, with blown-out building interiors, collapsed buildings, and fires, but survival would be much higher than in the severe damage blast zone. Buddemeier noted that because of the number of people in this zone who would survive but have significant injuries, the moderate damage zone is a priority in many response plans. Finally, the light damage blast zone would extend from approximately 1 mile to 3 miles, Buddemeier explained. Although most people in this zone would not be injured, it is still a zone of concern as there would still be significant damage as well as broken and flying glass. In addition, there would be minor crush injuries from structures collapsing or falling from the shock wave.

Fallout Zones

Buddemeier explained that fallout occurs when the explosive fireball, which is so hot that it actually shoots up like a bubble at more than 100 miles per hour, drawing in thousands of tons of dirt and debris, which then mix with the fission products (i.e., created in the explosion), creates a mushroom cloud. The cloud then rises several miles into the atmosphere, about 5 miles for a 10 kt bomb, where any winds in the upper atmosphere can move the cloud in different directions. When the particles fall back to earth, Buddemeier said, they emit dangerous radiation that can injure people and contaminate surfaces. Dangerous levels of fallout create visible dust and debris, he noted. In the 10 kt NYC example, during the first 2 hours of the event, the cloud would move to the south, over Queens (see Figure 2-3).

Survivors and Casualties

Before describing the specific results of the model with regard to survivors and casualties, Buddemeier reiterated that the model accounted for all of the buildings in the area. In addition, a starting assumption, which he hoped would not be the case in a real event but one that was useful for the purposes of modeling, was that some people were outside for the entire first 2 hours following detonation while others were indoors.

Most would not survive in the severe damage zone (see the red circle in Figure 2-4). However, in the moderate damage zone (see the orange ring in Figure 2-4), with a total population of 740,000 in the example, most people would survive, but there would be significant injuries—an estimated 250,000 "at-risk" injuries or exposures, which Buddemeier defined as injuries or

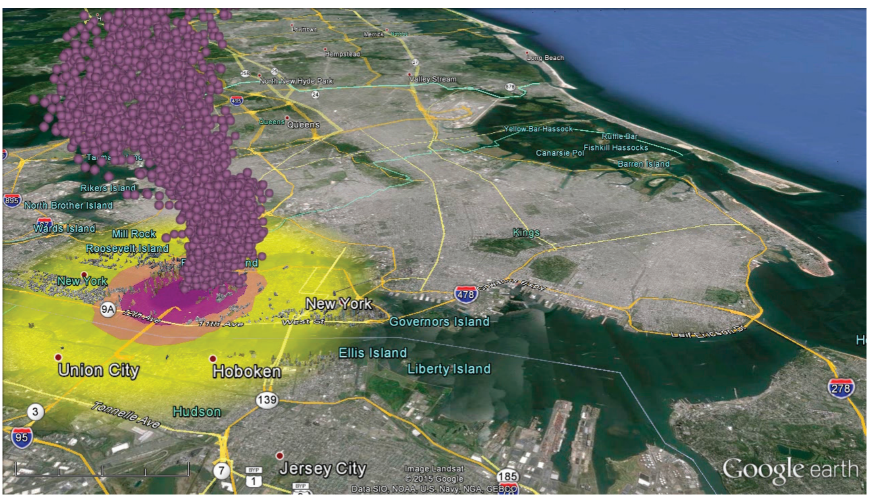

FIGURE 2-3 Model of the first 2 hours of fallout after a nuclear incident in New York City.
NOTES: Activity of the mushroom cloud during the first 2 hours of a modeled 10 kt nuclear detonation in NYC. The purple balls represent the cloud.
SOURCE: Buddemeier presentation, August 22, 2018.

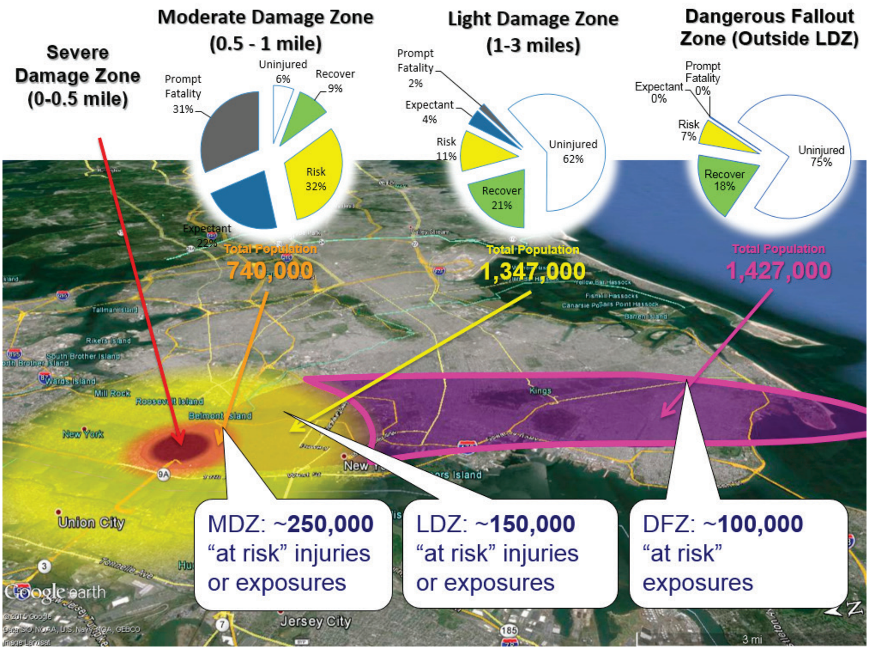

FIGURE 2-4 Model of expected post-fallout effects after a nuclear incident in New York City.
NOTES: Fallout after 2 hours. Colored contours on the ground represent the different blast zones (red, orange, yellow) and the dangerous fallout zone (purple).
SOURCE: Buddemeier presentation, August 22, 2018.

exposures that would benefit from medical care. In the light damage zone (see the yellow ring in Figure 2-4), with a total population of 1,347,000, most people would be uninjured, but there would still be an estimated 150,000 at-risk injuries or exposures. Finally, in the dangerous fallout zone outside of the prompt effect (see the purple section in Figure 2-4), with a total population of 1,427,000, most people would be uninjured, but there would be an estimated 100,000 people with at-risk exposure.

In sum, Buddemeier said there would be approximately 500,000 people in the at-risk category. Four hundred thousand people would also be classified as "low exposure," meaning that they may have been exposed to enough radiation to become sick but have a good chance at recovery without medical assistance. Buddemeier said that radiation takes time to manifest, with acute radiation syndrome often progressing over weeks, allowing for extended opportunities for medical intervention. He predicted that with medical care, more than 100,000 at-risk fatalities could be avoided.

Buddemeier emphasized the dynamic nature of nuclear incidents. In the NYC example, at 3 hours, then 4 hours, and so on, the cloud continued to move downwind, depositing radioactive material on the ground beneath it. Moreover, radiation levels change with time—they grow, then shrink back as fallout decays, Buddemeier noted. Initially, decay is rapid. In this example, the maximum extent of the dangerous fallout zone is only about the length of Queens (see Figure 2-4), reaching that maximum at about 2.5 hours after detonation. However, the hot zone—the second fallout zone—stretches down most of New Jersey, reaching its maximum extent at about 18 hours before shrinking back (see Figure 2-5).

Of note, the contours determined by this type of model and illustrated here in Figures 2-3, 2-4, and 2-5 are defined as areas where actionable

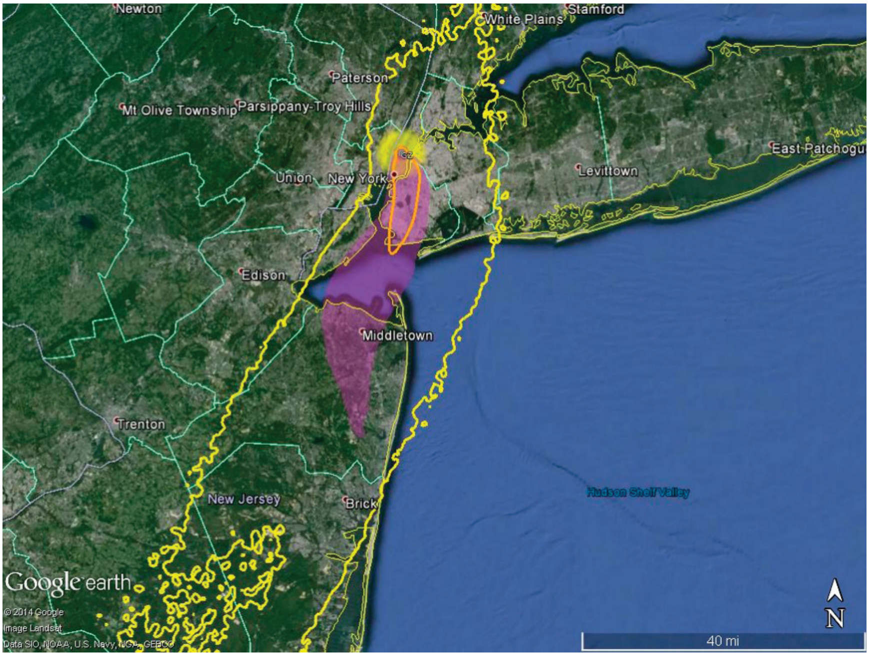

FIGURE 2-5 Fallout zones over time after a 10 kt nuclear detonation in New York City.
NOTES: Orange contour represents the maximum extent of the dangerous fallout zone 2.5 hours following detonation (this same area is represented by the purple shaded area in Figure 2-4); yellow contour represents maximum extent of the hot zone (18 hours after detonation); and purple shaded area represents the hot zone at 1 week.
SOURCE: Buddemeier presentation, August 22, 2018.

protections are necessary. There would still be detectable contamination outside of the hot zone. In this example, Buddemeier said, the entire eastern seaboard would have low levels of detectable radiation. After an event of this magnitude, there may be no "clean" area.

Key Fallout Considerations: Implications for Sheltering

Not only is fallout decay rapid, Buddemeier noted—with more than half of the energy being released in the first hour and 80 percent in the first day—but it is not a significant inhalation hazard either. The primary hazard from fallout is through exposure to the penetrating gamma radiation from the particles. Moreover, it is readily visible as it falls, as thousands of tons of dirt and debris are lofted into the air. Most importantly, it takes approximately 15 minutes for that fallout to arrive. "So you have time to take action to protect yourself," Buddemeier said.

"Where you are in a building makes a big difference." Being in a building away from the roof and ground outside confers better protection. "If you're in a basement," he said, "even better." Even being in a half basement of a single-story wood-frame house can be 10 times more protective than being outside (see Figure 2-6).

Sheltering in Place

Sheltering not only can save many people, Buddemeier stated, but it is also something that does not necessarily need to be done before a detonation. In the Times Square example, assuming that everyone stands outside for 12 hours after detonation—which Buddemeier noted is not recommended but is a helpful baseline assumption for modeling purposes—almost 1.5 million people outside the severe and moderate damage zone would have significant radiation exposure. However, if everyone were to run into even a low-quality shelter, nearly 1 million of those people would be saved from significant exposure. Buddemeier explained that if everyone ran into what is considered adequate shelter, such as a shallow basement in a wood-frame house or a two- or three-story brick structure, more than 1 million individuals would be saved from significant exposure. In cities like NYC or Washington, DC, where brick and cement buildings are ubiquitous, exposures could be reduced to a level at which nobody would be lethally exposed, Buddemeier predicted.

Get Inside, Stay Inside, Stay Tuned

Buddemeier explained that the concept that sheltering even after a detonation could save so many thousands of people from significant ex-

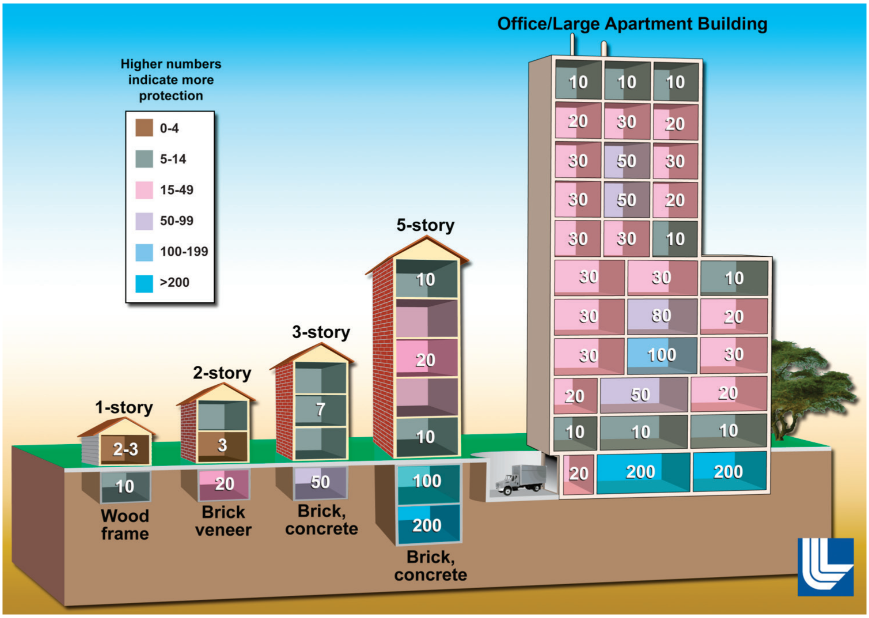

FIGURE 2-6 Levels of protection based on shelter type.
NOTE: Different degrees of protection from fallout while in a building, compared to being outside; the bigger the number, the better the protection.
SOURCES: Buddemeier presentation, August 22, 2018, and Buddemeier and Dillon, 2009.

posure helped generate the "Get inside, stay inside, stay tuned" campaign. The campaign advises people to get inside to the basement or middle of a building, plan on remaining there for 12–24 hours to avoid the highest levels of fallout radiation outside, and stay tuned by radio or, if available, cellular internet services (see Figure 2-7).

Higher Yields and Height of Burst

The relationship between yield and blast effect is not linear, Buddemeier pointed out. For a 100 kt yield, for example, the blast effect is only about double what it is for a 10 kt bomb.

Regarding height of burst, Hiroshima and Nagasaki were both detonated at between 1,500 and 2,000 feet off the ground. While both had the expected cap and stem mushroom cloud, both also had an air gap, and it was because of that air gap that there was no significant fallout (see Figure 2-8). Buddemeier explained that the radioactive material produced

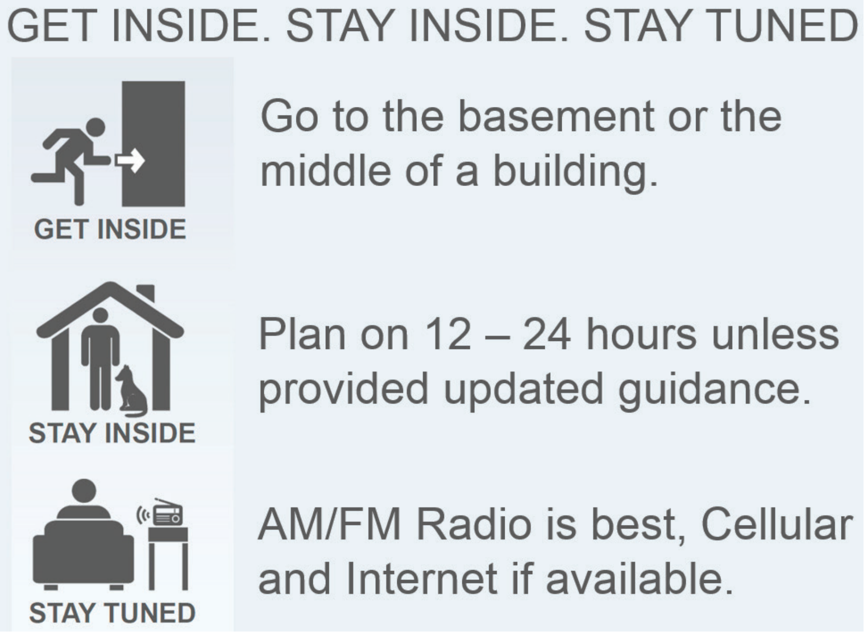

FIGURE 2-7 The “Get inside, stay inside, stay tuned” communication campaign for what to do in the event of a nuclear incident.
SOURCE: Buddemeier presentation, August 22, 2018.

in the explosion was so fine that it actually drifted into the atmosphere. It is only when a fireball falls to earth and the fission products mix with the dirt and debris that the heavier particles that fall back down are created, Buddemeier said. Although there is global fallout when a bomb is detonated that far off the ground, it is not the severe local fallout that causes the kind of issues he described in the NYC Times Square example.

Addressing Today’s Expanded Threat Base

In the event of an imminent nuclear threat, as MacKinney had mentioned, people would likely have 10–20 minutes to find a good shelter, Buddemeier said. He pointed out that the same shelter that protects against fallout can also protect against prompt effects.

In a no-notice detonation, however, “duck and cover” still works as protection against prompt effects, he said. For example, if someone sees a bright flash, because it would take several seconds for the blast wave to reach this person, ducking and covering can protect against the initial

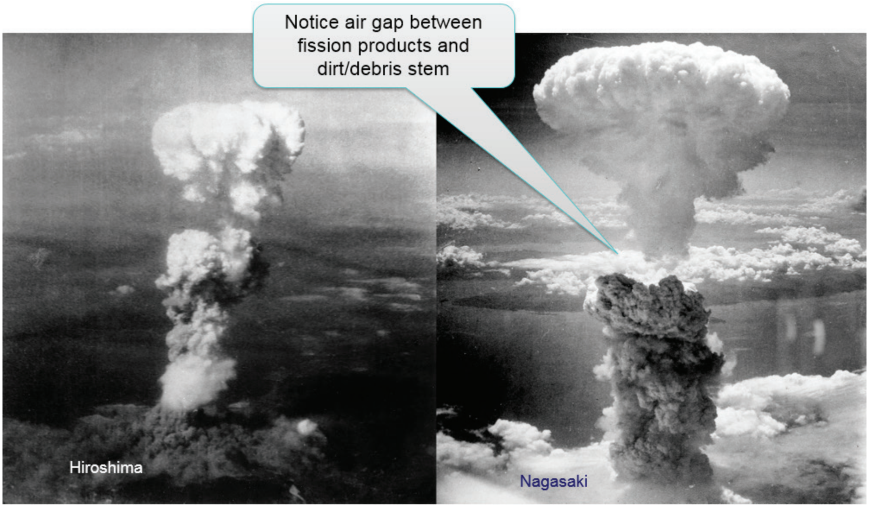

FIGURE 2-8 Comparison of Hiroshima and Nagasaki mushroom clouds 10 minutes after burst.
NOTE: The Hiroshima and Nagasaki cap and stem mushroom clouds with air gaps between the fission products (in the cap) and the heavier dirt and debris (in the stem).
SOURCE: Buddemeier presentation, August 22, 2018.

effect. However, to protect against fallout (i.e., if the fireball is close enough to the earth to generate fallout concern), given that it takes 15 minutes or more for fallout to reach the ground, then, following the initial effect, there is some time to find shelter and get into a basement or central room, Buddemeier said.

Regardless of warning time for those sheltering, Buddemeier said there should be a way to communicate with them about time spent sheltering, instructions for next steps, and potential hazards (e.g., fire) after sheltering.

"The bottom line," Buddemeier said, "is that 'Get inside, stay inside, stay tuned' works for both a threat of attack as well as if an attack does occur."

Saving Lives After a Nuclear Detonation

Buddemeier said that for those who are unable to get into adequate shelters and for people who are injured by the prompt effects, a rapid response could save hundreds of thousands of lives. In closing, he called for more analysis to better understand what the expanded threat means in terms of higher yields and heights of bursts and how to plan a response for those types of situations.

EXPLORING MEDICAL AND PUBLIC HEALTH PREPAREDNESS FOR A NUCLEAR INCIDENT: FROM THE PERSPECTIVE OF THE OFFICE OF THE ASSISTANT SECRETARY FOR PREPAREDNESS AND RESPONSE

Kevin Yeskey, principal deputy assistant secretary for preparedness and response, Office of the Assistant Secretary for Preparedness and Response (ASPR), U.S. Department of Health and Human Services (HHS), described the office's role in all-hazards preparedness and its work specific to nuclear threats.

ASPR's All-Hazards Charge

Because of its all-hazards charge, ASPR responds to a range of disasters and public health emergencies, Yeskey said. More specifically, under FEMA's Emergency Support Function #8, ASPR has 17 responsibilities, including water safety, food safety, environmental health, worker safety, and the provision of medical care. In all of its activities, Yeskey said, ASPR supports preparedness at state, local, territorial, and tribal levels. "The better prepared they are," he said, "the less we have to do, the less we have to engage, and the more resilient they become by doing that."

Yeskey recalled that when Robert Kadlec, current assistant secretary for preparedness and response, assumed his position, he spoke of 21st-century threats—such as emerging infectious diseases, nuclear threats, and other CBRN threats—and the need for contemporary solutions to those threats. Yeskey reiterated the all-hazards charge to ASPR and, like MacKinney, cautioned against specifically planning for any one event at the expense of others. As an example, he mentioned the New Madrid earthquake scenario,[1] where it has been predicted that a magnitude 7.7 earthquake would impact more than 150 counties across 8 states (Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee), displacing 2 million people and causing 86,000 casualties.

Challenges in Nuclear Incident Preparedness and Response

Yeskey listed several preparedness challenges in an all-hazards approach but also noted that the list specifically applied to a nuclear scenario because of the extent of patient movement and the need for specialty care. He predicted that in the event of a nuclear incident, many providers would offer support, but a methodical approach would be critical to a successful

[1] For more information on the scenario, see https://communities.geoplatform.gov/geoconops (accessed December 10, 2018).

medical response. "With competent people providing care—not just anyone who has a license and feels they need to be there," Yeskey said.

Lack of Medical Capacity

The National Disaster Medical System (NDMS), with its 94 teams, including 57 medical teams and 2 critical care surgical teams, still lacks the capabilities and capacity to respond to all of these new 21st-century scenarios, including a nuclear scenario, Yeskey said. While most teams are very skilled at providing initial stabilization and treatment, given that most team members are emergency or flight nurses, doctors, or paramedics, these scenarios would likely require specialty care in orthopedics, burns, trauma, and pediatrics, as well as rehabilitation when the initial response passed into a recovery phase. Yeskey emphasized the need to engage the private sector to help provide this specialty care. However, engaging hospitals and private health care systems in emergency preparedness is difficult, Yeskey said, because they are often concerned with day-to-day activities.

Jurisdictional Issues

Nuclear incident preparedness and response is also challenged by a range of jurisdictional issues. In the NYC detonation example described by Buddemeier, Yeskey pointed out that there were four states involved in that scenario. Within each of those states, each county and each city has its own procedures, protocols, emergency medical services (EMS) systems, and public health department, all of which operate separately. They may even have distinct communication systems and may not be aware of procedures in neighboring counties. In addition, jurisdictional boundaries may limit licensed professionals from crossing borders to practice their specialties, which is of particular concern in a nuclear scenario given that resources—including members of the workforce—will need to be divided strategically. Finally, jurisdictional issues unique to islands or remote places pose a specific challenge. It is hard to move equipment, people, and supplies to places that are several hundred miles away from the continental United States.

Workforce Training and Situational Awareness

Yeskey commented on CBRN training for medical practitioners: "If you talk to providers about what they are trained in and what they feel comfortable in . . . the general providers in the country don't know a whole lot about CBRN and the medical management of those cases." Yeskey also referred to the "fog of war," meaning that it is very difficult after an event to secure basic information from impacted jurisdictions about the operating status of their health care system, such as whether their emergency departments or operating rooms are open, whether they are on the power grid or how long their generators will last, and whether patients have been transferred, and if so, where.

Recovery

Yeskey mentioned that recovery after Hurricane Harvey (August 2017) in Texas only finished around June 2018 and that recovery from the 2017 hurricanes in the U.S. Virgin Islands and in Puerto Rico was still ongoing. Those were devastating events that impacted infrastructure, health care, and the migration of people to elsewhere, he said. "We are still recovering, trying to restore those areas to maybe a little bit better than normal—but at least to prehurricane levels," he added. He compared those recovery efforts to the nuclear scenario and the need to think not just about the immediate response to an event but also about the long-term recovery, including plans for displaced populations.

ASPR Operational Guidance

ASPR has been active in nuclear preparedness and response for more than 10 years and during that time has issued several operational guidance documents to help state, local, tribal, and territorial partners with preparedness planning in their specific jurisdictions, Yeskey said. He highlighted *A Decision Makers Guide: Medical Planning and Response for a Nuclear Detonation* (HHS/ASPR, 2017) and noted that ASPR has also assisted its federal partners in writing some of their guidance documents, playbooks, and manuals. In addition, ASPR works with subject matter experts, particularly in the health care field, to help identify needs and move forward with respect to these needs. ASPR has also engaged private industry on hospital preparedness for a nuclear event.

Allocation and Use of Scarce Resources: Triage and Trauma

Yeskey cautioned that despite the availability of operational guidance and other documents, an important factor to consider as the field moves forward is the allocation and use of scarce resources. Early on during a nuclear disaster, the need for medical countermeasures and other medical resources will outstrip regional supply. An important piece of addressing this will be figuring out how to triage patients to make sure they receive the care they need and that trauma is addressed.

Adding to the challenge will be combined injuries, Yeskey said, including individuals who suffer from physical injuries and radiation sickness. "It won't be conventional triage categories that are used," he said. In Yeskey's opinion, there should be further discussion around the allocation of scarce resources and convincing practitioners to incorporate different procedures, policies, and treatment guidelines for successful management of the overall scenario as well as individual patients.

Additional ASPR Responsibilities: Clinical Guidance, Stockpiling Medical Countermeasures, Medical Care, and Interagency Activities

Clinical Guidance

In addition to its operational guidance documents, ASPR has also issued clinical guidance. In Yeskey's opinion, a valuable reference—and one that has been very well received by the medical community—is the Radiation Emergency Medical Management website, www.remm.nlm.gov. A combined initiative by ASPR, the HHS Office of Planning and Emergency Operations, the National Library of Medicine, and other federal partners, it contains practical knowledge about the management of patients who have been exposed to radiation. Yeskey noted that after the Fukushima incident,[2] the website experienced an uptick in traffic, presumably because of efforts to prepare for incoming patients.

Medical Countermeasures in the Strategic National Stockpile

ASPR's Biomedical Advanced Research and Development Authority (BARDA) is responsible for the procurement and development of medical countermeasures for CBRN threats, and many of them are procured for the Centers for Disease Control and Prevention's (CDC's) Strategic National Stockpile (SNS) to be used in specific scenarios, including medical countermeasures for acute radiation syndrome. In collaboration with the American Burn Association, burn experts, and radiation experts, efforts are under way to develop countermeasures for burns as well, Yeskey said (burn countermeasures are not yet in the stockpile). Another late-stage development supported by BARDA is the development of biodosimetry for measuring the level of radiation exposure relatively quickly. Finally, BARDA is also examining innovative treatment pathways based on a better, different understanding of how injuries occur at the cellular level, with the goal being to intervene and stop the cellular cascade. (Yeskey referred

[2] On March 11, 2011, an earthquake caused a nuclear incident at three nuclear reactors at Fukushima Daiichi. For more information on the incident, see http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-accident.aspx (accessed December 10, 2018).

workshop participants to Steve Adams's presentation on the second day of the workshop for a more complete discussion of medical countermeasures in the SNS; see Chapter 7.)

Medical Care

ASPR's NDMS has 6,000 volunteers that it can deploy during a disaster to help with medical care, Yeskey said. In July 2018, a large NDMS training was conducted to bring volunteers up to speed on CBRN issues, including management of the SNS and use of its materiel. Yeskey identified two medical care issues of particular importance for a nuclear incident scenario: displaced people and pediatrics.

Yeskey invited participants to imagine a scenario in which there are 2 million displaced people, 40 percent of whom have at least one chronic medical condition and 50 percent have at least one prescribed medication; these people are located in shelters in areas where pharmacies will be closed. "So how are we going to make sure that those folks who need their daily medications are getting those so they don't turn into acute medical problems that have to be seen in emergency departments?" Yeskey asked. Compounding the challenge, he said, people would likely arrive at hospitals and clinics to request tests for radiation exposure. He reminded participants what had happened after the 2001 anthrax attacks and mentioned the large number of people who had arrived at emergency departments in Florida to request nasal swab testing for exposure.

Regarding pediatrics, he emphasized that, regardless of the type of care being provided—whether burn care, trauma care, or care for radiation exposure—the necessary equipment and supplies need to be in place to ensure that children are cared for properly.

Interagency Activities

ASPR's interagency work with CDC and the Food and Drug Administration (FDA) involves issuing emergency use authorizations, managing the stockpile extension programs to extend the life of components in the stockpile, ensuring food safety during a disaster, and examining critical infrastructure that could be damaged after an event like this that could impact not only the rest of the health care system but also the manufacturing process for saline and other medical countermeasures.

Development of a Regional Disaster Health Response System

While still in a pilot phase, Yeskey said, ASPR has been developing a tiered Regional Disaster Health Response System (RDHRS) aimed at overcoming the challenges he previously described (see Figure 2-9). Yeskey stressed that the focus of this regional system is readiness and that it does not replace normal patient referral patterns or the day-to-day activity of hospitals. Rather, he said, when those patterns and hospitals become overwhelmed or damaged, the regional system will provide an alternate way to ensure that patients receive the care they need when they need it.

With respect to how the regional system will operate, Yeskey explained that the intention is to capitalize on ASPR's investments in hospital coalitions and build on its Hospital Preparedness Program (HPP). The goal is to establish regional treatment centers ("regional referral centers" in Figure 2-9) across the country that are capable of caring for patients with complicated needs and are also able to enable smaller community hospitals to provide similar care through telemedicine, mobile teams, and trainings so that those smaller hospitals can keep patients alive until they arrive at a regional facility. Thus, there would be a baseline of trauma systems and health care coalitions that feed into regional centers. The system would be similar, he said, to ASPR's regional treatment network for Ebola.[3] In fact, he said, it is an expansion of that network. In addition, there would be medical operations centers ("regional disaster coordinating center" in Figure 2-9) to provide situational awareness, break down jurisdictional regulations and laws that prevent licensed practitioners from crossing state boundaries, and further leverage the Emergency Management Assistance Compact across states.

"The important piece of this," Yeskey said, "is exercises." Rather than conventional self-evaluated exercises, ASPR hopes to conduct exercises based on training and readiness standards. At the time of the workshop, the first pilot project was scheduled to begin on October 1, 2018.[4] Following the pilot projects, Yeskey said, ASPR hopes to identify best practices and expand to additional states and partners nationwide.

RESOURCES AND CAPABILITIES AVAILABLE AT THE FEDERAL LEVEL

This workshop was not the first time that the National Academies has evaluated medical preparedness to respond to a terrorist nuclear event, John Crapo, deputy program manager, National Nuclear Security Administration, DoE, began. He referred participants to the 2008 National Academies workshop Assessing Medical Preparedness to Respond to a Terrorist Nuclear Event (IOM, 2009). That workshop concluded with a wrap-up by

[3] For more information on this network, see https://www.phe.gov/Preparedness/planning/hpp/reports/Documents/RETN-Ebola-Report-508.pdf (accessed December 10, 2018).
[4] Two pilot projects are under currently under way: one at Nebraska Medicine in Omaha and another at Massachusetts General Hospital in Boston.

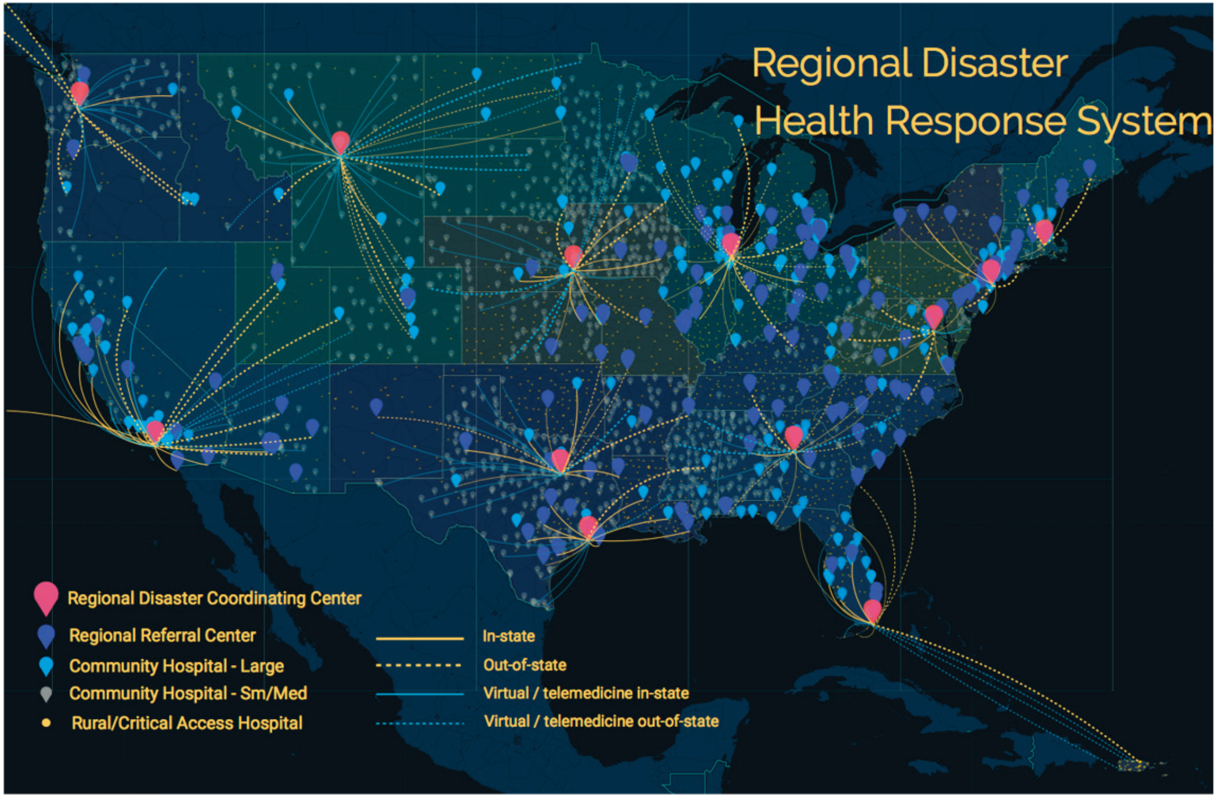

FIGURE 2-9 Notional depiction of a potential Regional Disaster Health Response System.
SOURCE: Yeskey presentation, August 22, 2018.

Georges Benjamin, executive director, American Public Health Association, during which he summarized nine main points reflecting the presentations and discussions, and Crapo revisited these in his remarks.

One of the main takeaways from the 2009 workshop was that local areas were only just beginning to consider planning for response to an IND or a radiological exposure detonation within their jurisdictions. There was also a lack of awareness at the local level of what assets might be available at the state and federal levels and how to procure those assets locally. In addition, Crapo said, there was an assumption that it would be weeks to months before federal resources could be fully mobilized to assist states and locals in response to certain events. Finally, there was a lack of clarity around the meaning of medical and public health preparedness for a nuclear incident.

The first "report card" on preparedness planning for a nuclear incident was released by FEMA in a report to Congress in 2010, in which it stated that more than 80 percent of urban areas were prepared to meet the challenges of a large-scale or catastrophic incident, but less than 50 percent had specific IND and RDD response plan annexes to their all-hazards plans (FEMA, 2010).

A second report card came out in 2013 in the form of a Government Accountability Office report on nuclear terrorism response plans (GAO, 2013), Crapo said. Of 27 major urban areas surveyed, 63 percent had RDD-specific response plans either completed or in development, and 60 percent had IND-specific response plans either completed or in development. "So we're moving in the right direction," Crapo said, "but we need to continue to move the needle to the right."

To that end, Crapo continued, the federal government decided to set an example for regional, state, and local entities for planning for nuclear and radiological incidents, beginning with Presidential Policy Directive 8, in 2011, which designated that the federal government would develop integrated national planning frameworks across five mission areas: prevention, protection, mitigation, response, and recovery. Echoing Yeskey, Crapo highlighted that within the response mission area, the defined planning architecture was based on the all-hazards paradigm (see Figure 2-10). Based on a Federal Interagency Operational Plan, each federal region was to develop its own regional operation plan, and states and local jurisdictions would be encouraged to develop their own all-hazards plans with guidance from FEMA, Crapo said. At all levels, nuclear/radiological annexes are encouraged to help plan for that specific threat.

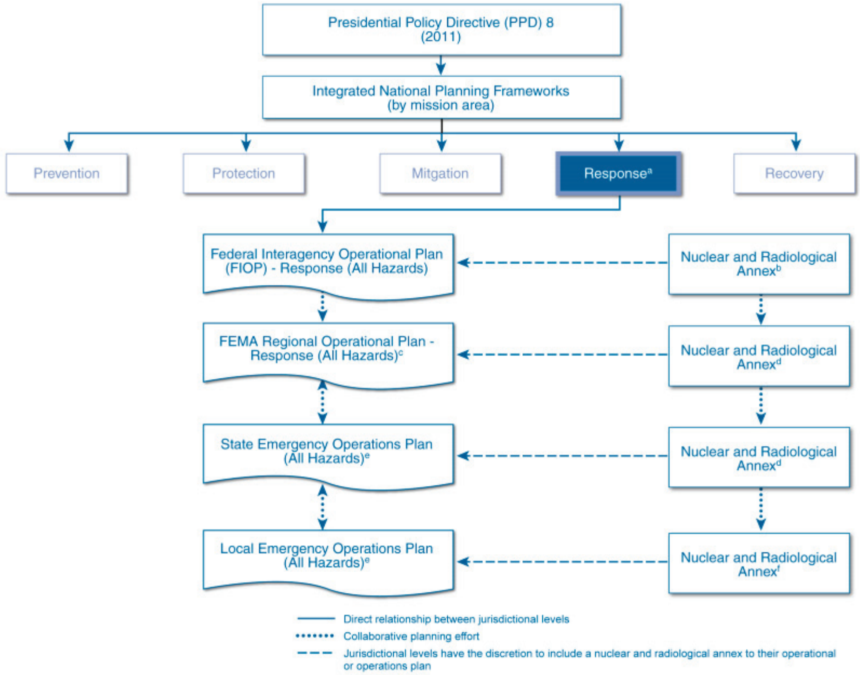

FIGURE 2-10 Federal planning architecture for a response to a nuclear or radiological incident.

[a]DHS issued its first National Response Framework in 2008 that included emergency support functions, incident annexes, and the partner guides. A new response framework is under development.

[b]FEMA is considering the need to revise the existing nuclear and radiological incident annex to the National Response Framework as an annex to a forthcoming FIOPs for the response and recovery mission areas.

[c]This plan is based on FEMA's Regional Planning Guide, which outlines the means to implement the planning process consistent with FEMA's Comprehensive Preparedness Guide (CPG) 101.

[d]State governments have the option to develop specific plans that are annexed to their emergency operations plans based on their assessment of the hazard risk, such as a nuclear and radiological annex. As of 2012, all regional offices, states, and Urban Areas Security Initiative locations must use the Threat and Hazard Identification and Risk Assessment process.

[e]This plan is based on FEMA's Comprehensive Preparedness Guide (CPG) 101.

[f]Local governments have the option to develop specific plans that are annexed to their emergency operations plans based on their assessment of the hazard risk, such as a nuclear and radiological annex. Local governments often use the Hazard Identification and Vulnerability Assessment process to develop their Hazard Mitigation Plans.

SOURCES: Crapo presentation, August 22, 2018, and GAO, 2013.

The Nuclear/Radiological Incident Annex

Adding to MacKinney's description of the *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans* (DHS, 2016b) earlier in the session, Crapo said that the annex is the document that guides federal response and planning efforts involving nuclear/radiological incidents. It identifies overarching coordinating responsibilities of the Federal Radiological Preparedness Coordinating Committee, which provides direction for some 20 federal agencies, departments, and offices responsible for ensuring efforts of the federal government in preparing and planning for response, and of the Radiological Emergency Preparedness Program, which is specific to nuclear power plant response.

Essentially, Crapo said, the annex lays out a concept of operations for a response to a nuclear or radiological incident by identifying the primary authorities (e.g., if an incident occurs at a DoD facility, then DoD is in charge); reinforcing the need to coordinate all planning efforts with regional, state, and local jurisdictions to ensure a coordinated and collaborative response; identifying additional federal agency capabilities to respond; and defining support and coordination elements. Crapo went on to discuss two of these components in more detail: federal agency capabilities and the support and coordination elements.

Key Federal Agency Capabilities

Department of Energy

Crapo said that within the federal response mission space, DoE has bifurcated its capabilities into two areas: (1) crisis response and (2) consequence management. As part of crisis response, DoE is responsible for searching for materials that may be used for nefarious purposes. To do this, it relies on its capabilities to conduct surveillance, identify materials outside of regulatory control, and train regional partners to stabilize devices containing materials outside of regulatory control until a Render Safe team can respond. With respect to DoE's consequence management capabilities, personnel are trained and equipped to provide timely, actionable, and scientifically defensible decision support to local decision makers for the protection of public responders and the environment. As part of its consequence management capabilities, DoE maintains monitoring and assessment, medical support, and modeling.

Consequence Management

In the area of modeling, Crapo explained that DoE's National Atmospheric Release Advisory Center (NARAC) at the Lawrence Livermore National Laboratory has a sophisticated 3-D modeling capability that can predict atmospheric dispersion of a release of radiological material from an explosive device. NARAC is connected to multiple meteorological centers and has atmospheric and assessment scientists who can produce a model of situational awareness based on the meteorological data. This is an important capability, Crapo said, because the fidelity of early information can be very sparse. However, they can provide an initial footprint to help inform planning efforts and protective action recommendations. Then, as additional information comes in, the models can be refined to reflect the "ground truth."

Although initial measurements are conducted at the state and local levels, they can be supplemented by DoE's regional Radiological Assistance Program (RAP), Crapo noted. DoE maintains nine RAP regions, each prepared to send teams to conduct monitoring activities in the event of a release of radiological material into the environment from any source but particularly an RDD or IND explosion. Each region is tethered to a national laboratory, with a core element of full-time staff that support the program.

In addition to RAP, DoE also maintains an Aerial Monitoring System (AMS) for rapid characterization of the magnitude and extent of a release from either a facility or an RDD or IND, Crapo noted. It does this through the use of radiation detection equipment and scientists on board both fixed and rotary wing aircraft. "Flying low and slow is the way to do that," Crapo said. Optimally, a helicopter would fly with the radiation detection equipment outside the aircraft to provide the level of fidelity needed to make critical protective action decisions. Unfortunately, he said, fixed wing aircrafts are better suited for the initial response, and therefore initial answers will be "coarse." Further details are pursued later through rotor wing capability. AMS capabilities come from the Nellis Air Force Base Remote Sensing Laboratory (RSL) in North Las Vegas and the Andrews Air Force Base RSL outside of Washington, DC.

Also responding out of RSL Nellis is a Consequence Management Response Team (CMRT) to conduct an initial assessment. With its monitoring/sampling and geographic information system (GIS) capabilities, it produces situational awareness, supports planning efforts, and informs protective action decisions. It also comes with a fairly light laboratory analysis capability, Crapo noted.

"Once we have done our sampling, once we have done our analysis," Crapo said, "it is important that we translate that scientific information into actionable and comprehensive information for key leaders and decision makers." That is the role of DoE's Consequence Management Home Team. It is empaneled mostly out of RSL Andrews, although it reaches out to other national laboratories, including Sandia National Laboratories, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory.

DoE also provides for medical management. Crapo's office sponsors the Radiation Emergency Assistance Center/Training Site (REAC/TS), a center of excellence for treatment of radiation injury located in Oakridge, Tennessee. The center provides advice and assistance in the management of radiation injury for victims of INDs or RDDs, either through virtual and in-person consultation or by deploying a team to a site. REAC/TS also maintains a Cytogenetic Biodosimetry Laboratory, where a dicentric chromosome assay is used to conduct retrospective dose assessments from blood samples. The assay results are provided to health care providers to drive treatment decisions. In addition, REAC/TS has a robust training capability to help the medical community become better prepared to respond to a mass casualty situation involving radiation exposure, Crapo said.

Other Federal Agencies Involved in the Response

In addition to DoE's capabilities, DoD offers a range of CBRN response capabilities as well, Crapo said. These include 22-person civil support teams that can respond immediately to an incident, much like DoE's RAP teams, and larger teams (1,500 people) of trained, organized, and equipped personnel that can be deployed within a certain period of time to assist with emergency medicine, decontamination, and other issues. "Lots of folks, lots of equipment, lots of help," Crapo commented.

Elsewhere in the federal government, the U.S. Department of Veteran Affairs (VA) maintains a Medical Emergency Radiological Response Team (MERRT), under Executive Order 12657 (1988), to assemble and deploy a health care professional team to the scene of an incident, where it can provide medical advice and assistance in treatment of radiation injury. Ultimately, Crapo said, VA would like to have 33 full teams, with each team having at least one physicist and one physician. Currently, MERRT has 17 health physicists, 8 physicians, and 3 emergency managers.

Crapo noted that these efforts and agencies were only a small sampling of capabilities available at the federal level and that other speakers would be discussing other capabilities, including within HHS, DHA and its component agencies, and the U.S. armed forces.

Support and Coordination of Federal Response

As defined in the *Nuclear/Radiological Incident Annex to the Response and Recovery Federal Interagency Operational Plans* (DHS, 2016b), the support and coordinating elements of the federal response include the Federal Radiological Monitoring and Assessment Center (FRMAC). Crapo said that at the scene of a radiological or nuclear incident, all federal radiological monitoring and assessment activities are coordinated by FRMAC (i.e., after the initial CMRT assessment). Another key support and coordinating element is the Interagency Modeling and Atmospheric Assessment Center, maintained by FEMA, which serves as a single point for the federal government for the coordination and dissemination of products related to the modeling of hazardous atmospheric releases. Yet another key coordinating element is the Advisory Team for Environment, Food and Health (A-Team). A collaboration among the Environmental Protection Agency, U.S. Department of Agriculture, FDA, and CDC, A-Team provides advice and assistance on decision making for protective actions for the public and responders. It responds both virtually and on the scene. Finally, Crapo mentioned the Nuclear/Radiological Incident Task Force, which was discussed further by Luis Garcia (see Chapter 7 for more information).

Asset Response Time Line

Figure 2-11 provides a snapshot of what to expect from the various federal agencies in support of state and local jurisdictions in response to a nuclear or radiological incident. Within the first few hours, state and local responders will be on the scene, as well as RAP and a Command Support Team. As time progresses, more and more people will show up. In Crapo's opinion, while the response may reach a robust capability within 48 hours, 72 hours is probably more realistic.

DISCUSSION

Speakers from the panel on federal roles and responsibilities participated in an open discussion with the audience, summarized below.

The Range of Potential Attacks: How Is the Federal Government Planning for Different Scenarios?

A participant who identified himself as a retired naval intelligence officer and a research ethicist commented on the mentality, or intention, of a perpetrator and remarked that there are many types of potential nuclear incidents that do not involve a bomb in a major city. He asked to what extent military intelligence is helping to define in an expansive way the nature of potential nuclear threats so that the agencies developing response plans can at least become aware of the broader range of actors and modalities that might be used in an attack.

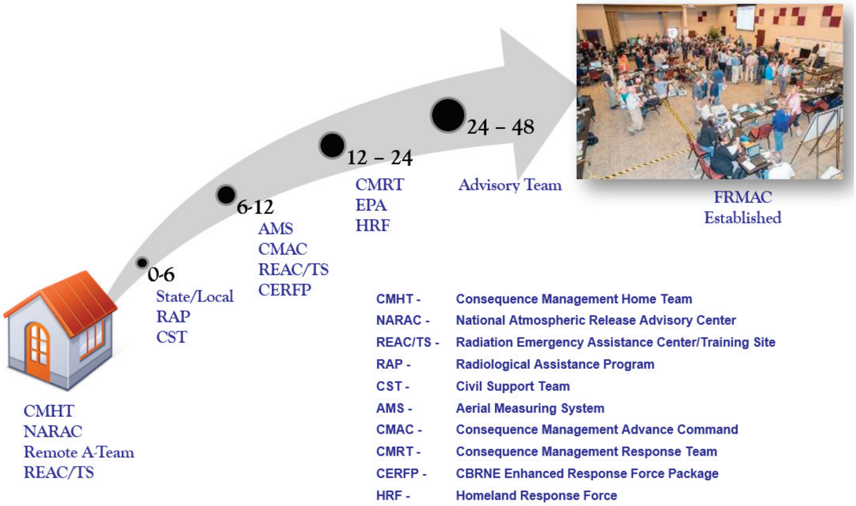

FIGURE 2-11 Time line (hours) depicting when federal agencies participate in a nuclear incident response.
SOURCE: Crapo presentation, August 22, 2018.

Disclaiming that he does not work for DoD or represent the intelligence community and is unable to divulge sensitive information, MacKinney responded that every potential threat is evaluated on an ongoing basis. In the past, the primary nuclear threat was terrorism. With respect to nuclear and radiological terrorism, the focus has been on RDDs and INDs. Although a nuclear bomb is extremely difficult for terrorists to achieve, nevertheless that possibility is monitored closely. The emerging threat from North Korea is one that MacKinney described as being in a “fuzzy zone” between terrorism and war. It would be an act of war if North Korea were to attack the United States, but the attack would be treated like a terrorist attack in terms of an internal U.S. government response. According to MacKinney, the same plans that were developed for a response to al-Qaida are being used when considering a North Korean attack.

ASPR’s Regional Disaster Health Response System

Jody Wireman, environmental health adviser, Defense Health Agency, asked for additional information on the rollout of RDHRS. Yeskey clarified that ASPR is not building more facilities. “We’re not here to build brick-and-mortar hospitals, burn centers, or anything like that,” he said. Rather, ASPR hopes to use existing infrastructure to better facilitate the delivery of care to patients who need it and to access the capabilities of existing facilities in a way that is meaningful. He mentioned that HPP evolved from a program that initially provided money to hospitals for purchasing and stockpiling items into a system that builds competencies. The regional system is currently at a point in its evolution where it is forming coalitions among EMS, public health, and hospitals (at least two hospitals per coalition) that work cooperatively, not competitively, to ensure that a region has the capabilities to take care of patients and provide care. Thus, not necessarily every hospital will maintain all capabilities, but the broader coalition will. In addition, Yeskey said, ASPR is investigating options to build state-to-state agreements so that resources can be exchanged without federal involvement, which is only time consuming and often ineffective for small-scale events.

Risk Communication: Accessing Initial Models

Ed McDonough, public information officer, Maryland Emergency Management Agency, asked Crapo what the time line would be for accessing the first DoE models that become available following a nuclear incident and whether state and local health agencies know how to access the models. Crapo replied that initial models should be available within 15–30 minutes of notification but would only be as mature as the information that was provided as part of the modeling request, although they would also take into consideration available meteorological conditions to indicate how particles would disperse in the atmosphere. Crapo said states should know how to access the models either directly through NARAC or through FEMA's FRMAC.

Electromagnetic Pulse Effect

David Winks, managing director, AcquSight, commented that in both air burst and surface burst scenarios, there is also an electromagnetic pulse (EMP) effect that could impact generator controls, medical equipment in the facilities, and the ability of vehicles to respond in the area. He asked Buddemeier if it would be possible to model EMP effects that might be outside the initial blast zone. Buddemeier agreed that EMP is a significant concern, particularly for high-yield, high-altitude detonations, during which there is a "lensing effect" through the atmosphere. For that type of situation, Buddemeier said that EMP effects need more evaluation. In contrast, with near ground-level detonations, although there is some EMP effect, it is much more constrained to the blast damage zones. While some local disruptions would be expected, transmission towers from AM/FM radio towers, for example, would still be working and could still reach into the areas of concern.

3

Current State of Nuclear Preparedness

Key Points Made by Individual Speakers

- Preparedness for a nuclear incident, especially state-sponsored attacks, varies widely among different geographical and government-level agencies; some jurisdictions have been preparing for nuclear incidents for decades because of nearby nuclear production or other relevant activity, and others have only recently begun to consider nuclear preparedness. No jurisdiction has a fully developed plan for a state-sponsored nuclear attack. (Lujan, McClendon, Williams)
- The Association of State and Territorial Health Officials uses an all-hazards approach in its public health preparedness planning and is now beginning to focus more on nuclear threats, through activities such as the National Alliance for Radiation Readiness and other global partnerships. (Hawkins)
- State and local jurisdictions are most concerned with workforce turnover, lack of funding for nuclear preparedness, the need for ongoing preparedness training, and the need to maintain an appropriate level of expertise on radiological and nuclear threats. (Hawkins, McClendon, Williams)

In the next panel session of the workshop, moderated by Roberta Lavin, executive associate dean and professor, College of Nursing, University of Tennessee, professionals representing state and local government agencies and related organizations were asked to consider the following: the current state of medical and public health preparedness for a nuclear incident; the relationship between current medical and public health preparedness and prior assumptions of the threat environment; possible changes to planning assumptions for nuclear incidents, with particular attention to the (re)emergence of state actor threats; and implications of these possible changes for nuclear incident prevention, planning, and response.

Patrick Lujan, emergency preparedness manager, Department of Public Health and Social Services, Guam, described the events of August 2017, when Guam made headlines worldwide following nuclear threats from North Korea. In October of that year, Guam was threatened again by North Korea. In response, Guam built up its research and planning for any future potential threats, Lujan explained. Lujan was followed by Michael "Mac" McClendon, director, Office of Public Health Preparedness and Response, Harris County Public Health. With its 33 cities, including Houston, Harris County is the third largest county in the United States. McClendon's office is responsible for all-hazards response and recovery planning, and his remarks were also informed by his participation in the National Association of County & City Health Officials (NACCHO) Radiation Workgroup. The third panelist was Chris Williams, deputy director, Office of Radiation Protection, Washington Department of Health. Part of his role is to oversee the state's Radiological Emergency Preparedness Program, which focuses primarily on radiation readiness for Columbia Generating Station, Hanford Nuclear Reservation, and Naval Base Kitsap. In addition, his office works with the Federal Bureau of Investigation and local fire and emergency medical services on radiological dispersal device (RDD) preparedness. Finally, Regina Hawkins, senior analyst, preparedness, Association of State and Territorial Health Officials (ASTHO), and co-lead, National Alliance for Radiation Readiness (NARR), offered an organization-level perspective as a convener of state and local health representatives.

CURRENT STATE OF MEDICAL AND PUBLIC HEALTH PREPAREDNESS FOR A NUCLEAR INCIDENT

Panelists discussed preparedness at several different levels, with Lujan describing Guam's experience as a U.S. territory first. At 33 miles long and 7 miles wide, and with a population of 170,000, Guam is among the largest islands in the North Pacific. Nearby smaller islands look to it for guidance and leadership, Lujan explained. However, until the North Korean threat emerged in summer 2017, nuclear planning was "foreign" to Guam, despite ample public health preparedness planning more broadly, he said. Thus, Guam aggressively pursued a memorandum of agreement with the

U.S. Department of Defense (DoD) to address Guam's response to this new threat, albeit with challenges. For example, the nearest Strategic National Stockpile cache is on the west coast of the continental United States, raising concerns about response time, Lujan said. In addition, Guam's health care workforce is aging, which makes it difficult to build up a medical professional volunteer program. This is true not just on Guam, Lujan said, but also on the outer Pacific Islands. However, compared to the other islands, because of its unique territorial status, Guam is able to lean on DoD to provide resources.

At the state level, Williams explained that Washington's Department of Health initiated its Radiological Emergency Preparedness Program in the 1970s because of the radiological hazards at the Columbia Generating Station, the Hanford plutonium development site, and the U.S. naval shipyards and submarine base. With the advent of public health emergency preparedness (PHEP) and the Office of the Assistant Secretary for Preparedness and Response (ASPR), U.S. Department of Health and Human Services, funding in 2002, the state began investing in public health preparedness on a broader scale. Although the PHEP- and ASPR-funded approach is an all-hazards one, the initial focus was on bioterrorism as directed from the federal government. In addition, the program also focused on threats that were specific to the state of Washington, including local disease threats, such as measles outbreaks, but also floods, wildfires, and other natural disasters, Williams said.

Nuclear incidents, including improvised nuclear devices (INDs) and other missile attacks, are not viewed as high-probability incidents, Williams said, and also a draft IND plan is in place. The radiological incidents are considered high probability to the extent that the state already deals with radiological hazards. Some of the PHEP and ASPR funding has gone into developing community reception centers close to Columbia Generating Station, Hanford, and in Kitsap County to offload the stress from hospitals in the event of an incident. Patients who might be impacted radiologically could then be sent to those centers. Ultimately, Williams said, threats are prioritized and addressed based on funding levels.

Williams said a key concern regarding nuclear threats is public perception. When the Fukushima incident occurred, Williams's office took calls for several months from Washington residents who were concerned about an incident that had happened thousands of miles to the west, separated by an ocean. "The concern of the citizens really impacted our office in terms of the time spent trying to alleviate their fears," he said. If an incident were to occur within Washington, self-evacuation would likely be a problem, with residents attempting to leave without understanding the magnitude of the threat. This, in turn, would impact people and hospitals outside of the impacted area, he said.

Addressing emergency support, Williams said the capacity of facilities in surrounding areas to handle the influx of patients from impacted areas and to treat those patients is a major challenge. Williams described an area of Seattle known as "Pill Hill," where a large number of hospitals, including a Level 1 trauma center, are located. If that area were to be hit, those hospitals and that trauma center would be affected and possibly destroyed, in which case facilities outside of the impacted area would be dealing with issues for which they are unprepared. Williams concluded by noting that Emergency Support Function #8 partner coordination should become a higher priority.

McClendon described nuclear preparedness at the local level. Until recently, he said, Harris County's nuclear preparedness efforts centered around transportation incidents related to shipping out of Port Houston or traveling to and from the port on the highway. Approximately 5 years ago, the Centers for Disease Control and Prevention (CDC) pulled McClendon and his colleagues into Atlanta for a 3-day summit on INDs, RDDs, and related threats, after which his office built and exercised plans, identified gaps, and developed about 25 partnerships across the county.

A key capacity-related challenge for a nuclear incident is derived from the county's responsibility to plan megashelter (a shelter with more than 1,500 beds) operations throughout in the event of an emergency. For example, during Hurricane Harvey, Harris County operated two 10,000-bed megashelters, one at the NRG Center and another at the George R. Brown Convention Center. If the county is also responsible for screening people following a nuclear event, it has to be better prepared, McClendon asserted. Recent nuclear preparedness training exercises have gone well, McClendon said, with respect to the use of electronic and paper screening tools. However, it is unclear how prepared the county is for a larger, state-sponsored event. While the county continues to engage the private sector to support preparedness—including private health care systems, medical societies, and nongovernmental organizations—the private sector partners are not used to the typical government command and control structure, McClendon said.

Workforce issues pose another capacity-related challenge, as made evident during Hurricane Harvey. Harris County Public Health employs 700 people, but only 360 employees worked during the peak of the disaster, while the remaining employees were either unwilling to work or were affected by the hurricane themselves. McClendon described the county's challenge in stressing to employees the importance of their role during an emergency response. "They do their day-to-day function," he said, "but when we have a Type 1 event going on at the local level, they are reassigned, and that is problematic right now for us." He called for refreshing the education and training of new employees so that they understand the importance of emergency response functions.

Regarding emergency management, McClendon hypothesized that if a state-sponsored event were to hit the city of Houston or Harris County, local responders would be on their own for the chaotic first 48 hours after the event, citing a period following Harvey during which entry into the county was exceedingly difficult. The experience led the county to preidentify employee needs during an emergency. Aside from broad all-hazards lessons in disaster preparedness, McClendon said that Harris County has not developed a response plan specifically for state-sponsored nuclear incidents.

Finally, Hawkins offered NARR's perspective on nuclear preparedness, representing a broad coalition of state and local health partners. Regarding its strategic priorities, ASTHO assists its members in building resilient workforces, supports them through technical assistance, provides them with tools and also empowers jurisdictions to develop their own tools for radiation readiness, and helps to shape policy to ensure that the voice of public health is represented. Hawkins remarked that although most of its constituents have adopted an all-hazards planning and preparedness mentality over the years, there has been greater interest recently in preparedness specifically for a radiological or nuclear incident. Hawkins mentioned ASTHO's participation in the Pacific Islands Preparedness and Emergency Response Summit and the sharing of federal (CDC, Environmental Protection Agency, etc.) materials and tools—including infographics and protective action guidelines—with Pacific Island members.

Turning to NARR, Hawkins has noticed growing interest among state and local public health practitioners through NARR's webinars and traffic to other resources. The webinars allow for subject matter experts to discuss the newest tools and discoveries, and in May 2018, NARR released guidance for traveler screening at international ports of entry following a radiological incident; other tools are also in development, she said.

EMERGENCE OF STATE ACTOR THREATS: HAS IT CHANGED PREPAREDNESS PLANNING? HAS IT CHANGED WHO IS AT THE TABLE?

Lack of Nuclear Expertise at the Local Level

McClendon said that because of Harris County Public Health's lack of expertise in radiation, it has entered into a memorandum of understanding with the University of Texas Health Science Center for health physics experts to advise and lead the county through a planning process. The county also leans on its state partners. In addition, the county maintains partnerships through health care coalitions and the private sector. As Houston is the "oil hub" of the United States, McClendon said, several oil corporations are headquartered there, with expertise in planning, responding, and recovering from catastrophic emergencies. For the past 20 years, Harris County has been under either a federal or state disaster declaration response every 9 months (whether due to hurricanes, tropical storms, floods, or other disasters), and as a result there have been many opportunities to work with private sector partners. McClendon predicted that in the event of a state-sponsored nuclear incident, the county would likely lean heavily on the private sector until state and federal support arrive. Based on past experience with Type 1 incidents—the most complex incidents according to the Federal Emergency Management Agency's emergency management grading scale—he described how local jurisdictions tend to scramble during the first few hours of a response, attempting to make sense of what is going on. He imagined that a state-sponsored nuclear incident would be so traumatic that it would stun them initially.

Williams agreed with McClendon that public health generally is not a radiation expert-oriented field. Although the state of Washington has an Office of Radiation Protection, there is no counterpart at the local public health level, Williams said, and Washington's health care coalitions lack expertise in radiation-related issues. Although Williams's office can provide that support, it has only seven staff, all of whom are dealing with other issues, primarily based on funding.

Nuclear Readiness at the Local Level: Calling for Support from Above

McClendon noted that further investment in nuclear preparedness will require further direction and funding from the federal government. The primary focus of Harris County Public Health right now is on day-to-day health promotion: obesity, smoking, other local health issues. When McClendon and colleagues approach the executive director about their planning process, the response is, "Where's your capacity, and where are your dollars? That's the bottom line," McClendon said. Of nuclear incident preparedness, he said, "if it needs to be elevated, then it has to come elevated to us."

Williams agreed with McClendon that an emphasis on nuclear readiness must come from higher level decision makers and be matched by adequate sources of funding. He reiterated that the focus is going to be on immediate, day-to-day issues unless a push is made from the sources that fund the state's preparedness to be better prepared for a nuclear incident. PHEP and other federal sources of funding for state and local health often dictate priorities for these jurisdictions, Williams said.

Optimism: Nuclear Preparedness Is on the Docket

Hawkins offered what she described as "a little bit of a silver lining" in that much of the activity over the past year with respect to the threat of a state-sponsored nuclear incident has acted as a catalyst. For her, one of her most important tasks with both ASTHO and NARR is the forging of very strong relationships with both members and federal partners. Over this past year, ASTHO's federal partners have been reaching out directly and even using ASTHO as a conduit for reaching out indirectly to its members. In Hawkins's opinion, ASPR has been mindful of state and local needs when making revisions to public health emergency preparedness planning. For example, she mentioned ASPR's reaching out regarding the new Regional Disaster Health Response System (RDHRS) and reaching out for feedback and input.

A Role for International Assistance?

Because of its distance from the U.S. mainland, Guam has learned to "think outside the box," Lujan said. Guam's closest neighbors are Japan, Korea, the Philippines, and Australia. He mentioned having recently attended a biosecurity exercise on smallpox that was hosted by the University of New South Wales, Australia. Lujan expressed concern about current geopolitical tensions in the North Pacific and called for making necessary amends so that Guam can seek international assistance should a state-sponsored event occur.

Cham Dallas, university professor of health policy and management and director of the Institute for Disaster Management at the University of Georgia, also touched on the topic of international assistance. He mentioned the World Health Organization's emergency medical teams and the discussions under way about extending the teams' focus to cover thermonuclear threats (Ian Norton discussed this resource in greater detail later in the workshop; see Chapter 6). He too thought that cooperation with other nations was worth considering and wondered how feasible it would be, citing a recent example from his own work supporting Chinese officials working on nuclear preparedness.

WORKFORCE TURNOVER: A MAJOR CHALLENGE TO PREPAREDNESS

Lavin, the moderator, asked panelists how preparedness efforts and plans at the state and local levels are relayed to hospitals, public health departments, and health care providers who are responsible for medical care in the event of a nuclear incident. In response, most of the panelists expressed concern about workforce turnover.

While McClendon commended ASPR's development of RDHRS, he cautioned that the magnitude of people impacted by a state-sponsored nuclear event would require spending more money on training hospital employees—the "boots on the ground" who do not worry about nuclear preparedness on a daily basis. Not only would the hospital employees need to be trained, but training efforts would also need to account for high staffing turnover at various levels, including nursing, and hospitals "have to start all over" 2 or 3 years after a previous training, McClendon said.

Radiation exposure treatment is unfamiliar even to some trauma physicians and providers, McClendon continued, and some providers do not maintain specialty skills across the course of their careers. He recalled how upon issuing a request through the Medical Reserve Corps for nurses to administer vaccines during an H1N1 epidemic, several of the nurses who responded had not administered a vaccine to a child in years. As a result, McClendon's office was forced to offer just-in-time training to educate the nurses on the administration of vaccines for children ages 0–8. He emphasized the need for ongoing and systematic funding to ensure that more hospitals employ providers who can treat people in a nuclear trauma situation.

Williams agreed that staff turnover is a challenge and that maintaining boots on the ground readiness requires ongoing effort. When preparedness activities were still part of the Health Resources & Services Administration (prior to moving to ASPR), he noted, Washington State purchased large quantities of equipment for hospitals to prepare for all-hazards threats and offered annual training to hospital staff. Williams echoed McClendon and noted the frequent and noticeable staff turnover at the training sessions. Many employees in coordinating positions remained, but there was high turnover among hands-on providers.

Hawkins agreed with McClendon's and Williams's concerns about workforce turnover. She noted that NARR has experienced recent turnover due to retirement, and she emphasized the criticality of maintaining subject matter expertise in the area of nuclear preparedness and medical response.

Willingness to Work in the Event of a Nuclear Incident

In addition to expertise and training, Hawkins raised another issue that continually appeared throughout workshop discussions: responders' willingness to work. She explained that there is a fear around radiological and nuclear preparedness even among those who are well educated and understand the risks of such an event.

Lacking in Resources But Strong in Networking: A Different Challenge

The situation in Guam is slightly different, Lujan explained. While the island lacks resources, networking is one of its strengths. Coordination is relatively smooth when an emergency occurs because the major decision makers in the police department, the fire department, hospitals, and other important command centers already know one another, and when the resources arrive, "we just roll," Lujan said.

COMPLACENCY: AN OBSTACLE TO NUCLEAR PREPAREDNESS

Williams explained that in 2002, when he joined Washington State's preparedness program, he had a conversation with his doctor about his work, and the doctor said, "That will never happen here," referring to a potential bioterrorist attack. Williams suspected that conversation would have played out similarly if the topic had been nuclear events. Ultimately, he said, the threat of a nuclear event is not on the public's radar, and people especially tend to avoid projecting the threat onto themselves directly.

McClendon agreed and added that even among local elected officials, the threat is not high on their radar. He suspected that Harris County could successfully draft and implement a plan as a receiver community in the event of a nuclear incident—if Harris County itself were not affected directly but took in displaced persons from the affected area. However, people do not want to project themselves as being the affected community, McClendon noted. Additionally, despite the possibilities for survival and recovery as described by Buddemeier, McClendon said that many officials have a fatalistic attitude toward a potential event. Thus, McClendon emphasized the need to educate even local officials about the threat environment, the realities for survival and recovery, and the need for preparedness planning (see Chapter 5 for additional discussion around communications tools and strategies).

DISCUSSION WITH THE AUDIENCE

Crisis Standards of Care

Jack Herrmann, deputy director, Office of Planning and Policy, ASPR, referred to Buddemeier's description of the magnitude of the potential public health and medical impacts of a state-sponsored nuclear incident (see Chapter 2) and asked the panelists about efforts being made to address crisis standards of care: Are state, local, and territorial jurisdictions working with the health care sector to develop response plans to potential emergencies of this magnitude, during which there may be hundreds of thousands of people needing care?

Williams replied that in his prior role with Washington State's Public Health Preparedness Program, he and colleagues developed a number of work groups to address crisis standards of care. However, groups focused primarily on pandemics and continuity of operations for situations during which, for example, there are more sick people than there are ventilators.

As far as he was aware, the state has not addressed crisis standards of care related to nuclear or radiological threats. McClendon described a similar situation for Harris County. There used to be a statewide crisis standards of care work group, but the effort stalled several years ago, and it has not been revived.

Preparedness for Ship and Sea-Related Delivery

David Winks, managing director, AcquSight, asked whether any of the jurisdictions represented on the panel had considered ships or submersibles being used to deliver an IND. Williams replied that Washington has a program whereby the state works with the U.S. Coast Guard and law enforcement officials to search for radiological sources on ships, particularly in the Puget Sound region. Trainings are conducted two or three times a year. In Texas, the Port of Houston Authority receives federal grant money to screen all containerized cargo that enters the port, McClendon explained. He said it is an active and well-supported program and that Port Authority is in constant communication with Harris County's hazardous materials team and the U.S. Coast Guard; they also have the ability to screen on highways as well.

Concerns About Local Preparedness and Public Outreach

Raymond Puerini, senior program analyst, NACCHO, echoed panelists' concerns about local preparedness and shared findings from NACCHO's most recent annual preparedness profile assessment indicating a low level of concern regarding radiation issues. About 20 percent of respondents expressed concern about an accidental release, and only 16 percent reported feeling very prepared for an actual radiation emergency. In addition, 42 percent of respondents reported that they were not conducting any preparedness activities related to terrorist threats, and 35 percent reported that they were not conducting any activities related to CBRN (chemical, biological, radiological, and nuclear) threats.

Puerini said that NACCHO has also engaged stakeholders at both the local and state levels to understand gaps in preparedness, some of which are the same as those described by the panelists, including a lack of perceived risk of being affected by a nuclear incident and lack of outreach and public awareness. In addition, he said, stakeholders reported organizational silos and competing priorities that make it difficult for leadership to buy in to preparedness. Of these, lack of outreach and public awareness is the most profound gap, Puerini said.

Puerini asked Lujan about the strategies being deployed in Guam when facing threats from North Korea to engage the public and make people feel safe and prepared. Lujan replied that the general strategy centered around CDC's shelter in place message, and the territory worked with the Department of Homeland Security and DoD to spread it. In addition, they partnered with the University of Guam to hold live broadcasts.

Partnering with Vendors

In addition to the partnerships described by Hawkins, Kris Arnold of the American Red Cross Scientific Advisory Council suggested pursuing partnerships with hospital product vendors. She mentioned the increased use of advisory assistance in hospitals and projected that with these partnerships in place, hospital officials would be more easily able to efficiently disseminate (via electronic systems) current knowledge and instructions for handling radiation contamination and other CBRN problems.

4

Updating Planning Assumptions of Nuclear Preparedness

Key Points Made by Individual Speakers

- Stakeholders in nuclear preparedness need to begin considering the threat of larger yield weapons (up to 100 kilotons [kt], 475 kt) and devote more attention to burn care, which could prove to be the "Achilles' heel" of a response due to the number of injuries and lack of expertise in that field. (Dallas)
- A state-sponsored nuclear attack anywhere in the United States would require a national response because fallout from larger weapons is greater, with radioactive material traveling farther and higher in the atmosphere. Despite gains made in the past decade, resiliency in the new threat environment is still a work in progress. (Whitcomb)
- At the state level, there is acknowledgment that the state would need additional resources to respond to attack, but there is confusion about whether such aid would originate through federal resources such as the U.S. Department of Defense or through mutual aid with other states. (Young)

Nuclear preparedness planning has been under way for decades, particularly in the past 20 years, but the reemergence of state actors has changed the threat calculus. In Panel Discussion II, moderated by Cham Dallas, university professor of health policy and management and director of the Institute for Disaster Management at the University of Georgia, panelists continued to explore possible changes to planning assumptions for nuclear incidents in response to the reemergence of state actor threats and the implications of these changes for the challenges of nuclear incident prevention, planning, and response. Based on his extensive field experience in radioactively contaminated areas, including 12 expeditions to Chernobyl and 6 expeditions to Fukushima, Dallas opened the panel with a brief presentation on the magnitude of the problem, with an emphasis on the overwhelming number of thermal burn casualties to be expected in the event of a thermonuclear detonation.

Dallas was followed by Robert Whitcomb, chief, Radiation Studies Section, National Center for Environmental Health, Centers for Disease Control and Prevention (CDC). CDC's work in this area has largely focused on assisting and supporting its state and local partners in public health preparedness, mostly in communication, education, and training. Much of this work is done by a small staff of radiation experts, education and communication professionals, and contractors who help to test CDC messages in various scenarios. CDC also has experience working with communities that have been impacted by fallout from nuclear weapons testing (e.g., communities living near nuclear testing sites in the Pacific), and Whitcomb focused his presentation on this experience. Finally, James Young, program manager, Radiological Emergency Preparedness and Emergency Management, North Carolina Department of Public Safety, offered a state-level boots on the ground perspective. Although his work focuses mostly on fixed nuclear power plants, other nuclear threats would fall under his purview too. His program has an active partnership with other state agencies, including law enforcement and intelligence organizations.

This chapter summarizes these remarks and the panelist discussion that followed. Summaries of remarks made during the question-and-answer period at the end of the panel are interspersed throughout the chapter where relevant.

MAGNITUDE OF EMERGING NUCLEAR THREATS

Dallas reiterated concerns that thermonuclear weapons are once again an emerging threat after having faded following the Cold War, not only because of current geopolitical tensions with North Korea but because of threats from other countries as well. He compared fatalities, casualties, and other impacts of three different nuclear weapon yield, all modeled based on what would happen if the detonations were to occur in Seoul, South Korea:

1. 25 kilotons (kt), which is slightly larger than the Hiroshima and Nagasaki devices and larger than the 10 kt yield typically assumed for planning purposes
2. 100 kt, which is in line with the potential yield of a North Korean device
3. 475 kt, which matches the size of weapons on U.S. Trident nuclear submarines (see Table 4-1)

With respect to fatalities in these modeling scenarios, there would be an estimated 33,000 from a 25 kt bomb, 110,000 from a 100 kt bomb, and 394,000 from a 475 kt bomb. Regarding prompt radiation, which is the radiation that occurs at the moment of detonation, there would be approximately 97,000 casualties from a 25 kt detonation, compared to 176,000 for a 100 kt detonation and 341,000 for a 475 kt detonation.

Dallas said casualties would be the major category of concern because those individuals would require treatment. While the relationship between yield and the number of people affected is nonlinear, the number of people affected by a larger yield detonation would quickly overwhelm any medical care system, as a typical hospital would already have 90–95 percent of its beds filled prior to a disaster. For a 25 kt bomb, there would be 67,000 casualties; for a 100 kt bomb, 229,000 casualties; and for a 475 kt bomb, 809,000 casualties.

TABLE 4-1 Comparison of Predicted Casualty Distributions for 25, 100, and 475 kt Nuclear Weapon Detonations in Seoul, South Korea

	25 kt	100 kt	475 kt
Fatalities (50% fatality; blast 8.1 psi)	33,000	110,000	394,000
Prompt radiation[a] (300 REM)	97,000	176,000	341,000
Casualties[b] (50% casualty; blast 4.9 psi)	67,000	229,000	809,000
Residential buildings destroyed (blast 3 psi)	155,000	504,000	1,674,000
Mass fires (50% chance)	239,000	1,064,000	3,800,000
3rd-degree burns	443,000	1,850,000	5,382,000
2nd-degree burns	770,000	2,891,000	6,838,000
1st-degree burns	1,592,000	4,586,000	10,413,000
Broken glass (0.6 psi glass shatters)	3,950,000	6,842,000	14,248,000

NOTE: kt = kiloton; psi = pound-force per square inch; REM = Roentgen equivalent man.
[a] Radiation emitted instantaneously by a nuclear explosion.
[b] Persons with injuries requiring treatment.
SOURCE: Dallas presentation, August 22, 2018.

Thermal Burns: A Weakness of the U.S. Health Care Systems in a Mass Casualty Situation

To Dallas, the number of potential thermal casualties expected as a result of fires following a thermonuclear incident overshadows nonthermal casualties, and he clarified that thermal burn casualties are not the same as radiation burns. Dallas said that some fires would be in the direct line of sight from the air burst, while others would be generated on the ground when materials catch fire because of the intense heat of the explosion. He clarified that the estimates shown in Table 4-1 are speculative as there are no data for thermonuclear weapons in urban areas; even if the estimates are far from accurate, he said, the statistics are staggering because "thermal burns are the Achilles' heel of our health care system for mass casualty management," Dallas observed.

Dallas was the first of several participants who emphasized the lack of capacity in the U.S. health care system to care for burn patients in a mass casualty situation. A typical hospital has three or four medical care personnel tending to a single burn patient. In a nuclear detonation situation, there would be an overwhelmingly large number of thermal burn patients and only a small number of qualified medical care personnel who would have survived to help, and he emphasized the importance of thermal burn care for the likely millions of patients who would require support in such a scenario.

Burn Care Discussion

Colleen Ryan, professor of surgery, Harvard Medical School, and a representative of the American Burn Association (ABA), agreed with Dallas's characterization of burn care as the "Achilles' heel" of the U.S. health care system and noted that there are approximately only 300 burn surgeons in North America. She described burn nursing as a similarly limited profession. Moreover, she stressed the need for enhanced capacity given that burn care requires months of attention and rehabilitation.

James Jeng, surgeon, Crozer-Chester Medical Center (Pennsylvania), and chair of ABA's Disaster Subcommittee, lamented the lack of quality training offered in burn surgery in the United States, noting that the requirement for burn training was removed from the formal syllabus for surgical training approximately 10 years ago. "I think it is incumbent on this country and the leadership to do whatever they need to do to reinstate burn training into the general surgical syllabus of the United States," Jeng said.

Other Types of Care: Injuries and Pediatric Care

Recognizing the dearth of burn surgeons and the limited number of training opportunities in burn care, Arthur Cooper, medical director, Harlem Hospital Injury Prevention Program, and a representative of the American Academy of Disaster Medicine, asserted that the situation is no less egregious in terms of preparation for pediatric burn and trauma care. Noting the numbers in Table 4-1, he pointed out that the expected injuries from falling glass are three times greater than the number of burn patients requiring care. He called for better training and preparation for pediatricians too.

Modeling: Different Assumptions, Different Impacts

During the open discussion with the audience, Buddemeier remarked on the "scary" and "defeatist" numbers presented by Dallas and clarified that the numbers are based on a simplified modeling approach that did not take into account the fact that 85 percent of the people in Seoul would be inside buildings at the time of an attack and thus have some protection from many of the prompt effects. With a warning system, many additional people would be able to take protective action from the detonation, Buddemeier said. In addition, actions taken immediately after a blast can help to avoid many of the fallout and post-detonation effects counted. Thus, Buddemeier concluded that Dallas's statistics were overestimates. "We can save a lot of lives," he said. "I completely agree," Dallas responded and noted that nonetheless the numbers illustrate the difference in impact between smaller and larger weapons.

Fallout from a Large Thermonuclear Weapon: Regional Impact

Whitcomb described differences in fallout between different-size weapons. The total atmospheric yield of all the above-ground nuclear weapons tests conducted at the Nevada Test Site,[1] primarily in the 1940s through the 1960s, was 1 megaton (Mt) total. Hundreds of small weapons tests were conducted there. In contrast, the yield of the more than 60 tests of large thermonuclear weapons conducted in the Pacific Proving Grounds[2] in the Marshall Islands totaled more than 108 Mt. An accident occurred in 1954 during Castle Bravo, the largest test at the Pacific site, and Whitcomb used this as an example to explain the possible effects of large-yield devices. The

[1] For more information, see https://www.atomicheritage.org/location/nevada-test-site (accessed December 10, 2018).

[2] For more information, see https://www.cdc.gov/niosh/ocas/ppg.html (accessed December 10, 2018).

fallout extended approximately 200 miles, with snowlike coral falling from the sky and exposing people on a Japanese fishing vessel and people on the Rongelap and Utirik Atolls to acute cutaneous radiation energy. Whitcomb explained that snow would have been an unusual phenomenon for a Pacific Island nation, so naturally children went outside and played in it. Those who were exposed experienced severe radiation burns between their toes, fingers, the crevices of their armpits, and around their necklines, and it was 1–2 days before islanders were evacuated. Whitcomb said that the fallout from higher yield tests is greater because radioactive particles are blasted higher into the atmosphere, where the winds are faster and move in different directions. This has implications for regional planning, namely that the impact could extend beyond the region where a blast occurs. In the event of a state-sponsored nuclear attack on the United States, the U.S. Department of Defense's (DoD's) focus would be on national defense, not defense support for civil authorities. As a result DoD medical resources should not be expected to be available for domestic response.

Building Resiliency

Whitcomb stressed the need to reconsider potential measures for building resiliency given that a thermonuclear detonation would likely divert DoD's focus from civil support to national defense. To build resiliency, Whitcomb called for extensive communication networks nationally, regionally, and locally to encourage communities to recognize a state-sponsored nuclear event as a threat. He also noted that a nuclear event should activate Emergency Support Function #8 functions and encouraged leveraging lessons from recent disasters in preparedness and response planning. Finally, he called for better coordination between the Office of the Assistant Secretary for Preparedness and Response (ASPR), U.S. Department of Health and Human Services (with its focus on medical systems), and CDC (with its focus on public health), emphasizing that the country's preparedness relies on such partnerships. Individual resiliency plays a role too, Whitcomb argued. He recalled the self-preservation training that he completed in elementary school for tornadoes and hurricanes and said that, in his opinion, similar training for self-preservation in the event of a nuclear explosion should be part of the educational system.

Educating the Public About What to Do in the Event of a Nuclear Incident

During audience discussion, Ed McDonough, public information officer, Maryland Emergency Management Agency, recalled the familiarity and call to action of a siren or television notification in the 1960s and 1970s. In his opinion, reeducating the public about what to do in the event of a nuclear emergency will require a massive effort across several agencies, including many stakeholders outside of traditional public health and emergency management. "We can't just have people hear a siren and go run out in the streets," he warned. Whitcomb agreed, but remarked that these issues are being addressed at the national level. He mentioned Emergency Support Function #15[3,4] and a radiation/nuclear communications work group in Federal Radiological Preparedness Coordinating Committee, through which federal agencies have coordinated and tested messaging, he said. However, Whitcomb said the federal government's primary focus has been for an improvised nuclear device (IND) scenario, and he suspected that the messages themselves and the source of messaging will both need to be updated. The source of the messaging is very important for compliance or self-preservation, he emphasized. Dallas explained that his fear is that media would spread dueling narratives, and as a result, the response community would need to be very aggressive in dealing with false information following an event.

Phillip Maytubby, director, public health protection, Oklahoma City-County Public Health Department, commented on the often competing messages and situational instructions from different federal entities. For example, during the Oklahoma City bombing, law enforcement officers nearly exchanged gunfire due to mixed messages received from federal leadership. He was curious whether the federal government has a nuclear incident communications protocol and information dissemination strategy already in place in anticipation of a nuclear incident. Whitcomb replied that a strategy "is still a work in progress" but noted that efforts are ongoing (this and other communications topics are addressed in Chapter 5).

Small Weapons Remain a Threat: The Importance of Preparedness at the Local Level

During audience discussion, Cooper recognized that the focus in nuclear preparedness is shifting back toward a possible thermonuclear event but cautioned that a smaller weapon may still be a perpetrator's weapon of choice. He emphasized that preparedness should address both large and small weapons, especially because local jurisdictions are likely to play a larger role in a small device response.

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[3] The radiological-specific annex to Emergency Support Function #15 (ESF#15) can be found here: https://www.fema.gov/media-library-data/1524598859382-128a5164750ee5540812a6e832bf0c4c/AnnexN.pdf (accessed December 10, 2018).

[4] ESF#15 is responsible for external affairs. https://emilms.fema.gov/is230c/fem0104160text.htm (accessed January 18, 2019).

Ripple Effects of a Nuclear Detonation

"A nuclear detonation anywhere is a nuclear detonation everywhere," Whitcomb said. It would impact communities far from the blast site, he said, particularly if it occurred on American soil. Whitcomb also touched on concerns that would arise should a nuclear attack occur elsewhere, including repatriation. The traveler screening guide from the National Alliance for Radiation Readiness, which Hawkins mentioned, and other activities similar to it would be put into action beyond their original purpose. CDC gained important experience, Whitcomb continued, through its recent year-long preparation for Operation Gotham Shield, a tabletop exercise of an IND scenario on the border between New Jersey and New York, coordinated by the Federal Emergency Management Agency as part of the national exercise program. He said that the exercise represented one of the main activities in CDC's Training Exercise and Preparedness Program, and such activities allow CDC to better assist state and local preparedness efforts too.

A STATE-LEVEL PERSPECTIVE: NORTH CAROLINA

Other Potential Targets to Consider in Addition to Metropolitan Areas: Military Bases

Describing state-level preparedness, Young argued that typical discussions of a nuclear weapon attack and preparedness for such an attack focus on metropolitan areas. In North Carolina, this includes Charlotte and Raleigh. Charlotte is a hub of business in the state as home to Wells Fargo, Bank of America, and Duke Energy. Raleigh is the state capital, home to North Carolina State University, and close to the University of North Carolina at Chapel Hill and Duke University. However, Young noted, when considering a potential state actor attack in North Carolina, other potential targets could include the state's three military bases: Fort Bragg, which is the largest Army base in the United States; Camp Lejeune, a Marine Corps base on the coast and the only operational Marine Corps base in North Carolina (i.e., with actual war fighters, not just training and education commands); and Seymour Johnson Airforce Base.

When considering the logistics of preparedness for a nuclear attack on one of these bases, an important difference between them and a metropolitan area is that they are located in areas with small populations. Young counted 13–15 hospitals within 35 miles of Charlotte, compared to only 3 hospitals within 35 miles of Camp Lejeune. Not only are there fewer hospitals, but in the event of a nuclear attack, transportation would be a major challenge near the bases because of less developed roads and infrastructure (e.g., a four-lane highway in Charlotte versus a two-lane road near the base). In addition, housing would be a challenge. As was learned with Hurricane Matthew, Young said that residents who live in affected areas are often reluctant to relocate, and even if they agree to do so, there are limited temporary housing options (e.g., hotels). Young predicted that it would be very difficult to temporarily house more than 1,000 people.

There are also fewer first responders in rural areas, Young said. If a blast were to occur in Charlotte or Raleigh, it is likely that a battalion chief for either the city or county fire department would be able to take control. That may not be the case in one of the smaller counties in which there may be only two or three first responders who themselves may have been impacted by the blast. Mutual aid would be a vital resource for these counties, Young said.

A Shift in Reliance on Federal Resources

Young agreed with Whitcomb that in the event of a state-sponsored attack, it is not clear which federal agencies the state could rely on with DoD's attention on national security concerns. He mentioned a Command Support Team that is part of the North Carolina National Guard and handles CBRN (chemical, biological, radiological, and nuclear) threats. Whereas a terrorist attack typically involves a single detonation, this may not be true in the case of a state actor. Similarly, when there is a problem at one of North Carolina's nuclear power plants, Young's office counts on the Federal Radiological Monitoring and Assessment Center to show up for support within 48 hours. He suspected that this may no longer be a valid assumption in the event of multiple detonations, and he ceded that decision-making responsibilities would become muddled in such a chaotic event.

A Shift in Reliance on Mutual Aid

North Carolina's emergency management community has an active and effective mutual aid program, Young said. In the past 2 years, the state has sent teams to support Puerto Rico's response to Hurricane Maria, helicopters and swift water boats to Houston to help evacuate people during Hurricane Harvey, and an incident management team to Hawaii to support the response to the Kilauea Volcano eruption. In return, North Carolina received ample support during Hurricane Matthew. However, Young explained that responders question their own safety at response sites too, and their level of comfort following a terrorist attack versus a state actor attack may differ if there is uncertainty about the possibility of multiple detonations. In that case, Young said, mutual aid may not arrive as quickly. When asked by Dallas what North Carolina would "give up" to other jurisdictions if an attack occurred elsewhere—for example, in Atlanta or Washington, DC—Young clarified that a state's primary responsibility is to take care of its own citizens, so that determination would be made first. After that, "everything is on the table," he said. He referred to the Emergency Management Assistance Compact's (EMAC's) standardized process for identifying a threat and determining mutual aid and noted that all 50 states belong to EMAC.

North Carolina's All-Hazards Approach

Young said that North Carolina uses an all-hazards approach to preparedness; the North Carolina Emergency Operations Plan covers most threats, with annexes covering certain individual threats, including hurricanes, winter storms, pandemic flu, and various types of agricultural disasters. The state does not have an annex for a nuclear detonation, he said. In the event of a nuclear attack, the state would rely on its all-hazards plan, supplemented by the North Carolina Radiological Emergency Response Plan. Young mentioned certain counties or cities where there are select radiologically trained state personnel, such as Charlotte, but those personnel are not distributed broadly or evenly across the state. Young echoed McClendon's and Williams's calls for a directive from the federal government—or, Young added, from senior elected leaders in the state, law enforcement, or the intelligence communities—that a nuclear incident is more likely to occur than previously believed.

REGIONAL RESPONSE: OPPORTUNITIES AND CHALLENGES

Building on Yeskey's description of ASPR's Regional Disaster Health Response System, Dallas asked the panelists how the regional planning process would be useful and what obstacles to its implementation exist. Young opined that with a larger weapon, a regional response would essentially become mandatory. Although North Carolina may have the capacity to respond to a smaller weapon, if, for example, Charlotte were destroyed or incapacitated, he said, "There is no way the state is going to handle that alone." State leaders recognize this, he said. He explained that, through its hurricane evacuation efforts, the state has built a good working relationship with neighboring states such as South Carolina, Tennessee, and Virginia, so state leaders understand the concept of a regional partnership and have a framework on which they can build. However, he said, the details of planning a nuclear incident response are daunting.

Whitcomb referred to the summary of a National Academies workshop, *Nationwide Response After an Improvised Nuclear Device Attack: Medical and Public Health Considerations for Neighboring Jurisdictions: Workshop Summary* (IOM, 2014b), in which several key issues relevant to a regional response were identified. While the proceedings are more than 5 years old, he offered that these concerns remain relevant. They included

- competition for federal and regional resources;
- loss or absence of jobs, income, schools, health care, and other basic components of daily life;
- increased mental health problems, including fear and other acute stresses from this type of overwhelming event;
- overwhelmed local medical and public health systems;
- increased concern about public safety (e.g., looting, increased crime);
- radiation concerns;
- sanitation problems (e.g., no sanitary pickup, wastewater treatment systems no longer functioning);
- sheltering needs;
- special needs of vulnerable populations; and
- suspension and curtailment of routine state and local government, public health, and safety functions.

Logistical Challenges: Moving Materials, Transporting Patients, and Accessing the Strategic National Stockpile

Andrew Scott, senior radiological/nuclear health adviser, Countering Weapons of Mass Destruction Office, U.S. Department of Homeland Security, voiced concern about the logistical problems of moving materials into and around an impacted site and simultaneously moving patients out of an impact zone to receive treatment at a regional or national health care facility. These problems would be especially challenging in the event of a state agent nuclear detonation, in which case all of the U.S. military's heavy airlift assets would be deployed elsewhere. Dallas commented on U.S. aeromedical evacuation capability, in particular the C-130 transport plane. In his opinion, it is an underused transport capability in nuclear incident planning given that ground transportation would be very limited and that helicopter availability would likely be limited as well. He imagined bulldozers removing debris to create makeshift runways for the planes to land. Tener Veenema of the Johns Hopkins School of Nursing and Bloomberg School of Public Health mentioned the Strategic National Stockpile (SNS) and expressed skepticism that the stockpile would be accessible within 12 hours of an event. She said access would depend on the scope of the event—including the possibility of multiple blast sites—and the location.

ROLE OF THE PRIVATE SECTOR IN PREPAREDNESS PLANNING

Dallas mentioned several countermeasures held in the SNS that are used to address acute radiation: sodium alginate (for strontium-90), diethylenetriamine pentaacetate (pentetic acid) (for plutonium), and insoluble Prussian blue (commonly referred to by its brand name, Radiogarse) (for cesium-137). Dallas was unaware of a single Food and Drug Administration–licensed facility that can produce any of the radio-protective agents in the stockpile. In his opinion, engaging the private sector would be an enormous resource for medical countermeasure production and other response capabilities, and he commended private sector involvement in other recent disasters. Whitcomb replied that the private sector already plays a role in procurement of SNS material, although it is true that there are no pharmaceutical companies involved with the stockpiled radiation-specific materials as many of these were produced elsewhere. The good news, he said, is that he believed ASPR's Biomedical Advanced Research and Development Authority (BARDA) has put significant investment in research and development of new medical countermeasures, including for acute radiation syndrome, and diagnostic tools for acute radiation.

However, during audience discussion, Paul Eder, senior medical diagnostics analyst with Tunnell Consulting and a contractor with the diagnostics division of BARDA, clarified that the diagnostic tools are not yet procured for the SNS, although discussions are under way to consider that action. In addition, he clarified that the medical countermeasures mentioned by Dallas are for inhalation radiation. In a nuclear weapon attack, cutaneous radiation injury would be the greater threat, and there are currently no medical countermeasures stockpiled for that. (Further discussion of medical countermeasures can be found in Chapter 7.)

Motivating the Private Sector

Eder suggested that states could play a role in supporting diagnostic testing through the private sector. He posed a scenario in which a large nuclear event leads to 100,000–200,000 individuals requiring testing for radiation absorption. In theory, states like North Carolina that have large reference testing laboratories (e.g., Quest, LabCorp) could provide very rapid testing within 1–7 days of an event. He noted, however, that such a quick response would require labs to prioritize the radiation testing and would require technicians to work around the clock during that period. Although the federal government could arrange contracts with these laboratories in advance of an event, until such logistics are worked out, Eder wondered whether there were actions that states could take in the meantime to incentivize the private sector to assist in testing.

While Young was unaware of any North Carolina state-level legal or contractual structure that would compel the private sector to respond, over the past several years, the state has been emphasizing partnerships with the business community, he said. Recently the state founded what it calls "the business EOC" (emergency operations center), whereby for every emergency the state includes representatives from the relevant business sectors.

For example, if a regular cell tower is damaged or destroyed, the state can request that AT&T or Verizon provide a cell tower on wheels. The banks headquartered in North Carolina have become active as well, Young noted, for example, by providing ATMs on trailers so that members of the public can access cash. Based on these experiences, Young did not anticipate that engaging private laboratories would prove to be an issue. Dallas added that while engaging the companies may work, training the technicians and motivating them to participate would be a separate challenge. Rather than a just-in-time training, he imagined some sort of short-term training conducted well in advance of an emergency event.

William Blakely, senior staff scientist, Armed Forces Radiobiology Research Institute, Uniformed Services University of the Health Sciences, commented on the World Health Organization (WHO) BioDoseNet,[5] a network of about 65–70 biodosimetry laboratories worldwide dedicated to dose assessment by cytogenetics. Most of the labs are federally funded, and most participate in annual exercises to demonstrate performance competency. Blakely's lab participates in these exercises every year. He suggested tapping into the network as a resource in the event of a national incident during which local resources are overwhelmed. In addition, he mentioned that there are more than 200 commercial laboratories in the United States with automated dicentric assay scoring systems, which are very helpful for high throughput analyses. He suggested an initiative to certify these labs to serve as a force multiplier in a response to a nuclear incident. Finally, Blakely also mentioned that WHO and the International Atomic Energy Agency are creating other international networks of a wider range of diagnostic labs (i.e., noncytogenetic) that could potentially be of use.

FEAR OF RADIATION: IMPLICATIONS FOR PLANNING

Workforce Incentives

Dallas echoed Hawkins's earlier concerns about the fear of radiation events and lack of willingness among medical care and public health personnel to respond in the event of a nuclear disaster. He wondered what guidance, moral appeals, or other incentives would encourage medical and public health personnel to show up to work at various response levels. CDC relies on monetary incentives, Whitcomb replied, and he mentioned the Division of State and Local Readiness within the Office of Public Health Preparedness and Response that issues the public health emergency preparedness (PHEP) grants. Although many of the preparedness efforts that

[5] For more information, see https://www.who.int/ionizing_radiation/a_e/biodosenet/en (accessed December 10, 2018).

began after 9/11 were initially bioterrorism-centric, that focus has changed. Now many of the state and local jurisdictions receiving PHEP funding address radiation preparedness too.

Whitcomb said that in addition to monetary incentives, there is a need to convince state and local preparedness and public health partners that the nuclear threat is a true risk. This applies even outside of major metropolitan areas or other target areas, he argued, stressing the regional nature of such an event. Young said that the fear factor is difficult to assess in North Carolina because most of the people who have been trained to respond to a nuclear power plant incident are volunteer firefighters, whom he described as likely to be afraid of radiation. He suspected that this fear would drive the volunteer response. Young stressed the need to ensure that both volunteers and professionals be certain that their families are being cared for so that they can concentrate on their jobs. He added that the challenge is not only convincing the workforce to show but also forcing nonqualified responders away. “Some folks are going to run to the fire no matter what their qualifications are,” he said. Ultimately, Young said, focusing on the potential to save lives during a response is critical to responders’ success. “Focus on the positives and the people you can help,” he said, “instead of zeroing in and getting tunnel vision on the people you can’t help or the things that you can’t fix.”

Public Fear: Implications for Assumptions About a Perimeter

Dallas elaborated on the fear of radiation and said that despite federal guidance for sheltering in place and public knowledge that buildings can provide significant protection from fallout, people have a natural tendency to flee. “Radiation is just different,” he said. He recalled the “stunning” fear of birth defects in Chernobyl. Approximately 30,000 of the 90,000 women who were pregnant while exposed to the contamination terminated their pregnancies, citing a fear of birth defects. Yet, according to Dallas, a follow-up of the other 60,000 full-term pregnancies showed no birth defects; even after this discovery, agitation about possible birth defects persisted. He suggested setting up a perimeter around a blast site to quell fear. Young replied that in nuclear power plant planning, the assumption is that a perimeter will be set up around the plume and contaminated area and that individuals entering and exiting the perimeter will be tracked. However, he admitted that implementing such a strategy would be difficult. “I’m not sure it’s going to be feasible, to be perfectly honest,” he said. Dallas suggested that the National Guard may play a role in maintaining perimeters when the fear factor is so significant.

5

Implications of Communication, Education, and Information Challenges

Key Points Made by Individual Speakers

- Effective communication is a critical tool in disaster preparedness and response, including nuclear events. While progress has been made in this area over the past decade, gaps remain in understanding the most effective ways to communicate with various stakeholders: addressing information needs for first responders and specific health care stakeholders, addressing fear among responders, and addressing information needs of vulnerable populations, including children. (Becker)
- Wireless emergency alerts, 90-character first-alert messages, are being researched and tested for their use in different hazard scenarios, including a nuclear incident. But they come with challenges, and there is still a lot to be learned about how to use them effectively. (Bean)
- Ventura County, California's innovative public information campaign on nuclear safety, launched in 2014, includes a series of video public service announcements. Despite bureaucratic hurdles during their production and release, there was positive public reception to the campaign. (Levin)
- "Get inside, stay inside, stay tuned" is a critical message for nuclear preparedness, and planners should do more to take advantage of teachable moments to spread consistent messaging across platforms, including social media. (Wieder)

In Session IV, workshop participants considered a range of communication, education, and information challenges posed by a nuclear incident; the implications of these challenges for capacity building; and opportunities and approaches to addressing them. The session opened with the workshop keynote address by Steven M. Becker, professor, community and environmental health, Old Dominion University. Becker prefaced his address by noting that the information he would be presenting was informed by research as well as his own field experience at sites of various incidents around the world involving radiation emergencies, including the Tokaimura criticality accident in Japan in 1999, the Chernobyl follow-up in Ukraine and Belarus, and the Fukushima Daiichi nuclear emergency following the Great East Japan Earthquake of 2011.

Becker's keynote was followed by a discussion among four panelists with expertise in communication related to nuclear detonation events. First, Hamilton Bean, associate professor of communication and director of the International Studies Program at University of Colorado, Denver, provided an overview of wireless emergency alerts (WEAs) and research on WEA messaging. In his presentation, Bean explained what WEAs can and cannot do currently and what remains to be learned. Next, Baruch Fischhoff, Howard Heinz University Professor at the Institute for Politics and Strategy and in the Department of Engineering and Public Policy at Carnegie Mellon University, discussed challenges and proposed solutions for improving risk communication in nuclear incident management. Robert Levin, public health officer of Ventura County, California, described Ventura County's innovative video-based public service announcement (PSA) approach to educating its citizens about nuclear incident preparedness. Finally, Jessica Wieder, director, Center for Radiation Information and Outreach, Environmental Protection Agency (EPA), discussed the many communication tools for detonation events that have been developed by the interagency Nuclear/Radiological Communication Working Group. In addition to describing the many publicly available interagency nuclear threat communication tools, Wieder provided some personal perspective on nuclear detonation messaging based on her 14 years of work in radiation communications and nearly 10 years of work on nuclear detonation messaging in particular.

This chapter summarizes Becker's keynote talk, the four panelist presentations that followed, and the open discussion with the audience.

NUCLEAR EVENTS: COMMUNICATION, EDUCATION, AND INFORMATION CHALLENGES

"Effective communication is one of the most important factors determining how any disaster or emergency situation unfolds," Becker began. This is true of natural disasters, technological disasters, and especially a nuclear detonation incident. Timely, credible, comprehensible messaging can reduce injuries and illnesses; prevent social, psychological, and behavioral impacts; help to maintain public trust and confidence; and facilitate recovery.

Becker pointed to the experience of Chernobyl to illustrate the importance of risk communication in radiation emergencies. The single most significant physiological impact of that accident was a dramatic increase in thyroid cancer. According to Becker, the World Health Organization (WHO) has made it quite clear that the main reason most of the cases occurred was because of the failure of risk communication and that if proper information had been communicated in a timely fashion, the results could have been different. Specifically, WHO concluded, "Since radioactive iodine is short lived, if people had stopped giving locally supplied contaminated milk to children for a few months following the accident, it is likely that most of the increase in radiation induced thyroid cancer would not have resulted" (Becker, 2012).

Becker emphasized, however, that while effective risk communication has enormous potential to reduce morbidity and mortality in a nuclear detonation scenario, this same scenario also poses enormous communication challenges. The event may occur suddenly and without warning. The devastation would be massive, with infrastructure damage close to the area of detonation. There would be the possibility and expectation of additional attacks to follow. Authorities would have very incomplete information initially yet at the same time would probably face a staggering and unprecedented demand for information, not only from the public but from the responder workforce as well. Time would be of the essence, Becker continued. Messages would need to be issued quickly. Finally, such an event would involve radioactive contamination, which is perceived by the public as one of the most feared of all hazards. "Radiation incidents have a remarkable capacity to produce widespread fear, a profound sense of vulnerability, and a continuing sense of alarm and dread," Becker said, citing Becker (2004, 2007) and Slovic (2001).

Furthermore, Becker continued, a lot of radiation-related concepts and terms can be complex and difficult to understand. For example, there can be confusion about incident types. According to Becker, a number of studies have shown that at least half of the public does not understand the difference between a dirty bomb and an atomic bomb. In addition, people have repeatedly indicated in different studies that they know the least about how to protect themselves from radiological agents compared to other kinds of situations. People have also reported lower confidence in their ability to respond to radiation incidents compared to other types of threats. Finally, there is significant evidence of fatalistic attitudes among the public with respect to radiation and radioactive contamination. People make comments like "I don't think we'd have a chance," "It's radioactive material. Once it gets in you, [you're] dead anyway," and "There is nothing you can do" (see Becker, 2004; FEMA, 2009; Kano et al., 2008; Lasker, 2004; Wray et al., 2008).

"The good news," Becker said, is that, despite these challenges and perhaps even because of them, there have been some very significant advances in nuclear incident communication over the past decade. Becker went on to discuss the research driving these powerful, improved communication tools.

Nuclear Incident Communication: Notable Advances

The foundational group of studies driving this past decade's new advances in nuclear incident communication were funded by the Centers for Disease Control and Prevention (CDC) in collaboration with the Association of Schools of Public Health in what was called the Pre-Event Message Development Project (PEMDP). PEMDP brought together four nationally known teams of researchers with strong expertise in communication and messaging, public health preparedness and response, and the technical aspects of the threat agents being examined. The main body of work was carried out between 2002 and 2006, followed by several years of follow-on studies through 2008. In 2009, other agencies picked up where the follow-on studies had left off and funded additional work.

Becker described PEMDP as a "monumental undertaking" that is still today one of the largest studies of its kind ever conducted, not just in the United States but worldwide. It involved more than 1,000 participants from across 9 different population subgroups of the general public and from multiple regions. Although the project covered four different classes of emerging threat agents (plague, botulinum toxin, chemical/nerve agent, and radiation), radiation, including both radiological and nuclear agents, received the most attention in terms of the number of focus groups and interviews.

According to Becker, PEMDP resulted in the first peer-reviewed scholarship specifically on communication and nuclear detonation events. He described how this research identified ambiguity in the way people interpreted the term *shelter in place* and that it was necessary to move beyond using that phrase and come up with alternatives, which have since been adopted by CDC and other agencies; determined clearly that people want to hear from individuals and agencies that have high credibility on health issues because most people's concerns center around health issues; found that people are very resistant to the idea of sheltering if they are not confident that their children are being well cared for in schools; and identified that there was no guidance on what people should do if they are in a vehicle during one of these events, findings that CDC put into practice (i.e., in guidance on what to do "if you are in a car, bus, or other vehicle during a radiation emergency").

In addition to PEMDP, there have been two other major study initiatives fueling the development of new communication tools for use during nuclear detonation events. The first of these was a group of studies carried out at King's College London in cooperation with the UK Health Protection Agency. These studies not only provided a British and European insight into population behavior and communication and information needs for this kind of event (Pearce et al., 2013), but because there were teams on the ground during the London polonium incident, they were also able to actually test messages and communications during the unfolding of an event (Rubin et al., 2007).

The second additional research initiative driving the development of new communication tools was the Study on Terrorism and Responses to Terrorism (START) and its groundbreaking work on WEAs. Becker lauded the work for providing a better sense of what WEAs can do, what they cannot do, and future directions that need to be explored. He noted that the panel would be discussing WEAs later (a summary of Bean's description and discussion of WEAs is provided later in this chapter).

Together, these sets of studies have fueled critical innovations and new tool development in nuclear detonation communication. These new tools range from CDC's guidance on what to do if in a car, bus, or other vehicle during a radiation emergency to Ventura County's unique communication initiative (which is described in detail later in this chapter) to the recently released *A Decision Maker's Guide: Medical Planning and Response for a Nuclear Detonation* (HHS/ASPR, 2017). Other recently released federal documents that have been informed by research and message testing, making them stronger than past documents, include the Federal Emergency Management Agency's (FEMA's) *Improvised Nuclear Device Response and Recovery: Communicating in the Immediate Aftermath* (FEMA, 2013) and EPA's *Protective Action Questions & Answers for Radiological and Nuclear Emergencies* (EPA, 2017b). Becker noted that Wieder would be discussing these and additional tools in greater detail later in the session (a summary of information presented by Wieder is provided later in this chapter).

So again, the "good news," Becker said, is that there has been a tremendous amount of research and that this research has plugged directly into agency efforts and has resulted in a variety of very powerful, very effective communication tools. The "not so good news," he continued, is that there are some major continuing gaps that need attention.

Continuing Gaps

First among the gaps is the need for additional large-scale, peer-reviewed research on nuclear incident communication. Becker argued this need to ensure that the field's understanding of people's concerns and information needs remains current and not dependent on data gathered a decade ago. Second, research is needed to test the effectiveness of already developed tools and to ensure that the testing is rigorous. Becker noted that Fischhoff would be discussing this later in the session (a summary of information presented by Fischhoff is provided later in this chapter). Third, research is needed to fuel the next stage of development of nuclear incident communication tools.

"We have great tools," Becker continued, but in his opinion, those tools have not been practiced enough. Thus, a second major gap, as identified by Becker, is a need for more attention on communication and information challenges in drills and exercises. There is usually more emphasis on practicing such skills as using a meter, measuring contamination, plume modeling, and so on—all of which are important, he acknowledged, but without extensive practice, the communication capabilities and skills that would be essential in a nuclear incident will not develop and will not be ready. In his opinion, it is not hard to incorporate content into drills. As an example, he cited a Community Reception Center (CRC) Drill Toolkit that was released by CDC and that included a set of drill actor cards, with each card pertaining to a different and what Becker described as "pretty taxing" communication-related challenge that either had to be addressed by the CRC staff or that was related to the CRC staff themselves (e.g., CRC staff being concerned that they will contaminate their families). These kinds of cards can effectively introduce communication issues and challenges into a larger drill and are the type of effort needed in every drill related to a nuclear incident, Becker urged.

A third gap is what Becker described as the desperate need for a communication strategy and messaging tools for areas receiving nuclear incident evacuees. Becker pointed to the Fukushima Daiichi experience to illustrate the importance of such a strategy and such tools. While there were many examples of helping and prosocial behavior in communities receiving evacuees and many impressive examples of courageous, kind behavior, there were also many documented problems. Some hotels refused to accept people from Fukushima. There were common suggestions that women from Fukushima were tainted, should not marry, and should not have children. Children from Fukushima were bullied, which was a problem after Chernobyl as well. They were bullied at school, nicknamed ("radiation"), ostracized, and isolated. Some health care facilities refused to provide treatment to people unless they showed certificates indicating that they had not been exposed to radiation. More generally, Becker said, there was immense stigmatizing of people, products, and geographic areas that were thought to be somehow associated with the accident. He suspected the same would be true of a nuclear detonation incident. Although there is content in some of the messaging documents that could be adapted for use in receiving communities, there is no targeted strategy or single set of tools driven by research and experience that could be used to address the concerns and information needs of people in receiving communities. This is a crucial gap and one that needs to be addressed, Becker urged.

A fourth gap is communication with children. "Do adults have a tough time understanding what is going on in a radiation emergency? Understanding the terminology, understanding what it means, understanding test results, understanding screening?" Becker asked. "Absolutely," he answered. Imagine what kids will experience in the context of a nuclear incident scenario. He described the large number of orphans, children who will never see their parents again, and the thousands of children who will be at least temporarily separated from their parents—perhaps for a long time, depending on where the device is detonated. All of these children will have concerns and information needs (Gurwitch et al., 2004). To prevent the situation from amplifying beyond what will already be a traumatizing one, it will be essential to have specialized, age-appropriate materials that can be used to answer kids' questions and to explain key aspects of the situation and the screening process and results. Becker stressed that this is not something that can be done after an event. It needs to be done pre-event and be in place and ready to use.

Finally, Becker identified as a fifth gap the need to address the concerns and information needs of responders. Not only would responders be the front line in any effort to manage a nuclear incident, but they are also public trusts whom people look to for information. Thus, if their concerns and needs for information are not met, it will have an impact not only on the responders but also, secondarily, on the public as well.

Research shows that responders of all sorts, including police, fire, emergency medical services, health care professionals, and public health, have an extremely high level of dedication to duty (Becker, 2004, 2009, 2010; Becker and Middleton, 2008). At the same time, this same very large body of research has also shown that responders of all types have a lower comfort level with radiation compared to other threats. Becker said that survey studies carried out not just in the United States but around the world have found that responders express a lower willingness to be involved in dealing with radiation events compared to most and sometimes all other types of incidents. As just one example of these many studies, Becker mentioned Veenema and colleagues' 2008 study on hospital-based nurses' willingness to respond to a radiation emergency, where a majority of nurses indicated that they were willing to respond at least some of the time, but more than 15 percent said that they were unwilling to work in any of the more serious radiation event scenarios (Veenema et al., 2008).

That all of these surveys show a lower willingness to respond despite responders being very dedicated to their duties has led to a lot of debate as to how many responders actually would respond to a nuclear incident. Will their dedication to duty overcome their fears, worries, and concerns? Or will their dedication be tested by the situation? In the context of that debate, Becker finds it useful to refer to what happened in Japan in the aftermath of the Fukushima Daiichi accident. Multiple surveys showed that large numbers of physicians and nurses left the area. The Japan Nursing Association reported a 40 percent drop in the number of hospital nurses in the area between March 2011 and September 2012. The Japan Nursing Association also reported that there were 768 open positions in August 2012 but only 174 applicants. "These are hard data," Becker emphasized.

Furthermore, the loss of large numbers of health care professionals from an affected area is not something that quickly fixes itself. The Fukushima Diaichi accident occurred in 2011. In 2015, there were continuing reports of major staff shortages. Becker shared one quote from a March 29, 2016, *Japan Times* article: "The nursing home Kawauichi in the Fukushima village of Kawauchi, which newly opened in November 2015, is struggling to find workers, while the needs are high for nursing care as many residents returning to the village are elderly. . . . Some people living outside the prefecture have declined to work here due to concern about radiation, said Mitsuhiro Hayashi, head of the facility."

Even 7 years post-disaster, while the number of medical doctors in Fukushima had finally reached and even exceeded pre-disaster levels, registered nurses, public health nurses, care workers, and clinical psychologists had still not returned in significant enough numbers to be able to fill available positions (Ohto et al., 2017).

For Becker, together these findings make it absolutely essential to have a messaging and communicating strategy to proactively address the concerns and information needs of responders. He stressed that this is not something that can be done "top-down." It needs to be a collaborative effort that directly engages responder groups and that uses a peer-to-peer approach. According to Becker, a peer-to-peer approach is usually the most effective when working with responders. In addition, he stressed the need to be cognizant of the fact that a big driver of health care professionals' leaving Fukushima was family concerns, including concerns about the well-being of children and the family unit as a whole. Thus, any effort related to messaging and communicating with responders needs to keep that in mind.

Becker added that it is important to remember that health care involves more than clinicians and public health. Hospitals cannot run without a staff. When contemplating the development of a messaging and communications strategy to meet the information needs of responders, it is crucial that all components of hospital staff be included. He mentioned the need for additional work to meet the information needs of other key personnel outside of the hospital—for example, utility workers and drivers.

In conclusion, Becker reiterated that effective communication has the potential to significantly reduce the public health impacts of a nuclear incident. However, while considerable progress has been made in research and the development of new nuclear incident communication tools, important gaps remain. For preparedness to improve, it is essential that these gaps be addressed urgently.

WIRELESS EMERGENCY ALERTS

"How many of you believe you have received a wireless emergency alert on your mobile device?" Bean asked the workshop audience. Almost everyone raised his or her hand. Bean said that when START work began on WEAs back in 2012, if he were to have asked this same question, almost no one would have raised his or her hand. Since 2012, WEAs have been used to alert people to flash floods, tornadoes, and other critical situations. Bean described in detail START's work on WEAs and the current advantages and limitations of WEAs.

Background and Research on WEA Messaging

Bean described WEAs as 90-character first-alert messages. The Federal Communications Commission (FCC) recently approved their expansion to 360 characters. The wireless industry has until May 1, 2019, to implement this capability. They are accompanied by a distinctive audible tone and vibration. The messages are geotargeted by the alert originator, which is usually a local, regional, state, or federal agency, but distributed by the commercial wireless sector, thus functioning as a public–private partnership. Bean noted that there have been some issues with overalerting certain geographic areas in the past, but effective November 30, 2019, FCC is requiring that all WEAs be sent with not more than 0.1 miles overshoot. The message contents and order of information are generally set, with a description of the hazard first, followed by location, time, protective action, and source. In a mock example that Bean showed, the alert read, "Radiological hazard warning in this area until 12:00 AM PDT. Take shelter now. USDHS." Because they are sent via cellular broadcast technology ("SMS-CB"), which is a little different than a typical short message service (SMS) text message, they cannot be backlogged during times of network congestion.

START began studying WEAs just as the WEA system was being rolled out across the United States. Other members of the START team, in addition to Bean, include Brooke Lu and Stephanie Madden, both of the University of Maryland; Dennis Mileti, University of Colorado Boulder; Jeannette Sutton, University of Kentucky; and Michele Wood, California State University, Fullerton. Dean led START's qualitative research efforts.

The START team's Mobile Devices Project (MDP) was divided into four phases. The first phase included historical research and an experts workshop to develop the mock WEA messages to be used. Phase 2 was all of the experiments, interviews, and focus groups that were used to test the messages. In phase 3, a community survey was conducted in the aftermath of the 2013 flooding in Boulder, Colorado, where WEA messages had been sent to the public alerting it of the flooding. Phase 4 involved the testing of longer, 280-character WEAs (Bean noted that this was before the FCC had decided on a 360-character limit). Together, these phases were intended to address the following question: What is the optimized content and form for public alert/warning messages about imminent threats distributed over new and emerging technologies?

Findings from the START work have been published in multiple outlets. Bean mentioned just two, the first being a paper in the *Journal of Contingencies and Crisis Management*, where Bean et al. (2016) described a study where they tested 90-character and 140-character WEA messages and tweets alerting people to an unfamiliar hazard, specifically a nuclear device detonation scenario. Participants were sent a message similar to the following: "Denver PD Take shelter now Radiological Hazard Warning in this area until 12:00AM MDT." They tested variations of the message, some with maps, some without. Not surprisingly, Bean said, participants differed in their interpretation of the messages, but almost all variations were deemed confusing, difficult to believe, and impersonal. Moreover, participants also consistently found the messages to be fear inducing and uninformative.

The second paper that Bean mentioned was a study on milling that was published in *Environment & Behavior* (Wood et al., 2018), where the researchers integrated qualitative and quantitative research findings and also focused on longer, 1,380-character messages, which is the maximum number of characters in a Common Alert Protocol–compliant message. A key finding was that, relative to shorter messages, longer public warning messages reduce people's inclinations to search for and confirm information, thereby reducing warning response delay. Bean interpreted these results to mean that shorter messages can cause confusion and fear, while longer messages can potentially help people and reduce the time it takes for them to respond to the message.

What WEAs Currently Can and Cannot Do

While there have been many decades of research on how to effectively alert and warn people via mass media channels such as television and radio, mobile devices create new opportunities and new questions. Of course, Bean clarified, many of the earlier research findings on how people understand and respond to messages still apply, but mobile technology offers new affordances and new constraints that researchers are just beginning to understand.

Before launching into his discussion of what WEAs currently can and cannot do, Bean emphasized his use of the word *currently* given how quickly wireless technology changes. In addition, he noted that his discussion would rely heavily on a 2018 National Academies report, *Emergency Alert and Warning Systems: Current Knowledge and Future Directions* (NASEM, 2018a), which covered START's MDP project as well as a number of other U.S. Department of Homeland Security (DHS)-funded WEA system research projects. In Bean's opinion, the National Academies (2018a) report is the most comprehensive and up-to-date summary of WEA-related research available.

Current Capabilities of WEAs

Emerging research indicates that, first, WEA messages can currently provide enabled device users with a geotargeted alert and warning message when facing an imminent threat, thereby reaching people at new times and in new places—for example, while they are sleeping, driving, hiking, or traveling. A representative quotation from the National Academies (2018a) report was that a "cell phone was found to provide 99.4% spatial coverage, although the coverage is influenced by spatial variability of signal strength."

Second, WEA messages can include vibration, sound, and light to help reach people with disabilities, although researchers indicate that some changes or adjustments are needed (NASEM, 2018a). Third, WEAs can also include a hyperlink for additional information, but only since 2016. Hyperlinks in WEAs were prohibited by FCC from 2012 through 2016. The current use of hyperlinks in WEAs is unclear. Bean said that he himself had yet to see an actual WEA that includes a hyperlink. Quoting from the National Academies (2018a) report, "Findings from our community event survey indicated that those who received a message with a hyperlink had a shorter delay (i.e., less milling) before beginning to check media" (Liu et al., 2018).

Perhaps the most significant finding, in Bean's opinion, which he considered both a benefit and a challenge of WEA messages, is their role in sparking what is known as milling behavior. Milling is the seeking of additional, confirming information from others regarding alert and warning messages. Quoting from the National Academies (2018a) report, "WEA SMS text messages do have a significant impact on physiological arousal, emotional response, cognitive processing, and behavior" (Glik et al., 2018), and "overall, the WEAs tested proved to be highly effective across all disaster types and when compared to other social messages, the WEAs were among the most shared by the test subjects" (Corley, 2018). Also quoting from the National Academies (2018a) report, "For 280-character messages, the message elements of guidance (what to do and how to do it) and time until impact (how much time people have to take the recommended action) play major roles" (Liu et al., 2018). The issue with milling, Bean explained, is that in a rapid-onset emergency, milling behavior can interfere with taking action quickly.

What WEAs Cannot Do (Currently)

Regarding what WEAs cannot do currently, first, they cannot include information to reliably overcome people's preconceived notions of hazards, nor can they reduce milling behavior. Bean explained that people bring to a hazard experience their preconceived notions and earlier experiences with the hazard, and these are very difficult to overcome no matter what people are told, especially if the message can only be 90 or 140 characters long. Quoting from the National Academies (2018a) report, "Subjects perceived the threat or urgency posed by a flash flood quite differently than other disasters on a physiological level" (Corley, 2018). Also, "recent research has provided clear evidence that message length influences response; messages that can fit in the initial 90-character length of a WEA message and the 140 characters of Twitter foster milling behavior and delayed response" (NASEM, 2018a).

Second, WEA messages cannot currently guarantee uniform issuance, interpretation, and response. In one study, a group of emergency managers was unable to effectively craft a 90-character message in a mock scenario (Griss et al., 2018). Bean explained that it is very difficult to do so under tight time constraints during an emergency. The National Academies (2018a) report summarized: "At this point, it is unclear what information is best included in a 360-character WEA message and what information is best included in linked content."

Third, WEA messages cannot currently include embedded multimedia content, such as a map or photo. All multimedia content has to be provided via hyperlinks. Quoting from the National Academies (2018a) report, "Some AOs [alert originators] perceived a WEA message as a 'bell ringer' technology while others believed that wireless alerts should directly embed or reference additional information" (Griss et al., 2018). According to Bean, FCC is considering how to embed multimedia content. Meanwhile, the hyperlink is the best that can be done.

Fourth, WEA messages cannot currently be provided multilingually, although a new FCC ruling has mandated that Spanish language capability must be implemented by May 1, 2019. Quoting from the National Academies (2018a) report, "Almost half of the respondents . . . expressed their wish to receive alert and warning messages in languages other than English."

Finally, WEAs cannot currently be integrated with social media. They are separate systems. Bean remarked that both alert originators and members of the public would like to see better integration because of how widely social media tools are being used. Quoting from the National Academies (2018a) report, "the WEA service needs to interface with social media to be relevant" (Griss et al., 2018).

Lessons for the Future

Bean noted that the National Academies (2018a) report goes into depth in terms of what needs to be learned about WEAs. Thus, again, Bean drew from the report.

Crafting More Efficient Messages

The first set of lessons that need to be learned is how to craft more efficient messages. Again, what information is best included in a message, and what information is best included in linked content? Bean mentioned evidence from recent studies that people are often very reluctant to click on hyperlinks because of their fear of spam or other cybersecurity issues. Some people do not even recognize a link as a link. This is important in the context of a nuclear incident scenario, where there would be a lot of detailed, technical information to communicate.

In addition to knowing where to put the information—that is, in the message or in a link—another lesson to learn is how to express time until hazard impact. What is the best lead time to ensure that appropriate action is taken? Currently, WEA messages include the expiration time of the message, which Bean said is not very helpful for some members of the public. They want to know when they need to begin taking protective action or when to stop.

There is a need to better understand the dynamics of opt-in versus opt-out systems. Currently, the WEA systems are opt out, meaning that when a person buys a mobile device, the device is automatically opted into the system. But if emergency managers send a false message or if over-alerting becomes a problem, people will be turned off and may opt out. What drives opt-in and opt-out behaviors?

Finally, how can longer, 360-character WEA messages best be used? What are the optimal message lengths for different hazards and different delivery mechanisms?

Meeting the Needs of Subpopulations

Bean called for a better understanding of the needs of nonnative English speakers and how to communicate messages in multiple languages. In what cases will templates and machine translation be "good enough"? Emergency managers also need to better understand how to reach people with differing abilities. How can messages be best presented to physically and cognitively challenged individuals? Finally, because there will be people who do not have access to mobile technology and will be missing the WEA messages (the "digital divide"), how can these new technologies be used while also ensuring that those with less access receive timely alerts?

Geotargeting

The geotargeting issues that need to be studied are more technical than these other issues. How can location be best communicated? How can messages be targeted effectively to a given hazard area? How can in-building information be used? Bean referred workshop participants to the National Academies (2018a) report for more details.

RISK COMMUNICATION IN NUCLEAR INCIDENT MANAGEMENT

In his evaluation of what he referred to as the "business case" for investing in risk communication research and building risk communication capacity, Fischhoff began by sharing some "good news." That is, there has been more than a century of research on human behavior that has been applied to many different risks and communication about those risks.

The National Academies have been producing reports on risk communication for many years. Fischhoff mentioned one, *Improving Risk Communication* (NRC, 1989), that is nearly three decades old but that still, he said, "reads well." In addition, *Toward Environmental Justice: Research, Education, and Health Policy Needs* (IOM, 1999) addresses the challenge of approaching communities that are typically not addressed respectfully and making certain that they are provided information that is dedicated to their needs. He also cited *Characterizing and Communicating Uncertainty in the Assessment of Benefits and Risks of Pharmaceutical Products* (IOM, 2014a), *Potential Risks and Benefits of Gain-of-Function Research* (NRC and IOM, 2015), and *Building Communication Capacity to Counter Infectious Disease Threats* (NASEM, 2017a). In the latter report, there is some discussion on the uncertainty in communications when allowed only 360 characters. In addition to these various National Academies reports, Frischhoff mentioned a June 2018 meeting, Governance of Dual Use Research in the Life Sciences: Advancing Global Consensus on Research Oversight, hosted by the Croation Academy of Sciences.

Fischhoff described the basic communication design process that underlies much of the work just presented by Bean and, before him, Becker.

It involves four steps: (1) analysis ("What decisions do people face?"); (2) descriptive research ("How do people currently make those decisions?"); (3) science-based intervention, which Fischhoff described as providing a "best guess" at what to do to help people make better decisions; and (4) evaluation ("Is it good enough?"). Then repeat this series of steps as necessary. This process has been applied to a range of topics, from radon to breast cancer to palliative care to vaccines. Each application has its own unique properties. For many of these risks, because there is so much psychology, the hardest part is analysis, such as figuring out what few things can be said in a 90- or 360-character message that are relevant to the diversity of decisions that different people face.

As an example of an analysis of one of these risks, Fischhoff mentioned a study that he did with his colleague Keith Florig on individuals' decisions that affect radiation exposure after a nuclear explosion (e.g., how urgently to seek shelter, when to evacuate) (Florig and Fischhoff, 2007). The genesis of the study was a National Academies meeting in this same room, but 15 years ago, which involved a radiological dispersal device (RDD) scenario exercise. One of the striking findings of that exercise was how imbalanced investments were in different components of the response. For example, there were five different plume models but no crafted message.

Despite all of this research, the bad news, Fischhoff said, is that each individual is himself or herself an intuitive behavioral scientist. "You would not get through life . . . if you did not have some ability to analyze other people's behavior," Fischhoff said. When interacting with someone one on one, if an individual does not communicate well, he or she receives feedback. But when going broadband, there is no feedback, yet whatever message is being sent probably works better for some people than for others. And one of the strongest psychological results, Fischhoff said, is that people exaggerate how well they communicate—that is, how well they understand others and how well others understand them.

Another challenge is that many of the organizations charged with managing risk can be limited by their own understanding of specific hazard, and this can impact how effectively they can communicate that risk to others. In developing communications it is necessary for organizations to have, or obtain, both a technical understanding of a specific hazard, like those related to a nuclear incident, and a developed sense of how the public will absorb and react to specific messages.

A final piece of bad news, Fischhoff continued, is that many organizations have no procedures in place for adapting communications to behavioral evidence.

Solutions for Improving Risk Communication

Fischhoff described three solutions to help improve risk communication.

Make Research Accessible

First, he called for making research on risk communication more accessible given the difficulty of reading scientific articles in peer-reviewed journals. This is something that he thought the research community ought to be able to do. He recommended several books: (1) *Thinking, Fast and Slow* (Kahneman, 2011), which Fischhoff described as a good introduction to the research and how the research develops; (2) *Theory and Practice in Policy Analysis* (Morgan, 2017); and (3) *Risk: A Very Short Introduction* (Fischhoff and Kadvany, 2011). In addition to these books, he mentioned an article he wrote for *Science*, "The Realities of Risk-Cost-Benefit Analysis" (Fischhoff, 2015).

In addition to these publications, Fischhoff mentioned that the National Academies hosted a series of three colloquia on the science of science communication. The colloquia led to special issues of the *Proceedings of the National Academy of Sciences* (Fischhoff and Scheufele, 2013, 2014) as well as colloquium proceedings (NAS, 2014; NASEM, 2018b). In addition, there was a National Academies consensus study report on the science of science communication, *Communicating Science Effectively: A Research Agenda* (NASEM, 2017b).

Fischhoff also called attention to a book produced by the Food and Drug Administration's (FDA's) Risk Communication Advisory Committee, which he chaired. The book, *Communicating Risks and Benefits: An Evidence-Based User's Guide*, contains more than 20 chapters on different topics (FDA, 2011). A criterion for being included was a claim on the part of the science that the science could not be made accessible, Fischhoff explained. Each chapter summarizes the relevant science, offers "best guesses" at the practical implications of the science, and shows how to evaluate communications based on that science.

Develop and Evaluate Prototypes

A second solution is to develop and evaluate prototypes for risk communication. Having a prototype for the communication process ensures that the audience, or representatives of the audience, knows that the problem is being addressed and that people are not going to be "blindsided" in some emergency situation. He suggested a template for communication that he described in Fischhoff (2015) that has a routine project development process (covering risk analysis, risk assessment, and risk management) and two-way risk communication at each step along the way. "You cannot have what is sometimes called a 'decide, announce, defend' communication strategy," he said.

Along with a prototype for the communication process, risk communication also needs content, something good enough that someone in a jurisdiction that does not have a research department can begin to adopt (see Table 5-1). He noted that the schematic shown in Chapter 2, Figure 2-5, serves as a terrific template for teaching the principles of sheltering. To further illustrate the usefulness of graphics, he showed an image of two human hands that is used to teach decontamination in an infectious disease situation. Different parts of the hands are shaded differently based on whether they are most frequently missed, frequently missed, or less frequently missed when one cleans one's hands. "It tells you a story," Fischhoff said—that is, that places on the hand that are likely to do the most damage are also those that are most frequently missed.

In addition to prototypes for process and content, prototypes are also needed for evaluation. Again he referred to FDA (2011), where each chapter contains a final section on how to evaluate communication with no money, little money, or money commensurate with the personal, organizational, or political stakes riding on effective communication. The simplest form of evaluation, which Fischhoff said there is no excuse not to do, is to ask a diverse group of people to think aloud as they read a communication. "You are always surprised by what it is that they take away," he said. However,

TABLE 5-1 Response Decision Rules

Distance from Blast	Fallout Arrival	Risk from 3-Hour Exposure	Recommendation
<4 kilometers	<10 minutes	Soon fatal	Shelter immediately.
4–20 kilometers	10–60 minutes	Soon fatal to 50 percent of exposed High cancer risk for survivors	Travel only if certain that better shelter can be reached before fallout arrives. Use time to prepare.
20–50 kilometers	1–2 hours	2–20 percent additional cancer risk	Travel only if exposure risk is small or benefit is large. Use time to prepare.
50–100 kilometers	>2 hours	0.5–2 percent additional cancer risk	Flee if fallout direction is known. Go home or collect family members. Otherwise, remain indoors.

SOURCE: Fischhoff presentation, August 22, 2018.

while conducting an evaluation protects an organization from putting out something that does not say what the organization thinks it says, it does not protect from putting out a message that does not address people's concerns.

Create Absorptive Capacity

A third way to improve risk communication is to create absorptive capacity—that is, the capacity to take in new information, incorporate it into products, and apply it appropriately to ongoing activities. This requires the right expertise, including subject-matter specialists who know the phenomenon, analysts who can extract the relevant information, behavioral scientists who can ensure the comprehensibility and credibility of the message, and practitioners who will make certain that the necessary interagency partnering, legal work, and other tasks are done to ensure execution. "If you miss any of these skills from your project, you are asking for trouble," Fischhoff said. As resources for general models for how to create this shared space for people from different communities to come together when absorptive capacity does not exist, he suggested *Intelligence Analysis for Tomorrow: Advances from the Behavioral and Social Sciences* (NRC, 2011a), *Intelligence Analysis: Behavioral and Social Scientific Foundations* (NRC, 2011b) and *Foundational Cybersecurity Research: Improving Science, Engineering, and Institutions* (NASEM, 2017c).

Finally, Fischhoff mentioned FDA's *Strategic Plan for Risk Communication* (FDA, 2009), which was developed during the Bush administration and revised during the Obama administration. He commended FDA's dedicated staff for working on the plan over such a long period of time. He also commended the FDA's Risk Communication Advisory Committee (RCAC) for providing so much good advice and for very little money. RCAC produces general guidelines on what to do during an emerging event—for example, if something goes wrong with a metal-on-metal hip joint—and when to put out messages. In addition, every quarter, FDA goes out and talks to mostly patients but also to patient representatives and technical specialists about a class of disease to gather information for use in setting the terms of a clinical trial or when deciding whether to approve a device. Fischhoff described it as a routine consultation, a way to find out what people want. It has earned FDA a lot of credit across diverse user communities. He suggested that the model could be adapted for use in this context as well.

A UNIQUE, VIDEO-BASED PUBLIC INFORMATION CAMPAIGN: VENTURA COUNTY, CALIFORNIA

"What I have learned as health officer over the years," Levin began, "is that in a threatening situation, public health's responsibility is to tell the public what they can do to protect themselves and friends and loved ones." He spoke about Ventura County's nuclear explosion information campaign, which was launched in 2014. The public information campaign included a series of PSA videos produced by readyventuracounty.org. The videos were developed with FEMA and CDC funding. During his presentation, Levin showed four of these videos.[1]

Ventura County Nuclear Planning

Ventura County Public Health began nuclear planning in the early 2000s. Levin wrote a 241-page nuclear explosion response plan, the Ventura County Sheriff's Office wrote a law enforcement plan, and Levin and colleagues established a plume trackers group for the county. Levin explained that knowing the direction of the plume would be critical to both the county's response and to public confidence but that if a detonation were to occur in Los Angeles County, Ventura County would not be able to count on their ability to track the plume.

Creating a Memorable Tagline: "Get Inside, Stay Inside, Stay Tuned"

Levin assumed initially that after these reports were written and groups were established, his work would be done. But he realized that if his concern was to minimize injury and death, the residents themselves would need to know what to do to protect themselves should a nuclear detonation occur. So in 2014, the county launched its public information campaign, with the goal being that every person in the county would know where to go and what to do if he or she were to see, hear, or learn of a possible nuclear detonation. And when would that goal be met? Levin asked. His answer: when people can recall a simple mantra. He met some classic great taglines: "Stop, drop, and roll," "Only you can prevent forest fires," and "If you drink, don't drive." Levin and colleagues wanted to define a tagline that was similarly memorable.

Ventura County Public Health worked with Wieder and the Nuclear Radiation Communications Working Group to come up with the tagline "Get inside, stay inside, stay tuned." Its advantage, Levin noted, is that it is alliterative. Its disadvantage is that its relevance is perceived to change with historical trends. When people know "Get inside, stay inside, stay tuned" as well as they do "Stop, drop, and roll," then, he said, "we will have taken a giant step towards local preparedness."

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[1] Two of the videos can be viewed online, at https://www.youtube.com/watch?v=2jIs-Lwh6U0 (accessed December 10, 2018) and https://www.youtube.com/watch?v=jGPetxZ3iMM (accessed December 10, 2018).

Planning a Public Information Campaign: Challenges Faced

Levin described how local elected officials went along with everything that Ventura County Public Health did as it prepared the four PSA videos. Not only did they not object, but they provided crucially helpful suggestions. Although he was concerned that Los Angeles County would request that it also needed to have a public information campaign to launch at the same time, making the release of the Ventura County program dependent on Los Angeles County developing its own program, this did not happen. The biggest obstacle was locally appointed administrators, who obstructed the effort until a top appointed official in the county requested that they clear the way. Levin noted, however, that they still were not allowed to pursue a planned national component to the campaign, only the local campaign.

Components of the Campaign and Its Launch

When planning the campaign and its launch, Levin and colleagues were aware that the biggest issue they would have to contend with would be people asking, "What do you know that we don't know?" With this in mind, prior to launch, a letter was sent to parents of all schoolchildren the Friday before launch. The campaign was launched with a press conference the following Monday, followed hours later by a series of town hall meetings throughout the county. Levin himself was in attendance to address any concerns. They also set up a phone bank, but they only received about 40 calls the first 2 days, so the phone bank was discontinued.

In addition to the PSA videos, the campaign included an 18-page information document for the general public;[2] a website containing the products they had created (plus extensive bibliographies with links for the general public, emergency responders, and health care professionals); a curriculum for teachers to use in schools; a disaster plan for schools; talking points for Parent Teacher Associations; potassium iodide guidance for physicians; a mailer that could be used to remind people of the campaign and its most important messages; just-in-time pocket guidance; and frequently asked questions for the general public.

Mistakes and Unanticipated Consequences

In reflecting on the campaign, Levin shared that one of his mistakes had been assuming that ongoing preparedness for a nuclear threat had

[2] Available online at https://www.readyventuracounty.org/wp-content/uploads/2018/05/VC-Nuclear-Safety-18pp-Education-Guide-Downloadable-FINAL.pdf (accessed December 10, 2018).

been accomplished by Ventura County and that nothing else needed to be done—in other words, that the impulse to maintain nuclear explosion preparedness would be self-perpetuating. He had been confident that different components of the county's emergency response team would exercise one aspect or another on a regular basis. But this had not happened. "Emergency responders are busy," he said, "and they have higher probability disasters to prepare for in California, like earthquakes and wildfires."

Upon reflection, another potential mistake was that he had been neglecting his full-time responsibilities as a health officer by putting so much time into this low-probability, high-consequence event, trying the patience of his county superiors. After launch of the public information campaign, he felt that he had been discouraged from putting more time into nuclear preparedness.

Despite some possible missteps, Levin shared that the most significant yet unintended outcome was that the reception by the community had been positive beyond expectations. Ventura County Public Health received feedback such as "What took you so long?" and "Finally, somebody is doing something about this." As far as Levin was aware, no public officials "got any heat" after the launch.

Improving Local Preparedness: Moving Forward

Levin described several steps to continue to improve Ventura County preparedness for a nuclear explosion.

Promote "Get Inside, Stay Inside, Stay Tuned"

First is to advance the level of knowledge of "Get inside, stay inside, stay tuned" by requiring health-related PSAs among the trailers in movie theaters. Some of these PSAs should be general public health announcements, Levin clarified, but some should also be nuclear preparedness announcements. In addition, he suggested conducting an exercise or tabletop every year that is visible to the public—even if it involves road closures for brief periods—and let the media know.

Second, Levin suggested picking a date, such as the anniversary of the Hiroshima explosion, and every year advertising on that date the "Get inside, stay inside, stay tuned" message. It would be similar to what is done in California every year during the Great California Shakeout, a yearly event where people participate in earthquake preparedness drills. He acknowledged that only about 1 percent of people would participate; nonetheless the news media would pick up on it and remind people of "Get inside, stay inside, stay tuned."

Third, Levin listed some actions that FEMA and the surgeon general could or should take: clarify that nuclear preparedness is a local responsibility and that the county health department, with local Office of Emergency Services assistance, is responsible and is the lead; have useful materials that local communities can use and modify; and attach financial rewards for local accomplishments and exercises.

Fourth, Levin called for carefully analyzing the impact of social media and how it can mislead the public in terms of the role it can play as an event progresses. How can this be shaped and controlled?

Fifth, Levin suggested preparing a public information campaign for launch but waiting until a threat or "saber rattle" creates public anxiety and makes public preparedness desirable. Ask permission then, he suggested. Still, wait a few months until the anxiety has subsided before the actual launch so that people do not worry that it is an imminent threat. Set a firm date.

Finally, in hindsight, Levin wishes that he had contacted the national press.

Changes Since Ventura County Launched Its Public Information Campaign

Ventura County's nuclear explosion public information campaign was based on one, two, or three devices of 10–15 kilotons. The increased power of the nuclear devices that characterize the North Korea threat significantly increase the expected number of deaths and casualties. Levin emphasized that although this new threat impacts all aspects of the emergency response, the "Get inside, stay inside, stay tuned" message still applies and would still save lives.

In addition, social media has changed, with both unofficial and official sources of news and opinion potentially exacerbating the tendency toward panic. People might be encouraged to flee instead of seek or remain in shelter.

NUCLEAR INCIDENT PUBLIC COMMUNICATION: TOOLS AND TEACHABLE MOMENTS

Get Inside, Stay Inside, Stay Tuned: Teachable Moments

Building on Levin's suggestion that communities have their communication campaigns prepared and ready to go, Wieder spoke about "teachable moments"—that is, moments that serve as opportunities—to communicate about what to do in the event of a nuclear threat.

She reflected on the great amount of time and effort on her part and on the part of many people in attendance at the workshop to ensure that the

"Get inside, stay inside, stay tuned" tagline was grounded in science and that it met the needs of the science community, the response community, the medical community, and communicators. In addition, she noted that, in her opinion, the message is an all-hazards message. Get inside and get information, and then act on that information, with some exceptions (e.g., a burning building).

It was because of all of this effort that had gone into developing the message that she could not sleep the night of January 13, 2018, the day of the false ballistic missile alert in Hawaii. "So many people would have died if that had been real because they did not know to get inside," she said. So at 1 a.m. on January 14, in what she described as a "very rare social media posting," she posted the following message on her public Facebook page:

> In the case of a nuclear threat—Get Inside. Stay Inside for 24-48 hours. Stay Tuned for instructions.
>
> Today's disastrous false alert in Hawaii has left me devastated and thankful. Devastated because, no matter how hard we try, we haven't done enough to tell the public what to do in the case of a nuclear threat. Thankful because I still have a chance to make it right.
>
> Today, I start with you, my family and friends. Get Inside. Stay Inside. Stay Tuned. Assuming you survive the initial blast—and many people will survive—staying inside can save you from deadly radiation exposure. Federal agencies don't always agree—shocking, I know—BUT they agree on this. CDC, EPA, and FEMA all say the same thing. Going inside can save your life.
>
> Want to know where to go or how to clean yourself if you think you have radioactive material on your body? There is consistent advice on that too, and it is easy to remember. Go deep and get clean. See CDC's infographic below.
>
> My heart hurts thinking about all those people who thought their world was ending. The text messages sent saying goodbye. People driving 100 mph to get to their families. Recovering alcoholics who decided on one last drink. Those who had a plan and acted and those that froze. Parents who grabbed their kids and huddled in fear and those that let their kids sleep because they didn't want them to be scared. I sit with tears in my eyes for the lives changed because of a false alarm.
>
> I am driven to do better. Educate more. If you are so inclined, help me pass the message on.

In the post, she attached a CDC infographic on "Where to Go in a Radiation Emergency"[3] and another on "Decontamination for Yourself and Others."[4] The post was shared 431 times, with 99 percent of the shares happening within the first 48 hours. Wieder clarified that she was not boasting about her social media status, rather using this post to illustrate that there are moments when people want information. She encouraged others to take similar advantage of these opportunities—these teachable moments. Doing so can potentially save lives. The "good news" is that the information that can be communicated during these teachable moments is available. "We already have it ready for you," she said, "so that you have it in your pocket for when those teachable moments come up."

The day after the false alert, viewership of EPA's "Protecting Yourself from Radiation" website increased 166 percent from the previous week. By January 17, it had returned to the typical viewership level. So although an entire state had been worried that a ballistic missile was going to hit them, the increased interest had been sustained only for 3 days. "These teachable moments are fleeting," Wieder said. "If we do not have the information ready to present to them, we have missed our opportunity."

Wieder went on to describe some publicly available interagency tools that have been put together over the past 9 years to help do just that: take advantage of teachable moments.

Publicly Available Federal Tools

First among the several federal tools issued in recent years for nuclear preparedness planning is the *Planning Guide for Response to a Nuclear Detonation* (FEMA and DHS, 2010). Wieder noted that the 2010 second edition included an entire new chapter (see Chapter 6) on public preparedness and emergency public information.

By 2013, significant leaps had been made in public messaging, with 14 different agencies agreeing on 85 pre-scripted questions and answers for the first 72 hours after an improvised nuclear device (IND) (FEMA, 2013). Although the messages included in that guidance (*Improvised Nuclear Device Response and Recovery: Communicating in the Immediate Aftermath*) were not written for state actor events, "Get inside, stay inside, stay tuned" is nonetheless consistent.

More recently, in *Protective Action Questions & Answers for Radiological and Nuclear Emergencies*, EPA (2017b) adapted Becker's work on

[3] See https://emergency.cdc.gov/radiation/pdf/infographic_where_to_go.pdf (accessed April 10, 2019).

[4] See https://emergency.cdc.gov/radiation/pdf/infographic_decontamination.pdf (accessed April 10, 2019).

RDDs, with questions and answers consistent with the FEMA (2013) document but written generically for any type of radiological incident. Because EPA (2017b) did not need the 14 agency seals, it did not need to go through an interagency review. Thus, Wieder said, it was able to use plainer language. The EPA document also includes new messaging on potassium iodide, including what it is, what it is not, and why table salt should not be used as a replacement. It also addressed specialized populations, including pregnant women, people with disabilities, and especially children. As an example of a question pertaining to children, one is "Can I give my kid a bath?" The answer is yes. But try to keep children from drinking the water.

Also, in 2017, EPA published *Protective Action Area Map Templates* (EPA, 2017a) for states and local jurisdictions to use. The templates are available in both PowerPoint and Word and are easily adaptable, using a multiple choice format.

In addition to these guidance documents, between 2014 and 2018, CDC came up with a number of infographics, two of which Wieder attached to the previously described Facebook post. Those and many others are publicly available on the CDC infographic resource library website.[5] They are available in 12 different languages. One of the CDC infographics is an animated infographic on where to go in a radiation emergency.[6] Also, in 2018, FEMA posted a video that echoed the CDC video about where to go in the case of nuclear emergency. That multiple agencies are sending the same message makes the message more powerful, Wieder said.

Social Media Messaging

"Social media is not just for cat pictures anymore," Wieder continued. "Social media is a place where people are getting their news." She cited a survey conducted by the Pew Research Center on the growth of social media news acquisition. Whether it is Facebook, Twitter, YouTube, Instagram, or another platform, all social media platforms enable some amount of news acquisition. During the false alert in Hawaii, people looked to social media for information. But there were no messages for a nuclear detonation scenario ready to go, at least not for social media, Wieder said. She emphasized that this has changed, however, with the leadership of Lauren Matakas. Since that false alarm, interagency work has led to agreement on a set of social media messages pertaining to nuclear attack warnings or events and immediate safety. In addition to "Get inside, stay inside, stay tuned," the messages also cover food and water safety, first aid, and

[5] See https://emergency.cdc.gov/radiation/resourcelibrary/infographics.asp (accessed December 10, 2018).

[6] See https://emergency.cdc.gov/radiation/protectiveactions.asp (accessed December 10, 2018).

helping neighbors. Wieder noted that they include the 90-character WEA message format and expressed excitement that the message length is being increased to 360 characters.

One-Stop Shop for Guidance Documents

All of the documents that Wieder mentioned can be found via FEMA's Emergency Support Function #15 (ESF#15) website.[7] More specifically, ESF#15 has an annex specific to radiological incidents (Annex N), which unlike other annexes includes a whole series of public information tools that was added in 2016. Moreover, in 2018, the annex was updated with the social media messages for a nuclear detonation scenario that were developed after the Hawaii false alarm.

Ongoing Efforts

"We have done a lot in the last 8 years," Wieder said. Although much has been learned from the Cold War civil defense era, the way people communicate now and the public mentality are very different than then. For example, after Fukushima, people were looking on EPA's nationwide environmental radiation monitoring system, RadNet,[8] for information on radiation levels across the United States. In the event of a nuclear detonation, they would do the same. Under the leadership of Angela Shogren, EPA is working to ensure that those data are presented in a way that the public will understand, knowing that radiation data and units mean very little to most people.

In addition to these radiation data visualization efforts, under the leadership of Stephanie Bacon, EPA is working with FDA and FEMA on an infographic on food, water, and medicine. This was a need that was identified during the Gotham Shield exercise, during which a protocol for an infographic was drawn up. EPA is finalizing it and considering ways to test it so that it is ready to use.

Wieder noted that Matakas, who worked on the social media messaging included in the ESF#15 annex, is also working with the interagency Nuclear/Radiological Communication Working Group to add a full social media annex to the interagency guidance on communicating in the intermediate aftermath of an IND (FEMA, 2013). The group is updating FEMA (2013) to ensure that it is based on the best possible science and that it is

[7] See https://www.fema.gov/media-library/assets/documents/34369 (accessed December 10, 2018).
[8] See https://www.epa.gov/radnet (accessed January 18, 2019).

representative of not just an IND scenario but also other, larger situations and possible air bursts.

Finally, based on another lesson learned during Gotham Shield, the interagency group is working on content for a flyer drop. Specifically, it is trying to figure out what information could be put on a piece of paper the size of a dollar bill (i.e., the size required if the U.S. Department of Defense were to conduct a flyer drop) that would be effective with people. About 3 months prior to the workshop, EPA partnered with CDC to do some public message testing around a flyer drop. What Wieder found interesting was that with the drops occurring at 8 or 12 hours after an event, they were expecting people to ask why it took so long to get the information out, but instead people were thankful that they had not been forgotten. “Please, if this were to happen, send something like this” was the type of feedback they received.

In closing, Wieder encouraged anyone interested to join the Nuclear/Radiological Communication Working Group, coordinated by Bacon. The group communicates via e-mail and through two to four conference calls per year. It identifies best practices and gaps and works together to try to fill those gaps. She also encouraged workshop participants to identify teachable moments. For example, educate your Lyft driver when he or she asks you what you did today. “That is one way we can save lives,” she said.

DISCUSSION WITH THE AUDIENCE

Following Wieder’s presentation, she, Becker, Bean, Fischhoff, and Levin participated in an open question-and-answer period with the audience, summarized here.

“Get Inside, Stay Inside, Stay Tuned”—But What Exactly Does *Inside* Mean?

There was some discussion about what exactly *inside* means. An unidentified member of the audience described two scenarios. First, she recalled 9/11, when she had been about to drive to school to pick up her child but realized that her child would probably be safer inside the school cafeteria than outside or in the car, so she had gone back home. Then, after she had gotten home, she wondered if she should go down to the basement but worried that the house might crumble on her. Second, she recalled having heard recently that during emergency situations where a lot of people are going to hospitals, the hospitals themselves are unsafe. She relayed a suggestion that hospitals be built in caves to avoid crumbling during a disaster. Together, these scenarios made her wonder, what is the definition of *inside*?

Wieder referred to Buddemeier’s graphic (see Figure 2-5). She suggested that the best place to go for a hurricane or a tornado is also probably the best place to go in a nuclear detonation scenario. If there is any pre-event warning, the concern is not only radiation but also flying debris and broken glass. "The basement, if you have one, is probably the best place to be," she said. In terms of hospitals, Wieder reminded the workshop that there will be an area beyond the blast zone.

Hopefulness and Optimism

Beyond the blast zone, Wieder continued, will be many lives that can be saved. She recognized the difficulty in expressing hopefulness and optimism given that so many people are going to die in what will be an absolutely horrific situation. "You cannot deny that fact and the tragedy that will be," she said. "The advice that we are giving at this point about where to go and how to get help and the discussions we are having about how to triage and how to get people to hospitals . . . it is all to save as many lives as we can under the infrastructure that we have."

Miscommunication, False Messaging, and Opting Out of Alerts

Matt Wynia, University of Colorado, expressed concern about how things intended in one way may be interpreted in other ways by other audiences. In the past, one of the arguments for avoiding talking about preparedness for a nuclear weapon event is that doing so could be interpreted by adversaries as an offensive endeavor. He imagined someone in North Korea, for example, interpreting U.S. discussion about nuclear weapon preparedness as something that the United States is doing to prepare for a launch of its own. Although in his opinion this is certainly not an argument for not being prepared, he expressed uncertainty about how to address it. How can preparedness activities, which are viewed as defensive, not be interpreted as offensive acts by others around the world?

Acknowledging that this was outside of his area of expertise, Levin compared the situation to the U.S. military exercises conducted just off the coast of North Korea. "It would irritate the heck out of them," he said, "but they would not necessarily see it as a specific and direct act of war."

Also on the topic of miscommunication, and based on his experience with miscommunication with respect to infectious disease emergencies such as Ebola and pandemic flu, Andy Pavia, Infectious Disease Society of America, asked the panelists what they have learned about how to ensure that their messages are communicated clearly, understandably, and with minimal hyperbole when they have to be sent through other messengers. He commented on how beautifully crafted and well-researched messages so often get filtered through news media and social media and are often lost in translation or amplified. He imagined a medical correspondent breathlessly standing in front of the television camera sweating about Ebola coming and attacking him.

A finding from his work, Bean replied, is that messages distributed from multiple authoritative sources are generally more effective. He described a focus group study where some people trusted the police department, while others absolutely did not. So any message coming only from that department would alienate a certain portion of the message receivers. But when the message is issued from DHS, the county office of emergency services, or other relevant departments or offices, more people are more willing to listen. Wieder agreed with Bean.

Related to miscommunication, there was also some discussion around false messaging. Cullen Case, Radiation Injury Treatment Network, asked whether there were any data on people opting out of WEAs after the false message was sent in Hawaii or under any other circumstances. Bean was unaware of any hard data, only anecdotal reports that people turn off their alerts after these kinds of incidents. Becker added that false messaging was an area requiring additional research, not only with respect WEAs but more generally. For example, following the Fukushima Daiichi accident, a number of false communications were issued by third parties that were disguised to look like authentic communications. He recalled in particular a message that provided wrong protective action information but was disguised to look like a communication from the Japan Medical Association. In addition to looking at what happens when false messages are issued, he called for more research into how to ensure authentic messaging and how to rapidly correct a situation when a false message is issued.

Developing New Communication Strategies

Erik Caull, Applied Research Associates, mentioned a project at Stevens Institute of Technology called Reinventing Civil Defense that focuses on nuclear risk communication, specifically how to reach millennials and other people who are "glued" to their cell phones. He noted that the proceedings for a discussion back in June 2018 would be posted soon on the institute's website[9] and that the institute would be posting several novel communications projects as well.

A Role for Poison Centers

Ziad Kazzi, American College of Medical Toxicology and Georgia Poison Center, explained the role of poison centers in guiding public health communication messaging during the Fukushima response. There were

[9] See https://reinventingcivildefense.org (accessed January 18, 2019).

about 400 calls to the poison centers in that 1-month period (March 2011). Most of the calls were information requests (e.g., on radiation exposure but also potassium iodide or other iodinated products), but there were also some exposure calls. According to Kazzi, these calls helped CDC to craft messages. He encouraged states to look to poison centers and other sources of information to help guide their messaging in emergency situations.

Another Teachable Moment?

Touching on Wieder's discussion of teachable moments, Caull described how in the 58 minutes following the issuance of the Hawaii alert, Pornhub activity on IP addresses in Hawaii decreased by 66 percent, on average, with a low of 75 percent less traffic than usual. For Caull, the decrease is instructive in that people's attention actually is diverted. They are looking for information.

The Importance of Emergency Preparedness Exercises

McDonough commented on the fact that even though it is 2018, social media messaging is not required in any of the exercises undertaken by the Maryland Emergency Management Agency. "If we are not required to do it, nobody is going to spend money for us to do it," he said. "We need to be forced to do that."

Becker concurred and emphasized the need to practice all aspects of the communication component of nuclear preparedness. He added that there is also a need to practice when things go wrong on how to recover. Without practice, he said, "we are really not going to be adequately prepared."

Prioritizing Nuclear Safety Messaging

David Snyder, local elected official and chair of the National Capital Region Emergency Preparedness Council, commented on the competition for time with first responders, with public information officers, and with emergency managers. He asked the panelists how they have attracted the attention of these various groups to prioritize nuclear safety messaging and then, once it is a priority, how they weave nuclear safety messaging in with all the other messages out there.

"When the time is right, that is when you present the idea," Levin said. He described how he was able to get the attention of the decision makers in Ventura County. After 9/11 and concerns about further terrorist acts, Levin approached the sheriff who was leading the county's terrorism preparedness group with the idea that something should be done about nuclear threats. Levin was enthusiastically provided resources to immediately begin preparedness efforts. It was not until about a year and a half later that he learned that the sheriff had received some classified information about a potential terrorist attack, and that was why he had been so enthusiastic. So, serendipitously, Levin had presented his idea at the right time.

Wieder described a different situation. At a 2010 national-level IND exercise, the White House Office of Science and Technology Policy and National Security Council together realized that they had no idea what they would tell the public in the event of an IND. They pulled a group of scientists, policy makers, and communicators together to figure it out. Initially, there was a lot of momentum given that the request had come from the White House. The challenge is maintaining that momentum. Relationship building and trust building are key. With those in place, then, Wieder said, "when opportunities present themselves to get the message across, you are the first person that they call." She said that the same communications group that was formed back then, in 2010, is still being maintained for no other reasons than because Wieder wants to continue having those working group conference calls and other people continue to participate. "Think coalition of the willing," she said. "These are people who want to do something. There is no mandate to do it. There is no funding to do it. But we recognize the need for it."

Also, as a way to compete with various groups' attention, Wieder suggested using "Get inside, stay inside, stay tuned" as an all-hazards message not specific to nuclear detonation. It could save a lot of lives in a number of different types of situations. She said, "Just getting people off of the streets for almost any emergency is good for getting responders to an event and helping people who need it."

Becker added that with respect to getting the attention of responders in particular, at no point has he experienced a shortage of responders to participate in any of the meetings, focus groups, workshops, hospital discussions, law enforcement facility discussions, or other preparedness gatherings that he has held. The key to getting their attention is not framing preparedness as "I have information I want to give you." Rather, tell them that there is a threat that could possibly affect them and their organization. Then ask them what resources they think they need. What information do they need? He and his team approach responders with the intention of helping them to do their jobs effectively in a way that is safe for them, protects their families, and allows them to discharge their duties and responsibilities.

Communicating with Responders

Blakely emphasized the importance of addressing not just the public but also responders in the event of nuclear emergency. He was reminded of being invited by the International Atomic Energy Agency to participate in a biodosimetry symposium in Hiroshima, where he had the opportunity to hear from an emergency medicine physician in Japan who had been asked by the government during the Fukushima incident to evacuate an older adult home of several hundred people. But after having transferred the elderly residents onto a bus and then transported them to another facility farther from the radiation contaminated area, the new facility had refused to accept them. They had been afraid that the residents would bring contamination with them and that they would lose funds. A number of the residents died during this time, with their deaths attributed to the disruption caused by moving them back and forth. Blakely called for better education and training for responders.

Becker agreed that first responders, hospital and health care personnel, and public health nurses and physicians are all professionals with a strong dedication to duty. At the same time, they are also people. "We need to remember that they have concerns and information needs," he said, underscoring that addressing those concerns and information needs is critical. He added that another lesson learned from Fukushima Daiichi was that even professionals with some past training wanted just-in-time refresher training that was not generic but informed by the specifics of the event. There was a radiation emergency assistance team on the ground in Japan that put together such a training. Over the course of its mission, it ended up training about 1,100 personnel. Becker described the demand as "enormous."

6

Challenges for Building Capacity Within the Health Care System

Key Points Made by Individual Speakers

- There are only approximately 3,270 burn nurses in the United States (about 0.1 percent of all hospital nurses), and there is a particular shortage of burn nurses who specialize in pediatric care. There are opportunities to extend expertise to other nurses, but it will require new practice guidelines, better use of technology (such as telemedicine), and adding nuclear event triage to the Advanced Burn Life Support curriculum. (Bettencourt)
- The Radiation Injury Treatment Network (RITN) includes more than 80 cancer centers, blood donor centers, and cord blood banks nationwide preparing to care for patients with acute radiation syndrome (ARS); it is included in several federal disaster response plans. National gaps in response capacity for nuclear incidents include the lack of knowledge around ARS in the medical community as well as a lack of knowledge about the resources available on radiation safety. (Case)
- Burn care is a gap in medical capacity, and there is a need for more research into the prevention of third-degree burns from lower tier burns (which have better potential to heal). Burn care should return to the surgery curriculum, and better training resources, including through telemedicine, should be made available to surgeons in case of a mass burn casualty event. (Jeng)

- In the event of a nuclear incident, biodosimetry testing will be critical during the first 7–10 days to determine who has been exposed. But are there enough blood tubes, complete blood count kits, etc., to handle the amount of testing required if, for example, 200,000 people need to be tested? (Jones)
- Biodosimetry and bioassay testing will both be critical to determining the original source of radioactive contamination (i.e., specific radionuclides) and the level of contamination following a nuclear incident. This information will be useful to determine which populations require follow-up medical attention (e.g., medical countermeasures) and which do not. (Jones)
- Medical toxicologists—especially those linked to RITN or government agencies—play an important role during a nuclear incident response, but their numbers are limited. Telemedicine is one way to help close the gap between the large number of casualties likely during such an event and the very small number of health care providers and medical volunteers with adequate knowledge to care for the casualties. (Kazzi)
- Although international resources are available (such as the World Health Organization's Emergency Medical Teams), country ownership is critical in any disaster response, including nuclear incidents, which require unique response skills. Motivating the workforce is also a key part of a successful response. (Norton)

In the final session of the first workshop day, moderated by Bruce Evans, fire chief, Upper Pine River Fire Protection District, Colorado, panelists with varied health care systems perspectives continued the exploration of communication, education, and information challenges posed by a nuclear incident; the implications of these challenges for capacity building; and opportunities and approaches for addressing them. The panelists were chosen based on their having served on the front lines of advances in responding to nuclear incidents that are either being proposed or are already works in progress. Much of the focus of the session was on burn care.

The panelists included Amanda Bettencourt, research fellow, Center for Health Outcomes and Policy Research, University of Pennsylvania School of Nursing, and nursing representative on the American Burn Association's (ABA's) Committee of Organization and Delivery of Burn Care; Cullen Case, Jr., program manager, Radiation Injury Treatment Network (RITN); James Jeng, Surgeon, Crozer-Chester Medical Center, Pennsylvania, and chair of the Disaster Subcommittee of ABA's Committee of Organization and Delivery of Burn Care; Robert L. Jones, chief of the Inorganic and

Radiation Analytical Toxicology Branch of the Centers for Disease Control and Prevention's (CDC's) National Center for Environmental Health; Ziad Kazzi, associate professor, emergency medicine, Emory University School of Medicine, and board member at the American College of Medical Toxicology; and Ian Norton, director, Emergency Medical Teams, World Health Organization (WHO).

This chapter summarizes the panelists' remarks on response capability priorities plus the open discussion with the audience that followed.

PRIORITIES FOR RESPONSE CAPABILITIES

Evans asked the panelists to describe their top priorities for response capabilities.

Perspective of a Burn Nurse

Bettencourt described burn care in a hospital environment as very nursing care intensive and very physical space intensive. Patients with the most acute burns are cared for in specialized burn intensive care unit (ICU) rooms, where plastic curtains surround a heated, humidified interior space and where nurses wear full personal protective equipment and take care of the patient through the plastic walls. Just changing a dressing on a patient can require three nurses at the bedside and can take 3–4 hours. "It is very time intensive, it is very high touch, it is very high tech, and it is very specialized," Bettencourt said. But burn nursing is also highly variable, and most places where burn nursing occurs cover a range of levels of care—from ICU patients (both ICU and burn ICU) to ambulatory patients who are healing to even clinical patients. The intensive and variable nature of burn care creates a challenge when considering the massive amount of injuries and different types of patients that would result from a nuclear incident.

Geographic Distribution of Burn Care Across the United States

Adding to the challenge is the limited geographical distribution of burn centers across the United States (see Figure 6-1). This includes both ABA-verified (67) and non-ABA-verified (42) centers, with a total of approximately 900 burn beds. Bettencourt noted that there are three ABA-certified burn centers in Canada. Differences between ABA-verified and non-ABA-verified centers vary, although generally ABA-verified centers have all of the burn care team members, including not just nurses but also rehabilitation specialists, psychosocial support, and other necessary capabilities. As shown in Figure 6-1, there are large geographic areas in the United States

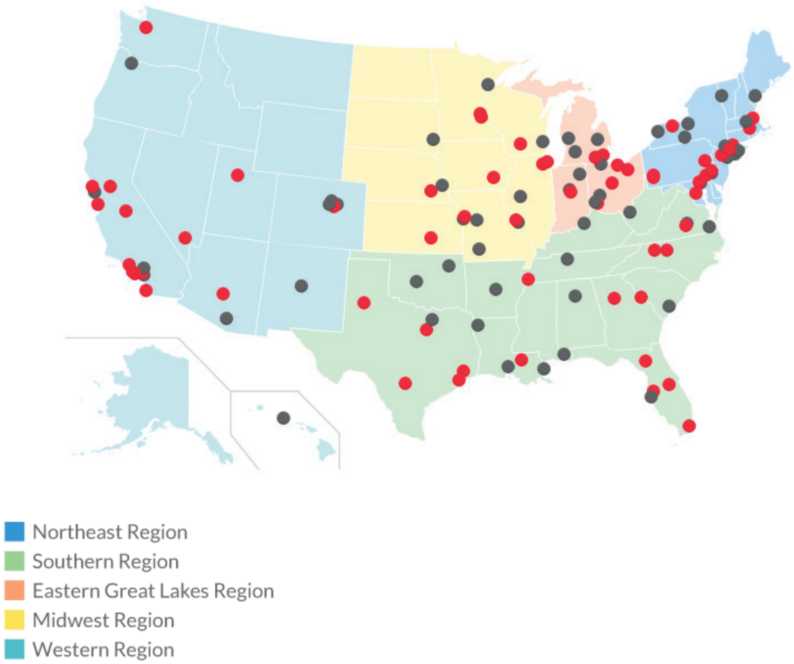

FIGURE 6-1 Distribution of ABA-verified (red) and nonverified (gray) burn centers in the United States.
SOURCES: Bettencourt presentation, August 22, 2018, and American Burn Association, 2018.

where there are no burn centers. "If there are no burn centers, there are no nurses. That is a problem," Bettencourt said.

Regarding pediatric burn care, only 39 of the 67 ABA-verified centers (58 percent) have combination adult/pediatric centers with the ability to take care of children varying depending on nursing staff. In some of these centers, only some of the nurses care for children. In others, all of the nurses can care for children. The three Canadian centers all have combined adult/pediatric units as well. With respect to comprehensive pediatric burn care and where most U.S. pediatric burn nurses are located, there are four freestanding pediatric burn hospitals and five burn units in freestanding children's hospitals.

U.S. Burn Nursing Workforce: Current Status

"Nurses are on the front line of all disasters and mass casualties," Bettencourt said. Yet most hospitals are understaffed, especially on nights and weekends. This has been evidenced during past natural disasters. Plus, she said, "there is a nursing shortage looming."

Currently, there are approximately 3,270 registered nurses (RNs) in the United States who have burn expertise. For perspective, there are about 1.7 million hospital RNs. This means that roughly only 0.1 percent of the hospital RN workforce has any burn expertise at all, and even fewer RNs have pediatric burn expertise. Among advanced practice (AP) providers, there is, on average, only one APRN or physician assistant (PA) per burn center. Many centers do not have any AP providers with burn expertise. There are only 109 APRNs or PAs in the United States with burn expertise. Bettencourt reiterated that most burn centers cover all phases of burn care, from ambulatory to ICU, sometimes with separate workforces at each level of care but sometimes with the same nurses working across all levels of care. Either way, when thinking about an influx of the number of burn patients described earlier in the workshop (see Table 4-1), Bettencourt expressed concern about the small number of people who would be able to take care of those patients. Regarding previous workshop participants' descriptions of burn care as the Achilles' heel, or rate-limiting step, of medical care in the event of a nuclear incident, Bettencourt agreed: "If you do not have a nurse to care for these patients, a lot of the care is going to get delayed and not happen."

Burn Nurse Competencies

A recent ABA task force identified nine burn nurse competencies (Carrougher et al., 2017):

1. *Initial assessment and management.* Bettencourt explained that the definitive factor deciding the course of burn care is how big and deep a burn is. Burn nurses are uniquely trained to assess this and determine a plan for the patient.
2. *Physiologic support.* This includes fluid resuscitation and ventilator management—again, unique skills that only burn nurses have. Although trauma nurses do have some background in fluid resuscitation, burn resuscitation is highly specialized and if done improperly can increase morbidity and mortality.
3. *Wound management.* Burn nurses are uniquely trained to not only assess but also manage burn wounds.
4. *Pain, agitation, and delirium.* Bettencourt explained that pain management from a nursing perspective includes things like dress-

ing changes and psychosocial support. A highly skilled nurse who can change a dressing quickly is often the best intervention—for children in particular—compared to narcotics or sedation. "Pain is not just drugs, but it is also technique," she said.

5. *Nutritional support*. Burn patients have unique nutritional needs.
6. *Psychosocial support*. Burn nurses are highly skilled at providing the necessary psychosocial support and determining, for example, when it is right for patients to see their face or scars.
7. *Rehabilitation*. Burn nurses receive specialized training in how to apply certain garments (e.g., burn splints) during rehabilitation.
8. *Discharge planning and after care support*. Recovery is a large part of burn care. Burn nurses help with school reentry, work reentry, and peer support.
9. *End-of-life care*.

Extending These Competencies to Other Types of Nurses: An Important Challenge

In Bettencourt's opinion, all of these competencies would certainly be useful in a nuclear incident scenario. Yet they are unique to burn nurses for the most part. Most nurses do not finish nursing school with any experience caring for burn patients. For Bettencourt, one of the biggest challenges is how to extend these competencies to other types of nurses.

Top Concerns

Among Bettencourt's top priorities or concerns, the first is that there are not enough burn nurses to care for thousands of burn patients, let alone the millions of patients predicted by some models (see Table 4-1). Pediatric burn nursing expertise in particular is extremely limited. Moreover, given the limited distribution of burn centers with pediatric care, in the event of a nuclear incident, transporting children to those centers may result in family separation and stress.

Bettencourt reiterated, however, that there is an opportunity to extend the reach of burn nursing expertise to other similar nurses. But this will require a few things, beginning with revisions to practice guidelines that take into consideration the nursing workforce. She mentioned a new type of dressing that can be kept on for about 1 week and that is being used a lot, particularly among children, as it reduces the number of visits (for outpatients) or dressing changes needed. When planning for a nuclear incident, she encouraged considering this type of strategy—tasks that can be done by other nurses as well, not necessarily burn nurses, and that conserve resources. In addition to new practice guidelines, telemedicine or teleburn ICU capabilities could be really helpful. She also mentioned ABA's Advanced Burn Life Support course for first responders, emergency room nurses, and burn nurses and physicians. Currently, much of the disaster training that most clinicians receive is through that course. She suggested adding nuclear event triage to the course. Finally, Bettencourt suggested thinking about opportunities where burn nurses could serve as consultants to the rest of the nursing community if one of these events were to occur.

Perspective of the American Burn Association: More on Burn Care as the Achilles' Heel of a National Response to Thermonuclear Detonation

Jeng continued the discussion on burn care as the Achilles' heel of a national response to a thermonuclear detonation and described some actions that ABA has taken recently that are relevant to a national response effort.

Crisis Standards of Care

First among these is ABA's publication of peer-reviewed guidelines for burn care under austere conditions (Cancio et al., 2017a,b; Jeng, 2017; Kearns et al., 2016; Young et al., 2016). Jeng remarked that this was a difficult project to gestate and finally get into print but that, in his opinion, it is one of the more important things that ABA's Committee on Organization and Delivery of Burn Care has done. It essentially serves as a "cookbook," he said, with instructions for how to carry on effective burn care without resources.

Jeng encouraged other groups of experts to address crisis standards of care, get them in print, and get care providers talking about crisis standards of care and how to apply them gracefully in a cogent, deliberate, premeditated fashion.

Another component to crisis standards of care, he added, is the reality that under austere conditions most people who would otherwise receive what he described as "full-court press" care will be "black-tagged" and receive only comfort care. He called for more work on the restriction of care tables that are used to support decisions about who receives full care versus comfort care. In addition, because the restriction of care tables differs dramatically depending on the number of casualties, situational awareness is crucial. Jeng said that his greatest fear is that in the aftermath of a disaster of, say, 200 casualties, responders would act as though there had been 2,000 casualties, inappropriately black-tagging many individuals. Thus, he also called for improvements in real-time situational awareness.

Mass Casualty Burn Drills

In addition to its crisis standards of care work, ABA has also been very proactive about mass casualty burn drills. Jeng agreed with other workshop participants who had expressed that it is one thing to drill at a high level in the federal government but quite another thing to drill with people who are on the front line and will actually be providing the care.

He described a session at the ABA annual meeting in April 2018 where ABA had run participants through some of the Gotham Shield exercise. Jeng showed a snapshot of the session and pointed out the facial expressions of the participants. "They are not pretending," he said. "There is a lot of anxiety in those faces." Jeng and the other organizers had set up a civilian defense alarm, a siren, which they had run throughout the whole 1.5-hour session. During the exercise, many people had asked him to turn off the siren. He would explain to them that it was a way to try to address what he called the "deer in the headlights" issue, which he emphasized is very real. He and many others in the burn community have lived through mass casualties and seen it. People freeze and do not know what to do. "You drill because you do not want people to act like deer in the headlights when it really happens," he said.

Breaking Down Silos

Jeng reflected on the fact that there are many people across the country who are working on mass casualty preparedness, yet there is also a lot of tribalism. He encouraged more efforts along the line of what ABA and RITN had begun working in the run-up to this workshop. They had scheduled a webinar to take place a couple of weeks afterward, where each organization would present to the other its response plans for a thermonuclear detonation. Then, from that platform, they will publish a practice guideline for combined care for radiation and thermal burns.

He called for trauma units in particular to break down their silos, as trauma professionals are really the "band leaders" for any big mass casualty event in the United States. "If we do not break down the silos, we are not going to make this country safer," Jeng cautioned.

Potential Areas for Further Action

Jeng suggested four actionable items, two of which are free; the other two are not free but compulsory if the burn care community is to cogently address casualty levels at 20,000 or 200,000:

1. *Return burn training to the U.S. surgery curriculum.* The first, free action is that burn training be returned to the general surgery curriculum in the United States. He reiterated that there has been no burn training for surgeons in the past 10 years. He explained that this is a consequence of not just the 80-hour work week but also financial constraints of academic medical centers and training programs that no longer have enough workforce to do burn rotations. Without any more burn surgeons being trained, he cautioned, "the 'piper' is going to have to be paid pretty soon." The organizations responsible for the surgery curriculum include the American Board of Surgery, the American College of Surgeons (ACS), and the Accreditation Council for Graduate Medical Education.
2. *Arrange a summit to break down silos.* Jeng's second action, also free, is that the assistant secretary for preparedness and response, Robert Kadlec, summon the leaders of the ACS Committee on Trauma, ABA, and other relevant organizations to a "sit-down" in Washington, DC, to come up with a solution. In Jeng's experience, when summoned by the executive branch, people show up. In his opinion, the executive branch does not use that power nearly enough. "Summon the people to break down the silos," Jeng said. "Make them sit down, and let them know that not only the executive branch but the public has eyes on this group of people." Later during the discussion period, James Ficke of Johns Hopkins Medicine responded to Jeng's call for a summit by calling attention to the fact that this workshop itself was just such an event. "We are here," he said.
3. *Invest in basic science and translational science research to keep second-degree burns from becoming third-degree burns.* Jeng emphasized that the only way there is going to be any cogent response to 20,000 or 200,000 burn casualties is to pour "big money" into basic science and translational science research about how to stop partial thickness burns from progressing to full thickness burns. In other words, the "magic bullet," he said, is how to keep second-degree burns from evolving, as they do, into third-degree burns. This is crucial because, by definition, second-degree burns (partial thickness burns) have the potential to heal without surgical intervention. In his opinion, this is a "fairly addressable" biological phenomenon.
4. *Invest in telepresence to act as an amplifier.* Again, the only way that there is going to be a cogent response to 20,000 or 200,000 burn injuries that are potentially salvageable is to invest in telepresence to act as an amplifier. No amount of training of burn surgeons or trauma surgeons will create enough surgeons to deal

with that many casualties. Investing in telepresence will require also addressing infrastructure and state jurisdiction issues.

Diagnostic Laboratory Challenges After a Nuclear Incident

Although the topic of burn care would reemerge as a topic of primary concern in the open discussion with the audience at the end of this panel, in the meantime, the focus of the discussion shifted to other key challenges to building capacity within the health care system. The first of these is diagnostic laboratory capacity. Jones discussed how a nuclear incident would require some type of diagnostic tool to determine who needs what type of medical management and explained the differences between different types of tools.

Radiation Diagnostics Terms

Radiation involves both "exposure" and contamination. A person is "exposed" to radioactive materials through gamma radiation—for example, in an improvised nuclear device blast or from the "ground shine" particles in the dangerous fallout zone that Buddemeier described earlier (see Figures 2-3 and 2-4). A person is contaminated either internally through inhalation or ingestion of radioactive particles or externally when particles are actually on the body. This can occur from fallout—that huge mushroom cloud of debris that can fall 1, 10, 200, 2,000, or more miles away. Jones explained that both "exposure" and contamination result in an exposure to a dose of radiation.

Use of Biodosimetry Versus Bioassays

Jones further explained that the appropriate diagnostic test for someone who has been "exposed" to gamma rays but has no external contamination (i.e., no radioactive particles on the body or clothes) is biodosimetry. Biodosimetry determines past radiation dose from an "exposure" incident. Such exposure could result either from the initial blast or by walking through the ground shine (e.g., when first responders enter a dangerous fallout zone or the public leaves). In a mass response to a nuclear incident, the primary biodosimetry test that would be used would be lymphocyte depletion kinetics. It is a complete blood count (CBC) test. He noted that there is another type of biodosimetry test, chromosome analysis, but it has extremely limited capabilities in the United States. In terms of other applications besides a nuclear bomb, biodosimetry is limited for measuring both nuclear power plant and radiological dispersal device (RDD) "exposure" but effective for measuring "exposure" from radiation exposure devices (REDs).

For external contamination, diagnosis could be done with handheld monitoring or with people walking through a radiation portal. Although most of the radionuclides in a nuclear incident situation would be gamma, the same test can be used to detect alpha, beta, or gamma contamination.

For internal contamination (i.e., radioactive particles inside the body), bioassays are the preferred choice. The bioassay is a urine test. It determines past, current, and ongoing radiation doses from an internal contamination incident. Jones explained that a bioassay test is more effective than an external contamination test in the actual fallout zone because the initial radioactive particles close to the detonation are not very respirable. Further out, however, at 20, 30, 50, or 100 miles out, they are respirable, and people can inhale them from the debris falling on the ground. In terms of other applications besides a nuclear bomb, the bioassay is an effective diagnostic tool for measuring contamination from nuclear power plant fallout and RDDs but not for REDs. Jones explained that an RED is effectively a solid piece of cobalt-60 just emitting gamma radiation.

Following a nuclear incident, the initial priority would be to quickly determine who needs medical management and radioprotective medical countermeasures, which are available either in the Strategic National Stockpile or locally. Thus, Jones said, the preferred method of testing during the first 7–10 days would be biodosimetry. He cautioned, however, that most labs with biodosimetry capacity have only just-in-time inventory. For multiple reasons, from product expirations to the cost of floor space, most labs do not have huge stockpiles. If there are 500,000 people that need to be tested, preferably twice or more, that amounts to more than 1 million tests. He asked, "Do you have the blood tubes, the needles, the syringes, the actual CBC kits locally to do a million tests in 7–10 days? You need to think about that."

Although bioassay testing can rapidly identify internal deposition of radionuclides and can quantify contamination, the capacity for bioassay testing is fairly limited. There is only one lab in the country, a CDC lab, that can do it. One of the issues with bioassay testing following a nuclear detonation is that the hundreds of radionuclides formed by the detonation itself constantly decay and re-decay. Thus, the tests are used only to detect and measure certain markers, such as cesium or strontium-90, based on what the U.S. Department of Energy and others are determining are present. Jones emphasized the importance of coordinating with state and federal epidemiology experts to determine the priority of bioassay testing.

One of the values of bioassay testing is that it provides information for population monitoring (i.e., based on the level of internal contamination). In many cases, bioassays provide negative test results for people who think that they may have been contaminated but are not truly contaminated, thereby relieving the stress on the public health system and overall health care system. This raises another issue, which is that it is hard for many people to grasp the concept of a negative result. Imagine people living 20, 50, or 100 miles away from a detonation who are convinced that they are contaminated and are going to die from cancer in the next year or two. Jones referred to Yeskey's earlier discussion of the large number of people showing up, demanding to be tested. He suggested that, in collaboration with local epidemiologists or other public health officials, perhaps only a subset of the community be bioassay tested to determine if the population really, truly has been exposed to a level of contamination that requires follow-up. Some communities may need follow-up; others may not. Conducting some bioassay testing and showing that a community is not more exposed than the rest of the unexposed population can reduce anxiety tremendously as well as reduce demands on the medical and public health communities.

Priorities

Jones concluded by emphasizing the need to think about how to prepare for the enormous amount of biodosimetry testing that will be required during the first 7–10 days. This is particularly important given the likelihood that the detonation would destroy all nearby diagnostic laboratory capabilities. The "good news," he said, is that there are thousands of labs that do CBC tests. The question is, do they have enough blood tubes and enough CBC kits to run the number of tests needed? He suggested thinking about reception or assembly centers—that is, places where blood samples would be collected and then, from there, sent to labs in other parts of the country.

In addition to ensuring that there are enough resources to conduct the number of tests that will be needed, another challenge would be tracking multiple test results (i.e., per person) and ensuring that the people who are making decisions about care receive the data. Jones imagined people being tested in one place and then evacuated to another place or being tested in multiple places. How are those data going to be combined? What do the laboratories need to do to prepare for that scenario?

In closing, he said that 60–70 percent of medical decisions are based on a lab test. In a nuclear detonation scenario—a resource-scarce environment with limited medical countermeasures—the response community will need to be able to identify who really needs these countermeasures and who does not.

Radiation Injury Treatment Network

Case provided an overview of RITN and its potential role in a nuclear incident and discussed what he perceived as some of the most important gaps, or priorities, in response capabilities based on his experience with RITN.

RITN is a group of 83 blood donor centers, cord blood banks, and cancer centers or hospitals with bone marrow transport (BMT) or hematology units that are working together to prepare for mass casualty incidents with radiological injuries that affect the marrow. Each year, RITN members are required to carry out a number of training and exercise tasks and to maintain institutional review board (IRB) approval of the RITN data collection forms and protocols. This is to ensure that that they are ready to receive casualties through the National Disaster Medical System (NDMS) in response to an incident.

Case described how RITN has had a lot of experience growing its network. It started with 13 centers or hospitals in 2006. He recalled a lot of resistance initially, particularly from administrators who questioned why a facility would want to receive these casualties. Case referred to the fear of contamination that previous speakers had discussed. In addition to fear, there were also concerns initially about who would pay for the care. But one of the biggest issues that they ran into initially was that most of the BMT or hematology units had only done annual evacuation drills. Most of them had no idea what NDMS was. Nor did they know what preparedness capabilities were in place at their own hospitals. “Since then, we have really engaged them into being involved in their preparedness activities at their hospitals,” Case said.

Gaps in Response Capabilities

The biggest gaps in response capabilities that Case sees in his work are fear and knowledge. “A lot of people are afraid of radiation,” he said, echoing many other workshop participants’ remarks. In addition, many medical professionals do not know how to care for people who have been exposed to radiation. Many have no idea what to do, he said. Most have heard of acute radiation syndrome (ARS), but they do not know what the signs or symptoms are, let alone how to care for it. Even within RITN centers, other than the primary physicians who work with RITN and perhaps one or two additional physicians who may be aware, the knowledge is minimal.

Regarding fear even among prepared providers, Case relayed how a few years ago, during an exercise in Salt Lake City, the trainees had had to pull patients off of a C-130 aircraft. Half of the patients had been actual kids pretending to be patients, and the other half had been dummies on stretchers. The first patient to come off the plane had been a pediatric dummy about 18–24 inches long. It had had a casualty tag on it. The trainees had brought the dummy into the hospital, where a strike team of 18 nurses and physicians had swarmed. Case said that they had been excited. They had been planning this for months and had participated in a tabletop and other exercises. A nurse had picked the dummy up and started reading the casualty tag: “3-year-old patient, Caucasian, female, expected 10-grade exposure to radiation.” At mention of “exposure to radiation,” everyone, including the nurse, had thrown his or her hands up and run backward. “These are people that are involved in radiation preparedness, have had training on it, recently had training on it, and were expecting it, and they still freaked out,” Case said. Since that exercise, RITN has facilitated more than 650 additional exercises. He said that he would like to think that the situation is better today. Even so, in his opinion, there is a lot of work to be done in this area.

Apathy and priority are other major issues for Case. There are many people who assume that a nuclear incident is not something that will happen to them. Even in 2017, with the threat from North Korea, although there had been more interest, in Case’s opinion, still there had been a lot of people who had believed that the media was making a “big hubbub” out of nothing. RITN tries to counter this apathy by requiring each hospital to do a tabletop exercise every year. RITN provides the scenario and facilitates six Web-based exercises. It offers continuing medical education credits to draw in both physicians and nurses. Case said that the feedback they receive from health care professionals who have participated in the trainings is positive, with many people reporting that having participated broadened their awareness about other resources and activities. During the exercises, people working in BMT and hematology or oncology units interact with other people both inside and outside their hospitals whom they do not interact with on a day-to-day basis. The exercises break down barriers and build confidence.

Administrative barriers, which were especially problematic initially, remain a gap. When RITN approaches a hospital, it usually takes about 18 months for the hospital to join the network. Hospitals want to know what their return on investment will be. RITN provides a small stipend of $8,000 per year. While not enough to cover a hospital’s efforts, it is unrestricted, which Case said hopefully comes across as something worth more than something that has to be used for a specific cause. A number of RITN centers have tracked their time, reporting that they have spent about $15,000 in labor hours every year on RITN activities. So when approaching a hospital, RITN really has to convince the administration that it needs to participate—that it is going to have to become involved in the event of an incident and that it needs to be prepared. Case noted that about 89 percent of U.S. hospitals are part of NDMS.

Competing priorities are another concern, Case said. The current Joint Commission and Centers for Medicare & Medicaid Services (CMS) requirements are focused on an active shooter threat. Case mentioned having colleagues who have been on the road for 8 straight months conducting active shooter exercises around the country for schools, hospitals, day cares, and other facilities. "We are always going to have something that is the newest that is going to distract everyone's attention and resources," Case said. The challenge is how to do both or at least not interfere in accomplishing what is being pushed currently.

Dissemination is another gap. Everyone within the core group who is interested in this topic knows about it, Case said, and the information is not secret or hidden. It is readily accessible. Yet, Case said, "it does not seem to really get out there." He commented on the lack of time that many people have to invest in keeping up and reading the resources that are available. On top of that is staff turnover. Getting people's attention is a "never-ending cycle," he said.

Role of Medical and Clinical Toxicologists in a Catastrophic Nuclear Emergency

Kazzi underscored the medical care challenges of a nuclear incident stemming from a very large number of victims combined with an inadequate number of health care providers and medical volunteers. However, he believes that there must be a way to close this gap. Telemedicine is one way. Medical toxicologists can also help. He described how medical toxicology serves as a resource—already they are involved with various things (e.g., linkages with RITN and other response agencies at federal, state, and local levels), and they provide specialized resources that support other providers and ensure the reach of technical knowledge to a wider area. He elaborated on many of the locations where clinical toxicologists operate, including as part of government and community planning, academic research and teaching, and poison control centers throughout the United States. Clinical toxicologists are also supporting the development of training courses for other providers to expand the specialized knowledge base around the use of medical countermeasures for radiation exposure and treatment of acute radiation sickness. Kazzi closed by highlighting the relationship between the toxicology resources and RITN, with 73 percent of RITN centers having a toxicology resource in the same geographic area.

A World Health Organization Perspective

An important lesson learned by the Global Outbreak Alert and Response Network from disasters, Ebola, trauma care in Syria, etc., is that self-deployers cannot be allowed to enter disaster areas, said Ian Norton, director, Emergency Medical Teams, WHO. It is not so much about individual expertise, he said. It is about how to plug into a system that can get you there safely, Norton explained. In other words, good intentions are not enough. Capacity requires logistics and the power behind those logistics. It requires an organization that can carry individuals.

Several nuclear response teams in China came to mind for Norton and a couple teams in Southeast Asia, but that was about it. He wondered if there was a way to embed expertise into generic teams and then copy those teams. Furthermore, Norton emphasized the need for increased national ownership, both ownership of the capacity building necessary to meet the needs of large-scale incidents and also ownership by a country or community's health leaders that they may face circumstances where they will not have the capacity to meet the need. In the latter case, Norton highlighted the importance of leaders owning the need to cut down on "red tape" required to properly use visiting resources in their communities. Norton pointed out the limitations of state-to-state license recognition in the United States as a significant challenge for response capacity, which he had heard in the day's discussions. Other lessons learned from past disaster work include the need to send a message of hope, not nihilism, and the importance of "flow" in triage and lab testing. He suggested perhaps considering centers of excellence of care given that certain types of incidents, like mass burn events or an outbreak of a highly lethal disease like Ebola, have the capacity to overtax the resources of a single country. Discussing burn events, Norton echoed Jeng's comments earlier in the session. The small absolute number of burn beds and burn specialists can mean that single events can quickly overtake the finite resources. In reflecting on the Ebola experience, Norton highlighted centers of excellence of care as a way to overcome fear and hesitation among providers. He remarked that knowing there was a center of excellence available was often a key factor in addressing the anxiety providers felt when working within a hot zone.

DISCUSSION: SHORTAGE OF BURN EXPERTISE

Following the panelists' presentations, the panel fielded questions from the audience and from Evans. Almost all the questions and discussion revolved around the shortage of burn care expertise.

Art Cooper of the American Academy of Disaster Medicine remarked that it would be difficult for surgery residencies to include burn care given the difficult "educational milieu." But a first step could be the excellent course offered by the ABA. In his opinion, instead of asking Kadlec to convene everyone in a room, he would suggest fundamental disaster education/training for everyone. "There are critical issues that the nation needs to address as soon as possible." Jeng suggested some additional courses and agreed that the syllabus is too tight already. He suggested that, as a start, at least all war surgeons receive some burn training. Many burn surgeons have military backgrounds.

This discussion prompted Evans to ask how people can be recruited into the system to help overcome some of these shortages. Kazzi pointed out that medical students need to be considered as well—they need disaster training. He noted that there is a CMS specialty course in medical toxicology.

The shortage in burn professionals applies to nursing as well, Bettencourt reminded the workshop. The number of burn nurses is related to the number of in-house burn patients. Thus, she reiterated that there are not a lot of burn nurses. However, there is an opportunity with advanced practice nurses[1]—having more of them might be a way to expand burn professionals.

Colleen Ryan of Harvard Medical College added that the shortage in burn expertise extends to other health care professionals as well, including therapists, pharmacists, etc. An entire team is required for burn care. She urged also extending the focus to rehabilitation and recovery.

When Evans asked the panelists what people themselves (i.e., non-providers) can do in the event of a burn given the shortage of burn expertise among health care providers, Jeng highlighted the role of bystander or buddy care[2] and emphasized the need for oral rehydration, etc. Buddy care will make a huge difference in the event of 20,000 or 200,000 casualties, he said. It is already operational in the military, he said, referring to NATO Role 1,[3] "buddy care" (i.e., point of injury care).

Ficke suggested that even Roles 2 and 3 could be expanded in hospitals and disaster drills conducted at these levels to really challenge the supply chain. Jeng agreed that disaster drills need to be brought down to the level of the responder.

In Jeng's opinion, while there is a shortage of trained workforce, and there are ways to deal with it, the "right" problem is not how to increase the number of experts needed. Rather, what can be done to attract people to burn care by making it a viable life choice? What are the incentives? Jeng agreed that because burn care is a market-driven system, it is not financially viable to simply increase the number of burn centers. In his opinion, that is

[1] An advanced practice registered nurse is a registered nurse educated at a master's or post-master's level and in a specific role and patient population.

[2] *Buddy care* is short for *self-aid and buddy care*, a U.S. Air Force training program that provides all deploying personnel "knowledge and skills to minimize injury and prevent death or disability in deployed environments or home station emergencies." See https://static.e-publishing.af.mil/production/1/af_sg/publication/afi36-2644/afi36-2644.pdf (accessed January 18, 2019).

[3] Roles 1, 2, and 3 refer to various NATO standard levels of medical treatment facility capability. See https://www.nato.int/docu/logi-en/1997/lo-1610.htm (accessed January 18, 2019).

a "brick wall." Bettencourt added that the same market effects are driving the shortage of burn nurses.

In Australia, there used to be a problem staffing Aboriginal community positions, Norton offered. To overcome this problem, it was decided that individuals would be preferentially selected from those positions to serve in overseas disaster response. The word spread quickly. Now recruiting to those communities is no longer a problem—they are competitive positions. "There are other things that drive people besides money," Norton said.

7

Capability-Building Challenges and Opportunities: Building Response Capability

Key Points Made by Individual Speakers

- If a nuclear detonation occurred in a major U.S. city, thousands of people would be exposed to survivable doses of radiation. Absolute lymphocyte count tests would be among the most reliable and scalable approaches to assess exposure among survivors, with two major national laboratory chains—Quest and LabCorp—hypothetically able to conduct up to 1 million tests within 24 hours in the absence of local labs likely to be destroyed during such an event. (Adalja)
- The Strategic National Stockpile holds several medical countermeasures relevant to a potential nuclear scenario, including cytokines, nausea medications, pain medications, sedatives, and burn kits. Accessing patient areas to maximize distribution of medical countermeasures would likely be a major challenge in any nuclear incident response. (Adams)
- A nuclear incident would lead to many thousands of people being displaced in shelters under the care of volunteers; challenges in the effective use of volunteers include their working in areas with above-ground radiation, requirements for mobilizing and screening volunteers, and the use of volunteers in nontraditional settings. (Casey-Lockyer)
- The U.S. Department of Veterans Affairs' Comprehensive Emergency Management Program could serve as a model for

other hospital systems; it offers training programs in handling patients exposed to radiation, and the training is tied to regulatory and financial incentives. (Couig)

- The destruction of hospitals and loss of medical personnel following the atomic bomb drop on Hiroshima illustrates the reality that medical capacity is deeply wounded by a nuclear incident; however, casualties can be reduced by ensuring a prepared and well-informed citizenry. (James)
- Challenges in the implementation of the Federal Emergency Management Agency's Nuclear/Radiological Incident Annex include coordination with other agencies, improvement of pre-incident preparedness, management of large-scale radioactive waste, reimbursement of host sites, and resource requests. (Garcia)

The Panel IV objective was to explore challenges, opportunities, and implications for building capability to respond to and recover from a nuclear incident, including building capacity for monitoring and long-term health surveillance among survivors. The panel, moderated by John Benitez, medical director of emergency preparedness, Tennessee Department of Health, included six panelists from across academia, government, and response organizations.

LARGE-SCALE TESTING FOR ACUTE RADIATION SICKNESS AFTER A NUCLEAR INCIDENT

Amesh Adalja, senior scholar, Center for Health Security, Johns Hopkins Bloomberg School of Public Health, described a previously published "thought experiment" that described a potential solution to testing millions of survivors following a nuclear incident for acute radiation sickness (ARS): the formation of a public–private partnership with two major national laboratory chains—Quest and LabCorp—to test and identify individuals at risk for ARS (Adalja et al., 2011). Following a nuclear detonation, Adalja explained, millions of people would likely be exposed to radiation, with the potential for hematopoietic patients—those who could be treated with antibiotics—to be saved following rapid and accurate identification. However, several challenges could emerge, including the sheer number of individuals who would need to be tested and population dispersal. Adalja and colleagues considered which factors to assess to understand who would be at risk for ARS; time to vomiting, a common side effect in the immediate period after exposure, was deemed to be too variable, and other high-tech solutions were not scalable. These included chromosomal dicentrics, which Adalja said is the gold standard but also acknowledged that it would be difficult to implement due to the need for specially trained personnel to conduct testing and the inability to scale it up.

Ultimately, Adalja said, he and his colleagues settled on absolute lymphocyte count (ALC) as the most reasonable solution to mass test for ARS. ALC, he said, is a common result on every complete blood count (CBC) test, and it records the amount of a specific type of white blood cells. The result is predictable and time dependent and decreases with radiation; thus, Adalja said, if practitioners record the time of the blast and time of exposure, extrapolation of the radiation dose is feasible. Moreover, the CBC test is automated and is a common task at laboratories and hospitals across the country, meaning the CBC test for ALC is a potentially scalable solution. Keeping in mind the likely reality that local medical infrastructure would be destroyed by a nuclear incident, Adalja said that he and colleagues approached the two major national laboratory chains about the feasibility of their role in this scenario. He explained that the companies would be a good fit for this role due to their national reach and their transportation and logistical capabilities. Based on feedback from the companies, Adalja believes that conducting 1 million CBC tests in 24 hours would be feasible. A potential benefit to partnering with the laboratories, he said, is the fact that many Americans already have active Quest or LabCorp accounts through routine medical care. Adalja said he hopes that with the reemergence of nuclear threats, this solution could prove useful in potential planning.

USE OF THE STRATEGIC NATIONAL STOCKPILE IN A NUCLEAR SCENARIO

Steve Adams, deputy director of the Division of Strategic National Stockpile (DSNS), Center for Preparedness and Response, Centers for Disease Control and Prevention (CDC), provided background on the Strategic National Stockpile (SNS) program and described formulas in the stockpile that would be distributed and dispensed in the event of a nuclear incident. He explained that the SNS has existed since 1999, and while it remained under the purview of CDC during the workshop, it moved under control of the Office of the Assistant Secretary for Preparedness and Response, U.S. Department of Health and Human Services, on October 1, 2018. The SNS maintains a portfolio of approximately $7 billion worth of medical materiel held in a series of strategically arranged repositories across the country to ensure proximity to populations and efficient transport. On the business side, Adams said, the SNS works with third-party vendors in the private sector to maintain business logistics and material oversight. For example, FedEx and UPS both play a role in the rapid transportation of supplies across the country. On the supply chain side, Adams said that in recent years the SNS has collaborated more with private-sector partners to amplify and complement the capacities that the SNS controls directly, either supporting materiel held in SNS warehouses or through contracts that guarantee the SNS access to vendor-managed inventory. Adams said that this day-to-day control over products provides insight on the supply chain and allows for better marriage between supply and demand.

Next, Adams reviewed products held in the SNS that would be relevant during a potential nuclear incident. First, he listed products held for radiation injuries:

- Cytokines, including Neupogen, Neulasta, and Leukine
- Nausea medications, including ondansetron
- Pain medications, including morphine and Oxycodone
- Antibiotics, including levofloxacin and amoxicillin
- Antivirals, including acyclovir
- Antifungals, including voriconazole

Adams also discussed SNS countermeasures used for burn and blast injuries, including electrolyte replacement (saline), wound care products, laceration repair kits, topical ointments, eye care kits, and burn care kits. However, Adams noted that the SNS and the Biomedical Advanced Research and Development Authority (BARDA) are working to revisit the formulary and potentially add new burn care items to the stockpile.

Lastly, Adams addressed distribution and dispensing of SNS products at the state and local levels. All states have response plans that include an SNS annex, as well as pre-identified receipt, stage, and store sites where SNS products would be received via commercial transport and distributed down to local jurisdictions. Ultimately, Adams said that jurisdictions are responsible for transport once they receive products from the SNS, but in a nuclear incident in particular, transport and distribution would be a major concern. Accessing the impacted areas would likely be difficult, and distribution strategies specifically for nuclear scenarios will need to be developed to ensure success, he said.

USE OF VOLUNTEERS DURING A NUCLEAR INCIDENT

Mary Casey-Lockyer, senior associate, Disaster Health Services, American Red Cross (ARC), stressed that a nuclear incident would be a catastrophic event that would require additional support beyond medical professionals. "We can't do this alone," she said. Willingness of health care professionals to respond, as well as the portability of health care licensure across jurisdictional borders, could prove to be major issues during a response, Casey-Lockyer said. Tied to this, she said, is the leveraging of nonprofit resources across borders; while the Emergency Management Assistance Compact allows states to share assets, it does not apply to nonprofit or nongovernmental organizations—for example, members of the Medical Reserve Corps (MRC) or professionals who serve on a volunteer basis with ARC—which are critical assets during major public health emergency responses.

Casey-Lockyer described her optimal state of readiness for a nuclear incident. She described a need for more CBRN (chemical, biological, radiological, and nuclear)-specific training (including individual- and family-level preparedness), ensuring that all health care professionals in the United States have a basic understanding of radiation physics and protection from radiation exposure/contamination; she said this type of education could go a long way in preventing fear among responders and suggested that it could be included in medical school, nursing school, and other formal health care education curricula (for staff in all 17 Centers for Medicare & Medicaid Services–covered entities). In order to maximize volunteers' impact during a nuclear incident, Casey-Lockyer said that volunteers should pre-affiliate themselves with a recognized disaster relief operation such as that of ARC.

Casey-Lockyer grappled with potential incentives for volunteers to respond to a nuclear incident, including financial incentives to health care systems for allowing providers to volunteer, as well as incentives for the volunteers themselves. Regarding surge, she discussed the possible use of a global health workforce to complement the 2.9 million nurses in the United States. Lastly, Casey-Lockyer said that above-ground radiation areas would be a major challenge for volunteer organizations, especially when incorporating volunteers from outside the event area. Shelters would need to be set up not only for survivors, she said, but also for the volunteer workforce itself. Additionally, organizations would be challenged to reconsider their responsibilities in areas such as decontamination, long-term care for orphans, and other unique issues.

ROLE OF THE U.S. DEPARTMENT OF VETERANS AFFAIRS IN A NUCLEAR INCIDENT

In the field of public health emergency response for nuclear incidents, the Comprehensive Emergency Management Program (CEMP) of the U.S. Department of Veterans Affairs (VA) could serve as a potential model for other hospital systems, said Mary Pat Couig, program manager, Office of Nursing Services, VA. Describing VA's health mission and responsibilities, Couig said that 6 million veterans used health care services at VA in fiscal year 2016, and there are 25,000 physicians and 98,000 nurses in the VA system. She noted that its public health emergency response responsibilities emerged out of Public Law 97-174 (1982), which founded the VA–U.S. Department of Defense contingency hospital system. In 1987, VA worked with the Federal Emergency Management Agency (FEMA) and other agencies to found the National Disaster Medical System, and in 2006 VA was included in the Pandemic and All-Hazards Preparedness Act (PAHPA), allowing VA to provide assistance to nonveterans. VA's Office of Emergency Management is the focal point for coordination of these activities, Couig said, and the office's vision is to create a resilient and prepared health care system in an all-hazards environment. Its work includes both field programs and response programs working with other government agencies in responses to recent disasters such as Hurricane Maria in Puerto Rico.

Couig said that CEMP offers several education and training programs, including the Veterans Health Administration First Receivers Decontamination Program; it is required at all 141 VA facilities with emergency departments or urgent care clinics. The training curriculum is designed to teach receivers the protocol for handing patients who arrive at the emergency department with radiation exposure, according to Occupational Safety and Health Administration regulatory requirements. She noted that the training includes a practical exercise component as a capstone, and there is a workgroup that regularly reviews and updates course materials. Importantly, she noted, the course is required every 3 years in order to maintain continuing education units, an incentive for course participation.

Couig discussed challenges to VA's emergency preparedness. She said the aging health professional workforce—more than two-thirds of VA nurses are over the age of 45—could prove to be problematic because advanced age could limit some individuals' capability to respond to a nuclear incident. Additionally, in the context of high workforce turnover, there is a constant need for continual training, especially among new employees. Couig also reiterated the importance of all-hazards training, especially in a 21st-century threats environment.

Couig ended her presentation by describing opportunities to leverage VA as a preparedness and response resource. She said that many VA medical centers have core teams for all-hazards preparedness, providing continuity during disasters. Additionally, MRC, Citizen Corps, and the National Guard/Reserves could provide training opportunities for responders. Couig closed with a call to action: the implementation of public health emergency preparedness training in schools down to the elementary level. She said that elementary students already conduct drills for active shooter events and other emergencies, so resiliency could be an easy concept to incorporate more broadly. In secondary schools, she said, public health preparedness concepts—including individual- and community-level preparedness and resiliency—could be incorporated into mandatory health classes.

COMMUNITY RESPONSE FOLLOWING A NUCLEAR EVENT: THE CAPACITY OF A PREPARED CITIZENRY

James J. James, executive director, Society for Disaster Medicine and Public Health, and editor-in-chief, *Disaster Medicine and Public Health Preparedness*, began his remarks by commenting on the diversity of participants in the room; as a veteran in the field of nuclear preparedness, he said, it was refreshing to see new stakeholders advancing the cause at this workshop. He subsequently noted that in emergency preparedness at large, responders too frequently take on the mentality of "the blind leading the blind," with distinct groups participating in a response without good communication, coordination, and leadership (he emphasized the 2010 earthquake in Haiti as a prime example of this problem). He also noted that planners are often blind to the realities and accurate predictions of all-hazards threats, making planning all the more difficult but still necessary.

James subsequently described the devastation of the atomic bomb dropped on Hiroshima in 1945, noting that of the 350,000 people who lived there, more than 30 percent died. More than 90 percent of the physician and nursing workforce in the area was wiped out, and medical infrastructure—including all hospitals—was destroyed. Expanding on the Hiroshima example, James admitted that medical systems in the United States and elsewhere likely do not have the capacity to care for all the casualties in the short term following an event, but he emphasized that they do have the ability to decrease the potential number of casualties before a nuclear incident occurs through the evolution of a more prepared citizenry. A prepared citizenry is an informed citizenry, he said, and this requires better public education about the potential threat.

James referred to an example discussed by Robert Whitcomb earlier in the workshop, the Castle Bravo nuclear test and its subsequent effect on the *Lucky Dragon 5* fishing boat. He said that among the 23 crew members who suffered from ARS, only 1 died as a result of injuries from this event; "radiation sickness is not a death warrant," he said. Long term, James said, they lived average lifespans, and the fear of genetic injuries and cancer as a result of radiation exposure remains overblown to this day. In popular culture, the *Lucky Dragon 5* event was incorporated into the legend of Godzilla, which only served to promote more antinuclear sentiment and fear around radiation in Japan and elsewhere. Helping the public better understand the true risks of radiation exposure will help the population stay safer after a nuclear event. James closed by announcing that he is currently planning to organize a working group on the topic of creating a more informed citizenry to further advance this cause.

NUCLEAR/RADIOLOGICAL INCIDENT ANNEX OF FEMA

Luis Garcia, chief, CBRN Support Branch, Response Directorate, Office of Response and Recovery, FEMA, described the Nuclear Radiological Incident Annex (NRIA), which is housed in FEMA and provides guidance for federal planning efforts around nuclear and radiological incidents (including improvised nuclear devices, radiological dispersal devices, radiation exposure devices, nuclear facilities, found radioactive materials, transportation incidents, foreign incidents, etc.). It serves as an operational annex to the Response and Recovery Federal Interagency Operations Plans, he said. Garcia presented a list of questions that are addressed in NRIA:

- How will various incident management roles be integrated and coordinated?
- How will interagency partners access the incident area or crime scene?
- What protocols, equipment, and expertise are needed to monitor responders' accumulated radiation dose data?
- How can we improve pre-incident preparedness at the federal level?
- How will large-scale radioactive waste be managed?
- What is the policy for reimbursing host states that provide sheltering and support services?
- How will resource requests be de-conflicted?

Garcia then described executive decision points, which he called a series of time-phased decision points for executive leadership with guidance on decision criteria, responsible entities, and other information. The decision points ensure that leadership, over the course of a long-term response, can accurately address key topics such as public information, crisis standards of care, waste management, population relocation, and remediation, among other topics, he said. NRIA also allowed for the creation of an interagency Nuclear Radiological Incident Task Force (NRITF), Garcia said, which was stood up within FEMA's National Response Coordination Center to allow subject-matter experts the opportunity to provide guidance and direction to senior leaders during national-level incident planning. Garcia explained that NRITF is an advisory body that does not replace any emergency support or recovery support functions; rather, he said, it provides recommendations on potential courses of action, guiding the prioritization of certain activities. It does not, however, have an operational or oversight capacity. Ultimately, NRITF members are asked to provide insight to meet mission requirements, known as critical information requirements (CIRs). CIRs can include incident characterization and protective actions. Garcia closed by describing the Radiological Operations Support Specialist training program, which bridges science and emergency management. As an emergency management agency, FEMA understands the importance of connecting complex scientific knowledge with an understanding of incident command structures and other logistical concerns, he said.

DISCUSSION

Validity of the Assumptions When Building Response Capability

Following the panel presentations, Benitez thanked the speakers and offered his own reactions. He said that in regard to response timing, many of our assumptions may not be valid during a chaotic and devastating nuclear incident; local capabilities will likely be completely destroyed near the impact site. Additionally, in regard to medical countermeasures, he said that third-party distributors may be in competition with one another to access disaster areas. Adams added that it is entirely possible that the demands asked of private distributors during an event would go beyond what they are reasonably able to support, a potential challenge in the distribution of important supplies and medications. He said that this makes pre-event planning all the more important, and the SNS, along with partners such as BARDA and the Healthcare Industry Distributors Association, are working to identify preferred areas for delivery and treatment.

Involvement of Private Laboratories

Benitez asked how distribution issues could affect Adalja's suggestion for mass testing. Adalja suggested that satellite laboratories could play a role as the national chains already have a footprint in many small towns and the companies employ many phlebotomists who would be able to participate in a mass CBC test drive.

Strategic National Stockpile

William Blakely of the Armed Forces Radiobiology Research Institute asked Adams about the use of diagnostic tools and devices in the SNS, including blood cell counts, needles, tubes for bioassay fecal collection, nasal swabs, and other products. Adams said that, as a general policy decision, the SNS largely does not focus on diagnostic products, largely because of the scarce resource environment in the commercial market. Blakely noted previous work he had done recommending more of those products be included in the stockpile, and he urged Adams to consider seeking out the recommended list.

Shelters and Displaced Populations

Casey-Lockyer remarked that there is a disconnect between sheltering and the medical resources being discussed, such as SNS materiel and testing centers; she said that individuals in shelters will need access to those resources, not only people in the hospital system. On a similar note, James expressed concern over the potential number of displaced persons as a result of a nuclear event; many families may even choose to leave their homes out of fear of proximity to an event. Garcia agreed that population displacement and relocation would be an issue during response and recovery, especially in relation to decontamination. Dan Hanfling, contributing scholar, Center for Health Security, Johns Hopkins Bloomberg School of Public Health, cited family separation at the U.S. border as an example of possible challenges that could occur with transportation of people, population management, and population connectivity.

Crisis Standards of Care: Questioning Whether It Is Actionable

James Jeng called out crisis standards of care as a recurring topic of discussion but asserted that it is not yet actionable due to a lack of situational awareness that would drive the concepts from theory into practice. Hanfling agreed that crisis standards of care is not a fully actionable concept yet, but it is worth further exploration by the National Academies and other bodies to identify barriers to implementation and possible methods to overcome them. John Dreyzehner, commissioner, Tennessee Department of Health, also agreed that crisis standards of care is a topic that requires further discussion; separately, he also urged others to consider crisis standards of privacy during a mass medical emergency, citing the Las Vegas shooting as a frustrating example of a time when privacy laws prevented practitioners from relaying important information to victims' family members.

8

Capability-Building Challenges and Opportunities: Ensuring Workforce Readiness and Response Capacity

Key Points by Individual Speakers

- Willingness to respond to disasters is scenario specific, with the highest perceived threat being the nuclear threats. Willingness to respond can be improved by increasing self-efficacy. (Barnett)
- As health care systems become leaner in their operations, it is increasingly important that they find creative ways to ensure readiness for emergencies. This can include through real-time bed availability monitoring, the use of telemedicine and regional hubs, and recognition of the essential staff at hospitals and other care settings. (Consuelos)
- The U.S. Public Health Service (USPHS) has several Response Deployment Teams to respond to major disasters and support additional federal response planning; USPHS values adaptability and flexibility in the face of unpredictable health risks. (Orsega)
- The National Disaster Medical System is a partnership among the U.S. Department of Defense, the U.S. Department of Health and Human Services (HHS), the U.S. Department of Homeland Security, and the U.S. Department of Veterans Affairs; it is housed in the Office of the Assistant Secretary for Preparedness and Response, HHS, and is intended to augment the nation's medical response capability. Its responsibilities include fatal-

ity management, patient movement, and provision of medical personnel. (Miller)
- Much of the disaster training that nurses receive while practicing does "lip service" to training but not much else. (Lavin)
- A recent systematic review failed to provide quantitative evidence that nurses would be willing and able to respond in the event of a nuclear event. (Veenema)
- In another recent study, one of the most concerning findings is that one-third of respondents (nursing schools) reported that radiation/nuclear emergency preparedness is not important or relevant to nurses. (Veenema)
- There is an urgent need to add radiation/nuclear issues to education curricula and get students out in the field through mission trips and other activities so that they are not afraid. (Lavin, Veenema)

Earlier in the workshop, Tener Veenema of the Johns Hopkins School of Nursing and Bloomberg School of Public Health called attention to the persistent threat of workforce issues. The intention of Panel Discussion V, summarized here, was to focus on workforce issues with greater granularity. Moderated by John Koerner, senior special adviser, Chemical, Biological, Radiological, Nuclear, High-Yield Explosive Science and Operations, the Office of the Assistant Secretary for Preparedness and Response (ASPR), U.S. Department of Health and Human Services (HHS), panelists were asked to consider workforce readiness, education, training, mobilization, and deployment (e.g., willingness to respond, workforce regulation, and other potential constraints).

HEALTH WORKERS' WILLINGNESS TO RESPOND TO NUCLEAR EVENTS

Daniel Barnett, associate professor, environmental health and engineering, Johns Hopkins Bloomberg School of Public Health, described what he called the "ready, willing, and able" framework. Barnett explained that *readiness* in this context means adequate physical infrastructure, human resource infrastructure, and personal/community preparedness and that *ability* means adequate skills and knowledge. Willingness, Barnett said, is the attitudinal component that is too often neglected; the infrastructure and resources can be in place for a successful response, but "without willingness, it is all for naught," he said.

Barnett described several studies that indicated overall hesitancy by health workers to respond to radiological or nuclear incidents. He said that one important study on the topic, conducted by Cham Dallas and colleagues, analyzed relative willingness to respond to an event categorized by disaster type (Dallas et al., 2017), comparing respondents in the United States and Japan. In both countries, respondents identified a nuclear bomb as the event most likely to make them unwilling to come to work (dirty bombs and nuclear power plant accidents were included separately too). A separate 2010 study (Stevens et al., 2010) also identified nuclear threats as the threat type with the lowest perceived competence to respond among Australian health workers; Barnett said these results are in line with past research by Paul Slovic, who has found that radiological and nuclear scenarios have the highest risk perception.

Barnett turned to his own research on willingness to respond among Medical Reserve Corps volunteers, hospital employees, and public health workers, which he conducted with colleagues at Johns Hopkins University and Ben Gurion University in Israel. He explained that while their research reviewed a dirty bomb scenario (relative to other events) rather than a nuclear incident, the low rate of willingness to respond to a dirty bomb scenario does not bode well for potential willingness to respond to a nuclear incident. Barnett also pointed out that the research illuminated several interesting differences between different groups' willingness to respond to a radiological event. For example, he said, they found that nurses are less likely than physicians to be willing to respond, a problem considering the size of the nursing cohort among the overall health care workforce in the United States. Moreover, he said, the research found no difference in willingness to respond between staff in radiology departments and other departments, a sobering result that indicates willingness to respond may go beyond understanding radiation physics. The lack of willingness, combined with the potential physical incapacitation of members of the workforce during an event, could put a large strain on surge capacity, Barnett said.

To address this problem, Barnett described a curriculum that he and colleagues designed called Public Health Infrastructure Training (PHIT), which they tested through a randomized controlled trial. The training intervention, which was intended to address the attitudinal and behavioral gaps in willingness to respond, attempted to boost public health workers' sense of self-efficacy, which Barnett described as "confidence that one can perform one's role." In the model used, efficacy was given more weight than threat, so even in jurisdictions where the perceived threat of a dirty bomb scenario was low, improvement in self-efficacy increased willingness to respond. Barnett described PHIT as a "train the trainer" curriculum and said it involves several learning approaches: tabletop exercises, role-playing exercises, debrief sessions, facilitated discussions, and recaps of prior events, among others. The 7-hour curriculum is intended for use over the course of 6 months, beginning with a discussion phase, a middle phase comprised of independent learning activities, and a final phase that incorporates experiential learning, Barnett said. Ultimately, PHIT increased willingness to respond to a radiological dirty bomb scenario regardless of severity by 14 percent. Self-efficacy saw a net increase of 25 percent over a 6-month window following the intervention period. Barnett concluded by noting that efficacy-based trainings could enhance willingness to respond across hazards, including radiological and nuclear events; he said that there is an opportunity for more exploration in the context of nuclear events because that area is still less established and researched.

A PENNSYLVANIA HEALTH CARE SYSTEM PERSPECTIVE

Michael Consuelos, senior vice president, clinical integration, The Hospital + Healthsystem Association of Pennsylvania (HAP), explained that nuclear preparedness in Pennsylvania largely ties back to the 1979 incident at Three Mile Island,[1] during which a nuclear reactor partially melted down. The amount of radiation released had no discernable health effects on plant employees or the public, but Consuelos said the "fear factor" was large and the accident led to enhanced planning and communication. Today, Pennsylvania is home to five nuclear power plants, each with its own 10-mile-radius emergency planning zones (see Figure 8-1). Numerous acute care facilities are located across the state, accessible from any of the planning zones.

Consuelos turned his attention to hospital capacity and presented data that illustrated the number of licensed and staffed beds in Pennsylvania hospitals from 1999 through 2017 (see Figure 8-2). He noted that since 2001 the state has lost almost 17 percent of licensed beds in the state, and when correlated to staffed beds, the drop is 6 percent. While the numbers have leveled out in recent years, Consuelos commented that health care systems in general are moving toward leaner operations models to limit expenses, a problematic trend when contrasted against population growth in urban areas that would be potential targets for a nuclear attack. Currently, he said, HAP is working with an outside vendor to achieve real-time bed status data. The system pulls data on an hourly basis from hospitals' bed management systems and categorizes them to incorporate details about usage: beds in the intensive care unit, emergency department, etc.

Consuelos pointed to seasonal influenza outbreaks as opportunities to test surge capacity in hospitals and health care systems across the country, a useful activity across hazards. Pennsylvania considers how an additional

[1] For more information on the incident, see https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html (accessed December 10, 2018).

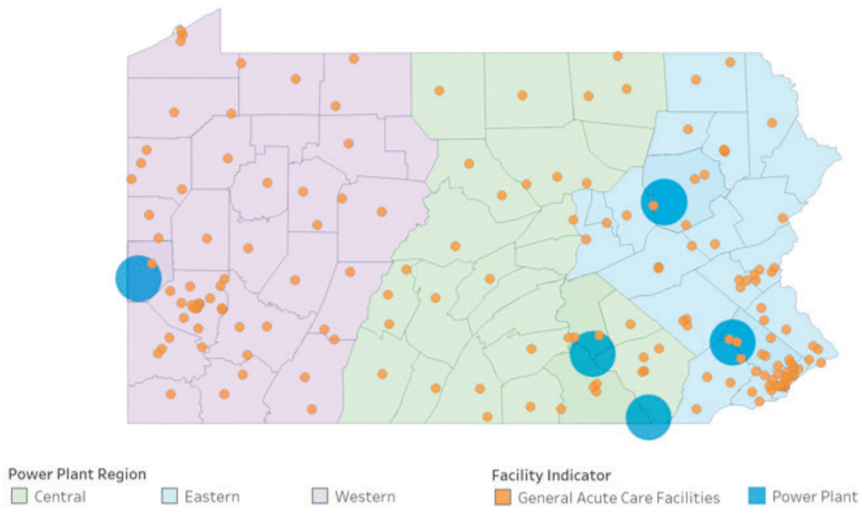

FIGURE 8-1 Location of Pennsylvania nuclear power plants and acute care facilities.
SOURCE: Consuelos presentation, August 23, 2018.

disaster during flu season would stress the system; "every disaster is a lesson to be learned," he said. He specifically pointed to the 2017 Las Vegas shooting as an example, when numerous responders traveled outside the planned emergency medical services routes and control system. Furthermore, Consuelos highlighted nonacute care settings—including ambulatory centers, nursing homes, and rehabilitation facilities—as potential sites for screening, basic medical treatment, and decontamination during a nuclear event to lessen the burden on hospitals. Referring back to the Regional Disaster Health Response System, Consuelos said that HAP strongly supports ASPR's plan to build the system and is actively seeking out ways to incorporate telemedicine as a way to conduct just-in-time training connecting regional centers to rural hospitals across the state.

Lastly, Consuelos addressed readiness and future needs. He said hospitals need to not only account for clinical needs but also community needs in the wake of a disaster; for example, during Hurricane Harvey, he said that several Texas hospitals stood up day care centers to meet the needs of the impacted community. Additionally, he spoke about the need to consider essential staff in hospitals. "Blurring the line between essential and nonessential individuals," he said, "we have been talking about health care workers, but if you ask me to go find another IV bag, where are they stored in my local hospital? I don't know where that is. And I don't know how to operate food [preparation]. I don't know how to clean a room well,

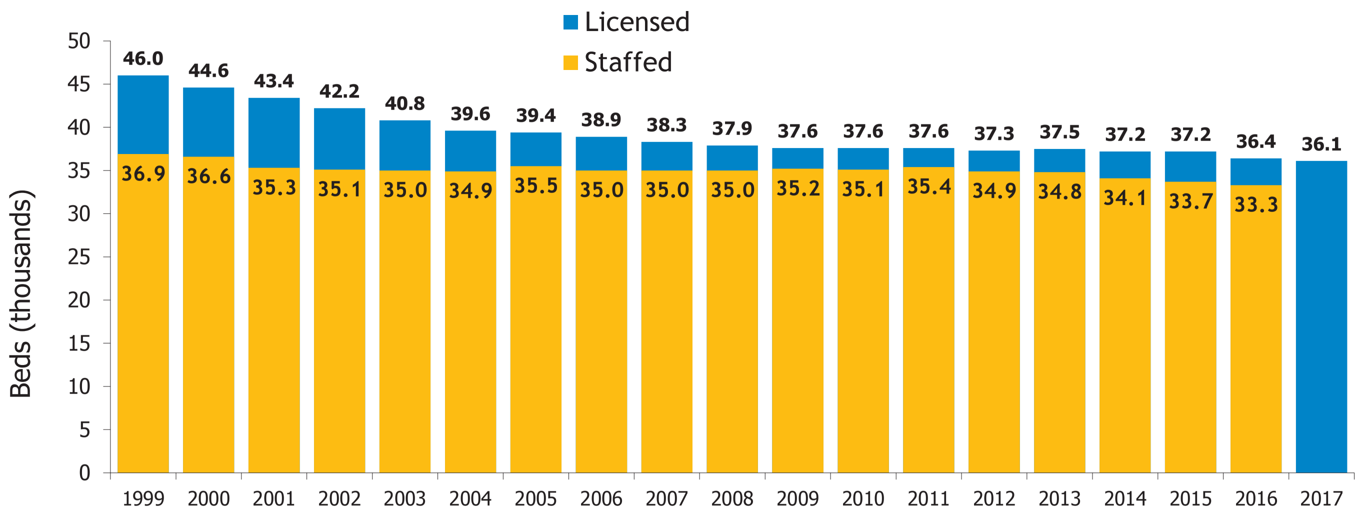

FIGURE 8-2 Number of licensed and staffed hospital beds in Pennsylvania, 2001–2017.
SOURCES: Consuelos presentation, August 23, 2018; data from the Pennsylvania Department of Health's Annual Hospital Reports (2018).

let alone an operating room. So we need to make sure that what we call our 'nonessential' individuals are really essential to running the hospital." Consuelos ended by noting the importance of Pennsylvania's nine health care coalitions and said its day-to-day work supports small events and would be the key to handling any future disasters too.

A U.S. PUBLIC HEALTH SERVICE NURSE PERSPECTIVE

The U.S. Public Health Service (USPHS) was established in 1798 and includes approximately 6,500 commissioned officers (including 1,500 nurses), led by the surgeon general, serving the needs of underserved populations across the United States, said RADM Susan Orsega, chief nursing officer, USPHS. Officers are deployed to states and localities but also to many federal agencies, including the Food and Drug Administration, the National Institutes of Health (NIH), and the Centers for Disease Control and Prevention (CDC). Orsega noted that the current surgeon general, Jerome Adams, has made collaboration and partnerships in disaster response a priority. Since 1999, USPHS has deployed 15,000 officers across 500 emergency public health missions. In 2006, following Hurricane Katrina, Orsega said, an HHS guidance document recommended that the department train, organize, equip, and roster medical and public health professionals in preconfigured, deployable teams. The five Response Deployment Teams are situated across the HHS regions and provide mass care at federal medical shelters. Regional incident support teams are another HHS resource, with one team located in each region. Orsega said these teams conduct needs assessments and typically operate as liaisons between state and local/trial incident management. Specific to the national capital region, Orsega also mentioned capital area provider teams, which provide medical and public health resources during deployment for special events such as a presidential inauguration or Independence Day festivities.

Next, Orsega addressed the USPHS's capacity and capabilities. Its capacity, she said, are the tools, technology, and accumulated knowledge that allow USPHS officers to act as subject matter experts. Its capabilities lie in the service's teamwork and talent. She emphasized the importance of cross-sector collaboration to ensure readiness for future disasters, particularly nuclear and radiological events. She said that in the current threat environment, a fundamental capacity of USPHS is its flexibility, adaptability, and ability to create partnerships: "The readiness to act, that ability to be aware of yourself in these complex, unpredictable, and vulnerable environments, is a fundamental capacity." She stressed that at a time when health care professionals may be exposed to unpredictable risks, the "soft technical skills" (collaboration, flexibility, etc.) add value to this cause.

NATIONAL DISASTER MEDICAL SYSTEM

The National Disaster Medical System (NDMS) takes a two-tiered approach to its management, explained Ron Miller, acting director, NDMS, ASPR. First, NDMS is a partnership that is mandated by federal statute to include HHS, the U.S. Department of Defense (DoD), the U.S. Department of Homeland Security, and the U.S. Department of Veterans Affairs (VA), and it is intended to augment the nation's existing medical response capability. Each federal entity brings distinct capabilities to bear, Miller said: VA brings medical emergency radiological response teams; DoD brings the National Guard and the CBRN Response Enterprise; and HHS brings NDMS teams, public health service teams, and components from CDC and NIH. Though not mandated by statute, Miller said that other federal agencies such as the Environmental Protection Agency and the U.S. Department of Justice can also play a role in NDMS responses. Miller noted that the second tier of management is specific to HHS as ASPR houses the Division of NDMS. NDMS includes 72 total teams; among them are 50 disaster medical assistance teams, 10 disaster mortuary response teams, 1 victim identification center team, 1 national veterinary response team, and 1 trauma critical team (formerly known as the International Medical Surgical Response Team). Miller described the four pillars of an NDMS response as patient movement, patient care, fatality management, and definitive care. Expanding on the pillars, Miller described NDMS components as follows:

- Provision of medical personnel (teams/individuals), supplies, and equipment to a disaster area
- Movement of patients from a disaster site to unaffected areas of the state, region, or country
- Definitive medical care at participating health care facilities in unaffected areas
- Management and coordination of the federal fatality management program
- NDMS response teams

Miller described several challenges in maintaining the NDMS workforce. First, he noted that members of NDMS teams serve episodically and are considered intermittent federal employees, not volunteers. As a result of this setup, he said, maintaining the operational skill sets of responders is crucial and difficult. NDMS does not train doctors on how to do their jobs; rather, NDMS focuses on training responders to act according to HHS and OSHA policies and regulations to ensure they are deploying safely. Tied to any NDMS response, Miller said, are the capacity and capabilities of state and local jurisdictions to which NDMS is deployed. If a jurisdiction is not well prepared, NDMS is forced to send more personnel and take on a larger response role.

NDMS continues to evolve, Miller said. Recently, the assistant secretary for preparedness and response, Robert Kadlec, organized a council of senior leaders across federal government partners through Emergency Support Function #8 (beyond only NDMS partners) to periodically review and update policies as needed in order to ensure needs are met and redundancies are limited. Miller explained that NDMS hopes to maintain preparedness for both natural and man-made disasters and mitigate operational gaps; he provided two examples of the latter. Following Hurricane Maria in Puerto Rico, ASPR noticed a gap in aeromedical evacuation capabilities in terms of proper staffing. This led to a training program on operations and functions for aeromedical evacuation that was implemented a week before the workshop took place, Miller said. Additionally, ASPR initiated a case management training program following challenges during evacuation from the U.S. Virgin Islands during the 2018 hurricane season. Overall, Miller pointed to increased partner engagement as a critical next step for improving the functionality and efficiency of NDMS.

PROVIDER KNOWLEDGE OF DISASTER PREPAREDNESS

Roberta Lavin, executive dean and professor, College of Nursing, University of Tennessee, described a study that assessed clinicians' knowledge about disaster preparedness. The multipronged study approach attempted to match core competencies in disaster preparedness—the investigators chose to use competencies outlined by the National Center for Disaster Medicine and Public Health (NCDMPH), Lavin said, because they were well formulated—with the educational offerings at universities (e.g., doctoral students at medical schools, nursing schools, public health schools, etc.) as well as state- and local-level professional training.

Lavin described the student survey component. Students were shown competencies and asked to rate their confidence level on a scale from 1 to 7 in their ability to complete the task. An average response over 4 (50 percent confidence) was marked green (see Table 8-1). Among the groups surveyed, Lavin noticed that the nursing students were the most confident in their abilities, which she attributed to the fact that they were already registered nurses before returning for doctoral studies, meaning they had prior experience as practicing clinicians.

Among university administrators—deans and other faculty—a separate survey showed that confidence was not nearly as high as it was among students, Lavin said. Noticeably, administrators from osteopathic medicine programs were much more confident in their teaching than were other administrators. She noted that the response rate among medical faculty was so

TABLE 8-1 Student Responses

Confidence Regarding Disaster Preparedness Based on Education	Mean [Scale: 1–7]			
	MPH	DNP	D.O.	M.D.
Solve problems under emergency conditions (1)	4.11	4.61	4.04	3.95
Manage behaviors associated with emotional responses in self and others (2)	4.29	4.8	4.5	4.32
Act within the scope of one's legal authority (3)	3.59	4.67	3.96	3.13
Facilitate collaboration with internal and external emergency response partners (4)	3.59	4.2	3.65	3.37
Use principles of risk and crisis communication (5)	3.6	4	3.39	2.74
Report information potentially relevant to the identification and control of an emergency through the chain of command (6)	3.71	4.24	3.62	2.82
Contribute expertise to the development of emergency plans (7)	3.29	3.83	3.16	2.47
Refer matters outside of one's scope of legal authority through the chain of command (8)	3.27	4.3	3.57	3.03
Maintain personal/family emergency preparedness plans (9)	3.93	4.7	3.94	3.63
Employ protective behaviors according to changing conditions, personal limitations, and threats (10)	3.88	4.44	3.84	3.32
Report unresolved threats to physical and mental health through the chain of command (11)	3.48	4.37	3.9	3
Match antidote and prophylactic medications to specific biological/chemical agents (12)	2.54	3.11	2.93	2.58
Assist with triage in a large-scale emergency event (13)	3.22	4.56	3.87	3.32
Report an unusual set of symptoms to an epidemiologist (14)	4.06	4.31	3.79	3.11
Present information about degree of risk to various audiences (15)	3.73	3.72	3.32	2.71

NOTE: DNP = Doctor of Nursing Practice; D.O. = Doctor of Osteopathic Medicine; M.D. = Doctor of Medicine; MPH = Master of Public Health.
SOURCE: Lavin presentation, August 23, 2018.

low that those results were not useful (see Table 8-2). Ultimately, Lavin said, the data demonstrated trends that both students and university administrators agree that there is inadequate education on disaster response competencies offered in these doctoral programs. Looking specifically at the NCDMPH core

TABLE 8-2 Administrator Responses

Confidence Regarding Disaster Preparedness Competency in Program	Mean [Scale: 1–7]			
	MPH	DNP	D.O.	M.D.
Solve problems under emergency conditions (1)	3.25	3.61	5.25	2
Manage behaviors associated with emotional responses in self and others (2)	3.13	4.14	6	2.75
Act within the scope of one's legal authority (3)	4	4.39	6.25	3
Facilitate collaboration with internal and external emergency response partners (4)	3.38	3.65	5.25	2
Use principles of risk and crisis communication (5)	3.63	3.82	5.25	2
Report information potentially relevant to the identification and control of an emergency through the chain of command (6)	3.13	3.39	5	1.5
Contribute expertise to the development of emergency plans (7)	2.63	3	4.75	2
Refer matters outside of one's scope of legal authority through the chain of command (8)	3.25	3.84	5.25	2
Maintain personal/family emergency preparedness plans (9)	2.25	3.35	5.25	1.25
Employ protective behaviors according to changing conditions, personal limitations, and threats (10)	2.75	3.5	5.5	1.25
Report unresolved threats to physical and mental health through the chain of command (11)	2.75	3.51	5	1.5
Match antidote and prophylactic medications to specific biological/chemical agents (12)	3.25	3.16	5.5	1.5
Assist with triage in a large-scale emergency event (13)	2.63	3.63	5.75	2
Report an unusual set of symptoms to an epidemiologist (14)	4	3.47	5	1.5
Present information about degree of risk to various audiences (15)	3.88	3.19	4.75	1.75

NOTE: DNP = Doctor of Nursing Practice; D.O. = Doctor of Osteopathic Medicine; M.D. = Doctor of Medicine; MPH = Master of Public Health.
SOURCE: Lavin presentation, August 23, 2018.

competencies, Lavin and colleagues matched survey responses with the list to check whether respondents felt they were meeting each competency. Red indicated "no," beige indicated "somewhat" (e.g., the competency was mentioned often, if not fully taught), and green indicated "yes" (see Table 8-3).

TABLE 8-3 Crosswalk of Competencies and Survey Data

Competencies	Student				Administration				Measure
	MPH	NP	D.O.	M.D.	MPH	NP	D.O.	M.D.	
1.0 Demonstrate personal and family preparedness for disasters and public health emergencies (PHEs)	25	46	18	16	33	62	75	25	Covered moderately to thoroughly
2.0 Demonstrate knowledge of one's expected role(s) in organizational and community response plans activated during a disaster or PHE	19	8	9	3	25	31	75	25	Covered moderately to thoroughly
3.0 Demonstrate situational awareness of actual/potential health hazards before, during, and after a disaster or PHE	39	9	14	3	63	32	75	0	Covered moderately to thoroughly
4.0 Communicate effectively with others in a disaster or PHE	18	6	9	3	38	31	75	25	Covered moderately to thoroughly
5.0 Demonstrate knowledge of personal safety measures that can be implemented in a disaster or PHE	3.88	4.44	3.84	3.32	2.75	3.5	5.5	1.25	Confidence
6.0 Demonstrate knowledge of surge capacity assets, consistent with one's role in organization, agency, and/or community response plans	3.22	4.56	3.87	3.32	2.63	3.63	5.75	2	Confidence
7.0 Demonstrate knowledge of principles and practices for the clinical management of all ages and conditions affected by disasters and PHEs, in accordance with professional scope of practice	27	8	17	8	62	25	75	0	Covered moderately to thoroughly
8.0 Demonstrate knowledge of public health principles and practices for the management of all ages and populations affected by disasters and PHEs	30	10	14	3	63	31	75	0	Covered moderately to thoroughly

9.0 Demonstrate knowledge of ethical principles to protect the health and safety of all ages, populations, and communities affected by a disaster or PHE	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10.0 Demonstrate knowledge of legal principles to protect the health and safety of all ages, populations, and communities affected by a disaster or PHE	17	9	21	3	63	35	75	0	Covered moderately to thoroughly
11.0 Demonstrate knowledge of short- and long-term considerations for recovery of all ages, populations, and communities affected by a disaster or PHE	12	7	13	3	25	23	75	0	Covered moderately to thoroughly

NOTE: DNP = Doctor of Nursing Practice; D.O. = Doctor of Osteopathic Medicine; M.D. = Doctor of Medicine; MPH = Master of Public Health; n.d. = no data.
SOURCE: Lavin presentation, August 23, 2018.

The results indicated an overall lack of education in disaster preparedness and response, Lavin said.

Separately, Lavin said that she and colleagues conducted interviews with 13 individuals who served as trainers to professional health care workers. A trend emerged from those conversations: Once graduates of the various professional and doctoral programs enter the real world, disaster preparedness drills are given "lip service," but most staff do not partake in real drills. For example, she said, the average bedside nurse will never participate in a disaster preparedness drill over the course of his or her career; she expressed alarm at the lack of emphasis on disaster preparedness at both the educational and professional levels. Lavin closed by acknowledging an important gap in her research, explaining that the researchers neglected to include any survey questions about the inclusion of ethics training in programs. She emphasized the importance of ethics in this arena because of the potential institution of crisis standards of care during an emergency. Lavin investigated the inclusion of ethics in nurse practitioner doctoral programs and sampled 10 schools of various sizes across the country; only 4 offered ethics courses. She emphasized the need to investigate ethics training further in the future to ensure that future leaders and practitioners are well prepared to respond to nuclear threats and other emergency events.

NURSE WORKFORCE READINESS FOR RADIATION EMERGENCIES AND NUCLEAR EVENTS

Veenema described three studies on which she worked as part of her service as the National Academy of Medicine's Distinguished Nurse Scholar-in-Residence for the 2017–2018 year. She said that the topic of nurse workforce readiness was important to her given her experience in the field, and she also noted that it aligned with ASPR's desire to quantify workforce readiness in a more tangible way.

National Nurse Readiness for Radiation Emergencies and Nuclear Events: A Systematic Review of the Literature

Veenema's first study, a systematic review, was based on the belief that the nursing workforce is a critical component of a potential public health response to a large-scale radiation or nuclear event, but there is uncertainty about nurses' willingness or readiness to respond to such events (Veenema et al., 2019a). She listed several of the roles that nurses would likely occupy during such an event: triage for radiation exposure and contamination; decontamination; staffing community reception centers; and providing ongoing mental health counseling, health education, and intensive clinical care to patients with burn injuries, trauma injuries, or acute radiation syndrome (ARS). Working with the National Academies Research Center and several colleagues who attended the workshop, Veenema said she developed a detailed search strategy with detailed inclusion/exclusion criteria to examine four relevant databases (Embase, PubMed/Medline, Scopus, and Web of Science). The search, which included international literature as well, examined whether there is quantifiable empirical evidence of readiness within the nursing workforce, and it examined literature as far back as 1979 to capture the sentinel global radiation disasters in recent history. Veenema explained that the search strategy resulted in the identification of 1,796 manuscripts, of which 62 met the study's inclusion criteria. The majority of the 62 studies were graded as being low-level evidence, and they were predominantly descriptive; in fact, many of them were narrative articles from the Japanese literature on Fukushima and other events. Through a thematic analysis, Veenema said she and colleagues identified that while themes such as education, training, and mobilization were addressed, robust metrics for measuring readiness were absent from the literature. "Our review failed to provide quantitative evidence to support that nurses in the U.S. are able and willing to serve in these roles," she said.

National Assessment of Nursing Schools' and Nurse Educators' Readiness for Radiation Emergencies and Nuclear Events

The second study Veenema presented used an online radiation nuclear survey, a questionnaire adapted from previous work by Veenema, Lavin, and Couig, updated after additional input from subject matter experts in radiation and nuclear emergency preparedness (Veenema et al., 2019b). To distribute the survey, Veenema partnered with the American Association of Colleges of Nursing (AACN) and the Organization for Associate Degree Nursing (OADN) and ultimately sent 3,000 surveys to potential respondents in May 2018. The overall response rate was 20.6 percent, Veenema said. However, a deeper dive into the results showed that the response rate among AACN schools was high (72 percent) and the response rate among OADN schools was low (2.1 percent); the organizers attributed that to the timing of the survey distribution, when many associate's degree programs were already closed for the summer.

Veenema said that participation was voluntary, but zip code was an optional response category that helped provide insight into the demographics of respondents; approximately half of respondents were administrators (e.g., deans, associate deans), and the other half were faculty with curriculum input. The results of the survey indicated that 71.5 percent of all schools of nursing in the United States that responded to the survey teach either no radiation content or less than 1 hour of radiation content. Reasons for this, according to respondents, included inadequate time in the curriculum/schedule and a lack of a mandate by accrediting organizations, Veenema said. Others said the topic did not occur to them as a possible topic for inclusion (20.7 percent), some believed there was no perceived risk or topical importance (10.4 percent), and some were simply not sure why their school did not offer courses on the topic (22.6 percent). She expressed concern that almost one-third (31.3 percent) of respondents believed that the topic of radiation/nuclear preparedness was not an important or relevant topic to their school. Addressing competencies for responding to nuclear events, Veenema said the survey found that between 77 and 90 percent of schools did not cover this content. A number of motives were mentioned by respondents when considering what it would take to add radiation and nuclear preparedness to nursing curricula: free expert-developed course content, new requirements in the AACN guidelines, funding for new course development, or a radiation/nuclear event on U.S. soil.

Veenema also described some cognitive dissonance that seemed to exist around risk perceptions for nuclear incidents: 92.5 percent of respondents said they believed that radiation/nuclear emergency preparedness was important, but only 12.5 percent of nursing schools confirmed the existence of a radiological/nuclear disaster plan. Furthermore, 6 percent reported having drilled for such an event, and only 9.7 percent reported that faculty would know what to do during that type of emergency.

Following up on the survey results, Veenema hoped to link the perceived risk with the actual risk that each school faced. As a result, she and colleagues created a series of maps that layered information to better characterize the risk relationship. Among the data points plotted on the maps, Veenema listed the following:

- The 99 active nuclear reactors licensed to operate in the United States; these include 60 total locations, with 23 one-reactor sites and 37 sites with two or more reactors
- The top five research facilities based on their power levels: the Massachusetts Institute of Technology; the National Institute of Standards and Technology; the University of New Mexico; the University of California, Irvine; and the Atomic Energy Commission, Rhode Island
- The 80 high-level nuclear waste sites (many overlap with existing nuclear reactors)
- 50-mile emergency planning zones around nuclear sites, which is the typical distance used for radiation disaster plans
- Schools of nursing, including schools affiliated with respondents
- Geographic fault lines and affiliated slip rates
- Federal Emergency Management Agency (FEMA) region mapping

Veenema noted that while analyzing these maps, she discovered that 295 schools of nursing are located in close proximity to the planning zones, and 53.7 percent of the schools were completely unaware of their proximity to radiation sources. Regarding the fault lines, she pointed to University of California, Irvine, as an example of a nuclear reactor that lies on a major fault line, with a slip rate greater than 5 millimeters. She also explained the importance of FEMA region inclusion and commented that the information is relevant not only to nursing schools but also to emergency planners across the country. Several regions—including Region 9 (West), Regions 1–3 (Northeast), and Region 5 (Midwest)—all housed dozens of schools that were unaware of their proximity to nuclear sources.

Analysis of Nurse-Specific Roles in Federal Radiation and Nuclear Disaster Planning Documents

The third and final study was still being developed at the time of the workshop, Veenema said. She said that were a nuclear incident to unfold, there is concern among nursing leadership across the country that federal response planning is built on assumptions about the capabilities of the workforce that may not be accurate. Veenema explained that this study will systematically cross-check all relevant federal planning documents related to radiation and nuclear response needs to identify which capabilities and objects are nurse dependent and the roles and responsibilities delegated to and expected from nurses and present an analysis of the results. She emphasized the importance of not only having enough nurses to respond but also having nurses who are trained with specific skills and abilities in order to successfully respond to a nuclear event. Mobility, willingness to work, and integrity of quality care will all be major concerns during a response, she commented.

MODERATOR'S SUMMARY OF OVERARCHING TOPICS

Before initiating discussion between the panelists and members of the audience, Koerner listed several overarching topics he had heard during the presentations:

- Considerations for enhancing surge capabilities in an environment where health systems are becoming leaner (this includes incorporating workers from nonacute health care settings)
- Leveraging partnerships in order to make a response more scalable and flexible as needed
- Sustaining workforce readiness beyond simple training

- The ethics of responding to an emergency in a scarce resource environment, when practices will likely differ from the day-to-day responsibilities of health care practitioners
- The importance of quantifying and defining readiness and understanding perceived versus actual risk

GAPS IN WORKFORCE READINESS AND WAYS TO CLOSE THOSE GAPS

Koerner asked the panel about common challenges in willingness to respond, based on the workshop presentations and discussion: Are the challenges systemic or organizational? Are they based on the individual? What are gaps in readiness, and how do we address the root causes at a national level? Barnett responded that willingness to respond is scenario specific, so someone may have different feelings about a nuclear event compared to another potential threat. He also stressed the importance of good motivation; just having the tools to do the job will not force people to respond.

Veenema identified four potential courses of action to close the readiness gap:

- Quantifying the direct and indirect costs of having an unprepared workforce (she said this will force leaders to grapple with the price of poor preparedness)
- Identifying and agreeing on robust metrics for quantifying readiness across disciplines
- Addressing the knowledge gap by updating medical and nursing curricula, which she described as an easy first step
- Addressing the issues around willingness to respond by taking lessons from recent disasters and doing more to consider potential workforce shortages before they happen

9

Building Preparedness and Response Capability: Looking to the Future

During the workshop's final panel, moderators from previous sessions were asked to share their reactions to workshop discussions and consider a path forward to achieving an appropriate state of readiness for nuclear incidents. Session moderator Laura Wolf, director, Division of Critical Infrastructure Protection, the Office of the Assistant Secretary for Preparedness and Response (ASPR), U.S. Department of Health and Human Services (HHS), also provided a brief overview of ASPR's Division of Critical Infrastructure Protection as it connects to nuclear preparedness. This chapter summarizes her presentation, the moderators' wrap-up, and the audience discussion that followed.

ASPR'S CRITICAL INFRASTRUCTURE PROTECTION PROGRAM

Critical infrastructure has four main components, which Wolf referred to as "the four *s*s": staff, stuff, systems, and space. Wolf explained that the combination of properly trained staff, robust utility systems, access to necessary resources (e.g., pharmaceuticals, medical materiel), and resilient physical space can help the health care and public health sectors ensure resilience and risk mitigation. She emphasized that the Critical Infrastructure Protection Program (CIP), ASPR, considers infrastructure to go beyond simply hospitals; it also includes pharmacies, dialysis centers, health clinics, and other components of the broader health care system.

Wolf described the core functions of CIP. Because critical infrastructure is owned mostly by the private sector, CIP's network of partners is critical to its success. Through the network, CIP supports private sector and other stakeholder coordination of preparedness, response, and recovery efforts and supports insights-driven decision making through the connection and analysis of quantitative and qualitative data, Wolf said. CIP also supports risk management, and for the past 3 years, it has supported the development of a Health Care and Public Health Risk Identification and Site Criticality Toolkit,[1] which she described as an "objective, data-driven, all-hazards risk assessment" for partners. The toolkit will be released at the end of 2018, she said. In its role as a convener of diverse stakeholders, Wolf said that CIP maintains communications efforts between its stakeholders, leads Emergency Support Function #8 responsibilities for HHS, and has organized several working groups in cybersecurity, supply chain resilience, and biotechnology threats and opportunities.

MOVING FORWARD: PRIORITIES IDENTIFIED BY INDIVIDUALS ON THE REACTION PANEL

Wolf asked the panelists to reflect on priorities for moving forward that were identified and discussed throughout the course of the workshop.

Current State of Preparedness

Roberta Lavin, the moderator of Session 1 (summarized in Chapter 3), focused on the current state of preparedness for a nuclear incident. She prioritized the following:

- **Lack of available expertise in radiation/nuclear science for state and local planners.** Lavin reemphasized the lack of expertise in radiation and nuclear threats among state and local public health staff across the country. Other panel members agreed as well.
- **Lack of funding to plan adequately for nuclear incidents.**
- **Confusion around crisis standards of care.** Lavin expressed concern that state and local public health practitioners and health care partners do not understand how to implement crisis standards of care during a nuclear incident; several panelists noted that this issue has not been adequately addressed. Lavin pointed out that in large part because of complacency around the threat of a nuclear incident, the health care workforce is not being trained on the standards, accessing them, or using them.

[1] See https://www.phe.gov/Preparedness/planning/RISC/Pages/default.aspx (accessed January 18, 2019).

- **Constant change of personnel.** Lavin summed up the concern of state and local staffing turnover: "Once you get people to know what they need to know, they leave," she said.

Planning Assumptions

Cham Dallas, who moderated the second panel session on planning assumptions (summarized in Chapter 4), prioritized the following:

- **New threats are changing planning assumptions.** The possibility of a nuclear device much larger than 10 kilotons, Dallas said, completely upends previous planning efforts.
- **Questions around what jurisdictions will "give up" in the event of a nuclear incident nearby or elsewhere.** Touching on a point mentioned by James Young during his session, Dallas questioned how jurisdictions would support one another in the event of a nuclear incident given the sensitivity of resource sharing and allocation during such a deeply traumatic and potentially consuming event.
- **Assumption that responders will show up in the event of a nuclear emergency.** We cannot make assumptions that people will show up to work during a possible nuclear emergency, Dallas said. Many people inappropriately believe that the possibility of a nuclear incident is the most catastrophic threat. Even as knowledge is increasingly disseminated on this topic, fear and denial spreads easily, he said.
- **Need for nonfinancial incentives.** Dallas noted that ASPR and other federal entities already offer financial incentives to state and local jurisdictions to remain aware and prepared for nuclear threats, but he said he believes that nonfinancial incentives should be increasingly sought out.

Communication Challenges

Steven Becker, keynote speaker and moderator of the session on communications (summarized in Chapter 5), discussed the following takeaways from his panel:

- **The importance of effective communication.** Citing its emphasis and focus at this workshop, Becker noted the importance of effective communications as an emerging issue in nuclear preparedness (he mentioned the past 10 years as a particularly important period of development) and, more broadly, other disaster preparedness as well. He cited effective communication as an important tool for public readiness in the face of a horror scenario.

- **Communication is inexpensive.** Not only is effective communication one of the most important tools; it is also one of the least expensive intervention strategies, Becker said.
- **Priority research gaps.** Becker identified several research gaps in communications that he deemed to be high-priority issues: testing the effectiveness of pre-developed communications tools across demographic groups; research to inform the next stage of development on nuclear incidents, including addressing issues around stigma and new technologies such as wireless emergency alerts; and research to understand effective strategies, forms of outreach, and tools for first responders and health care workers.
- **Importance of drills and exercises.** Becker stressed the importance of testing new communications tools through drills and exercises, for nuclear incidents and other disaster planning. He suggested the development of an exercise guide or manual.
- **Audience-appropriate communication materials.** Becker suggested creating interdisciplinary work groups to inform the communication needs of several groups, including children and specialists who play important roles in a potential nuclear incident response.

Challenges to Building Capacity

Bruce Evans, moderator of the panel discussion on challenges to building capacity (summarized in Chapter 6), described priority areas from his panel discussion:

- The importance of buddy care
- The need for more burn care resources, including the workforce
- The need for high-fidelity simulation, including successful drills with distractors or additional stressors put on participants
- Encouragement of participation in international disaster response to build experience
- The likely shortage of bioassays during a response

Building Future Response Capacity

John Benitez, moderator of the panel discussion on building response capacity (summarized in Chapter 7), prioritized the following:

- **Changing federal operating assumptions.** Benitez noted that the operating assumptions of several federal organizations—including the Strategic National Stockpile, the Federal Emergency Management Agency, and the U.S. Department of Veterans Affairs—will continue to change, and it will be important to monitor to ensure readiness for a nuclear incident.

- **The use of volunteers during a response.** Benitez stressed that volunteers will likely be critical during a chaotic response to a nuclear incident, and he emphasized the importance of leveraging lay, professional, and just-in-time volunteers during a response.

Ensuring Workforce Readiness

Finally, John Koerner, who moderated the panel discussion on workforce readiness (summarized in Chapter 8), mentioned his takeaways from the panel:

- **Criticality of developing metrics to quantify readiness.** Koerner suggested the implementation and use of metrics to quantify levels of preparedness for nuclear events; currently, there are not enough data to understand readiness, he said. This includes understanding the availability of the workforce to surge up during an event for needs such as boots on the ground and lab work. Additionally, the workforce should partake in ethics training to ensure good care during an incident.
- **Systems approach.** Koerner suggested that stakeholders begin to frame the medical and public health systems as a "system of systems" in order to clarify how the various complex components, resources, and organizations fit together. He also mentioned the possibility of taking on a CONOPS (continuity of operations) approach to nuclear preparedness; he said the systematic linkages that such an approach would create between health care coalitions, other nontraditional resources, and the government would be useful during a potential response, especially in the context of a new regional framework.

Wolf ended the panel by analyzing several of the points made by speakers. Regarding communications, Wolf agreed that more research is needed and that findings from this arena should be translated appropriately into policy and action. She also emphasized the "bang for your buck" appeal of communications strategies, explaining that despite its low cost, successful communication has the potential to have a broad reach and impact in nuclear incident preparedness and response. She described updating planning assumptions around nuclear threats as another example of "low-hanging fruit" that has the potential to impact preparedness in important ways. Regarding professional response readiness, Wolf emphasized Koerner's point about ethics training, noting that an understanding of the interdependencies of crisis standards of care will prove critical during a potential nuclear incident.

ADDITIONAL TOPICS IDENTIFIED BY THE AUDIENCE

Following the panel discussion, Wolf solicited the audience for additional gaps and potential solutions in nuclear preparedness. Several audience members offered responses.

David Eisenman, associate professor, Geffen School of Medicine and Fielding School of Public Health, University of California, Los Angeles, mentioned willingness to respond as the key issue in his opinion. He noted that while it is important that medical professionals remain willing to respond, hospitals also cannot function without other staff support, including administration and maintenance. He noted that this problem is also connected to the interdependency of the health care workforce, as pediatrics, burn care, lab staff, and others will need to work in coordination to ensure a successful response. Eisenman also underscored the importance of communication with the public because ultimately, he said, community members are the first line of defense following a disaster.

Regarding workforce issues, Alan Siniscalchi of the Connecticut Department of Public Health and the Council on State and Territorial Epidemiologists called attention to the potential role that epidemiologists could play in a nuclear response, particularly with respect to data analysis. Art Cooper suggested an update to the "ready, willing, able" framework that would put "able" first; he suggested this because those who are able to respond appropriately are more likely to do so, he said. He also suggested creating a platform for just-in-time training for nuclear preparedness in order to make relevant material easier to teach, access, and update. Mary Casey-Lockyer suggested ramping up first aid training for volunteers because despite the possibility of radiation injuries, many individuals will require other first aid care following a nuclear incident. Lastly, Ann Knebel, deputy scientific director, Division of Pre-Clinical Innovation, National Center for Advancing Translational Sciences, National Institutes of Health, emphasized the importance of engaging medical experts in areas addressed in less detail at the workshop—such as oncology—to ensure that a holistic approach is taken when managing thermonuclear patients and to ensure that radiation expertise is available.

Jessica Wieder emphasized a message from her presentation earlier in the workshop about the importance of teachable moments as a way to raise awareness about specific concerns. She noted, for example, that September 2018 was National Preparedness Month, a perfect time to spread messages about the causes discussed at the workshop. Wieder also mentioned the importance of federal coordination for nuclear preparedness, and she said that entities should work to ensure that messaging is consistent across platforms.

Michael Consuelos stated that workshop participants should continue to pay attention to inevitable upcoming disasters in order to learn from them. In the next year and beyond, he said, other disasters will occur, and preparedness stakeholders should use those experiences to record lessons learned in real time and test new ideas to improve disaster preparedness and resilience.

10

Reflections on the Workshop and Opportunities for Moving Forward

Tener Veenema described the workshop as inspiring, informative, at times alarming, and powerful in highlighting the obstacles to mounting a systematic health care response to a nuclear incident. Jim Blumenstock summarized several of his key takeaways from the workshop, and Kevin Yeskey adjourned the meeting with closing remarks that reflected the Office of the Assistant Secretary for Preparedness and Response's (ASPR's) thoughts on the meeting and potential action items discussed.

BLUMENSTOCK'S KEY MESSAGES

The Reality of a Nuclear Threat

Blumenstock reinforced a point made evident at the beginning of the workshop: The possibility of a nuclear incident is real, and "an incident anywhere is an incident everywhere." The magnitude of any type of nuclear assault, he said, would transcend geopolitical, or state, boundaries. Such an event would have significant second- and third-order consequences that would impact the nation as a whole and regions far from the blast site itself. "Clearly, the issue here is national," Blumenstock said. "And the complacency that may exist in pockets of the country that it could never happen there or to them really needs to be addressed and neutralized because that is not a healthy planning mindset."

Guidance Documents and Innovative Practices

Blumenstock was impressed by the wealth of relevant guidance documents discussed at the workshop; these included both planning and technical assistance documents as well as promising, innovative practices that have been made available by U.S. government agencies and other entities. He recalled, however, that all too often these types of products become the "best-kept secrets in the national capital region." He called for an effort to create a compendium of these guidance documents and other resources to be reissued to the larger practice community to ensure that practitioners who ultimately are responsible for implementing these guidelines know that they exist. He suggested the National Alliance for Radiation Readiness could serve as a convener and distributor of the described resources.

All-Hazards Preparedness Versus Incident-Specific Response Planning

Blumenstock observed that all-hazards preparedness was mentioned several times over the course of the workshop and said that nuclear preparedness efforts benefit from the foundational elements provided through the paradigm. In his opinion, nuclear response planning must continue to leverage and capitalize on that approach. His one caution, however, was that the all-hazards approach does not address all elements of a potential nuclear incident response; he said that preparedness efforts need to strike the right balance between the all-hazards approach and planning for specific threats. "So how do you manage that message of reinforcing the importance of all-hazards preparedness," he asked, while "also realizing that a nuclear incident-specific response has its own needs and capacity limitations and gaps that need to be filled?"

The Potential to Save Lives

Blumenstock said that several presenters emphasized that notwithstanding the consequences of a nuclear incident, lives can and will be saved through effective public education and by deploying a skilled, educated, and sufficiently resourced public health, health care, and first-responder workforce. "The response apparatus and the public must be motivated and driven by this positive outlook," Blumenstock said, "and not be taking a fatalistic outlook that there is nothing we can do, so we shouldn't prepare."

Planning Assumptions

If such an incident were treated as an act of war, then military assets most likely would not be available to assist the civilian community in its public health and medical response. Blumenstock pointed out that this in and of itself demands a significant shift from traditional planning regarding what federal, especially military, resources would be available within U.S. jurisdictions to assist civilian support. On a related issue, Blumenstock referred to the discussion around Emergency Management Assistance Compact (EMAC). While EMAC would certainly provide state-to-state support and assistance, given that the magnitude of a nuclear incident would be unprecedented, it is unclear how rich the available resource pool would be from state to state. This would be especially true in the early days of an incident, when multiple jurisdictions could be impacted and there would be uncertainty around the impact across the country.

International Assistance and the Global Health Emergency Workforce

Regarding international assistance in the event of a nuclear incident in the United States, Blumenstock mentioned concern voiced from the Pacific Rim regarding proximity to and reliance on other countries that may be closer logistically and from where it might be easier to provide support compared to Hawaii or the continental United States (see Chapter 3). This raises questions about what doctrines, policies, or procedures are in place to allow that to happen effectively and efficiently. Also during the workshop, there was some discussion about the World Health Organization's global health emergency workforce and how it is expanding and how it may provide support and assistance if and when necessary.

Crisis Standards of Care

For Blumenstock, it was quite clear that a nuclear incident would trigger a scarce resource environment requiring a crisis standards of care posture. Implied in that statement, he said, are the following questions: At what point should a "playbook" of crisis standards of care for a nuclear scenario be developed? How well in advance can and should that be done—including using the playbook to conduct training and exercises—rather than waiting for an incident to happen and using it on a "just-in-time" basis?

Unique Needs of the Pediatric Population and Public Resilience

Blumenstock mentioned a recurring thread that emerged throughout the workshop: the unique and specific needs of the pediatric population in the event of a nuclear incident, ranging from communications and education through medical countermeasure availability and clinical care. Blumenstock also called for if not a national conversation, then a regional conversation around public resilience and nuclear preparedness. For him, the public service announcements in Ventura County demonstrate that it is possible to do this (see Chapter 5). In his opinion, a nuclear incident should be considered part of the spectrum of threats and risks that the U.S. public is facing. In his opinion, the more it is talked about with appropriate information from credible sources, the more comfortable the public will be and the more focused on how to become better prepared.

Research Needs Moving Forward

Blumenstock highlighted several areas of potential research that would help advance preparedness and response for a potential nuclear incident. Specifically, he mentioned the need for more effective communication strategies, as discussed by Steven Becker and others. For example, he said, stakeholders could do more to understand the power of social media, both positive and negative, and its applications. In addition, he said, emerging technologies (such as wireless emergency alerts) could be pursued as a useful tool for successful public outreach and education. Separately, Blumenstock highlighted the clinical aspects of burn care as an additional research gap, especially around mortality associated with third-degree burns.

Workforce Needs and Collaboration

Blumenstock noted that workforce needs and gaps were discussed repeatedly throughout the workshop. In particular, he mentioned the importance of supporting nuclear response skills development, education, and training among current and future members of the public health and health care workforces; the challenge of addressing responders' fears and discomforts regarding a nuclear incident; the role of volunteers and technology (e.g., telemedicine) as "force multipliers" during a response; and the need for specific training and medical curricula in areas such as medical toxicology and burn care to ensure that physicians, nurses, and support service staff are competent and comfortable handling complex and unfamiliar injuries. "We need to be much more serious and focused on teaching, training, and exercising against this type of scenario," he said. Finally, Blumenstock mentioned the discussion toward the end of day 1 on partnerships and collaboration and how "we are all in it together" (see Chapter 6). Now is the time, he said, to clear silos away, whether those be among disciplines, jurisdictions, or just "turf and parochial" issues. He observed that even just having everyone here in the same room and engaging in conversation for 8 hours has led to a couple of courses of action, with people planning to get together to work through some of the barriers and gaps.

ASPR'S CLOSING REMARKS: CALL FOR AN ACTION PLAN

Yeskey recalled a past meeting with national experts in disaster response and emergency management and medical operations during which someone commented, "A disaster is just a hard day."

"This scenario is not just a hard day," Yeskey said of a nuclear incident scenario, echoing earlier workshop speakers. The standard strategies for triaging patients will not work, Yeskey said, if responders must account for both radiation and conventional injuries. He said there will be limited resources, limited countermeasures, and limited staff and personnel to take care of these patients, and if resources are not used effectively and efficiently, people who could survive will not. Responsible allocation of services and scarce resources will be critical, he noted. Ensuring that medical and public health personnel know how to use services and resources is critical to delivery, Yeskey said, and he referred to the list of countermeasures held in the Strategic National Stockpile and elsewhere. Most health care professionals are not familiar with the use of such particular medications, and he noted there may also be additional novel medications in use issued through emergency use authorizations. Ultimately, Yeskey said that crisis standards of care will be important following a nuclear incident, especially because the standards could remain in effect for a long time post-incident. "We don't talk about that much in public," he said. "Even in the medical community, we don't spend a lot of time addressing crisis standards of care." Yeskey described the response efforts after a potential nuclear incident as a shared responsibility. He called attention to the talent and expertise that the federal government brings to the table but asserted that no single entity can operate independently of others in this space. Governments, private industry, academia, and nongovernmental organizations all need to work together.

Emphasizing Preparedness

Typically, a national disaster comes with a warning. At the time of this workshop, for example, in preparation for a response to Hurricane Lane, ASPR had sent several disaster medical assistance teams to Hawaii and had already deployed a management team several days before. However, during a potential nuclear scenario, there would only be approximately 20 minutes to warn the public before a blast. "So what you have in your communities is what you have for a while," Yeskey said. No-notice events are especially difficult, Yeskey commented. He compared a nuclear incident scenario to an earthquake scenario. "It's going to happen, and it's going to be bad very fast." He stressed that support following a nuclear incident likely would not arrive quickly, so "if you are not ready and not prepared and you don't have those tools available," he said, "you are going to be in a hole, and those are going to be hard to dig out of." Thus, the real work, in his opinion, is preparing communities prior to an event. This includes educating practitioners and providers about the threat environment, ensuring community education and resiliency, and ensuring strong communication plans.

Windows of Opportunity for Medical Care

In response to a nuclear incident, Yeskey stated that stakeholders should consider the potential "windows of response" in relation to the likely patient populations that will emerge following an event: trauma patients, patients with acute radiation sickness (ARS), patients with burn injuries, patients with chronic injuries who require long-term rehabilitation, and patients with mental health issues, among others. During the initial response—only a few days—the focus should remain on traumatic injuries. In the following days and weeks, many will likely require attention for ARS. Yeskey also expressed concern for displaced populations, which could number upward of hundreds of thousands of people. Many in this group could rely on regular medication or suffer from chronic medical conditions, making long-term treatment—in shelters or other settings—difficult. Poor access to medications or care could create a larger burden on the health care system after it is already damaged and overwhelmed, Yeskey said.

Finally, the last window of opportunity is rehabilitation, Yeskey noted. He said this window is important and is often forgotten in planning and exercises. He posed several questions for consideration: What happens 1 year after a nuclear incident when people who suffered traumatic injuries require rehabilitation? How do these injuries increase the burden on recovering health care systems? How are these patients cared for? Yeskey also noted that while the risk of cancer from radiation is low, for those who do suffer that fate, it is a significant setback, and long-term recovery becomes all the more important.

Yeskey identified three crosscutting issues for the public health and health care communities to consider in response to a nuclear incident: mental health, audience-specific and age-specific communications strategies, and fatalities management. He noted that while fatalities management had not been discussed at the workshop, the topic warranted further attention as it is an inherently difficult issue (e.g., identifying human remains and matching loved ones with their families).

Windows of Opportunity for Communications

Yeskey stressed the initial message repeated throughout the workshop of "Get inside, stay inside, stay tuned." "But then what?" Yeskey asked.

He encouraged the audience to imagine someone—hungry, thirsty, scared—sheltering for 2 days after an event. Naturally, he said, those sheltering will have questions: Is it safe to drink tap water? Is it safe to eat from canned food that has dust on top of it? Is it safe to eat vegetables that have been outside? These and other environmental and public health issues should be addressed in a consolidated message across jurisdictions, Yeskey said. Looking toward long-term recovery, Yeskey commented that many people would likely wonder when they could return to their homes and communities: When is it safe, and how "safe" is safe? How "clean" is clean? Yeskey noted that these are the types of questions often asked during recoveries from hurricanes and other disasters, and he suggested that lessons can be drawn from preexisting bioterrorism planning.

Developing an Action Plan

Lastly, Yeskey urged that the next step in nuclear preparedness be to consider an action plan by identifying priorities and delegating roles across stakeholders. He observed that there are numerous roles for ASPR based on the workshop discussions and noted that the government is well suited to delineating roles and designating funding. He reiterated, however, that this is a shared responsibility, and the private sector is absolutely better suited to performing certain tasks than the government. Looking ahead to the next 12 months and beyond, Yeskey said ASPR will engage organizations already working in this space, including the American Burn Association (ABA), the Association of State and Territorial Health Officials, the National Association of City & County Health Officials, and the Radiation Injury Treatment Network (RITN). ASPR's Regional Disaster Health Response System will help to address some of the concerns brought up at the workshop, he said, but there is more work to be done and more partnerships to facilitate. He cited a budding partnership between ABA and RITN—"we need more of that kind of action." As he adjourned the meeting, Yeskey commented that collective action can lead to solutions in this arena, but time is of the essence.

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A

Workshop Agenda

August 22–23, 2018

National Academy of Sciences Building—Fred Kavli Auditorium
2101 Constitution Avenue, NW, Washington, DC 20418

Meeting Objectives

- Understand the current state of medical and public health preparedness for a nuclear incident and how these relate to the prior assumptions about the threat environment
- Discuss possible changes to planning assumptions for nuclear incidents, with particular attention to the (re)emergence of state actor threats and the implications of those changes for nuclear incident prevention, planning, and response
- Consider the implications for capacity building of potential communication, education, and information challenges posed by a nuclear incident and opportunities and approaches for addressing them
- Explore challenges, opportunities, and implications for building capabilities to respond to and recover from a nuclear incident, including building capability for monitoring and long-term health surveillance among survivors

DAY 1—AUGUST 22, 2018

Session I Introduction and Overview of the Workshop

8:00 a.m. **Chairs' Welcome**

Jim Blumenstock
Chief Program Officer, Health Security
Association of State and Territorial Health Officials
Workshop Planning Committee Co-Chair

Tener Veenema
Professor of Nursing and Public Health
Johns Hopkins University School of Nursing
Johns Hopkins Bloomberg School of Public Health
Workshop Planning Committee Co-Chair

Session II Briefing: Federal Planning for Nuclear Incidents (*Unclassified*)

8:15 a.m. **Briefing Panel: Federal Planning for Nuclear Incidents**

Brooke Buddemeier
Principal Investigator, Global Security Directorate
Lawrence Livermore National Laboratory

John Crapo
Deputy Program Manager, National Nuclear Security Administration
U.S. Department of Energy

John MacKinney
Senior Policy Adviser, Countering Weapons of Mass Destruction Office
U.S. Department of Homeland Security

Kevin Yeskey
Principal Deputy Assistant Secretary for Preparedness and Response
Office of the Assistant Secretary for Preparedness and Response
U.S. Department of Health and Human Services

9:00 a.m. **Q&A**

Session III Current State of Nuclear Preparedness

9:15 a.m. **Panel Discussion I: Current State of Preparedness**

Moderator: **Roberta Lavin**
Executive Associate Dean and Professor
College of Nursing, University of Tennessee

Regina Hawkins
Senior Analyst, Preparedness
Association of State and Territorial Health Officials
Co-Lead, National Alliance for Radiation Readiness

Michael "Mac" McClendon
Director, Office of Public Health Preparedness and Response
Harris County Public Health
Chair, Radiation Workgroup
National Association of County & City Health Officials

Patrick Lujan
Preparedness Manager
Department of Public Health and Social Services, Guam

Chris Williams
Deputy Director, Office of Radiation Protection
Washington State Department of Health

10:15 a.m. **Q&A**

10:45 a.m. *Break*

11:00 a.m. **Panel Discussion II: Updating Planning Assumptions**

Moderator: **Cham Dallas**
University Professor of Health Policy and Management
Director, Institute for Disaster Management
University of Georgia

MG Arthur J. Logan
Adjutant General
Hawaii State Department of Defense

Robert Whitcomb
Chief, Radiation Studies Section
National Center for Environmental Health
Centers for Disease Control and Prevention

James Young
Program Manager, Radiological Emergency Preparedness, Emergency Management
North Carolina Department of Public Safety

12:00 p.m. **Q&A**

12:30 p.m. *Lunch*

Session IV Implications of Communication, Education, and Information Challenges

1:30 p.m. **Keynote: Communication, Education, and Information Challenges of Nuclear Events**

Steven M. Becker
Professor, Community and Environmental Health
Old Dominion University

2:00 p.m. **Q&A**

2:15 p.m. **Presentations: Implications of Communication, Education, and Information Challenges for Building Capabilities—Lessons from Research**

Hamilton Bean
Associate Professor of Communication
Director, International Studies Program
University of Colorado Denver

Baruch Fischhoff
Howard Heinz University Professor
Institute for Politics and Strategy, and Department of Engineering and Public Policy
Carnegie Mellon University

Robert Levin
Public Health Officer
Ventura County, California

Jessica Wieder
Public Affairs Specialist
Environmental Protection Agency

3:15 p.m. **Q&A**

Session V Challenges for Building Capacity Within the Health Care System

3:45 p.m. *Break*

4:00 p.m. **Panel III: Challenges for Building Capacity—Health Care Systems Perspectives**

Moderator: **Bruce Evans**
Fire Chief
Upper Pine River Fire Protection District, Colorado

Amanda Bettencourt
Research Fellow, Center for Health Outcomes and Policy Research
University of Pennsylvania School of Nursing

Cullen Case, Jr.
Program Manager
Radiation Injury Treatment Network

James Jeng
Surgeon, Crozer-Chester Medical Center, Pennsylvania
Chairman, Disaster Subcommittee
Committee on Organization and Delivery of Burn Care
American Burn Association

Robert L. Jones
Chief, Inorganic and Radiation Analytical Toxicology Branch
National Center for Environmental Health
Centers for Disease Control and Prevention

Ziad Kazzi
Associate Professor, Emergency Medicine
Emory University School of Medicine
Member, Board of Directors
American College of Medical Toxicology

Ian Norton
Director, Emergency Medical Teams
World Health Organization

5:15 p.m. **Q&A**

Day 1 Wrap-Up

5:45 p.m. **Chairs' Reflections and Preview of Day 2**

Jim Blumenstock
Chief Program Officer, Health Security
Association of State and Territorial Health Officials
Workshop Planning Committee Co-Chair

Tener Veenema
Professor of Nursing and Public Health
Johns Hopkins University School of Nursing
Johns Hopkins Bloomberg School of Public Health
Workshop Planning Committee Co-Chair

DAY 2—AUGUST 23, 2018

8:00 a.m. **Welcome and Recap of Day 1**

Jim Blumenstock
Chief Program Officer, Health Security
Association of State and Territorial Health Officials
Workshop Planning Committee Co-Chair

Tener Veenema
Professor of Nursing and Public Health
Johns Hopkins University School of Nursing
Johns Hopkins Bloomberg School of Public Health
Workshop Planning Committee Co-Chair

Session VI Capability-Building Challenges and Opportunities

8:15 a.m. **Panel Discussion IV: Building Response Capability**

Moderator: **John Benitez**
Medical Director, Emergency Preparedness
Tennessee Department of Health

Amesh Adalja
Senior Scholar
Johns Hopkins University Center for Health Security

Steve Adams
Deputy Director, Division of Strategic National Stockpile
Office of Public Health Preparedness and Response
Centers for Disease Control and Prevention

Mary Casey-Lockyer
Senior Associate, Disaster Health Services
American Red Cross

Mary Pat Couig
Program Manager, Office of Nursing Services
U.S. Department of Veterans Affairs

James J. James
Executive Director
Society for Disaster Medicine and Public Health
Editor-in-Chief, *Disaster Medicine and Public Health Preparedness*

9:15 a.m. **Q&A**

9:30 a.m. **Panel Discussion V: Ensuring Workforce Readiness and Response Capacity**

Moderator: **John Koerner**
Senior Special Adviser, CBRNE Science and Operations
Office of the Assistant Secretary for Preparedness and Response
U.S. Department of Health and Human Services

Daniel Barnett
Associate Professor
Environmental Health and Engineering
Johns Hopkins Bloomberg School of Public Health

Michael Consuelos
Senior Vice President, Clinical Integration
The Hospital + Healthsystem Association of Pennsylvania

Roberta Lavin
Executive Associate Dean and Professor
College of Nursing
University of Tennessee

Ron Miller
Director (Acting), National Disaster Medical System
Office of the Assistant Secretary for Preparedness and Response
U.S. Department of Health and Human Services

RADM Susan Orsega
Chief Nursing Officer
U.S. Public Health Service

Tener Veenema
Professor of Nursing and Public Health
Johns Hopkins University School of Nursing
Johns Hopkins Bloomberg School of Public Health
Workshop Planning Committee Co-Chair

10:30 a.m. **Q&A**

10:45 a.m. *Break*

Session VII Workshop Wrap-Up

11:00 a.m. **Reaction Panel: Building Preparedness and Response Capability—A Way Forward**

Moderator: **Laura Wolf**
Director, Division of Critical Infrastructure Protection
Office of the Assistant Secretary for Preparedness and Response
U.S. Department of Health and Human Services

Steven M. Becker
Professor, Community and Environmental Health
Old Dominion University

John Benitez
Medical Director, Emergency Preparedness
Tennessee Department of Health

Cham Dallas
University Professor of Health Policy & Management
Director, Institute for Disaster Management
University of Georgia

Bruce Evans
Fire Chief
Upper Pine River Fire Protection District, Colorado

John Koerner
Senior Special Adviser, CBRNE Science and Operations
Office of the Assistant Secretary for Preparedness and Response
U.S. Department of Health and Human Services

Roberta Lavin
Executive Associate Dean and Professor
College of Nursing, University of Tennessee

12:00 p.m. **Closing Remarks**

Robert P. Kadlec
Assistant Secretary for Preparedness and Response
U.S. Department of Health and Human Services

12:45 p.m. **Day 2 Wrap-Up**

Jim Blumenstock
Chief Program Officer, Health Security
Association of State and Territorial Health Officials
Workshop Planning Committee Co-Chair

Tener Veenema
Professor of Nursing and Public Health
Johns Hopkins University School of Nursing
Johns Hopkins Bloomberg School of Public Health
Workshop Planning Committee Co-Chair

1:00 p.m. **Adjourn Workshop**

B

Workshop Speaker Biographies

Amesh Adalja, M.D., is a senior scholar at the Johns Hopkins University Center for Health Security. He also serves on the City of Pittsburgh's HIV Commission and on the advisory group of AIDS Free Pittsburgh. He is board certified in internal medicine, emergency medicine, infectious diseases, and critical care medicine. Dr. Adalja is currently a member of the Infectious Diseases Society of America's (IDSA's) Diagnostics Committee and its Precision Medicine Working Group, as well as one of its media spokespersons; he previously served on its public health committee. He is also a member of the American College of Emergency Physicians Pennsylvania Chapter's EMS & Terrorism and Disaster Preparedness Committee as well as the Allegheny County Medical Reserve Corps. He was formerly a member of the National Quality Forum's Infectious Disease Standing Committee, where he currently is an expert reviewer, and the U.S. Department of Health and Human Services' National Disaster Medical System, through which he was deployed to Haiti after the 2010 earthquake; he was also selected for its mobile acute care strike team. He has served on U.S. government panels tasked with developing guidelines for the treatment of botulism and anthrax in mass casualty settings and the system of care for infectious disease emergencies and as an external adviser to New York City Health and Hospital Emergency Management Highly Infectious Disease training program, as well as a Federal Emergency Management Agency working group on nuclear disaster recovery. Dr. Adalja is an associate editor of the journal *Health Security*. He was a contributing author for the *Handbook of Bioterrorism and Disaster Medicine* and is also a contributing author to the upcoming edition of *Clinical Microbiology Made Ridiculously Simple*.

He has published in such journals as the *New England Journal of Medicine*, the *Journal of Infectious Diseases*, *Clinical Infectious Diseases*, *Emerging Infectious Diseases*, and the *Annals of Emergency Medicine*. Dr. Adalja is a fellow of IDSA, the American College of Physicians, and the American College of Emergency Physicians. He is a member of various medical societies, including the American Medical Association, the HIV Medicine Association, and the Society of Critical Care Medicine. Dr. Adalja completed two fellowships at the University of Pittsburgh—one in infectious diseases, for which he served as chief fellow, and one in critical care medicine. He completed a combined residency in internal medicine and emergency medicine at Allegheny General Hospital in Pittsburgh, where he served as chief resident and as a member of the infection control committee. He was a clinical assistant professor at the University of Pittsburgh School of Medicine from 2010 through 2017. He is a graduate of the American University of the Caribbean School of Medicine, and he obtained a bachelor of science degree in industrial management from Carnegie Mellon University. Dr. Adalja is a native of Butler, Pennsylvania, and actively practices infectious disease, critical care, and emergency medicine in the Pittsburgh metropolitan area.

Steven Adams, M.P.H., is the deputy director of the Division of Strategic National Stockpile at the Centers for Disease Control and Prevention (CDC). Mr. Adams has served CDC in a variety of leadership roles, including his current position since the inception of the Strategic National Stockpile in 1999. He has helped lead the organization's growth to what is now a $7 billion national response asset and has directly engaged with state and local authorities in their preparedness and response efforts to large-scale public health emergencies. Mr. Adams also represents CDC in collaboration with the World Health Organization, other United Nations agencies, and private-sector partners and leads an international technical assistance effort to assist high-priority countries in Africa develop their response capabilities to public health threats such as Ebola and pandemic influenza. He holds a master's degree in public health from the University of North Carolina at Chapel Hill and a program certificate from Harvard's National Preparedness Leadership Initiative.

Daniel Barnett, M.D., M.P.H., is an associate professor in the Department of Environmental Health and Engineering at the Johns Hopkins Bloomberg School of Public Health, where he has a joint appointment in the Department of Health Policy and Management and is on the core faculty of the Office of Public Health Practice & Training. His research interests include evidence-based approaches to organizational enhancement of public health emergency preparedness. He is a member of the National Council on Radiation Protection and Measurements. Dr. Barnett previously worked at

Baltimore City Health Department's Office of Public Health Preparedness and Response, where he conducted disaster preparedness training activities for the department's workers. He received his M.D. at The Ohio State University College of Medicine and Public Health; his M.P.H. at the Johns Hopkins Bloomberg School of Public Health, and he is a graduate of the Johns Hopkins General Preventive Medicine Residency Program.

Hamilton Bean, Ph.D., M.B.A., APR, is associate professor in the Department of Communication at the University of Colorado Denver. He currently serves as director of the University of Colorado Denver's International Studies Program. He specializes in the study of communication and security. Since 2005, he has been affiliated with the National Consortium for the Study of Terrorism and Responses to Terrorism—a U.S. Department of Homeland Security Center of Excellence. His research has been published in numerous international academic journals and edited volumes, and his wireless emergency alerts–related research collaborations appear in the *Journal of Contingencies and Crisis Management*, *Environment & Behavior*, *Public Relations Review*, and *Review of Communication*.

Amanda Bettencourt, M.S.N., is a predoctoral fellow at the Center for Health Outcomes and Policy Research at the University of Pennsylvania School of Nursing, Philadelphia (Penn). As a pediatric clinical nurse specialist, her focus is on achieving the best possible outcomes for hospitalized children. Her current doctoral research at Penn examines the relationship between nursing (e.g., nurse staffing, work environment, education level) and patient outcomes. As a clinical nurse specialist, she helped ensure high-quality nursing care and optimal outcomes for adult and pediatric burn and trauma patients at Regions Hospital in St. Paul, Minnesota, and at the University of Florida Health Shands Hospital in Gainesville, Florida. Ms. Bettencourt was also previously the nurse manager for acute care services at Shriners Hospitals for Children–Boston, where she led an interprofessional team of pediatric burn clinicians. Additional affiliations include the National Association of Clinical Nurse Specialists, Society of Critical Care Medicine, and Sigma Theta Tau. Recently, Ms. Bettencourt was elected to the board of directors at the American Association of Critical Care Nurses. She serves on the American Burn Association's Organization and Delivery of Burn Care Committee and is national faculty for the Advanced Burn Life Support Course. Her current publications are in the areas of nursing and patient safety, burn care, and pediatric delirium. Ms. Bettencourt earned a bachelor of science in exercise science from the University of Florida, an accelerated bachelor of science in nursing from the University of North Carolina at Chapel Hill, and a master of science in nursing from Johns Hopkins University, Baltimore. She will complete a Ph.D. fellowship at the University of Pennsylvania in spring 2019.

Brooke Buddemeier, M.S., CHP, is a certified health physicist (radiation safety specialist) in the global security directorate of Lawrence Livermore National Laboratory (LLNL). He supports the Risk and Consequence Management Division in its efforts to evaluate the potential risk and consequence of radiological and nuclear terrorism. LLNL does this by providing expert technical information in nuclear threat assessment, nuclear incident response, and forensics and attribution. Mr. Buddemeier is a council member of the National Council on Radiation Protection and Measurements (NCRP) and on the scientific committees that developed Commentary No. 19, *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism* (2005), and NCRP Report #165, *Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers* (2010). Mr. Buddemeier is an active member of the Health Physics Society (HPS) and member of the HPS Homeland Security Committee. From 2003 through 2007, Mr. Buddemeier was on assignment with the U.S. Department of Homeland Security (DHS) as the weapon of mass destruction emergency response and consequence management program manager for Science and Technology's emergency preparedness and response portfolio. He supported the Federal Emergency Management Agency and DHS's Operations Center as a radiological emergency response subject-matter expert. He also facilitated the department's research, development, test, and evaluation process to improve emergency response through better capabilities, protocols, and standards. Before moving to DHS, he was part of LLNL's Nuclear Counterterrorism Program and coordinated LLNL's involvement in the National Nuclear Security Administration's Radiological Assistance Program (RAP) for California, Hawaii, and Nevada. RAP is a national emergency response resource that assists federal, state, and local authorities in the event of a radiological incident. As part of RAP's outreach efforts, Mr. Buddemeier has provided radiological responder training and instrumentation workshops to police, firefighters, and members of other agencies throughout the nation. He has also trained radiological emergency responders on the use of specialized radiological response equipment throughout the United States and in Kazakhstan. Mr. Buddemeier has also provided operational health physics support for various radiochemistry, plutonium handling, accelerator, and dosimetry operations at LLNL for more than 15 years and has been working on emergency response issues for more than 10 years. He has participated in radiological emergency responses and exercises throughout the world. Mr. Buddemeier is a certified health physicist through the American Board of Health Physics (2000). He holds an M.S. in radiological health physics from San Jose State University (1997) and a B.S. in nuclear engineering from the University of California, Santa Barbara (1987).

Cullen Case, Jr., EMPA, CEM, CBCP, CHEP, is the program manager for the Radiation Injury Treatment Network, where he leads the preparedness activities of 80 hospitals, blood donor centers, and cord blood banks preparing for the medical surge from a radiological incident. As the senior manager of logistics and emergency preparedness for the National Marrow Donor Program, he is responsible for the delivery of cellular therapy/marrow worldwide, organizational preparedness, crisis response, business continuity, and the exercising of plans. While in the U.S. Army he managed the logistical responses to Hurricanes Bertha and Fran in North Carolina (1996) and Hurricane Mitch in Nicaragua (1998).

Mary Casey-Lockyer, M.H.S., CCRN, is currently the senior associate for Disaster Health Services at the national headquarters of the American Red Cross. For more than 6 years, she has fulfilled this role for program development and continuous quality improvement for Disaster Health Services at national headquarters. As a Disaster Health Services manager/chief with the Red Cross, she has been on 17 national deployments, most recently to the 2017 Florida Hurricane Irma response plus supporting response operations in California, Nevada, Puerto Rico, Texas, and the U.S. Virgin Islands from the Red Cross national headquarters' Disaster Operations Coordination Center. Mary continues to act as the Red Cross liaison to the Secretary's Operations Center at the U.S. Department of Health and Human Services and serves on the board of Healthcare Ready. She has published many articles, most recently "Disability Integration Throughout the Disaster Cycle of Prepare, Respond and Recover" in the *Journal of Business Continuity and Emergency Planning*, spring 2017.

Michael J. Consuelos, M.D., M.B.A., FAAP, is the senior vice president for clinical integration at The Hospital + Healthsystem Association of Pennsylvania (HAP). He is the executive leader responsible for HAP's emergency preparedness programs. He also supports member organizations in their quality and patient safety collaboratives, physician leader engagement, health care data analytics, value-based purchasing, and progress toward population health management. Dr. Consuelos has more than 20 years of clinical integration and physician leadership experience. He has led health system capital planning, strategic business ventures, physician compensation plans, and community pandemic and mass casualty preparations. More recently, he has focused on population health management and developing physician compensation models that advance value-based care systems. His experience in emergency preparedness began during his service in the U.S. Army. In his last assignment, Dr. Consuelos was the chief of medicine at Ireland Army Community Hospital, Fort Knox. His leadership duties included mass casualty and biochemical response at Fort Knox and Army

Reserve clinics in three other states. He also led the 2009 H1N1 pandemic preparations and coordinated community response for Lehigh Valley Health Network. Dr. Consuelos holds a bachelor of arts in psychology with high honors from Princeton University and a doctor of medicine from the University of Pennsylvania School of Medicine. He completed his pediatric training at the Children's Hospital of Philadelphia and the Walter Reed Army Medical Center. He is a board-certified pediatrician and a fellow of the American Academy of Pediatrics. Dr. Consuelos received his executive M.B.A. from the Pennsylvania State University Smeal College of Business.

Mary Pat Couig, Ph.D., M.P.H., received a bachelor of science in nursing from Fitchburg State University, a master of public health degree from the Johns Hopkins Bloomberg School of Public Health, and a doctor of philosophy degree from the Uniformed Services University of the Health Sciences. Prior to her retirement in 2006, she served as the chief nurse officer of the U.S. Public Health Service (USPHS). During her tenure as chief nurse officer, she collaborated with the Federal Nursing Services Council (Air Force, Army, Navy, USPHS, Veteran's Health Administration, and the American Red Cross) and local, state, national, and international colleagues on strengthening nursing's role and preparation for public health preparedness. Currently she is a program manager for emergency management in the Office of Nursing Services, U.S. Department of Veterans Affairs.

John Crapo, M.S., M.Sc., CHP, is a deputy program manager within the Office of Nuclear Incident Response at the National Nuclear Security Administration. In that capacity, he manages the atmospheric modeling, aerial radiation measurements, and radiation emergency medicine portfolios for the office. He also serves as a federal team leader for teams deployed in response to a radiological or nuclear incident. Prior to his current assignment, he was the associate director for national security at Oak Ridge Institute for Science and Education. Mr. Crapo is a retired naval officer and is certified in the comprehensive practice of health physics by the American Board of Health Physics.

Baruch Fischhoff, Ph.D., is Howard Heinz University Professor, Department of Engineering and Public Policy and Institute for Politics and Strategy, Carnegie Mellon University (CMU). A graduate of the Detroit Public Schools, he holds a B.S. (mathematics, psychology) from Wayne State University and a Ph.D. (psychology) from the Hebrew University of Jerusalem. He is a member of the National Academy of Sciences and of the National Academy of Medicine. He is past president of the Society for Judgment and Decision Making and of the Society for Risk Analysis. He has chaired the Food and Drug Administration Risk Communication Advisory Committee and been a member of the Eugene (Oregon) Commission on the Rights of Women, the U.S. Department of Homeland Security's Science and Technology Advisory Committee, and the Environmental Protection Agency's Scientific Advisory Board, where he chaired the Homeland Security Advisory Committee. He has received the American Psychological Association (APA) Award for Distinguished Contribution to Psychology, CMU's Ryan Award for Teaching, an honorary doctorate of humanities from Lund University, and an Andrew Carnegie Fellowship. He is a fellow of APA, the Association for Psychological Science, Society of Experimental Psychologists, and Society for Risk Analysis. His books include *Acceptable Risk*, *Risk: A Very Short Introduction*, *Judgment and Decision Making*, *A Two-State Solution in the Middle East*, *Counting Civilian Casualties*, and *Communicating Risks and Benefits*. He has co-chaired three National Academies colloquia on the science of science communication.

Regina Hawkins, M.P.H., is a senior analyst for preparedness at the Association of State and Territorial Health Officials (ASTHO). She leads the Directors of Public Health Preparedness peer network and the National Alliance for Radiation Readiness. Ms. Hawkins assists state health departments in the formulation of policy decisions and efforts to develop preparedness plans. Prior to joining ASTHO, she worked as an intern for the National Association of County & City Health Officials. Ms. Hawkins holds a bachelor of science in applied science in public health from Youngstown State University and a master of public health from Saint Louis University, where she concentrated in biosecurity and disaster preparedness and environmental and occupational health.

James J. James, M.D., Ph.D., M.H.A., serves as the executive director of the Society for Disaster Medicine and Public Health and editor in chief of *Disaster Medicine and Public Health Preparedness*. Dr. James is board certified in general preventive medicine, earned a doctorate in medicine at the Cincinnati College of Medicine, a doctorate in public health from the University of California, Los Angeles, School of Public Health, and a master's in health care administration from Baylor University. Previously, he was director of the American Medical Association Center for Public Health Preparedness and Disaster Response, which oversaw the development and deployment of the National Disaster Life Support suite of courses (more than 110,000 medical and public health personnel trained) as well as other innovative mass casualty developments such as the health security smart card and the Citizen Ready preparedness and recovery training modules. Dr. James has served on many federal and private boards and committees in major policy and research functions in disaster medicine and public health. Dr. James served 26 years with the U.S. Army Medical Department, serving in a multitude of capacities. His last assignment was as the commanding general of William Beaumont Army Medical Center in El Paso, Texas. Upon retirement in 1997, he was awarded the Distinguished Service Medal, the military's highest peacetime honor. He went on to join FHC Options in Norfolk, Virginia, where he oversaw the building and management of the FHC Options team responsible for winning several multibillion-dollar U.S. government-managed care contracts. Dr. James also served as director of the Miami-Dade County Health Department and led the Miami-Dade County Health Department as it investigated and responded to the anthrax attacks of 2001. In 2002 the Miami-Dade County Health Department was awarded the Governor's Sterling Award.

James Jeng, M.D., is a surgeon at the Crozer-Chester Medical Center in Pennsylvania, and he also serves as the chairman of the Disaster Subcommittee, Committee on the Organization and Delivery of Burn Care, American Burn Association. Prior to his current position, Dr. Jeng was a professor of surgery in the Mount Sinai Health System in New York City. Dr. Jeng has provided state-of-the-art burn care for both run-of-the-mill and extreme injuries in a three-state area of 7 million inhabitants (catchment area–abutted burn centers at Johns Hopkins, Medical College of Virginia, and University of Pittsburg). For two decades, he has taught surgical trainees from Georgetown University, The George Washington University, the U.S. Army and U.S. Navy, and Howard University. His teaching areas include trauma, acute care surgery, surgical critical care, burn care, and bench and translational research. Dr. Jeng became a recognized leader in the American burn community over two decades in diverse areas, including burn shock, end points of burn shock resuscitation, laser applications in burn care, laser Doppler velocimetry and microvascular analysis, the National Burn Repository and data mining, data standards for burn care software, contingency planning for mass burn casualties, interface between the burn care community, the American Burn Association, and key components of the federal government, nationwide situational awareness of burn care assets, uniform practice guidelines in burn care, and burn care under austere conditions. Internationally, Dr. Jeng is currently leading burn community efforts in burn disaster preparedness. In the role of International Society for Burn Injuries committee chairman, he helped launch a six-pronged methodology with deliverables aimed at 2016: (1) codify and diffuse knowledge on burn shock resuscitation using only oral fluids, (2) catalog and diffuse knowledge of all known possible topical therapies for burn injuries, (3) systematically study and report on the phenomena/incidence of burn mass casualties around the globe so as to understand the extent of the problem, (4) continue efforts to bring further organization/connection between burn care providers and local governments, (5) catalog, diffuse, and strengthen linkages between all of the

NGOs with involvement in the worldwide burn care space, and (6) publish a multiauthor opinion piece in the journal to catalyze database development and data mining for burn injuries around the globe.

Robert L. Jones, Ph.D., is the chief of the Inorganic and Radiation Analytical Toxicology Branch, National Center for Environmental Health, at the Centers for Disease Control and Prevention (CDC). Dr. Jones has worked at CDC for 25 years, and his current responsibilities include the planning, implementation, oversight, and completion of programs related to public health that involve nonradioactive and radioactive elements or their isotopes. These programs involve research and development of a wide variety of analytical methods to enable CDC to assay and monitor the exposure of populations to toxic or essential elemental exposures and radionuclide contamination. These analytical methods include both total elemental analysis as well as speciation of arsenic and mercury. Dr. Jones and his team are also developing a variety of analytical radionuclide bioassay methods for emergency and terrorism preparedness and response. These methods will allow CDC to assist the states in responding to a major radiological or nuclear incident and allow for the assessment of contamination and exposure in people and to enable the efficient use of medical countermeasures and allow for rapid medical management decisions. Dr. Jones earned a B.S. in chemistry (1977), an M.S. in physical chemistry (1979), and a Ph.D. in biophysical chemistry (1986), all from Georgia State University. Prior to his current position at CDC, Dr. Jones served as chief (acting), Inorganic and Radiation Analytical Toxicology Branch (2007–2008); chief, Inorganic Toxicology and Radionuclide Laboratories, CDC (2002–2007); chief, Inorganic Toxicology Laboratory, CDC (2000–2002); and research chemist, CDC (1993–2000).

Robert Kadlec, M.D., M.S., is the assistant secretary for preparedness and response (ASPR) at the U.S. Department of Health and Human Services (HHS). The ASPR serves as the secretary's principal adviser on matters related to public health emergencies, including bioterrorism. The office leads the nation in preventing, responding to, and recovering from the adverse health effects of man-made and naturally occurring disasters and public health emergencies. As such, the office coordinates interagency activities between HHS, other federal agencies, and state and local officials responsible for emergency preparedness and the protection of the civilian population from public health emergencies. Dr. Kadlec spent more than 20 years as a career officer and physician in the U.S. Air Force before retiring as a colonel. Over the course of his career, he has held senior positions in the White House, the U.S. Senate, and the U.S. Department of Defense (DoD). Most recently, he served as the deputy staff director to the Senate Select Committee on Intelligence. Dr. Kadlec previously served as staff director for Senator

Richard Burr's subcommittee on bioterrorism and public health in the 109th Congress. In that capacity, he was instrumental in drafting the Pandemic and All-Hazard Preparedness Bill, which was signed into law to improve the nation's public health and medical preparedness and response capabilities for emergencies, whether deliberate, accidental, or natural. Dr. Kadlec also served at the White House from 2002 to 2005 as director for biodefense on the Homeland Security Council, where he was responsible for conducting the biodefense end-to-end assessment, which culminated in drafting the National Biodefense Policy for the 21st Century. He served as special assistant to President George W. Bush for biodefense policy from 2007 to 2009. Earlier in his career, he served as the special adviser for counterproliferation policy at the Office of the Secretary of Defense, where he assisted DoD efforts to counter CBRN (chemical, biological, radiological, and nuclear) threats in the wake of 9/11 and contributed to the FBI investigation of the anthrax letter attacks. He began his career as a flight surgeon for the 16th Special Operations Wing and subsequently served as a surgeon for the 24th Special Tactics Squadron and as special assistant to J-2 for chemical and biological warfare at the Joint Special Operations Command. He was named U.S. Air Force Flight Surgeon of the Year in 1986. Dr. Kadlec holds a bachelor's degree from the U.S. Air Force Academy, a doctorate of medicine, and a master's degree in tropical medicine and hygiene from the Uniformed Services University of the Health Sciences, as well as a master's degree in national security studies from Georgetown University.

Ziad Kazzi, M.D., was born in 1975 and raised in Beirut, Lebanon. Dr. Kazzi trained in emergency medicine at Emory University in Atlanta (2000–2003), where he served as a chief resident before completing a subspecialty fellowship in medical toxicology at Emory University, Georgia Poison Center, and the Centers for Disease Control and Prevention (CDC) in Atlanta. He is board certified in both emergency medicine and medical toxicology. Dr. Kazzi joined the Department of Emergency Medicine at the University of Alabama at Birmingham between 2005 and 2008, where he served as a medical toxicologist for the Regional Poison Control Center in Birmingham and the Alabama Poison Center. Currently, he is an associate professor at the Department of Emergency Medicine at Emory University in Atlanta, Georgia, as well as the director of the International Toxicology Postdoctoral Fellowship Program at Emory University. He is also the assistant medical director of the Georgia Poison Center and a guest researcher at the National Center for Environmental Health at CDC, where he participates in emergency preparedness and response activities in radiation. As an emergency physician and toxicologist, Dr. Kazzi specializes in the recognition, triage, and management of poisonings and holds a deep interest in the areas of radiation and international toxicology. Over the past decade, he became involved in clinical toxicology activities globally that range from education to injury prevention and clinical consultation in the Middle East and North Africa region, Georgia, and India. He holds an adjunct appointment at the American University of Beirut and directs its clinical toxicology services. He is an active and founding board member of the Middle East North Africa Clinical Toxicology Association and currently serves as its president. He is also a board member of the Medical Toxicology Foundation and the American College of Medical Toxicology, at which he chairs the International Committee and the Clerkship Council on Medical Toxicology.

Robert M. Levin, M.D., is the health officer/medical director for Ventura County Public Health. He has served in that capacity for the past 20 years. Most recently, Dr. Levin has worked on nuclear preparedness, including a written nuclear plan that delineates Ventura County's response to a nearby nuclear detonation and a public information campaign for residents of the county. Dr. Levin received his medical degree from the University of Missouri in Columbia. He completed his pediatric residency at San Francisco General Hospital and the University of California, San Francisco. He is board certified in pediatrics and pediatric infectious diseases. He served as chairman of pediatrics at Natividad Medical Center in Salinas, California. In 1987 he moved his family to Chicago, Illinois, to become program director for the pediatric residency training program at Christ Hospital in Oak Lawn, Illinois, and then, in 1994, chairman of the Department of Pediatrics at Mount Sinai Hospital, Chicago. He came to Ventura County in 1998 to assume his current position as Ventura County's public health officer. As health officer, Dr. Levin has been the chief medical officer overseeing all Ventura County terrorism-related activities and threats. In October 2007, on behalf of Ventura County, he published the *Ventura County Nuclear Explosion Response Plan*. His work on nuclear public information was partially funded by FEMA and the CDC. He has addressed national audiences on the topic of the local impact of a nuclear detonation and the development of a pre-nuclear explosion public information campaign for the U.S. Department of Homeland Security, the Institute of Medicine, NATO, and the Centers for Disease Control and Prevention in such cities as Washington, DC; New York City; Atlanta; and Los Angeles.

MG Arthur "Joe" Logan, M.S.S., was appointed as the adjutant general of Hawaii on January 1, 2015. As adjutant general, he oversees the training and readiness of 5,500 soldiers and airmen of the Hawaii National Guard. He also serves as the director of Hawaii Emergency Management Agency, provides direct support to the Office of Veterans Services, and is the Homeland Security adviser to the governor. General Logan received his commission in 1984 from the Hawaii Army National Guard Officer Candidate School, Hawaii Military Academy. With more than 36 years of service, he has served in significant positions of authority and responsibility, including commander, 227th Engineer Company; brigade engineer officer, 29th Separate Infantry Brigade; commander, 1st Battalion, 487th Field Artillery; counterdrug coordinator, Hawaii Army National Guard; commander, Regional Police Advisory Command, Operation Enduring Freedom, Kabul, Afghanistan; chief of staff, Hawaii Army National Guard; and chief of staff, Joint Staff, Hawaii National Guard. Before assuming his current position, he served as the G3, Hawaii Army National Guard. He has also held assignments in Pennsylvania and Afghanistan and has received numerous awards throughout his career, including the Legion of Merit, the Bronze Star, the Meritorious Service Medal, and the Army Achievement Medal. He received a B.A. in justice administration and management from Hawaii Pacific University (1993), graduated from the Command and General Staff College in Fort Leavenworth, Kansas (1998), and received a master's in strategic studies from the U.S. Army War College (2004).

Patrick Lujan, M.P.A., is the public health emergency preparedness manager for the island of Guam. He has been instrumental in the overall planning for the potential nuclear attacks made to the island by North Korea. He has been at the forefront of all public health preparedness and response issues on Guam and the Pacific since 2010.

John MacKinney, M.S., M.P.H., is the senior policy adviser for the U.S. Department of Homeland Security Countering Weapons of Mass Destruction (WMD) Office, on detail from the Office of Policy, where he has served as director of nuclear and radiological policy. Mr. MacKinney has more than 25 years of experience bringing people together to solve major homeland and national security challenges. He has expertise in applied risk sciences, policy analysis and development, nuclear and radiological issues, WMD counterterrorism policy and strategy, and WMD terrorism response. He advises and supports the CWMD assistant secretary and other department leadership in all matters related to nuclear and radiological policy, especially nuclear terrorism prevention, counterterrorism, deterrence, and response. In his policy role, Mr. MacKinney coordinates departmental and interagency policy development to counter WMD terrorism and leads and coordinates policy development with the White House. He has served on a number of senior-level White House National Security Council, Homeland Security Council, and Office of Science and Technology Policy committees and working groups, providing policy and technical input on development, writing, vetting, clearing, and implementation of a number of nuclear- and homeland security-related presidential directives and guidance, including Presidential

Policy Directives 8, 25, 33, 35, 38, and 42. Mr. MacKinney previously led the radiological/nuclear research portfolio at the Environmental Protection Agency's National Homeland Security Research Center, where he built and led a team of Ph.D.s and engineers investigating response countermeasures to radiological dispersal device and improved nuclear device attacks. He has served as an expert consultant to the World Bank on nuclear issues. Mr. MacKinney holds a master of science degree in geophysics from the University of Wisconsin and a master of public health degree from the Johns Hopkins University and is certified in risk sciences and public policy through the Risk Sciences and Public Policy Institute.

Michael W. "Mac" McClendon is the director of the Office of Public Health Preparedness and Response and the Emergency Management Coordinator at Harris County Public Health (Texas). Mr. McClendon joined Harris County Public Health in November 2005 as the emergency management coordinator. In August 2006 he was named chief of the Office of Public Health Preparedness and in March 2007 was named the director of the Office of Public Health Preparedness and Response. Mr. McClendon is responsible for the all-hazard planning, response and recovery to public health emergencies within Harris County, Texas. Mr. McClendon also serves as the Harris County Office of Homeland Security and Emergency Management Emergency Support Function #8 health and medical liaison. Mr. McClendon was formerly the emergency response chief for a major chemical manufacturer and has more than 29 years of experience in emergency response and management. Mr. McClendon is a former chair of the National Association of County & City Health Officials (NACCHO) Preparedness Policy Advisory Group, current chair of the NACCHO Radiation Workgroup, and currently serves on the Incident Management, Big Cities & Jurisdictions and Public Health Preparedness work groups. He is also member of the State of Texas and the Federal Emergency Management Agency Urban Search and Rescue Team, where he serves as a task force safety officer.

Ron Miller, M.S., serves as the director of the Division of the National Disaster Medical System (NDMS) within the Office of the Assistant Secretary for Preparedness and Response at the U.S. Department of Health and Human Services. NDMS is comprised of health professionals who augment health care systems to save lives during disasters. NDMS has multiple types of teams that support public health and medical needs during disasters, including Disaster Medical Assistance Teams, Disaster Mortuary Response Teams, and National Veterinary Response Teams. The program also handles federal patient movement, mass fatality management, and definitive care through NDMS hospitals.

Ian Norton, M.D., is an emergency medicine doctor with postgraduate qualifications in international health, tropical medicine, and surgery and works for the World Health Organization (WHO) headquarters in Geneva managing the new Emergency Medical Team Unit. Previously the director of disaster preparedness and response at the National Critical Care and Trauma Response Centre, Darwin, Australia, he led the development of the government of Australia's Australian Medical Assistance Team and its field hospitals and disaster response capacity. He helped design training programs for disaster response teams and wrote the Australia national trauma and burns plans. He has led the Australian government medical team deployments to the Ashmore reef boat explosion (2009), Pakistan floods (2010), Solomon Islands Dengue outbreak (2013), and Typhoon Haiyan—response in the Philippines (2013), including a 50-bedded surgical field hospital for Tacloban city within days of the storm. He has also worked in Timor, India, Chile, Myanmar, Tonga, Vanuatu, Solomon Islands, Papua New Guinea, and Indonesia on capacity building and disaster-related projects. Before a career in disaster medicine, Ian worked in the remote "Top End" of Australia in emergency medicine and aboriginal health. He is the lead author of the WHO global classification and standards for Foreign Medical Team deployment to sudden onset disasters, which led to his appointment to the WHO. The text effectively set standards that were previously not in place and that had seen teams in Haiti and other disasters perform operations they were not trained for or run out of drugs and supplies through poor preparation. In that role, he now leads the creation of a directory of Emergency Medical Teams that have reached a minimum quality standard and can be deployed to help countries in need; more than 90 of the world's teams have already joined this initiative to raise the standards of medical response teams. In this role, he also manages training and capacity building of disaster and outbreak response teams in countries most likely to be affected by emergencies. He was deployed for more than 5 months to the West African Ebola outbreak (2014–2015) and led the coordination of more than 60 medical teams in Guinea, Sierra Leone, and Liberia and the design and build of five large Ebola treatment centers in Monrovia, along with the blueprint plans for building by the United Kingdom, the United States, and world food program in the three worst-affected countries. He led the coordination of 149 medical teams in Nepal during the earthquakes (April–May 2015) and the trauma response coordination in Mosul, northern Iraq (2016) and Yemen and responses to outbreaks such as the diphtheria outbreak among Rohingya refugees in 2017–2018.

RADM Susan Orsega, M.S., serves as the chief nursing officer of the U.S. Public Health Service (USPHS). As chief nursing officer, RADM Orsega leads the Commissioned Corps of the U.S. Public Health Service (Corps)

Nurse Professional Affairs and advises the Office of the Surgeon General and the U.S. Department of Health and Human Services on the recruitment, assignment, deployment, retention, and career development of Corps nurse professionals. RADM Orsega is a senior program management officer at the National Institute of Allergy and Infectious Diseases of the National Institutes of Health (NIH). She is responsible for the operational management of international research partnerships with South African and Malian governments, involving 150 international nurses and researchers and 7,000 research participants. In 2015, RADM Orsega played a fundamental role in the U.S. government NIH Ebola response and was instrumental in the implementation of the first human vaccine trial in Liberia and the operational management of the first Ebola Z-Mapp trial in Sierra Leone. RADM Orsega's expertise in disaster care is evident by her selection to a USPHS medical team deployed after 9/11 as well as 13 other national and international disaster/humanitarian U.S. government missions serving in roles with progressive nursing and leadership responsibilities. She was selected as the only USPHS nurse officer on the Advance Planning team, USS Pacific *Peleliu* Navy ship health diplomacy mission. Currently, RADM Orsega is a member of the Response Deployment Team-1. RADM Orsega began her career in the USPHS Commissioned Corps in 1989 in the Junior Commissioned Student Externship Program. At that time, when the HIV/AIDS epidemic was unfolding, RADM Orsega continued to advance her nursing and scientific knowledge with an emphasis on education and is recognized as a subject matter expert in realm of HIV/AIDS global research, advanced nursing practice, health diplomacy, and disaster response. She has authored 14 articles in peer-reviewed journals and presented at 22 major scientific and nursing conferences around the world. RADM Orsega is the recipient of the NIH director's award in 2002 and the distinguished Uniformed Services University Graduate of School of Nursing Alumni of the Year award in 2015. She served as the vice chair for the inaugural USPHS Federal Public Health Nursing Strategic effort that is in alignment with the U.S. Affordable Care Act, the surgeon general's National Prevention Strategy, and the Future of Nursing Report. RADM Orsega's solid understanding of the USPHS organization is a direct result of her consistent and long-term involvement from a junior officer to leading and participating in multidisciplinary and nursing PHS teams. Throughout her USPHS career, she has been actively involved in the nurse category. RADM Orsega served as chair of the Nursing Professional Advisory Committee (N-PAC) and on various N-PAC subcommittees, including Readiness and Response (chair), Awards (chair), and Events (member). She has worked with nurse leaders in other uniformed services over the past 13 years in various working groups, sharing best practices, and is currently serving on the Uniformed Services University, Graduate Nursing Program Doctor of Nurse Practice

Transition Team. RADM Orsega's leadership strength is in bringing multidisciplinary members from different governments, organizations, cultures, and languages together toward a common mission, connecting talents with initiatives. One of her primary goals in every assignment is to disseminate knowledge to improve nursing practice and health systems globally. RADM Orsega received her bachelor of science nursing degree from Towson University. In 2001, she obtained her master's degree of science from the Uniformed Services University of Health Sciences Nurse Practitioner program. In 2013, she was inducted as a fellow in the American Association of Nurse Practitioners.

Robert C. Whitcomb, Jr., Ph.D., M.S., CHP, is chief of the Radiation Studies Section, National Center for Environmental Health at the Centers for Disease Control and Prevention (CDC). Dr. Whitcomb joined CDC in June 1993. In his current position, he serves as radiation subject matter expert and CDC spokesperson for technical and public health issues related to environmental radiation and nuclear/radiological emergency response. Previously, Dr. Whitcomb worked with the Illinois Department of Nuclear Safety. His primary area of expertise is the assessment of radionuclides released to the environment and the impact on public health. He has authored or co-authored numerous journal articles and is a recognized expert in domestic and international public health response in nuclear/radiological emergencies. Dr. Whitcomb is a member of National Council on Radiation Protection and Measurements and the Health Physics Society. He is certified in comprehensive practice by the American Board of Health Physics and served on the board of directors of the Health Physics Society (2004–2007). In addition, he serves on the World Health Organization's international roster of experts in radiation, environmental hazards and health effects. Dr. Whitcomb holds a B.S. in biology from Florida Southern College and an M.S. and a Ph.D. in environmental engineering sciences from the University of Florida.

Jessica Wieder is the director of the Environmental Protection Agency's (EPA's) Center for Radiation Information and Outreach. Ms. Wieder was EPA's radiation communication lead during the response to the 2011 Fukushima Daiichi nuclear accident. She has facilitated international panels on radiation risk public communication and was part of the contingency planning team for the 2011 launch of the Mars Science Laboratory. In 2010, Ms. Wieder was detailed to Federal Emergency Management Agency's (FEMA's) Chemical, Biological, Radiological, Nuclear, and Explosives Branch, where she helped establish FEMA's Improvised Nuclear Device Response and Recovery Program and created the intergovernmental Nuclear/Radiological Communications Working Group. With her guidance, the working group developed the nuclear detonation messaging document *Improvised Nuclear Device Response and Recovery: Communicating in the Immediate Aftermath*. Ms. Wieder was also the lead author for the communications chapter for the second edition of the White House's *Planning Guidance for Response to a Nuclear Detonation*. In 2013, Ms. Wieder was awarded EPA's Exemplary Customer Service Award for her leadership in enabling all levels of government to provide quick, effective communications to the American people in response to large-scale radiological emergencies.

Chris Williams, M.S., is currently a deputy director with the Washington State Department of Health's Office of Radiation Protection. Mr. Williams started his career with Science Applications International Corporation in Las Vegas, Nevada, in the late 1980s conducting impact assessments for the Yucca Mountain High-Level Nuclear Waste Repository Project. In the mid-1990s, Mr. Williams went to work for the Washington Department of Health in the EMS and Trauma System office as a research manager and statewide planner. In 2002, Mr. Williams joined the newly formed Public Health Emergency Preparedness and Response program and became its deputy director in 2007. Aside from a 9-month period as the acting director for the program, he maintained the deputy role until coming to the Office of Radiation Protection in 2015. Mr. Williams earned his bachelor's and master's degrees from Western Washington University. He is also a graduate of two Harvard University executive education programs: Leadership in Crises and the National Preparedness Leadership Initiative. Mr. Williams has training as an incident commander, planning section chief, and liaison officer for the Department of Health's Incident Management Team. During emergency response, he typically reports to the State Emergency Operations Center (SEOC) to represent the agency in the SEOC policy room. In addition, Mr. Williams represents the Association of State and Territorial Health Officials as an executive committee chairperson for the National Alliance for Radiation Readiness.

Laura Kwinn Wolf, Ph.D., is the division director for critical infrastructure protection in the Office of the Assistant Secretary for Preparedness and Response (ASPR), U.S. Department of Health and Human Services. In this role, Dr. Wolf tracks threats to health care and public health and leads a voluntary public–private partnership to mitigate risks across the sector and leverage public and private resources in disaster response and recovery. In 2017, Dr. Wolf was responsible for national-level coordination between the federal government and critical infrastructure owners and operators in the health care and public health sector for Hurricanes Harvey, Irma, and Maria and the response to WannaCry and NotPetya international ransomware incidents. She previously served in ASPR's Office of Policy and Plans as the executive secretariat for the Federal Experts Security Advisory Panel for select agent biosecurity, represented the United States at the Biological Weapons Convention, and advised on policy for funding dual use research of concern. Dr. Wolf was honored as a Center for a New American Security Next Generation National Security Fellow in 2011 and a Partnership for Public Service Excellence in Government Fellow in 2012. Dr. Wolf earned her B.S. in biology from the Massachusetts Institute of Technology and Ph.D. in microbiology from the University of California, San Diego, after which she transitioned to policy work via an AAAS Policy Fellowship in the office of Senator Edward Kennedy (D-MA), where she covered preparedness, antibiotic resistance, and genetic and infectious diseases for the Health, Education, Labor, and Pensions Committee.

Kevin Yeskey, M.D., currently serves as the principal deputy assistant secretary to the assistant secretary for preparedness and response, U.S. Department of Health and Human Services (HHS). The office leads the nation in preventing, responding to, and recovering from the adverse health effects of man-made and naturally occurring disaster and public health emergencies. Dr. Yeskey spent more than 24 years as a physician in the U.S. Public Health Service (USPHS) and retired as captain. In his USPHS career, he served in various agencies in HHS, including the Indian Health Service, Health Resources and Services Administration, and Centers for Disease Control and Prevention. From 2007 to 2012, he was the deputy assistant secretary for preparedness and response and the director of the Office of Preparedness and Emergency Operations. From 1986 to 1999, Dr. Yeskey was a member of the HHS Disaster Medical Assistance Team of the National Disaster Medical System (NDMS), serving as the team commander from 1993 to 1999. He was the chief medical officer for the NDMS program from 1998 to 1999. Dr. Yeskey also served as the medical policy adviser to FEMA operations prior to retiring from the USPHS. Dr. Yeskey received his bachelor's degree from Brown University and his medical degree from the Uniformed Services University of the Health Sciences. He has been board certified in emergency medicine for more than 30 years.

James Young has been the Radiological Emergency Preparedness program manager for the State of North Carolina since 2014. As such, he oversees the planning, equipping, and exercising of the state's ability to respond to an emergency at one of the three nuclear power plants in the state or at one of the seven within 50 miles. He has assisted with the development of the state's Radiological and Nuclear Detection program and was the lead planner for the electromagnetic pulse plan. Mr. Young began his nuclear career as a submarine officer in the U.S. Navy.