

Decision Processes and Determinants of Hospital Evacuation and Shelter-in-Place During Hurricane Sandy

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Context: Evacuation and shelter-in-place decision making for hospitals is complex, and existing literature contains little information about how these decisions are made in practice.

Objective: To describe decision-making processes and identify determinants of acute care hospital evacuation and shelter-in-place during Hurricane Sandy. **Design:** Semistructured interviews were conducted from March 2014 to February 2015 with key informants who had authority and responsibility for evacuation and shelter-in-place decisions for hospitals during Hurricane Sandy in 2012. Interviews were recorded, transcribed, and thematically analyzed. **Setting and Participants:**

Interviewees included hospital executives and state and local public health, emergency management, and emergency medical service officials from Delaware, Maryland, New Jersey, and New York. **Main Outcome Measure(s):** Interviewees identified decision processes and determinants of acute care hospital evacuation and shelter-in-place during Hurricane Sandy.

Results: We interviewed 42 individuals from 32 organizations. Decision makers reported relying on their instincts rather than employing guides or tools to make evacuation and shelter-in-place decisions during Hurricane Sandy. Risk to patient health from evacuation, prior experience, cost, and ability to maintain continuity of operations were the most influential factors in decision making. Flooding and utility outages, which were predicted to or actually impacted continuity of operations, were the primary determinants of evacuation. **Conclusion:** Evacuation and shelter-in-place decision making for hospitals can be improved by ensuring hospital emergency plans address flooding and include explicit thresholds that, if exceeded, would trigger

evacuation. Comparative risk assessments that inform decision making would be enhanced by improved collection, analysis, and communication of data on morbidity and mortality associated with evacuation versus sheltering-in-place of hospitals. In addition, administrators and public officials can improve their preparedness to make evacuation and shelter-in-place decisions by practicing the use of decision-making tools during training and exercises.

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This research was supported by the 2013-2014 Johns Hopkins Environment, Energy, Sustainability, and Health Institute (E²SHI) Fellowship and the 2013-2014 Lipitz Public Health Policy Award. M.D.M. was supported in part by funding from the National Institute for Occupational Safety and Health (NIOSH) Education and Research Center (ERC) for Occupational Safety and Health at the Johns Hopkins Bloomberg School of Public Health (#T42-OH 008428); the 2015 Johns Hopkins Health Resources and Services Administration (HRSA) Trainee Fellowship Program Agreement (#A03HP2750); the 2013-2014 E²SHI Fellowship; the 2013-2014 John C. Hume Award; and the 2014-2015 Victor Raymond Memorial Scholarship.

The funders had no role in the design and conduct of the study, or collection, management, analysis, and interpretation of the data. The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of any of the funders.

Thomas A. Burke contributed to this work prior to his tenure at the US Environmental Protection Agency (EPA). The views expressed are his own and do not necessarily reflect the policy positions of the EPA. While working on this research, Thomas A. Burke was affiliated with the Department of Health Policy and Management at the Johns Hopkins Bloomberg School of Public Health, in Baltimore, Maryland.

The authors declare no conflicts of interest.

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DOI: 10.1097/PHH.0000000000000404

KEY WORDS: decision making, disasters, emergency preparedness, hospital evacuation, shelter-in-place

On October 29, 2012, Hurricane Sandy made landfall in Brigantine, New Jersey, ravaging the mid-Atlantic region of the United States. Hurricane Sandy was the second costliest cyclone in US record-keeping history, after Hurricane Katrina of 2005, and the largest named storm on record in the Atlantic Ocean. Of the 147 deaths directly attributed to Hurricane Sandy, nearly half ($n = 72$) occurred in the mid-Atlantic and Northeastern United States.¹ In addition to resulting in direct mortality, Hurricane Sandy had devastating impacts on the mid-Atlantic region's health care systems, particularly hospitals.^{2,3} In New York City alone, to ensure safety and continuity of medical care, approximately 6300 patients were evacuated from 37 health care facilities.⁴

In Hurricane Sandy's aftermath, researchers and news media questioned why hospitals that were literally adjacent and had ostensibly similar risk profiles made differing decisions about evacuation and shelter-in-place (ie, stay on-site until danger passes).⁵ For example, because of a 14-ft storm surge, fuel pumps supplying backup generators at New York University Langone Medical Center were damaged, necessitating the urgent evacuation of 322 patients—including 21 infants from the hospital's neonatal intensive care unit—overnight during the storm.^{6,7} A short while later, nearby Bellevue Medical Center was evacuated for the first time in its 275-year history.^{8,9} In contrast, the Veterans Administration New York Harbor Healthcare System's Manhattan Campus, which neighbors these facilities, had evacuated preemptively, thus avoiding the need for any emergency evacuation during the storm. There was also lingering uncertainty about why New York government officials had not ordered evacuation of hospitals in low-lying areas as they had in anticipation of Hurricane Irene in 2011.¹⁰ Commentators called for "clear and consistent criteria to guide evacuation decisions," as well as integrated local and regional decision making for sentinel events.^{11,12}

In response to similar calls after Hurricane Katrina in 2005, the US Department of Health and Human Services funded the development of tools to support hospital evacuation and shelter-in-place decision making.^{13,14} In addition, the Centers for Medicare & Medicaid Services and The Joint Commission require hospitals to have emergency plans, which could include evacuation procedures.¹⁵⁻¹⁷ Given the existence of these tools and requirements, questions arise about the capability of decision makers to employ these resources, as well as whether this enhanced capacity has influenced the capability of decision makers.¹⁸

In November 2012, the Institute of Medicine convened an expert working group to establish a *Science Preparedness*¹⁹ research agenda for Hurricane Sandy.²⁰ Participants identified determining what criteria informed health care facility evacuation decision making during Hurricane Sandy as a top research priority, as well as whether decision makers used guidelines, tools, and literature to assist them in these decisions. The existing literature contains little information about these priority areas. One study has examined hospital evacuation and shelter-in-place decision-making processes during Hurricane Sandy, but its generalizability is limited as it considers only a single federal hospital facility.²¹ This article presents the results of interviews with government and hospital officials throughout the mid-Atlantic region regarding evacuation and shelter-in-place decision making during Hurricane Sandy. Findings may enable hospital executives and the public health emergency management community to better prepare for and respond to future major public health emergencies.

● Methods

Selection and recruitment of participants

From March 2014 to February 2015, semistructured interviews were conducted with key informants in 4 mid-Atlantic states to identify factors that significantly influenced decisions to evacuate or shelter-in-place acute care hospitals during Hurricane Sandy. Interviewees were purposefully sampled to include at least 1 hospital representative from Delaware, Maryland, New Jersey, and New York, as well as 1 public health and 1 emergency management official whose areas of responsibility encompassed each hospital. Additional interviewees were added through snowball sampling.

Hospital interviewees were senior leaders (eg, chief executive officers [CEOs]; directors of emergency management). Government participants included in the study were those who held senior leadership roles during Hurricane Sandy (eg, secretary/commissioner of health; director of emergency management). Potential interviewees were excluded if they lacked direct knowledge about and involvement in decision making or if their employer never considered evacuation (or ordering evacuation) during Hurricane Sandy.

Each state hospital association validated hospitals for inclusion, with the exception of New York, where the association for the metropolitan New York area was consulted to ensure relevant hospitals were invited to participate. In addition, the relevant state health department and the New York City Department of Health

and Mental Hygiene were consulted to ensure relevant hospitals were not omitted.

Data collection and analysis

Semistructured interviews were conducted in person or via phone with 1 or 2 informants with the exception of one health department that preferred an in-person facilitated group discussion. A semistructured interview guide was piloted with an emergency management official and revised on the basis of feedback from the pilot interview and several experts in health care emergency management. The guide included the following domains: decision processes, information and decision-making aids, and lessons learned. These domains were selected on the basis of both gaps in existing literature and our research aims of understanding how evacuation and shelter-in-place decisions for hospitals are made in practice and how such processes can be improved. Interviews were audio recorded and transcribed with participant permission. Transcripts were compared with recordings, and any errors were corrected. Study materials were labeled with unique, random identification numbers.

To capture immediate reflections, contact summary sheets were completed after each interview.²² Peer debriefing with an impartial peer who possessed subject matter and methodological expertise but filled no other role in the study was conducted throughout data collection, coding, and analysis to foster reliability and validity of findings.²³ A combined deductive and inductive approach was used to identify themes. A priori themes were selected on the basis of relevant literature and our research objective.^{24,25} Additional themes were generated through open, unrestricted coding. Transcripts were coded using QSR NVivo for Mac v10.1.3 (Burlington, Massachusetts).

A Johns Hopkins Bloomberg School of Public Health institutional review board determined this study was not human subjects' research and was therefore exempt.

Results

Between March 2014 and February 2015, we interviewed 41 key informants from 32 organizations. Of the 50 individuals meeting study inclusion criteria, 84% agreed to be interviewed. Of the 36 organizations recruited to join in this study, 89% participated. Two organizations did not reply to invitations, and 2 organizations were willing to participate but interviews were ultimately not scheduled because of scheduling conflicts. In addition, one public health agency, which was unable to participate in an interview because of

ongoing emergency response activities, provided a written statement, which was analyzed in a manner consistent with the methods outlined earlier for the interview transcripts. Key informants ($n = 42$) worked for organizations representing 5 sectors involved in public health emergency response: hospitals ($n = 19$), hospital associations ($n = 2$), public health agencies ($n = 11$), emergency management agencies ($n = 7$), and EMS agencies ($n = 3$). Five key informants were employed in Delaware, 12 in Maryland, 13 in New Jersey, and 12 in New York. Key informants described their roles and their institutional and community decision-making processes and identified determinants in the decisions to evacuate or shelter-in-place 15 acute care hospitals during Hurricane Sandy in 2012 (Table 1).

Hospital evacuation: A difficult decision and last resort

Key informants from all sectors and states reported that hospital evacuation and shelter-in-place decision making is extremely difficult. One informant remarked, "The evacuation order is the hardest thing that we will ever have to do in our careers . . ." Many informants expressed that these decisions could have no positive outcome. One informant said, "It is always going to be a hard decision because if you move everybody and [the storm] doesn't come then you get criticized and if you don't move everyone and it hits you, you get criticized." Some key informants perceived the decision to evacuate as having catastrophic consequences for decision makers and their institutions. As one informant said, "[T]his whole evacuation decision is like a career-ending decision." He continued to describe consequences for hospitals stating, "There [are] hospitals in New Orleans, they evacuated, that's the last thing they ever did. They never opened again."

Ultimately, key informants viewed evacuation as a last resort. One decision maker said, "As a health care administrator, one of the things you learn early on is evacuation is like the last thing you do . . ." Reflecting on the decision not to evacuate during Hurricane

TABLE 1 • Evacuation and Shelter-in-Place Status of Hospitals by State

State	Evacuated		Sheltered-in-Place	Total Interviewed
	Preevent Evacuation	Postevent Evacuation		
New York	2	2	2	6
New Jersey	1	1	2	4
Maryland	...	...	3	3
Delaware	...	...	2	2
Total	3	3	9	15

Sandy, another informant stated, “Evacuating that facility is not something that we want to do. We really don’t. We want to keep it open at all costs”

Use and adequacy of decision-making aids and emergency plans

Key informants from all states and sectors characterized hospital evacuation and shelter-in-place decision making as a collaborative process where decision makers consulted trusted advisors within and outside of their institutions and then made a decision based on their implicit understanding of what needed to be done. Key informants recounted using weather forecast data; however, with one exception (noted below), key informants did not report using decision-making guides to determine whether hospitals should be evacuated in light of these forecasts.

When asked whether the hospital relied on any tools or checklists, one CEO whose hospital evacuated said, “One would think. That day we did not. We just worked on our instincts.” A public health official stated,

I use a common sense approach in terms of garnering all the facts, in terms of determining whether the patient is going to be in danger, and that to me is what the decision parameter is going to be. So maybe I’m old school and just common sense, I’m not going to rely on a lot of tools, I’m going to gather as much information as I can, and we’re going to have to make some credible decisions based upon what we know about their ability to continue to provide the service for the patients.

Although most key informants reported a preference for relying on instinct and trusted advisors rather than decision-making tools, they did not explain this preference or indicate whether they were familiar with or had access to any decision-making aids. There was one exception to this sentiment: informants from one hospital described employing an existing decision tree, which was designed to help leadership determine whether to evacuate or shelter-in-place, from their emergency operations plan during Hurricane Sandy.

Several key informants explained that existing emergency plans did not meet their needs during Hurricane Sandy. For example, in New York City, informants perceived the citywide coastal storm plan to be inadequate because its decision-making algorithm, developed after Hurricane Irene, described the roles of key stakeholders involved in decision making but not *how* to determine whether a hospital should be evacuated. One New York City informant said,

[T]here wasn’t a formalized decision-making process with criteria. I mean there was a decision-making algorithm but there [weren’t] criteria for when to evacuate or not. There was a city storm plan and it said if there’s a hurricane you evacuate. But [Sandy was]

borderline between a tropical storm and a hurricane. And second of all, everyone recognizes that in some cases evacuating is risky. And so the written plan did not provide guidance really for the situation we were in and so we just used our judgment without any hard criteria

Similarly, another CEO whose hospital evacuated reported that their emergency plans did not address the circumstances faced during Hurricane Sandy:

I mean we have emergency plans for a lot of different kinds of situations. Let’s say you have a shooter drill in town or mass casualties, something or other. I mean they have checklists and how-to’s for a lot of different situations. At the time they did not have one anticipating this flooding.

While 2 hospital officials articulated thresholds for tolerable storm surge and wind that would have necessitated evacuation had they been exceeded, all other key informants indicated that their respective plans lacked explicit, predefined criteria or triggers for evacuating.

Influential factors and determinants of hospital evacuation and shelter-in-place

Key informants considered several factors, discussed later, in their determinations of whether to evacuate or shelter-in-place hospitals during Hurricane Sandy. The most influential factors were risk to patients, ability to maintain continuity of operations (COOP), and prior experience. Hospital executives also identified cost as an influential factor. The primary determinants of acute care hospital evacuations that occurred during Hurricane Sandy are presented in Table 2.

Risk to patients

All key informants perceived evacuating hospitalized patients as a “risky undertaking.” Many informants stated that hospitalized patients would be at risk of death or increased morbidity from the physical transportation and transfer of care. According to one informant,

[T]here’s a lot of risk in moving patients that are sick. Whether they’re critically sick or marginally sick or still need hospitalization, there’s a lot of risk and a lot of disruption, and a lot of uncertainty and discomfort for families. And then you have to assure the continuity of care for that patient. So that patient is starting over; and they’re starting over at a time when everyone is gearing up for a major emergency.

Another key informant explained their hospital’s hesitancy to evacuate stating, “We don’t want to move these patients because some of them might die.” Some key informants explicitly referenced literature on adverse health effects of evacuation, which influenced

TABLE 2 ● Primary Determinants of Acute Care Hospital Evacuation During Hurricane Sandy as Reported by Decision Makers

Hospital	Type of Evacuation	Determinant
Hospital A	Preimpact evacuation ^a	<i>Planned utility outages (steam, electric):</i> Utility company proactively turned off steam service and underground electric grid supplying hospital to prevent damage from flooding and saltwater intrusion and enable quicker restoration of service poststorm.
Hospital B	Preimpact evacuation ^a	<i>Prior experience:</i> Institutional memory of a 1992 nor'easter storm during a full moon, its impact on the facility, and similarity to circumstances during Hurricane Sandy (arrival of storm coinciding with high tide).
Hospital C	Preimpact evacuation ^a	<i>Anticipated utility outage (electric) and flooding:</i> Anticipated flooding and subsequent damage to electrical switchgear, which was located below expected storm surge level.
Hospital D	Postimpact evacuation ^b	<i>Sustained utility outages (sewage and power) and flooding:</i> Primary power from electrical grid was lost because of an explosion of a transformer at power company substation. Loss of water pressure and functional sewage systems prompted evacuation. Also, flooding of basement resulted in damage to fuel pump supplying generator. Full power loss was imminent.
Hospital E	Postimpact evacuation ^b	<i>Sustained utility outage (power) and flooding:</i> Primary power from electrical grid was lost because of an explosion of a transformer at power company substation. Storm surge flooding resulted in failure of backup electrical systems (specifically fuel pumps).
Hospital F	Postimpact evacuation ^b	<i>Sustained utility outage (power) and flooding:</i> Failure of primary and secondary (external) backup generators that became damp and shorted out, as well as facility flooding.

^aPreimpact evacuations were anticipatory evacuations that occurred prior to Hurricane Sandy's arrival.

^bPostimpact evacuations were reactive evacuations that occurred after facilities sustained damage. Reactive evacuations occurred either while the storm was ongoing or in its immediate aftermath.

their decision making during Sandy. One public health official stated, "[T]here's literature of there being a mortality rate from evacuation itself. So there was no non-risky decision, so we're weighing the risk of evacuating versus the risk of sheltering in place."

Continuity of operations: impact of flooding and utility outages

Key informants characterized their decisions as comparative risk assessments where they weighed the risks associated with evacuation against the potential for essential hospital services to fail while sheltering-in-place and the risk such interruptions would pose to patients. Although informants did not employ formal decision-making aids, they informally assessed whether hospitals could maintain COOP. Key informants were primarily concerned with whether hospitals would be able to sustain power, although there was consideration of disruption to other essential utilities (eg, water, steam, sewage, oxygen). They perceived storm surge or flooding as the primary threat to COOP. For hospitals that evacuated, disruption of utility services—whether preplanned, anticipated, or sustained—was referenced as the most common determinant.

Prior experience

Key informants perceived prior experience to significantly influence shelter-in-place and evacuation deci-

sion making during Hurricane Sandy. Decision makers reported relying on both their personal previous experience and institutional knowledge of how their facilities had fared in prior storms. Hurricane Irene, which occurred 1 year before Hurricane Sandy, was perceived to influence shelter-in-place and evacuation decisions during Hurricane Sandy. One informant stated, "The experience with Hurricane Irene and those evacuations, you know, it colored the response then to Sandy." Another informant described the prior experience evacuating for Hurricane Irene as "the little boy that cried wolf." The majority of informants perceived hospital evacuations during Irene as unnecessary and having resulted in decision makers being hesitant to evacuate the following year. According to one New York informant,

We had been through Hurricane Irene. We had evacuated hospitals and nursing homes from zone A for that and found it to be disruptive and dangerous. So we had that image in the back of our mind. And so when Sandy came in it looked like it was going to be not that bad as far as structurally so we decided not to evacuate.

Hospital key informants from 2 different facilities reported that although evacuation during Hurricane Irene was ultimately unwarranted, the experience had a positive impact on decision making during Hurricane Sandy. Serving as "the best exercise you could ever ask for," it gave their hospitals confidence that they could successfully evacuate.

Cost: A consideration for hospitals

Government officials were adamant that cost was not a factor in their decision making and that public safety was their primary concern. One public health official said,

I know there were questions in the wake of this, oh, well did you not evacuate because of a cost issue? And that absolutely never got into the conversation. Decisions were strictly based upon what we thought was the safest option.

In contrast, hospital key informants presented cost as a significant factor in evacuation and shelter-in-place decisions. Hospital informants felt the costs of evacuation and repatriation were nominal compared with the potential for lost revenue while their facilities were evacuated. One hospital informant who evacuated stated,

We took obviously a financial hit. When you cancel all elective surgeries, you cancel all your outpatient visits, that's a financial hit. Again you have to look at risk and benefit obviously to put someone in harm's way for financial reasons is absurd, but I would be not truthful if I didn't say that's a consideration. You have to be fairly confident that you are going to sustain some kind of damage or risk for your patients before you make a decision that you are going to send your patients away.

● Discussion

Hospital evacuation is rare.²⁶ This study capitalizes on a significant disaster to learn from the experiences of hospital executives and government officials who were faced with evacuation and shelter-in-place decisions during Hurricane Sandy. Results provide insight as to how evacuation and shelter-in-place decisions for acute care hospitals are made in practice as well as opportunities to increase resilience to future public health emergencies.

This study revealed that key informants perceived hospital evacuation and shelter-in-place decision making as challenging. Our findings suggest that improved collection, analysis, and communication of data on morbidity and mortality associated with evacuation versus sheltering-in-place of hospitals would enable decision makers to more accurately assess risks. Emergency response and evacuation/shelter-in-place decision making can be improved by resolving deficiencies in existing emergency plans, including explicit thresholds or triggers for evacuation and addressing flooding. While significant work has been done to develop public health emergency preparedness capacity since Hurricane Katrina (eg, hospital infrastructure hardening and development of evacuation decision support tools), further efforts are needed to build leadership and manage-

ment capabilities—specifically evacuation and shelter-in-place decision-making capability—of decision makers.

Results of this study illustrate that government officials and hospital executives perceived evacuation to be risky. Studies have demonstrated that evacuation significantly exacerbates existing physical and mental health conditions among nursing home residents.^{27,28} Yet, similar data on the effects of hospital evacuation are lacking. To our knowledge, only one study has examined morbidity and mortality associated with acute care hospital evacuation. This study, which analyzed a 1983 evacuation of the Denver Veterans Administration Medical Center, found no increased mortality and limited excess morbidity in the month following evacuation.²⁹ The generalizability of this study may be limited, given the hospital's patient population and access to government and military resources.

Many questions remain about the downstream health effects of hospital evacuation: Do hospital patients suffer delayed adverse health effects after evacuation? Do evacuation-related deaths occur weeks or months later? Do pre- and postevent evacuations pose the same risks to patients? Given that decision makers in our study reported basing evacuation and shelter-in-place decisions on health risks, additional research should be conducted to quantify longer-term mortality and morbidity (eg, 30- and 90-day consequences) associated with evacuation versus sheltering-in-place for acute care hospitals, as well as whether outcomes differ by facility acuity or patient demographics. Objective data about differential mortality and morbidity associated with evacuation versus shelter-in-place will enable decision makers to more accurately assess risks.

Another important finding from our research is that hospital executives identified cost as an influential factor when making evacuation and shelter-in-place decisions. This represents an important contribution to hospital evacuation literature, which has not previously identified cost as a factor in health care or disaster managers' decisions to evacuate.²⁴ Concerns about lost revenue from business interruptions should be used to incentivize hospital executives to invest in preparedness and mitigation initiatives to stave off evacuation.

A significant problem identified by this study is that emergency plans did not meet the needs of decision makers during Hurricane Sandy. Although The Joint Commission emergency planning requirements were updated post-Hurricane Sandy, neither the standards in effect during Hurricane Sandy nor the 2014 standards require hospital emergency plans to address *how* evacuation and shelter-in-place decisions will be made.³⁰ Both hospital and government emergency plans should include processes and criteria for

determining whether hospitals should evacuate or shelter-in-place. The intensity of extreme precipitation and flooding is predicted to increase with climate change.³¹ Given that this study identified flooding as one of the most common determinants of hospital evacuation during Hurricane Sandy, evacuation triggers should not be based solely on a storm's designation as a hurricane or its Saffir-Simpson categorization, both of which are determined by wind speed. The scope of emergency plans should be broadened to address at minimum all coastal storms, not just hurricanes.

Finally, this study revealed that decision makers relied on instincts rather than tools or guidance to make hospital evacuation and shelter-in-place decisions. Presumably, hospitals that opted to shelter-in-place genuinely thought they could sustain COOP, although this was too often not the case. Relying on instinct is problematic; using checklists or decision-making aids can ensure that important factors are not inadvertently overlooked, which may be more likely in decisions made under stress. Generic decision-making tools such as the Agency for Healthcare Research and Quality's Hospital Evacuation Decision Guide and similar state-based decision guides were publically available at the time of Hurricane Sandy. Such decision-making tools, aids, and guidance are of little utility if those responsible for evacuation and shelter-in-place decisions do not utilize them. While there is inherent uncertainty in weather forecasts and storms may exceed predictions, employing decision-making aids may enable hospital executives and government officials to more accurately assess risks. Facility-specific decision-making aids should have objective criteria that, when informed by weather forecasts, would trigger evacuation. Future training and exercises could be devoted to introducing decision makers to existing and new decision support tools, providing the opportunity to practice using these resources and practice implementing strategies to make crisis decisions, thereby enhancing the leadership and management capabilities of decision makers.

● Limitations

Our study is based on interview data collected 18 months after the event in question and is therefore subject to recall bias and selection bias. However, the combination of purposeful and snowball sampling was most appropriate for identifying participants who possessed firsthand knowledge of evacuation and shelter-in-place decision making for hospitals during Hurricane Sandy. Our study findings may also be limited by social desirability bias, particularly given the high stakes and scrutiny of the decisions examined. Because of the density of acute care hospitals in the New

York/New Jersey metropolitan area, the generalizability of some findings may be limited, but it is likely that most findings will be applicable to other major cities and future natural disasters.

● Conclusion

Decisions to shelter-in-place in or evacuate hospitals during extreme weather events are challenging. This research, which addresses a priority area in the Hurricane Sandy *Science Preparedness* agenda, examines how these complex decisions occur in practice. Hospital and government emergency plans were inadequate during Hurricane Sandy. Responses to future public health disasters can be improved by ensuring that hospital emergency plans address flooding hazards and consider all coastal storms, not just those technically defined as hurricanes. Hospital emergency plans should specify how protective actions will be decided upon and include explicit criteria that would trigger evacuation, if exceeded. In addition, access to morbidity and mortality data for hospital evacuation and sheltering-in-place would enable decisions makers to more accurately compare risks and select the most appropriate protective action given the circumstances.

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