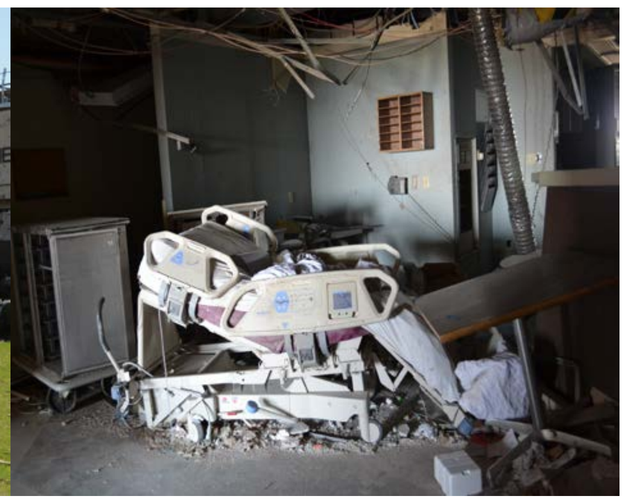
A Prescription for the 21st Century: Improving Resilience to High-Impact Weather for Healthcare Facilities and Services



American Meteorological Society
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Foreword

The American Meteorological Society's (AMS) Policy Program shares knowledge and understanding to assist with decision making on society's challenges related to weather, water, and climate. Information can empower the decision making process by providing a thorough understanding of the context, thus allowing for robust solutions that can best solve the problem. Decisions have the capability to effectively meet society's challenges for the earth system when they are built on the breadth and depth of knowledge that the weather, water, and climate enterprise holds.

With this philosophy in mind, the AMS Policy Program conducted a study exploring how to improve resiliency to high-impact weather for healthcare facilities and services. The study started with a workshop that engaged a wide range of stakeholders. The workshop discussions provided new understanding of many perspectives on resilience and created new knowledge with a strategy to improve resilience for the health system. This report shares the new strategy for improving resilience which first understands the risks one faces, then resolves the vulnerabilities of health facilities, and finally, prepares for the continuity of health services. Each of these aspects provides a layer of resilience which, when added together consecutively, creates a health system that can remain intact and operational during and after a high-impact weather event.

Many of the great contemporary challenges that society faces involve weather, water, and climate. This report explores how to improve resilience through risk management - to increase resilience by understanding likely threats and reducing vulnerability. It describes resilience at the community level and suggests redundant systems as powerful tools for increasing resilience. These ideas can apply not just to improving the resilience to high-impact weather, but also for other weather, water, and climate challenges that society faces. As a result, this study provides a tool for the ongoing efforts to create a resilient earth system.

Shalini Mohleji
Director of study
Policy Fellow, AMS Policy Program

Executive Summary

Healthcare facilities and services provide key underpinnings for a thriving community. Therefore ensuring their resilience to high-impact weather is critical. The resilience of the healthcare system is particularly important against the potential impacts from weather events like tornadoes, hurricanes, and floods. High-impact weather events of every disaster type continue to wreak havoc every year on local communities across every region of the country. They damage infrastructure and property with an economic impact that is increasing, and more so, they can cause a human impact. The supply and demand for healthcare during and after high-impact weather events creates a pragmatic paradox where the supply decreases when health infrastructure is damaged but the demand increases from the injured and ill victims of the events. This highlights the importance of establishing resilient healthcare facilities and services to serve society, especially during times of great need such as with high-impact weather events. As more communities emerge in areas vulnerable to high-impact weather, the need will grow for resilient healthcare facilities and services.

Understanding the importance of a resilient healthcare system prompts the question - how can we as a society increase that resilience? The American Meteorological Society (AMS) Policy Program conducted a workshop to explore ideas on increasing the resilience for healthcare facilities and services. In this report, we present a strategy for improving resilience that first understands the risks one faces, then resolves the vulnerabilities of health facilities, and finally, prepares for the continuity of health services. Each of these aspects provides a layer of resilience which, when added together consecutively, creates a health system that can remain intact and operational during and after a high-impact weather event.

The initial step and foundational layer for increasing resilience is risk management. To improve resilience, one must first understand their risks since increasing resilience essentially involves a series of actions to reduce risk. Risk management starts with identifying risks. The second step assesses the level of tolerable risk. For risks above the tolerable level, risk reduction methods must be developed. For healthcare facilities and services, both The Joint Commission[1] accreditation process and property/business insurance serve as vehicles for risk management. They provide systematic approaches to assist with managing the risks of property damage and service interruption caused by high-impact weather. The Joint Commission provides an accreditation process which prompts healthcare institutions to identify and address the risks for a) their facilities b) the continuity of their services and c) the safety of their patients and staff. Theoretically, property/business insurance prices risk actuarially to assist customers in identifying and assessing their risks. Both The Joint Commission and insurance offer value in providing better understanding of the risks that one faces. However they encounter barriers that hinder their full efficacy. An in-depth discussion of the value provided, and barriers of The Joint Commission accreditation process and property/business insurance can be found in Section I.

[1] The Joint Commission. About The Joint Commission.
http://www.jointcommission.org/about_us/about_the_joint_commission_main.aspx

Health facilities can manage their risks through three different approaches aimed at reducing facility vulnerabilities. First, *hardening structures* reduces structural vulnerabilities through actions to fortify buildings, such as constructing floodwalls around a hospital's exterior. Second, *incremental adaptations* reduce operational vulnerabilities through relatively smaller actions adapting routine practices for potential threats that could disrupt the functioning of a facility. For example, relocating critical components like HVAC (Heating, Ventilation, and Air Conditioning) systems to higher floors reduces both their vulnerability to flooding, and the likelihood of a facility shutting down from a HVAC failure. Finally, *innovative practices* seek to shift the conventional ways in which health facilities and services operate by significantly transforming standard practices to improve their functionality. One example diversifies a hospital's energy portfolio to include renewable energy, thus adding a backup to the conventional energy source for a facility, while also adding redundancy in the source of power. All three approaches are described in greater detail in Section II.

The continuity of health services is crucial to resilience and requires that facilities have a management plan for their operations in the potential circumstance when capacity and capabilities are limited. Facilities lose their capacity when their resources are reduced such as dwindling medical supplies, pharmaceutical stocks, available beds, food, potable water, and even clean linens. Facilities lose their capability to provide health services when they lose critical services such as power, HVAC, and plumbing or when they have limited staff. In order to remain operational, especially in post-event times when the demand for healthcare services is heightened, facilities must have strategies in place for providing services with reduced capacity and capabilities, as described in Section III.

Information can aid decision making on what risks to reduce and how to reduce them within each layer of resilience. In particular, the decision making process can benefit from environmental information on climate, weather, hydrology, and topography, as described in Section IV. Improving resilience seems most meaningful and effective on a community level. The risks to each community can vary and the community members know their risks and the way their community operates better than outsiders. They are also more invested in having their own community prosper. Therefore decisions on what and how to improve resilience are likely to be most successful when they are made and implemented by the community itself. Section V discusses resilience in the community context.

This report presents many of the ideas that emerged from the workshop discussions. Two key ideas involve new conceptualizations. The first conceptualizes resilience as something that can be improved by means of successful risk management; the second conceptualizes redundant systems as a means to efficacy. The workshop pushed participants' thinking into new dimensions to consider different approaches to reducing structural and operational vulnerabilities of health facilities. The discussions explored relationships between individuals and their healthcare facilities and services. This study identifies the important relationship between local communities and their healthcare system, particularly for implementing resilience improvements. It also recognizes two valuable networks that help healthcare facilities and services remain operational: health coalitions and public-private partnerships.

The workshop pushed our thinking to two new conceptualizations. The first conceptualizes resilience as something that can be improved by means of successful risk management; the second conceptualizes redundant systems as a means to efficacy.

Introduction

The provision of healthcare is necessary for a community to prosper, and critical when impacted by weather events like tornadoes, hurricanes, and floods. High-impact weather events of every disaster type continue to wreak havoc every year on local communities across every region of the country. They damage infrastructure and property with an economic impact that is growing, and more so, they can cause a human impact. The supply and demand for healthcare during and after high-impact weather events creates a pragmatic paradox where the supply decreases when health infrastructure is damaged but the demand increases from the injured and ill victims of the event. This highlights the importance of establishing resilient healthcare facilities and services to serve society, especially during times of great need with high-impact weather events. The importance of facilities such as hospitals, treatment centers, and long-term care residencies highlights their need for structural integrity and safety to shelter patients. The criticality of healthcare services demonstrates the necessity for continuity of services to meet vital patient requirements.

The function of healthcare facilities and services extends to a broader network of actors than just the health system. The full network should be engaged in building the resilience of the health system. The American Meteorological Society (AMS) Policy Program organized a workshop on October 17-18, 2013 to address the goal of improving resilience for healthcare facilities and services. The workshop included many diverse and engaged parties: 1) the insurance and healthcare accreditation sector as the stakeholders assessing associated risk; 2) the development sector consisting of city planners, building engineers, and land developers who determine the vulnerability level of facilities; and 3) the healthcare continuity of services sector focused on providing continuous care with pharmaceutical supplies, health IT, and health services. By convening these diverse but connected stakeholders, the workshop encouraged discussion and promoted new understanding of perspectives, ultimately exploring systems solutions to improving resilience to high-impact weather for healthcare facilities and services.

In this report, we present a strategy for improving resilience that first understands the risks one faces, then resolves the vulnerabilities of health facilities, and finally, ensures the continuity of health services. Each of these aspects provides a layer of resilience, which is stacked consecutively. A lower layer needs to be completed in order to achieve the subsequent layer. For instance, the first layer involves risk management because one needs to understand the risks they face before they can work to reduce them. Then facilities can become more durable by reducing the structural and functional risks that the risk management phase had made evident. Likewise, the facility structures need to be intact in order for the facilities to provide continuous healthcare services. Finally, all of these phases should be ongoing efforts but when preparing and responding to an actual weather event, decision makers can use forecast information to minimize the impact to the healthcare facilities and services. Thus the layers of resilience presented in this report provide a framework for creating a health system that can remain intact and operational during and after a high-impact weather event.

The foundational layer for increasing resilience is risk management. The second layer focuses on creating durable facilities. The next layer ensures the continuity of health services, finally topped with a layer of usable information to assist with decision making. Resilience is more likely to be achieved when all of these layers are present, particularly at the community level. This report focuses on how to improve resilience to high-impact weather for healthcare facilities and services by exploring ideas ranging from those currently practiced to the new and innovative.

Figure 1: Layers of resilience

We present a strategy for improving resilience by first understanding the risks one faces, then resolving the vulnerabilities of health facilities, and finally, ensuring the continuity of health services. Each of these aspects provides a layer of resilience.

Section I: Risk Management

To improve resilience, one must first understand their risks since increasing resilience essentially involves a series of actions to reduce risk. Understanding risk involves knowledge of the potential threats in terms of the types of weather-related events that are likely to occur and one's vulnerabilities that could lead to impact. Risk can best be managed if properly understood therefore it is important for this step of creating knowledge and understanding to come first before any actions are taken to reduce risk. Both The Joint Commission accreditation process and property/business insurance serve as vehicles for risk management by providing systematic approaches to assist with understanding and addressing the risks of property damage and service interruption caused by high-impact weather.

For healthcare facilities and services, both The Joint Commission accreditation process and property/business insurance serve as vehicles for risk management. They provide systematic approaches to assist with managing the risks of property damage and service interruption caused by high-impact weather.

<u>The Joint Commission</u>

The Joint Commission accreditation process prompts healthcare institutions to identify and address the risks to a) their facilities, b) the continuity of their services, and c) the safety of their patients and staff. The accreditation process addresses vulnerability to high-impact weather through its categorization within the institution's emergency management function. The process promotes preparedness in six critical elements of emergency management: communication, resources and assets, safety and security, staff responsibilities, utilities management, and patient and clinical support activities.[2]

The Value in the Accreditation Process

One of the strengths of the accreditation process, in its emergency management function, lies in The Joint Commission's framing of risk management within a community context. The accreditation process addresses the need for healthcare facilities to collaborate with the community of healthcare institutions in the region, and also the local community at large. For example, healthcare institutions must establish avenues for sharing updated information with the network of other healthcare institutions in the region when in emergency situations. When developing their planning activities, the accreditation process requires organizations to partner with the local community to prioritize potential risks identified in their Hazard Vulnerability Analysis (HVA). Healthcare institutions must also consider their role in emergency management services

[2] The Joint Commission (2014). Survey activity guide for health care organizations. http://www.jointcommission.org/assets/1/18/2014_Organization_SAG.pdf

for the "community, county, and region".[3] Conceptualizing the community as a whole and understanding the individual and emergent vulnerabilities within such a system is a potentially more effective and sustainable framework for improving societal resilience than addressing individual components like the vulnerabilities of the health system in isolation. This will be discussed further in Section V.

Barriers for The Joint Commission

However, some Joint Commission accredited organizations encounter challenges in creating more resilient healthcare institutions. Through its accreditation process, The Joint Commission issues performance-based standards for healthcare institutions.[4] The standards may be challenging for older hospitals to achieve. The Joint Commission is concerned about the aging infrastructure of healthcare facilities with many U.S. hospitals built in the 1940-1950's era when the Hill-Burton Act had provided funding for construction of new hospitals.[5] These older hospitals require upgrades to reduce structural vulnerabilities that are often costlier than they can finance. With this concern, the standards address the need for contingency plans that are risk-based and challenge organizations to develop plans in accordance with the concept of the HVA. They can develop plans by evaluating the risks through four key phases of the "all-hazards" approach: mitigation, preparation, response and recovery. Overall, the accreditation process includes a systematic vehicle for assessing and reducing risk. The process encourages beneficial outcomes of improved resilience; however, challenges external to the process hinder some of its potential success.

<u>Insurance</u>

What is the role of insurance? With regard to risk, is insurance meant to spread the risk over a larger pool of the vulnerable, transfer risk from the more vulnerable to less, compensate for risk incurred, or reduce risk? Insurance actually plays all of these roles which improve the economic sustainability of the vulnerable. However, beyond economic sustainability, only risk reduction makes the vulnerable safer by actually reducing their risk.

What is the role of insurance? With regard to risk, is insurance meant to spread the risk over a larger pool of the vulnerable, transfer risk from the more vulnerable to less, compensate for risk incurred, or reduce risk?

[3] The Joint Commission (2014). Survey activity guide for health care organizations. http://www.jointcommission.org/assets/1/18/2014_Organization_SAG.pdf

[4] The Joint Commission. About The Joint Commission. http://www.jointcommission.org/about_us/about_the_joint_commission_main.aspx

[5] Bazzoli et al. (2006). Construction activity in U.S. hospitals. *Health Affairs*, May 2006. Vol. 25, No. 3, pp. 783-791.

The Value in Insurance

In the policy context, insurance is considered a vehicle for reducing risk through its underwriting capabilities. Insurance underwriting prices risk based on actuarial calculations and utilizes pricing to discourage risky behavior and even incentivize safer behavior. For instance, insurance providers like Zurich Insurance Group work with customers to identify mitigation strategies and preparedness activities that increase resilience. Therefore, the underwriting process should serve as a correcting measure to reduce risk. Through premium pricing, insurance underwriting provides several opportunities for customers to address the level of risk they actually, and potentially, could face. The deductible level reflects the customer's risk tolerance (among other aspects) while premium prices reflect the level of risk that the customer is facing. In this capacity, insurance plays a critically important role of informing customers - by identifying and quantifying their risks - and empowering them with decision-making capabilities by presenting risk management options.

Barriers to Insurance Efficacy

Insurance encounters a number of barriers to reducing risk. In a policy context, underwriting is actuarially derived and reflects risk through direct correlation of pricing and risk. However, insurance becomes a political token where politics override the policy context. Property and business insurers face challenges with their customers who do not want, or cannot, pay the high costs of actuarially based insurance. This causes political forces to intervene, most often in the form of subsidies, to make insurance more palatable to constituents. While subsidizing insurance premiums incentivizes wider spread coverage, it distorts the pricing signal so that it no longer directly reflects the level of associated risk.

A distorted pricing signal also distorts all of the aforementioned roles for insurance including how risk is spread across society, the transfer, and compensation for risk incurred. By not reflecting the actual level of risk, these roles for insurance also spread, transfer, or compensate a lesser level of risk. At some point when weather events cause an impact reflecting the actual level of risk, customers will be demanding more from insurance – in terms of payments - than they contribute, in terms of premiums. This will alter the insurance sector's capacity for coverage thus disrupting its very purpose and offering the most significant barrier to insurance efficacy. Ultimately, a distorted pricing signal reduces the level of risk aversion intended by the underwriting process. Once the pricing no longer presents disincentives for risky behavior, such actions are likely to ensue, straying further from risk reduction and often even increasing the risk incurred.

Governance of insurance is a complex system that serves as another barrier to insurance efficacy. State regulators are constrained by the political viability of policies, so political forces often play into state decisions resulting in the subsidized insurance rates, distorted pricing signal, and smaller reductions in risk. With the private sector providing most insurance coverage, the bottom line is the driving force and subsidized rates not only distort the pricing signal, but consequently, the capacity signal by affecting the insurance sector's capacity to stay solvent and provide coverage. Furthermore, each state has its own regulatory structure so the rules in one state will differ from those of another state. This poses challenges for the insurance sector to provide interstate or regional insurance. Both of these issues cause barriers for insurance to be effective.

For insurance to really serve as a vehicle for reducing risk, these barriers must be overcome. A number of both small and large changes to the insurance system can propel insurance into a more effective tool for improved resilience. On a smaller scale, more information may prove useful to customers to better understand the level of risk they face. Customers may more effectively manage their risks if better informed of them with information based on scientific data (e.g., weather, climatological, hydrological, geological, topographical, and engineering data) and how risk is reflected in insurance costs (e.g., deductibles and premiums).

The insurance structure currently pays out mostly post-event after a claim is filed. This is logical because the losses incurred are unknown until they materialize. However, a mechanism to provide some amount of generalized pre-event payout would enable preparedness actions that could ultimately reduce the post-event payout. Another large change to the insurance structure would remove the rate suppression by eliminating subsidized rates and applying actuarially derived rates. To smooth such a major transition and make insurance more affordable and politically viable, the insurance sector could offer benefits for safe measures or the state could provide tax incentives for risk averse behavior. Finally, on the largest scale, changes in the governance structure could allow insurance to be more effective if state regulators adopted the same regulations nationwide.

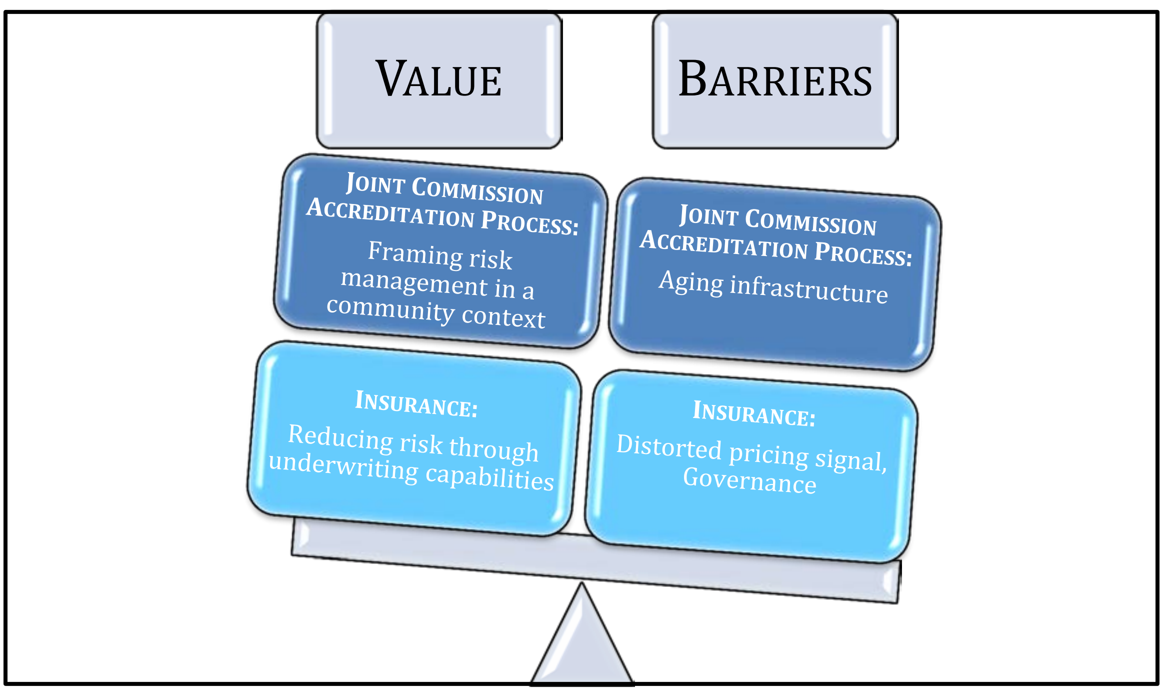

Figure 2: The value and barriers to The Joint Commission accreditation process and property/business insurance

These changes could strengthen society's ability to manage risk by improving its capability to identify and assess the risks. Once the risks are understood, the critical next step for improving resilience is to reduce the risks. For healthcare facilities, three different approaches can reduce the risks.

Section II: Creating Resilient Health Facilities

The next layer of resilience focuses on creating resilient infrastructure. For health facilities, this infrastructure focuses largely on hospitals but also on other healthcare facilities such as nursing homes, special needs centers, long-term care facilities, and physician's offices. The risks to health facilities can be managed through three different approaches aimed at reducing facility vulnerabilities: Hardening structures, Incremental adaptations, or Innovative practices.

The workshop discussions highlighted three different approaches to increasing resilience for healthcare facilities: hardening structures, incremental adaptations, or innovative practices.

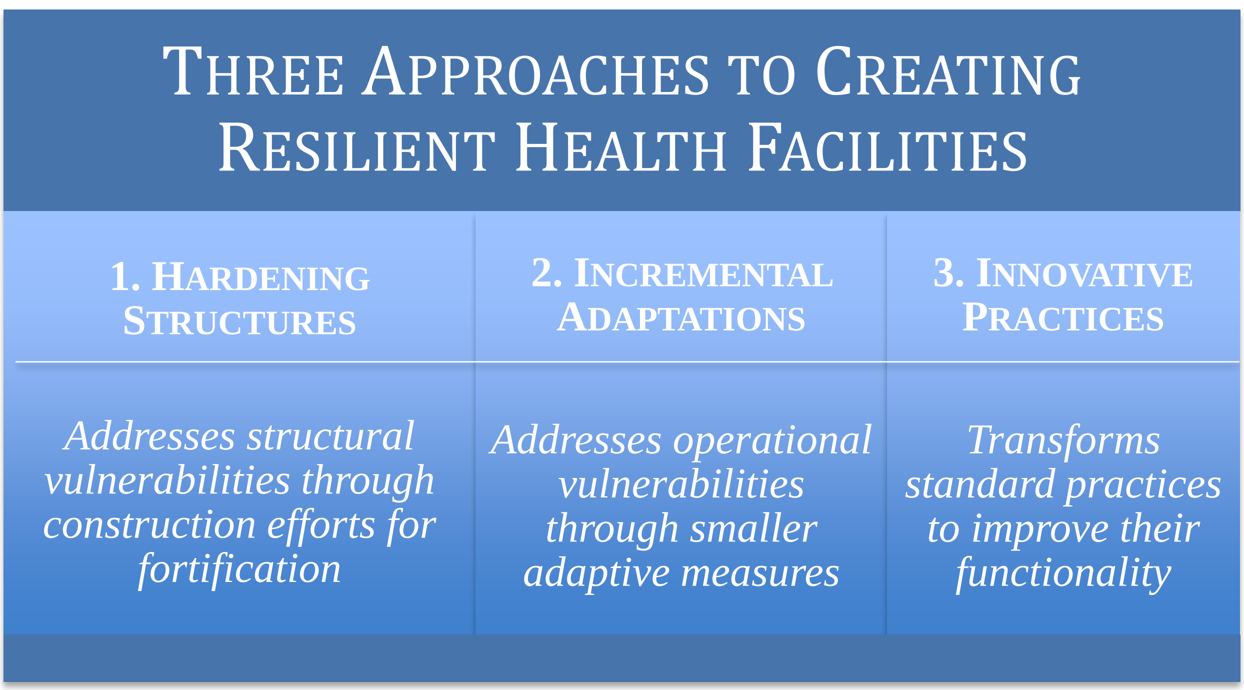

Figure 3: Approaches to creating resilient health facilities

Hardening structures

The first approach for creating resilient healthcare facilities is essentially to fortify the structure. This embraces the concept that a building is only as strong as its weakest link. It assesses buildings, mostly hospitals in this context, and determines both the critical components that must not be compromised by any impact, as well as the structural vulnerabilities that could lead to damage. This approach hardens the structure and builds protective measures for a building to endure high-impact weather with limited resulting damage. Flooding and winds are the weather conditions of most concern with high-impact weather, whether through hurricanes, severe storms, blizzards, or tornadoes. Structures are accordingly fortified to sustain the impacts of flooding and severe winds.

Floodproofing starts with determining which critical components are vulnerable to flooding. This is of particular importance for hospitals where it is common practice to locate vital medical equipment like MRI, CT Scan, Gamma Knives, hyperbaric chambers, and radiation therapy machines in the basement or ground floors. Each of these multi-million dollar machines is a heavy piece of equipment that will rely on backup generators, should the need arise. These factors motivate decisions to keep these machines in the basement or ground flood, contributing to their vulnerability. Other critical components often placed on low-level floors include utility rooms with generators, HVAC (Heating, Ventilation, and Air Conditioning) systems, and plumbing systems. These components are critical to the hospital remaining operational and cannot be compromised.

Hardening the structure to protect these components from flooding includes options such as constructing floodwalls around the exterior of the building, waterproofing low-level floors through new construction using waterproof materials, and installing submarine doors or gates outside of equipment and utility rooms. These options are applicable to both existing and new structures. In addition, other options also exist for new hospitals such as elevating the grade for the site and burying utility or heating/cooling distribution systems underground. Fortifying facilities also involves installing alternate backup systems for critical systems such as electrical, HVAC, water and plumbing. Another option is to install a cogeneration plant for the hospital to ensure a sustained system with backup capability.

For high-impact winds, structural vulnerabilities in terms of the building envelope are a main concern, particularly roofs, walls, windows, and large doors. The Insurance Institute for Business & Home Safety (IBHS) recommends designing the building envelope so that it performs as a unified system. Specific actions can be taken to harden the structural elements. To prevent roof covers from detaching from the building, roof covers and perimeter edge flashing can be designed to withstand winds, with a minimum wind resistance safety factor of 2.0. For enhanced structural performance, IBHS recommends that structures include a continuous load path from the roof deck to the foundation in order to maintain structural integrity for the entire building. Large commercial doors found in various shipping and receiving areas are more resilient if wind and impact rated. Existing doors could be retrofitted to provide greater wind resistance. Facilities in areas vulnerable to extreme high winds, such as those from hurricanes and tornadoes, could consider constructing a community shelter in accordance with FEMA and International Code Council codes.

Windows are of major concern with high winds, both in terms of the vulnerability they present for structural integrity but also for patient safety if they are blown inward. During the recovery from the 2011 Joplin tornado, Mercy Strategic Projects and McCarthy Building Companies, Inc. jointly constructed the new hospital in Joplin, Missouri. They spent considerable time testing and designing laminate glass windows to sustain high-wind impact. They designed windows that could sustain winds of 250 mph in critical care wings of the hospital including the Intensive Care Unit (ICU), Neonatal ICU, and Pediatric ICU, from which patients cannot be moved; and 140 mph winds for other parts of the hospital where patients can be more mobile, such as the Emergency Department.

Fortifying buildings involves significant construction efforts to reduce structural vulnerabilities and ultimately improve resilience. These efforts can be very costly, such as the endeavor taken on by the University of Texas Medical Branch system, where the total cost equaled $1.3 billion. Costs on this order of magnitude are difficult to fund by any individual health facility and require extraordinary external support. However, such efforts pay off if structures are able to endure harsh conditions with minimal impact and even smaller recovery costs.

Instead of major construction efforts, the second approach incorporates incremental adaptive measures to build more resilient hospital functions. It focuses less on structural vulnerabilities and more on operational vulnerabilities seeking to avoid potential loss of service or harm to patients.

<u>Incremental Adaptations</u>

The second approach assesses the facility with the goal of keeping it operational and avoiding functional failures. It reduces operational vulnerabilities through relatively smaller, compartmentalized actions than the first approach. This approach adapts routine practices for potential threats that could disrupt facility functioning. Critical systems including electrical, HVAC, water, and plumbing systems are assessed. If they exist on the lower floors of the hospital, this approach relocates these systems both to higher floors to avoid flood damage, and interior corridors to avoid wind damage. Usually one HVAC system supports the entire building but in this approach, a second system may be added, allowing the first system to circulate only within the first floor and the second to circulate air to the rest of the building. This measure protects patients in the case of flood damage so that potentially contaminated air is not continuously circulated throughout the entire building. Sewage backup is another concern with flooding. An adaptive measure places backflow prevention devices on sewage lines and connects sump pumps to the emergency power system. Another measure transitions a single stockroom of supplies to an allocation of supplies to every floor instead. This reduces the risk of potentially losing all supplies to flood damage and it also provides easier access to necessary supplies when time is limited such as with an impending tornado.

Multiple electrical systems are an important adaptive measure to ensure backup capabilities that allow the hospital to remain operational continuously. Since most operational components of the hospital rely on power, the electrical system must have one or more backup systems with emergency generators able to provide several days' worth of power, often standardized to more than 96 hours of power. These systems should increase their backup capacity for more than several days and provide backup power for many more critical operations. Emergency power should also be provided for the HVAC system, sump pumps, computers (for access to medical records), bathrooms and showers, lighting, and food preparation.

Hardening structures and incremental adaptations assess structural and operational vulnerabilities. However the third approach – Innovative practices - seeks to build resilience not necessarily by reducing vulnerabilities but by transforming the role of hospitals in the community. The innovative practices approach considers the location and functioning of hospital facilities and seeks to make them more physically and ideologically accessible to the community to ensure that they can serve as the vital resource they need to be within a community.

<u>Innovative practices</u>

Innovative practices seek to shift the conventional ways in which health facilities and services operate by significantly transforming standard practices to improve their functionality. One of the innovative practices for hospitals rethinks the location of facilities and makes them more easily accessible to their community, ultimately improving their utility and contributing to improved community resilience. This increases the hospitals' ability to serve as a community resource in routine times as well as when transportation networks may be damaged due to high-impact weather. Greater accessibility includes urban design strategies for designing new multimodal transportation networks that enable access to healthcare facilities for all segments of the population including those without cars or the less mobile. The location of healthcare facilities also becomes an increasingly important issue as demographic shifts in the U.S. move away from individual communities toward large urban centers and emerging megaregions in the future. At present, 50% of the global population lives in cities with 75% of the population expected to live in cities by 2050.[6] Large urban corridors will become the new reality and the strategy for the location of hospitals will need to shift to meet future needs. As Aseem Inam suggests, urban design must begin with cities: how they work, how they change, and what impacts they have in creating enabling versus destructive impacts.[7]

Larger populations will increase the demand for healthcare and the use of hospital resources. One innovative practice for hospital resources focuses on transforming

[6] The Rockefeller Foundation. 100 Resilient Cities Centennial Challenge. http://100resilientcities.rockefellerfoundation.org/resilience
(presented by Lindsay Waters during the workshop)

[7] Inam, Aseem (2008). *Meaningful urban design.* Writing Urbanism: A Design Reader. Douglas Kelbaugh and Kit Krankel McCullough (eds.) Routledge.
(presented by Lindsay Waters during the workshop)

energy usage in facilities by adding renewable energy to their energy portfolios. Adding renewable energy to the existing conventional energy sources provides additional energy when facility usage increases and it also provides a backup source in case the main source is compromised.

Possibly the most innovative practice creates a spectrum of roles for health facilities by expanding from the provision of critical care to including more on well-being and health management. Hospitals and the larger network of health facilities all contribute to a spectrum of care: improving well-being, assisting with health management, and the traditional roles of acute care, then long-term care. The critical care end of the spectrum is well established, but the space for well-being and health management could be enhanced. Adding this component to the current health spectrum provides more access to healthcare for the community. It could even create an innovative shift in the way society perceives healthcare by moving it away from critical care and toward greater well-being. This could potentially strengthen the overall health of the community as well as the individual roles for health facilities within a community.

Innovating the spectrum of healthcare across the network of facilities distributes the burden more evenly, capitalizes on the expert services of individual facilities, and alleviates some of the pressure weighing on hospitals. Hospitals are currently hard pressed to keep up with demands on their resources and services as they operate under increasingly tighter financial circumstances. Outside of hospitals, healthcare facilities include physician offices, outpatient surgery centers, acute care facilities, ambulatory services, and long-term care. Distributing healthcare across all of these facilities allows them to excel in their specialty care and provides overall better health services to society. It also eases the pressure off hospitals for providing all of a patient's care, some of which may not match the quality of specialized facilities. It also allows them to focus on providing the critical care that they need to provide. The distribution of care also creates multiple nodes of health services within the network and forms a redundant and failsafe system, which is critical for resilience.

In fact, while the three approaches – Hardening structures, Incremental adaptations, and Innovative Practices - differ from each other, they all promote redundant systems that provide some type of alternative if the primary system fails. Traditionally, the concept of redundancy carries negative connotations as the opposite of efficiency and that it is necessary only for potentially faulty systems. When we are applauded for reducing redundancy, it is based on the assumption that the system will always work and that redundancy is unnecessary. This is a dangerous and unrealistic assumption in the context of resilience, where redundancy is actually an asset worth achieving. The costs can be high to create redundant systems whether in new facilities, retrofitting in old facilities, or even in diversifying such as in the energy portfolio. Furthermore, the high costs are required upfront during installation and the payoff may only be evident after a high-impact event occurs down the road. However, when a high-impact event does occur, the benefits outweigh the costs because the facility will avoid losses from functional failures and service interruptions, while also ensuring healthcare for patients in need. In addition, the upfront costs of installing redundant systems will be less than the costs of full rebuilding for a system damaged by an event. The delayed payoff, however, often makes the installation of redundant systems a low priority for facilities.

> ***When we are applauded for reducing redundancy, it is based on the assumption that the system will always work and redundancy is unnecessary. This is a dangerous and unrealistic assumption in the context of resilience where redundancy is actually an asset worth achieving.***

Whether it means a backup generator or an energy portfolio split between conventional and renewable energy, there should always be at least one, if not more than one, system in place with the capability of filling a void, should the primary system fail. As Thomas Fisher states, "We are at our best when we have imagined and accounted for the worst."[8]

Section III: Continuity of Health Services

With resilient infrastructure in place, the next layer of resilience addresses the continuity of health services to ensure the provision of healthcare without interruptions, as disruptive weather events could cause. The continuity of health services is critical for patients, particularly during and after a destructive weather event when the demand for healthcare increases. Following a high-impact weather event, health facilities will be faced with reduced capacity and capabilities and they must plan to remain operational under the constrained circumstances.

> ***Following a high-impact weather event, health facilities will be faced with reduced capacity and capabilities and they must plan to remain operational under the constrained circumstances. Facilities lose <u>capacity</u> when their resources are reduced… Facilities lose <u>capability</u> to provide health services when they lose critical services.***

Facilities lose capacity when their resources are reduced such as dwindling medical supplies, pharmaceutical stocks, available beds, food, potable water, and even clean linens. Some of these resource shortages can be managed proactively by stocking supplies ahead of time particularly for non-perishable items like some pharmaceuticals, equipment, and linens. The difficulty lies in perishable supplies not only because they cannot be stockpiled well in advance but also because these supplies are shipped from external destinations. Often the roads are damaged after a high-impact weather event, eliminating the transportation network necessary for deliveries.

[8] Fisher, Thomas (2012). Designing to Avoid Disaster: The Nature of Fracture-Critical Design. Routledge. (presented by Robin Guenther during the workshop)

In fact, the breakdown of transportation networks is the crux of supply chain disruptions during high-impact weather events. Supplies such as medications and food cannot be delivered to health facilities because the roads and often even air travel are disrupted from high-impact weather. This assumes that the distribution centers are intact and just the transportation networks have broken down but sometimes even the warehouses and shipment centers are impacted. Distribution centers are often strategically located regionally so there is a higher probability that the center serving any particular community is in the same region and if the region is impacted, the distribution center is also affected.

Facilities lose capability to provide health services when they lose critical services such as power, HVAC, and plumbing or when they lose staff. Health services are only possible with both these critical services and the workforce, so it is crucial that both are managed to be available at all times. Critical services have been discussed in the previous section with consideration to maintaining alternative backup systems. In the face of limited staffing, managing the workforce requires a shifted structure based on prioritizing the most critical healthcare needs. For example, the ICU (Intensive Care Unit) may fill its staff shortages with doctors from Inpatient or Operating Room (OR) staff; Inpatient doctor positions would then be filled by Outpatient doctors whose positions would be filled by nurses temporarily.

However, competencies pose a big challenge to the shifted structure strategy. If the staff shifts from their normal positions in to new positions during a staff shortage, do they possess the core competencies needed for the new role? If not, hospitals could adopt new training strategies to train staff in acquiring the competencies for their main roles, as well as basic competencies to perform in their shifted role.

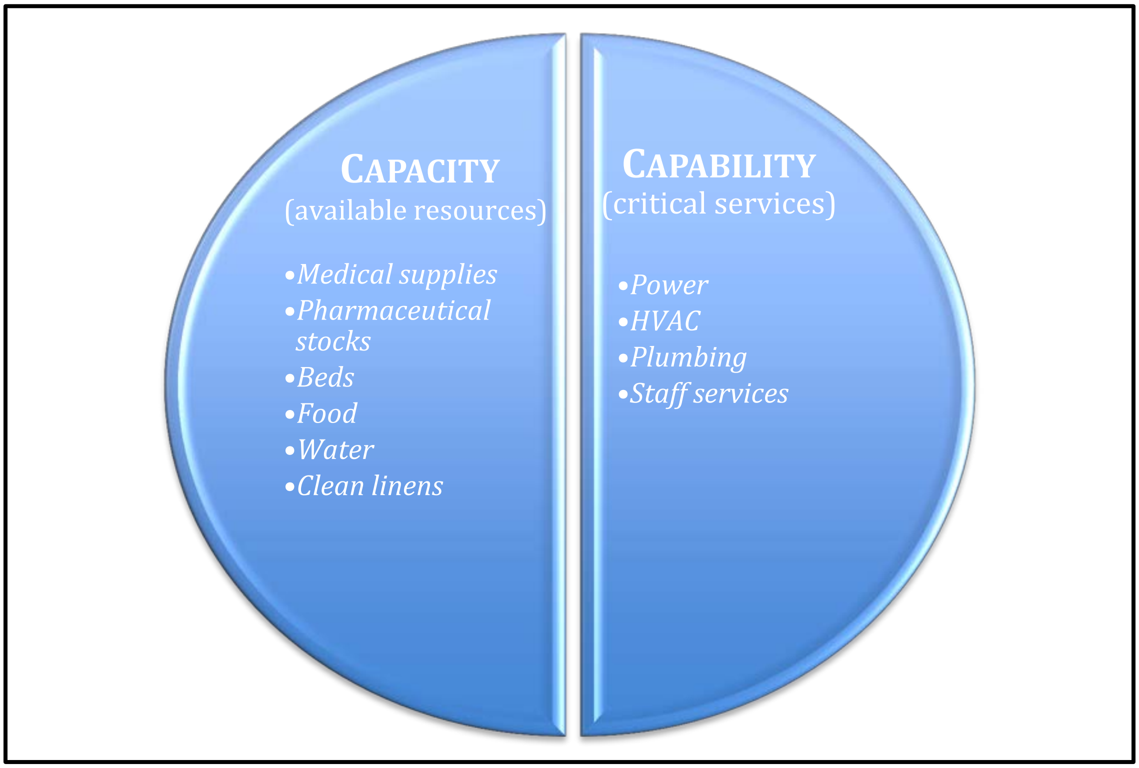

Figure 4: Continuity of services relies on capacity and capability

The other service that supports the provision of healthcare is the IT system for electronic medical records. Electronic medical records are so important to health services since hard copies of medical records carry large risks of being destroyed from high-impact weather events. Electronic records also offer ease of transferal which becomes necessary if one facility evacuates patients and transfers them to another facility. The main requirement for the use of electronic records is a continuous power supply to allow access electronically. This reaffirms the need for a resilient power system.

Designing resilient buildings and operations represent some of the decisions that can be more effective and efficient if they are based on useful background information. As discussed in Section I, information on risks and vulnerabilities can improve the decision making process. In the context of this workshop, the decisions are for preparedness actions to reduce vulnerability and response during a weather event. In making these types of decisions, useful information highlights the scientific risks and vulnerabilities related to weather, climate, and the environment.

Section IV: Information for Decision Making

In each of the layers of resilience, decisions must be made on how to design buildings, provide health services, or even respond to a potential high-impact weather event. While the decision making process relies on many factors, providing weather, climate, and environmental information can inform the process with relevant information on the threats and vulnerabilities that create risk.

Risk management is empowered by information on likely threats and existing vulnerabilities, which ultimately highlight the level of current and future risk. As mentioned in Section I, vehicles like The Joint Commission's accreditation process and property/business insurance act as knowledge informants to expose risks that may otherwise be unknown to people. Climatological information provides knowledge on the most likely types and frequency of weather events for an area, as well as potential risks possible with the effects of climate change in the future.

Decision makers focused on improving structural resilience can benefit from climatological information such as the probable sustained wind speeds and gusts associated with a likely weather event, as well as the likely precipitation patterns and flood events for a region. Useful engineering information can provide details on the maximum wind speeds or flood levels that a building can sustain as well as land planning information on the community's topography and landscape. Hydrological information on watersheds, drainage systems, and the location of all flood protection structures (e.g., dams, levees) can assist with flood management decisions.

National and regional weather forecasts are crucial for supply chain networks, particularly when large-scale regional storms such as blizzards and hurricanes are threats. Transportation networks are the crux for supply chain networks and weather disruptions to air and road travel can impede upon the transport of goods. Suppliers use weather forecasts to strategize and manage their operations geographically in efforts for uninterrupted operations. The longer out the forecast outlook can predict, the better it is for decision makers managing distribution. This provides them with more lead time to adapt normal operations, which is a major logistical endeavor, for pending bad weather.

Weather forecasts can assist with emergency response decision making by providing advanced lead time for bad weather. For tornado prone areas, a matter of minutes can aid the response process. For hurricane prone areas, decision makers must make evacuation decisions 72 hours ahead of time. Workshop participants largely discussed their needs for weather forecasts that maximize lead time and granulate resolution to a community level. For instance, the regional variation requires fine resolution forecasts for Galveston, Texas where the medical facility sits on a barrier island with much greater vulnerability to winds (driving storm surge) than inland areas within the same region. In Joplin, Missouri, a tornado's damage can vary greatly by the mile. However, the great challenge with providing greater forecast lead time and resolution is to concurrently maintain accuracy of the forecast.

Spatial and temporal resolution of forecasts are of critical importance and the greater the resolution can be - while maintaining accuracy - the more beneficial the forecast is to decision makers.

Currently meteorologists issue forecasts at county levels but emergency response decision makers would benefit greatly if the spatial resolution could be improved. This is of particular importance for healthcare facilities since evacuation decisions are made first to other facilities intraregionally, then interregionally. Spatial resolution of forecasts is of critical importance and the greater the resolution can be - while maintaining accuracy - the more beneficial the forecast is to decision makers faced with decisions on patient evacuations and transfers.

The weather enterprise is working to provide useful tools to assist decision makers who are dealing with high-impact weather risks. The National Weather Service (NWS) recently started an effort to increase threefold the spatial resolution of its Global Forecast System (GFS) model. Several years ago, the NWS started issuing high-impact weather warnings by polygons to improve the spatial resolution from county forecasts. The National Hurricane Center (NHC) continues to improve its Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model to predict the impacts of storm surge (wind driven water pileups). The results from the SLOSH model help emergency managers determine evacuation zones from flood threats. Academic research is pursuing decision support tools such as real-time data management to notify emergency managers of impending high-impact weather.[9] The private sector provides tailored forecasts for customers with specific information needs such as providing aviation weather information.

The decision making process can be improved not only by information but also by greater relationships between decision makers and the members of the weather enterprise. Meteorologists and emergency managers are increasingly communicating in real-time when high-impact weather events evolve. Programs like the National Weather Service's NWSChat provide opportunities for greater real-time communication. Since the Joplin tornado, the Joplin area's NWS meteorologists have started to update every hospital staffer with more frequent tornado information during pending severe weather. Many good relationships have begun and there are ample opportunities for more collaboration between information providers and decision makers as ongoing decisions are made about threat, vulnerability, and ultimately risk to high-impact weather.

In thinking about approaches to building resilient structures and services, we look at how health providers, facilities, and services can strengthen the health system. However the health system is larger than just the healthcare components; it also involves the community of individuals who rely on health services and the networks that the health system relies upon for its success.

[9] The University of Alabama in Huntsville. Automated data delivery and processing for disaster events. http://www.itsc.uah.edu/main/posters/automated-data-delivery-and-processing-disaster-events

Section V: Community Resilience

Perhaps the most meaningful and effective scale for resilience focuses on the community level. While it is a national goal with state jurisdiction, the foundation of resilience is at the community level and deeply rooted in community functions. The community is comprised of interconnected moving parts including public health, healthcare, transportation, commerce, environment, and education. These parts have separate functions and must be robust individually, but rely on each other in order to make a resilient community at large - much like the parts of an engine must each be in good working order for the engine as a whole to operate smoothly.

The healthcare function of the community can build its resilience internally through actions discussed in Sections II and III but also externally in collaboration with other functions of the community. Improving facilities and services strengthens the internal function but integrating healthcare with the other functions of the community uses a systems approach across the spectrum lending to both a more resilient healthcare function and community.

> ***Improving facilities and services strengthens the internal function but integrating healthcare with the other moving parts of the community uses a systems approach to strengthen across the spectrum lending to both a more resilient healthcare function and community.***

Building networks is necessary to connect interdependent parts of the community together and two specific types of networks are relevant to the healthcare function. Health coalitions are a network connecting together different healthcare facilities and public health departments within a community. These coalitions can strengthen the healthcare function by creating a coordinated, interoperable, and somewhat unified healthcare effort. If one facility loses capability during a disaster event, unaffected facilities within the coalition can step in to fill those needs. Therefore a health coalition shifts the strategy from building the capacity for individual facilities to building the collective capacity for the coalition of facilities.

A unique issue for healthcare is that service must be provided continuously with specific practices in place. For instance, dialysis cannot be temporarily interrupted or substituted for with other medications. Consider this in contrast to the transportation sector of a community which can close a damaged road and provide an alternate route. The requirements for continuous and specific health services demand that the system be operational at best capability during all times. Networks such as health coalitions allow this to be possible by sharing the responsibility of healthcare service and preparing for challenges such as surge capacity, supply shortages, or even disease outbreaks.

The other type of network involves public-private partnerships. Key public-private partnerships link health facilities with other critical facilities in the community to ensure service of water, waste treatment, power, and communications. Public-private partnerships also connect health facilities to local gas stations, grocery stores, hardware stores, pharmacies, and transportation entities within the community to aid in the provision of necessary resources and services. Healthcare facilities, especially hospitals, are the cornerstone of a community because they provide needed care for the sick and injured, but also a refuge when other parts of the community fail. For instance after Superstorm Sandy hit the Jersey Shore, a portion of that community lost power, access to food and water, and even their homes. Residents took refuge in Barnabas Health, the local hospital that remained operational with emergency generated power, food, and water. Barnabas Health had established partnerships with several gas stations near the facility in which it paid for a portion of their fuel supply on a regular basis in exchange for guaranteed fuel for its emergency generator should the community lose power. This partnership allowed Barnabas Health to remain open and functional during a critical time for the community.

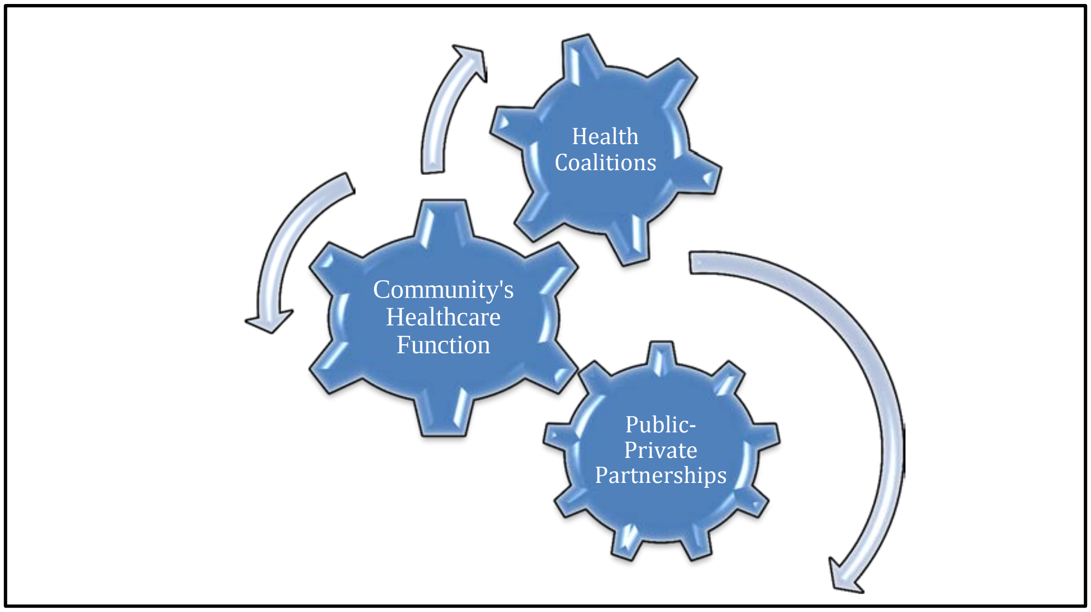

Figure 5: Networks for a community's healthcare function

The Barnabas Health case also exemplifies the intertwined relationship between hospitals and the community. Residents of the community will often seek refuge in the hospital when in need of shelter and resources and those same residents are often the work force that composes the hospital staff. The post-disaster period is the most critical time for a hospital to be operational and to do so it must have its workforce available, as discussed in Section III. This means that health facilities must consider the resilience of the residents of their community to ensure they can endure in the wake of disaster both for their own safety and well-being as well as for the operational needs of the hospital.

Resilience must be considered in terms of building up the community – across all functions at all times – rather than constrained to any particular function (e.g. healthcare) during the time of a disaster event only. Community vulnerabilities are chronic detractors from resilience and a disaster event will amplify those vulnerabilities.

Furthermore, disaster events will exploit vulnerabilities at the most difficult instance when destruction and harm are coupled with loss of resources and time. By that point, it is too late to build resilience and so the process must be in place before any such situation can present itself.

Conclusion

In this report, we present a strategy for improving resilience to first understand the risks one faces, then resolve the vulnerabilities of health facilities, and finally, ensure the continuity of health services. Each of these aspects provides a layer of resilience which, when stacked together, creates a health system that can remain intact and operational during and after a high-impact weather event.

The foundation of resilience at the base level is risk management through assessing the vulnerabilities that health systems should and could reduce. The Joint Commission's accreditation process is built, in part, on the concept of risk management resulting in a systematic process for exploring and addressing vulnerabilities. Property and business insurance provide a vehicle to manage the risks that health systems face by theoretically pricing risk actuarially to assist customers in identifying and assessing their risk.

After identifying and addressing the risks faced by health systems, they can take three different approaches to reduce the vulnerabilities of their healthcare facilities. *Hardening structures* involves a number of actions to fortify buildings and reduce structural vulnerabilities. For example, constructing submarine doors outside utility rooms prevents flood damage to the utility system and installing wind resistant windows protects against severe wind damage. *Incremental adaptations* reduce operational vulnerabilities through relatively smaller actions, adapting routine practices for potential threats that could disrupt facility functioning. Relocating critical components like utility or HVAC systems to higher floors reduces their vulnerability to flooding. *Innovative practices* seek to shift the conventional ways in which health facilities and services operate by transforming standard practices to improve their functionality. Examples include diversifying a hospital's energy portfolio to include renewable energy or designing multimodal transportation networks to make health facilities more accessible to the community.

These three approaches present options for *how* to reduce vulnerability and the insurance sector is poised to assist with the related question of *how much* vulnerability to reduce. Through pricing structure, deductibles, and premiums, insurance reflects a customer's risk tolerance as well as the level of risk. Decision makers are faced with the difficult task of determining the level of risk they are willing to face. When improving resilience to high-impact weather events, should decision makers prepare for the most likely weather event, one level more severe than the most likely event, or the worst-case scenario? These decisions are constrained by time and money in complicated ways that involve funding processes and political viability.

The continuity of health services is crucial to resilience and requires that facilities have a management plan for their operations in the potential circumstance where capacity and capabilities are limited. Improving the resilience of healthcare services requires planning for the uninterrupted provision of healthcare through the management of resources, supporting services, and the workforce. Planning involves early stockpiling of non-perishable resources, backup power systems, maintenance of the medical IT system, and shifting staff responsibilities during workforce shortages based on the most critical needs.

High-impact weather events simply exploit and exacerbate existing vulnerabilities. If the system already has weaknesses, high-impact weather events will only aggravate them. Therefore, with the goal to improve the resilience of the healthcare system, it makes sense to start with a robust healthcare system in every facet possible. The workshop focused on the resilience of healthcare structures and services however there are additional facets of the health system with the patients and care. The need for resilient healthcare facilities and services builds on the premise that healthcare itself is robust. While the provision of healthcare involves a deeply complex system with elements worthy of debate, the robustness of healthcare as a system within itself is worth considering before we can think about improving the resilience of healthcare systems to high-impact weather events.

Redundancy adopts pragmatism with humility to prepare for system failures with the great irony that it ultimately prevents a complete system failure. Therefore redundant systems should be considered one of the strongest tools we possess for improving resilience.

For both healthcare facilities and services, the concept of redundancy emerges in a new light, not as an inefficiency worth eliminating, but as a safety net full of alternatives. The framework of a streamlined single point system has revealed itself to be a single point failure system that can grind the health system to a halt. A redundant system provides a multiple point system with a number of options available should the primary system fail. Redundancy adopts pragmatism with humility to prepare for system failures with the great irony that it ultimately prevents a complete system failure. Therefore redundant systems should be considered one of the strongest tools we possess for improving resilience.

As we expand our thinking on improving healthcare resilience in the face of high-impact weather, we encounter a conceptual space where the relationship is transformed between individuals and their healthcare. Section II suggests a spectrum of care that adds more health services of well-being and health management for individuals and makes health facilities more physically and ideologically accessible to the community. Section V discusses how hospitals serve as a cornerstone of the community, which inherently connects residents to their health systems, whether they are aware of it or not. Empowering the community to take more ownership for the success and sustainability of their health systems can lead to community level actions that build the resilience of their health systems through any of the approaches suggested in this report or beyond.

Increasing the resilience of healthcare facilities and services is of timely importance as we face a rapidly growing urban population situating itself in geographic locations vulnerable to every natural hazard that threatens the U.S. As we urbanize, society has created a growing and compounded vulnerability from its heavy interdependencies with infrastructure and technology, all of which are fragile and highly susceptible to impact. This increasing and ubiquitous vulnerability will only lead to greater impact of weather events until society is able to reconcile it. This is one of the great contemporary challenges that we face which we can resolve through strategic actions designed to reduce our vulnerability, and ultimately our risk, not only for healthcare facilities and services but for every function of society.

The increasing impact of weather events on society is one of the great contemporary challenges that we face which we can resolve through strategic actions designed to reduce our vulnerability, and ultimately our risk, not only for healthcare facilities and services but for every function of society.

Appendix

Workshop Program

October 17, 2013

7:30am - 8:00am Continental Breakfast

8:00am - 8:15am Welcome
SHALI MOHLEJI, American Meteorological Society

Part I: What has recent experience taught us about how the healthcare sector performs during weather-related disaster events?

8:15am - 10:15am Case Studies
Moderator: DAN HANFLING, Inova Health System

1. STEVEN LEBLANC, The University of Texas Medical Branch
2. NEIL BRYANT, Barnabas Health
3. LEWIS GOLDFRANK, New York University Langone Medical Center
4. JOHN FARNEN, Mercy Strategic Projects and STEPHEN MEUSCHKE, McCarthy Building Companies, Inc
5. JOHN COPENHAVER, Contingency Management Group and BILL WITTEL, Hall County Public Safety Liaison

10:15am - 10:30am Coffee Break

10:30am - 11:30am Case Studies Panel
Moderator: DAN HANFLING, Inova Health System

1. STEVEN LEBLANC
2. NEIL BRYANT
3. LEWIS GOLDFRANK
4. JOHN FARNEN, STEPHEN MEUSCHKE
5. JOHN COPENHAVER, BILL WITTEL

11:30am - 12:30pm Lunch

Part II: How can the broader network assist the healthcare sector in building resilience?

12:30pm - 2:00pm Risk Assessors
Moderator: DEBRA BALLEN, Insurance Institute for Business and Home Safety

1. THOMAS SANTOS, American Insurance Association
2. ANNETTE KONIECZKA, Zurich North America
3. MICHAEL WIDDEKIND, Zurich North America
4. JOHN MAURER, The Joint Commission

2:00pm - 2:30pm Coffee Break

2:30pm – 4:00pm Development sector
Moderator: BRIAN MASTERSON, U.S. Air Force

1. CHUCK MICCOLIS, Insurance Institute for Business and Home Safety
2. LINDSEY WATERS, HKS Architecture
3. STEPHEN MEUSCHKE, McCarthy Building Companies, Inc and JOHN FARNEN, Mercy Strategic Projects
4. ROBIN GUENTHER, Perkins and Will

4:00pm - 5:30pm Continuity of Service sector
Moderator: JOE BARBERA, Institute for Crisis, Disaster, and Risk Management, The George Washington University

1. MICHAEL BARDIN, Perkins and Will
2. ARASH AZADEGAN, Supply Chain Disruption Research Laboratory, Rutgers Business School
3. LUIS KUN, Center for Hemispheric Defense Studies, National Defense University
4. HOWARD GWON, Johns Hopkins Medicine

5:30pm – 7:00pm (optional) **Working Dinner: How can we improve healthcare resiliency, both in infrastructure resiliency and healthcare service continuity?**
How do we expand these improvements nationwide?

October 18, 2013

8:00am – 8:45am Continental Breakfast

8:45am – 10:00am Panel Discussion With All Workshop Speakers
Moderator: SHALI MOHLEJI, American Meteorological Society

1. *In your opinion, which one of the following three scenarios seems most likely in the near future, long-term future and why?*
   a. *A degraded health system from today*
   b. *The status quo health system*
   c. *An upgraded health system*

2. *What are the greatest challenges to building resilience for health facilities and services?*

3. *Where are the current and future opportunities for building resilience?*

4. *What should the priorities be for building resilience of the health system?*

5. *What should next steps be following this workshop?*

10:00am – 10:30am Coffee Break

10:30am - 12:00pm Panel Discussion with Working Dinner Group Leaders

1. *How can we improve healthcare resilience, both in infrastructure resiliency and healthcare service continuity?*

2. *How do we expand these improvements nationwide?*

12:00pm – 12:30pm Wrap-up
WILLIAM H. HOOKE, Associate Executive Director, American Meteorological Society