



THE SURGE AFTER THE STORM:

The Impact of Hurricane Sandy on Hospitals in New York City

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PART I

Anticipating Sandy: When NYC shut its doors

Dr. Chris McStay was anxiously gazing through the wet panes of the large glass atrium that shielded the century-old façade of Bellevue Hospital – America’s oldest hospital that had a long tradition of serving the most destitute in what New Yorkers believe is the greatest city in the world. He was looking for telltale signs of the impending storm: rain, high winds, swirling dust, rattling panes. He knew that Hurricane Sandy was fast approaching, and all the hospitals were on high alert – as they had been, just one year ago, when Hurricane Irene had threatened to disrupt New York City (NYC).¹ Irene’s visit was largely inconsequential and New Yorkers were now skeptical of the Mayor’s abundant warnings and precautions for Hurricane Sandy.

Hurricanes over the Atlantic traveling west toward the US usually die down at sea, or continue toward the Gulf coast. One in twenty make landfall, typically in Louisiana or Mississippi (1). Therefore, a week prior, when the European Weather Center in the UK predicted that New York and New Jersey potentially lay in the path of Hurricane Sandy, meteorologists and disaster planners in the US took notice and began following the storm’s trajectory closely.² In the ensuing days it was abundantly clear that Hurricane Sandy would directly affect New York City and its surrounding areas.³ On October 26, Governor Andrew Cuomo declared a state of emergency for the entire state of New York. Michael Bloomberg, Mayor of New York City, advised the approximately 375,000 residents living closest to the water’s edge in an area demarcated “Zone A” to evacuate their homes by seeking shelter with friends or family, or to head to one of the 76 hurricane shelters set up in the city (2).

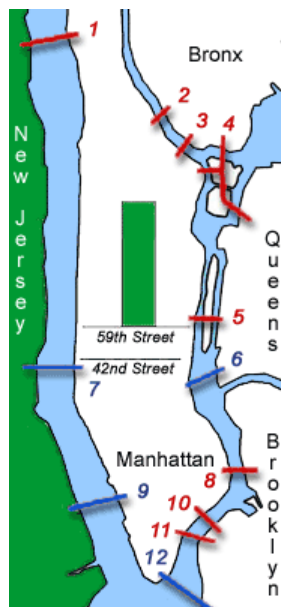
Mayor Bloomberg was entering the final year of his three terms as Mayor of the city. His team had successfully prepared for Irene, and was once again taking abundant precautions to protect the city from Hurricane Sandy. The city’s subway system was closed by October 28, and subway entrances and vents on the city’s sidewalks were boarded down. The two arterial tunnels to Manhattan--the Midtown Tunnel from Queens and Holland Tunnel from New Jersey--were closed to traffic. The Mayor ordered public schools to close on Monday, October 29, and those living in low-lying areas of NYC (Zone A) to evacuate. By Monday afternoon, bridges to Manhattan were being closed down in anticipation of high winds. The roads were empty and people were instructed to stay in-doors. By Monday evening, all roads leading to Manhattan were shut and the island city was essentially isolated from the other boroughs.

¹ New York City contains five boroughs, and the most densely settled is named Manhattan. It is geographically an island joined to the other boroughs and the mainland area of New York State by bridges and tunnels.

² While most hurricanes get weaker as they move into cooler waters, this was not the case with Sandy. According to Radley Horton of the Center for Climate Systems Research, “Parts of the North Atlantic were five degrees warmer than normal. You could see it as you watched those satellite images, as Sandy passed over that unusually warm water, it increased its strength” (1). In addition, a nor’easter had been developing inland, and was moving parallel to Sandy’s course. These two storm systems would eventually merge and create one “Super storm” that was over 1,100 statute miles in diameter at one point (3).

³ Not only did meteorologists become certain that New York and New Jersey were in Sandy’s path of destruction, but they also forecasted that the storm would hit at high tide. In another stroke of misfortune, the moon was in its full phase on both October 29. A full moon meant higher tides than usual rose along the coast in the moments before landfall (3). As anticipated, the storm arrived at the worst possible time – high tide during a full moon – creating surges of water up to 12.5 feet high (4).

FIGURE 1: Bridges and Tunnels to and from Manhattan



Bridges and Tunnels to Manhattan

1. George Washington Bridge
2. Third Avenue Bridge
3. Willis Avenue Bridge
4. Triborough Bridge
5. Queensborough (59th Street) Bridge
6. Queens Midtown Tunnel
7. Lincoln Tunnel
8. Williamsburg Bridge
9. Holland Tunnel
10. Manhattan Bridge
11. Brooklyn Bridge
12. Brooklyn Battery Tunnel

Red: Bridges Blue: Tunnels

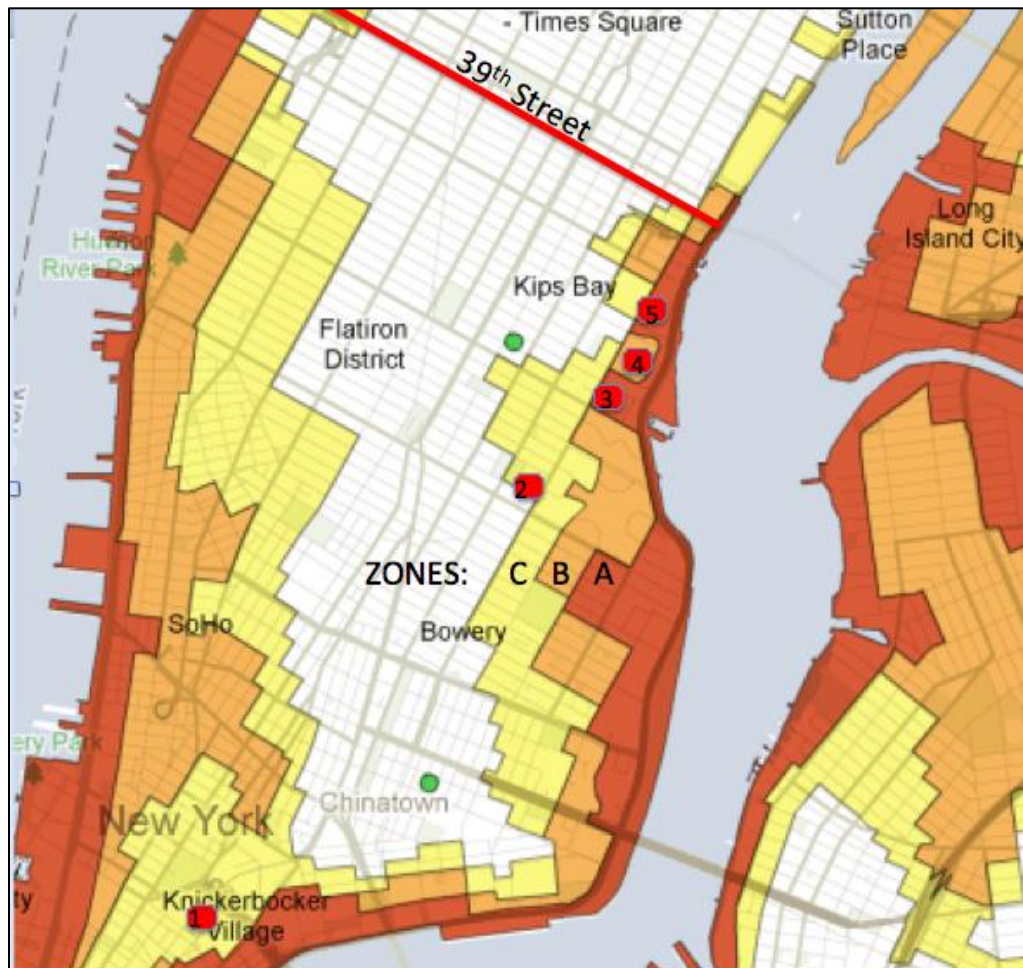
Adapted from <http://www.ny.com/transportation/crossings/> Accessed April 1 2016.

Hospitals would stay open

In August 2011, prior to Hurricane Irene, several hospitals in NYC had been instructed to evacuate their patients in a controlled environment. State Health Commissioner Dr. Thomas Farley and City Health Commissioner Dr. Nirav Shah had overseen the transfer of over 10,000 patients from seven acute-care hospitals and 39 psychiatric, adult-care, and nursing homes in preparation of Hurricane Irene. However, a year later, in 2012, the health commissioners had decided against a proactive evacuation plan for Hurricane Sandy given the risks entailed in these large volume patient transfers. They stated that the costs to the system and the potential losses to the hospitals had not been a consideration in the decision process (5). Joseph Bruno, the Commissioner of the city's Office for Emergency Management (OEM) was also satisfied by the inter-hospital coordination and medical preparedness for Sandy. The teams at OEM supporting health facilities had been assigned a larger coordination space than during Irene.

Subsequently, the Mayor had exempted hospitals and nursing homes in Zone A from his evacuation order, advising them to shelter in place. The commissioners did however ask vulnerable nursing homes to increase staffing at their facilities and to transfer out patients that required mechanical ventilation. They instructed area hospitals to make preparations for prolonged power outages; cancel elective procedures and discharge patients who were healthy enough; evacuate patients who were utility dependent (i.e. on ventilators, etc.); increase staffing to 150% of normal rates by 5 pm for long-term care facilities (LTC) and adult-care facilities (ACF); transfer LTC patients on ventilators to safer locations; and to override normal approved capacity when receiving patients, if necessary. They also encouraged dialysis centers to remain in operation on Sunday, October 28 (2).

FIGURE 2: Hospitals below 39th street in relation to Evacuation Zones A, B and C



Hospitals in lower Manhattan: 1. New York Downtown Hospital; 2. Beth Israel Medical Center; 3. VA Hospital; 4. Bellevue Hospital; 5. NYU Langone Medical Center.

Figure recreated for this case from previously accessible Google map at New York Times (2011)

At this time, New York Downtown Hospital evacuated their patients voluntarily after receiving notice of potential pre-emptive utility cut during the storm (6). The Veterans Affairs (VA) hospital in downtown Manhattan had also chosen to evacuate. By 2:45pm on October 29, the VA's 132 patients had been discharged to be transferred. The director's decision to evacuate the hospital was based on its location in Zone A. The hospital's elevator banks and steam systems were below sea level and back-up generators were at ground level, all susceptible to the predicted 11 ft. storm surge.

New York University Langone Medical Center (NYU) had transferred or discharged most of its patients before Hurricane Irene. In preparation for Sandy, it stopped elective surgeries and discharged as many patients as possible, but over 200 patients remained, including the chairman of its board Mr. Langone (7). The ED was closed ahead of the storm, and a skeletal team was left in the ED, consisting of one doctor, one nurse, and

one technician. With the ED closed, Langone was deferring arrivals to other area EDs, including Bellevue.

After Irene, NYU Langone had raised their generators above ground level and they expected no interruptions in their power supply. Also, the hospital had already conducted five evacuation exercises in calendar year 2012, the last just days prior to Sandy. NYU had infrastructure that they believed would support them throughout the storm. In a later interview, hospital spokeswoman Allison Clair observed that the emergency power system was designed and built according to all safety codes. "We were confident," she said, "we could withstand a [storm] surge of approximately 12 feet" (8). Elsewhere in the city, South Beach Psychiatric Center on Staten Island had also closed due to flooding concerns.

Dr. McStay's emergency department at Bellevue Hospital was also in Zone A, but well prepared. His team had paid particular attention to staffing needs. Due to the expected road closures, staff were provided temporary resting facilities on hospital premises. The planning team had gone through their roster of preparatory questions: Were there enough staff to rotate shifts? Was there enough food to feed the hospital staff? Were there enough beds for the staff to sleep in? Dr. McStay prepared his staff to be at the hospital for two or more days. Hospital census was relatively low, and no elective surgeries were scheduled. Given that roads were empty, and the city fairly hard to navigate, they expected a quiet night - as did emergency departments across the city.

Hurricane Sandy—hour by hour

On Monday afternoon, October 29, winds had reached 60 mph and were expected to reach 90 mph by evening. The storm made landfall near Atlantic City in New Jersey. On the west side of Manhattan, the Hudson river overflowed on to the island; on the east, the East River (in fact, an inlet from the Atlantic Ocean) was sweeping across the "FDR,"⁴ the north-south expressway that marks Manhattan's eastern bank. The roads were empty. Like Dr. McStay, New Yorkers watched the storm in awe from behind the safety of their windows.

Water seeped into the subway tunnel and debris covered tracks as water rushed in and out. Seven subway tunnels between Manhattan and Brooklyn were flooded. The subway system suffered its worst damage in its 108-year history. As water washed over the runways of JFK (John Fitzgerald Kennedy) and LaGuardia airports, over 15,000 flights were cancelled. La Guardia airport suffered extensive damage.

By 7:30pm, water is reported in the basement of several NYU Langone buildings as the 14.5 foot storm surge sweeps across the East River. Their Command Center loses power and moves to a secondary predetermined location.

At 8:30pm, as hospital administrators across the city were anxiously following the progress of the storm in their respective emergency command centers, downtown Manhattan plunged into darkness. An additional one million residents of Long Island lost power, 185,000 in Westchester country, 1.3 million in New Jersey, and more than 400,000 in Connecticut (9).

⁴ FDR stands for the 32nd President of the United States, Franklin Delano Roosevelt.

Floodwater seeped into the Consolidated Edison (ConEd) plant on 14th street and FDR, causing an explosion that resulted in immediate loss of power south of 39th street (10)(11). This area included five major hospitals, approximately 17 nursing homes, nine police stations and 23 fire stations. Bellevue and NYU Langone were both on this grid. Both hospitals lost power and were now dependent on their back-up generators.

The Fire Department of New York (FDNY) started receiving calls from all boroughs. The storm had flooded over 51 square miles of the city. According to the Associate Medical Director of the New York City Fire Department, Dr. Dario Gonzalez, transfers between boroughs were extremely difficult. Lower Manhattan rescues could only occur by bridge, as the usual tunnels for exit were flooded, and most bridges were still closed.

NYU Langone's buildings switched to emergency power. However, their backup systems failed and the lower floors of the medical complex's main Tisch Hospital building lost all power. Its Health and Hospital Corporation (HHC) building also switched to backup power (7)(12). Phone lines and computer systems failed. Elevators stopped functioning as water flooded the elevator pits. By 9pm, administrators came to the grim decision that both buildings needed to be evacuated. About 215 patients had to be moved out, safely and promptly.

Over at Bellevue, the generators were on the 13th floor and functioned for about 30 minutes before the basement pumps shunting fuel to the generators were flooded. When the pumps failed, the on-site National Guard troops began continuously ferrying buckets of fuel up the flights of stairs to keep the generators working. Were Bellevue to close as well, Manhattan's bed capacity would be reduced by 65% in areas of the city below 42nd Street (6).

By midnight, Beth Israel Medical Center was the only major hospital functioning south of 42nd Street. Hundreds of nurses and doctors, including ER physician Dr. Paul Krieger began preparing for the onslaught of patients they would begin to receive - all night, and for months to come.

PART II

Evacuating New York's landmark hospitals

NYU Langone

The storm surge had surpassed all expectations. Combined with the high tide, the rising waters had flooded the basement of NYU Langone. The back-up system had failed and the hospital needed to be evacuated. But evacuation decisions are never easy. The NYU Langone Medical Center is a 1,069 acute bed facility with approximately 20,000 employees. It had over 1,500 active clinical research projects, and ranked #1 in patient / licensure revenue in the United States. With six Centers of Excellence, over 234 million USD in research funding, 1,581 full-time faculty, and over 1000 residents

Shutting the hospital, albeit temporarily, would have repercussions on patients, staff, and revenue. The impact on NYU Langone's reputation would be significant. The Medical

Center's affiliate hospitals included the adjacent public hospital, Bellevue, which had also lost power, and the Manhattan VA hospital that had already been evacuated. Evacuating NYU Langone therefore meant sending patients outside the NYU hospital system, resulting in a significant and real loss of revenue. The concern was that the evacuation experience might result in the transferred patients not wanting to return to NYU for their care. Dr. Brotman, the hospital's senior vice-president recalls that on October 29, "things went downhill very rapidly and very unexpectedly" (13). The leadership had not anticipated such large-scale and total failure of their generators. Within hours of the power outage it was obvious that the need for evacuation was urgent and unavoidable.

NYU Langone's leadership had to conduct real-time negotiations with area hospitals to make space for their patients, to reach an agreement of transferring patients back to NYU eventually, and to allow NYU physicians to practice at the other hospitals to assist in the care of their own as well as other patients.

Over the next 14 hours, 322 patients were evacuated (2). Evacuation entailed transporting patients down several flights of stairs. In 2010, the hospital had procured 30 Med Sleds -- special lightweight sleds designed for transporting patients during emergencies. The Med Sleds proved to be useful, but were insufficient. Hospital staff and EMS personnel assisted in lifting and carrying patients down the stairs. By the time all patients were evacuated, the floodwaters in the basement were teeming with biohazardous material and human waste, and the hospital was looking at a long recovery process ahead.

NICU evacuation

Among the most vulnerable of NYU Langone's patients, were newborns, many of whom were less than a month old and admitted to the Neonatal Intensive Care Unit (NICU). The NICU had had prior experience with evacuation. During Irene, they had transferred ten neonates to six receiving hospitals in under 16 hours (under controlled conditions) (14).

Familiar with the transfer process and particularly concerned about the extreme vulnerability of their patients, the NICU was perhaps better prepared than other departments in the hospital. They had printed paper copies of their patients' medical records and had made advance arrangements with area NICUs should an evacuation become necessary. Maimonides Hospital had agreed to accept more than half of NYU Langone's 21 NICU patients. Maimonides, however, was in the borough of Brooklyn--on the other side of the several closed bridges and tunnels that led to it from Manhattan.

At 7 pm on October 29, at the first signs of potential electric failure, the NICU began preparing for complete power loss. Staff were issued handheld radios and electronic medication cabinets were left unlocked. Evacuation was ordered at 9:00pm. NICU patients were prioritized based on their need for ventilator support, acuity of health needs, and the battery life of equipment they were dependent on (14).

Due to travel route closures imposed by the flooding, new transfer arrangements had to be made. The NICU staff had to cope with the new reality that acceptance procedures were ad hoc and varied significantly from facility to facility where decisions were made either by the on-call neonatologist or the hospital administrator or were entirely dependent on hospital staffing (14). This kind of ad hoc coordination relied on the

faculty's personal connections and access to NICUs throughout the accessible area of Manhattan.

The NICU at NYU Langone was located on the ninth floor. Without elevators, staff had to transport the infants down the unlit stairwells – a difficult task with any patient, but even more so with the life-saving equipment that the critically ill children were dependent on. Each child was carried down the stairs by a team of three to six staff members: two nurses holding the infant, ensuring that the warming pump, monitor, or IV pumps remained functional; one doctor hand-ventilating the patient or monitoring vital signs; and additional nurses carrying oxygen tanks, medications, or other equipment (14). At times, members of the NYPD and FDNY were also involved.

Eventually, all 21 NICU patients were transferred to one of six hospitals: New York-Presbyterian – Cornell, New York-Presbyterian – Columbia, Mount Sinai, St. Luke's, Lenox Hill, and Montefiore (14). The last infant left NYU Langone at 1pm, 4.5 hours after the ConEd power failure accident.

Bellevue: When the NYC safety-net fails

Dr. McStay had his task cut out for him. He was responsible for safely transitioning the care of his ED patients to emergency departments and physicians across the city.

Having been through the preparation for Hurricane Irene one year prior, Bellevue was believed to be mostly prepared for Hurricane Sandy. In addition, there was plenty of time to prepare as doctors and administrators watched the forecast in the days before Sandy struck.

When the storm began, the ED was quiet; doctors saw very few incoming patients and discharged whom they could. The unprecedented storm surge and the ConEd accident resulted in the back-up generators kicking in. Once the fuel pumps failed, the generators shut down and the ED lost electricity 45 minutes after the initial power failure. Dr. McStay knew that the emergency lights in the corners of the room would last another 30 minutes. The ED was not busy, and patients were discharged or transferred out with relative ease. Although the ED was evacuated, the rest of Bellevue Hospital stayed open. Its census of over 700 patients that evening included critically ill patients, many psychiatric patients, and prisoners from nearby prison facilities brought to Bellevue for medical care.

The general consensus was that the hospital had enough fuel, water, and food to last more than 72 hours, the benchmark guideline for stand-alone capacity for hospital preparedness. The elevators had failed, and the National Guard troops continued to haul buckets up the 13 flights of stairs to fuel the generators. Medical devices running on electricity continued to hum along and the patients were in no imminent danger - as long as fuel was transported to the generators. The telecommunication systems had also shut down, as had cell phone service in downtown Manhattan due to cell phone tower failures (15). The hospital staff used stairs to commute between patients and to communicate with each other. Doctors discharged as many patients as they safely could.

Bellevue Hospital (now called the NYC Health + Hospitals / Bellevue) was founded on March 31, 1736, and is the oldest public hospital in the United States (16). Driven by its mission to serve the poor and destitute, Bellevue typically runs at full capacity, and the

ED is always full. Each year the hospital treats some 27,000 inpatients. It also handles about 89,000 Emergency Service visits as well as 300,000 outpatient visits in more than 90 adult and pediatric ambulatory care clinics (17). Though one of several public hospitals in New York, it is the largest and most critical safety-net for New Yorkers without access to the private hospitals (18). Medicaid patients and the uninsured constitute nearly 80% of ED patient visits at Bellevue (19). Keeping Bellevue open was not only necessary for the hundreds of thousands that depended on it but was also a matter of pride for this mission-driven bellwether institution.

By October 31, power had not been restored within Bellevue. Hospital toilets and waste removal mechanisms were failing and the hospital began to feel unsanitary. It would have been unsafe to continue to keep the hospital open. For the first time in its more than two and half centuries of history, Bellevue hospital had to close. By evening, 300 patients still remained at Bellevue and needed to be evacuated as soon as possible (20).

The hospital evacuation center was charged with determining how many patients could be sent to each receiving location. Physicians in the inpatient units at Bellevue identified priority patients to be transferred, prepared their paper medical records, then arranged for the patient to be brought down to the staging area. Patients who were unable to walk down the stairs were carried down via Med Sleds. The National Guard troops continued to help with the evacuation process. Once in the staging area, hospital staff would double check the patient's name, date of birth, and their final destination, and the patients (along with accompanying staff) would be loaded into the waiting ambulances.

In preparation for Sandy, FEMA had provided an additional 368 ground ambulances from across the US (2). Ambulances that responded to Bellevue and NYU Langone for evacuation included both local and out of state ambulance personnel, the latter often unfamiliar with the geography of the city's hospitals, a problem compounded by the many road closures and diversions (8). Ambulances outside Manhattan could respond only once the bridges reopened the next day.

Bellevue's allied institutions, the Manhattan VA and NYU Langone were also shut, necessitating transfers to the many public and private hospitals in the city located north of 42nd street. NYC's high density of hospitals allowed the system to absorb these evacuations from three key downtown hospitals in Manhattan. However, Bellevue's patient mix was far from typical. It saw a large number of psychiatric patients and was the receiving hospital for prisoners of New York City awaiting trial or processing. Maimonides Medical Center in Brooklyn took 50 patients from Bellevue, Mount Sinai received 10 psychiatric patients from Bellevue and 30 other patients, and New York-Presbyterian Hospital received a few (20)(21). St. Luke's and Roosevelt hospitals took another 200 patients from Bellevue (21). Some of Bellevue's patient prisoners were transported to Riker's Island, the closest penal institution, but others were evacuated upstate to Utica--Riker's having exhausted its clinical care and protection capacity (22).

The last two patients to be transferred from Bellevue were a morbidly obese gentleman, and a patient on LVAD (left ventricular assist device, or heart pump). Neither could be brought down via stairs until one of the elevators was restored two days later. In all, 725 patients were evacuated. There were no deaths attributed to the hurricane or to the transfer process at Bellevue.

Nursing homes

Hundreds of patients in adult care facilities and nursing homes were also evacuated. Initially instructed to shelter in place, nursing homes received explicit instructions from the State regarding staffing levels, stocking of food and medication, and preparation of medical records in case of evacuation (23). Despite these instructions, some nursing homes failed to add staff for the storm, failed to stock up on medication and flashlights, and failed to adequately prepare for evacuations. Many nursing home residents and adult home residents spent up to three days in cold dark facilities before being reached by first responders (24). In violation of several state regulations, many evacuated residents were not accompanied by a staff member and were transferred without their medical records, significantly jeopardizing care at the host facilities (2)(23). At least 60 adult-care or nursing facilities in the city suffered from severe flooding, power failure or staffing shortages. Within a week, 26 facilities had to shut down, and citywide residential facility capacity was reduced by 4,600 beds (6).

Beth Israel: Staying power

Beth Israel Medical Center's back up generators did not fail. Located on 15th street and Second Avenue, its ED was the only operational emergency department in lower Manhattan. Anticipating a huge surge in the ensuing days, it did not receive a significant number of initial in-patient transfers from the evacuating hospitals. During the hurricane, the hospital was well staffed with many providers on stand-by on its premises. After the power failures at Bellevue and NYU Langone, Beth Israel braced itself for the coming days.

The influx of patients began on October 30. People came to the hospital to seek care, to seek shelter or even to simply charge their personal electronic devices. By October 31, the ED was at twice its normal volume (25). Many ED patients were chronically ill and dependent on electrically powered devices or on oxygen (25).

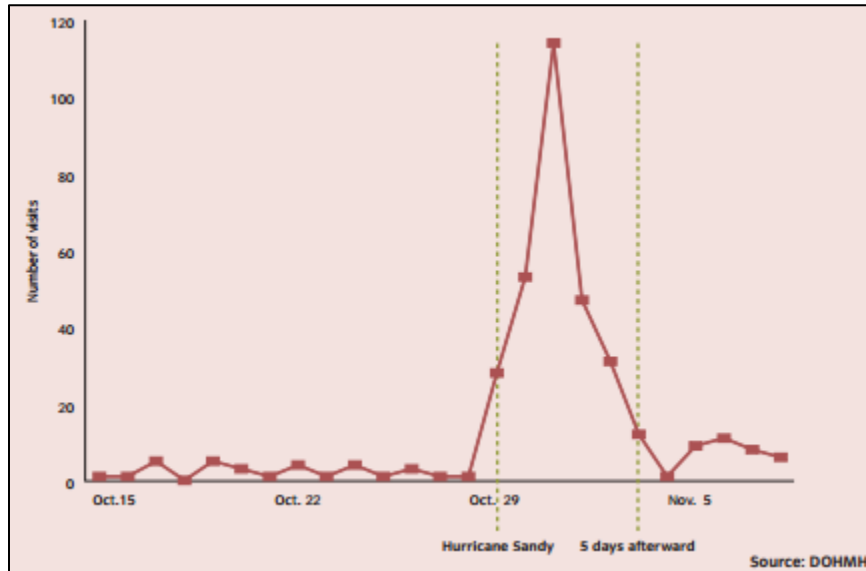
Dr. Kreiger remembers that the ED and hospital administrators had to improvise on their feet. Once the storm had passed, the floodgates of patients had opened, and the hospital had to immediately begin to cater to an increasingly complex patient mix. Residents recall the influx of the elderly, the frightened, the homeless, and those who needed their medications to be refrigerated.

To accommodate those with chronic needs, the detoxification wing was converted into a faux nursing home (with a 1:20 nurse-to-patient ratio). These patients did not need urgent care; they simply had nowhere else to go.

At one point, recalls Dr. Kreiger, a patient on dialysis would come to the ED every three minutes. All seven dialysis centers in Lower Manhattan had lost power and potentially hundreds would need dialysis. A quick triage system was set up, and physicians from the ED and the nephrology service agreed that those with a potassium level of 6 were to be sent home and asked to return the next day. Using an outpatient dialysis unit, a section of the ED was converted into a temporary dialysis wing - the only one in Lower

Manhattan (25). In the immediate aftermath, 27 patients in the ED were awaiting dialysis.

FIGURE 3: ED visits needing dialysis in New York City



Source: City of New York. (2013). Retrieved from http://s-media.nyc.gov/agencies/sirr/SIRR_spreads_Hi_Res.pdf Accessed April 1, 2016

This “on-your-feet-improvisation” was a mantra that Beth Israel staff recall was almost ubiquitous. Hospital staff “task-shifted” to take on responsibilities outside their usual scope of work. Clinicians answered phones, helped keep the ED clean and distribute meals to the patients. An influx of outpatient providers helped relieve ED staff during the busiest days of the immediate response. Although many of these doctors were primary care physicians and had not worked in an emergency department for years, their presence helped ED physicians focus on incoming patients (25).

By the end of the first week, the ED was seeing a daily average of 500 patients (up from its norm of 300). Ambulance arrivals rose by 64% in the first month; and the inpatient daily census rose to 750 from the baseline of 650. An additional ED area was opened to accommodate the influx, and the inpatient area was expanded by 5% by adding beds to in the inpatient rooms (26). Due to this voluminous surge, some patients that would normally be admitted had to be sent home. Eventually, a cardiologist was stationed in the ED to manage and fast-track patients with chest pain that could be discharged after lab tests and an expedited stress test. Not originally a part of the hospital’s surge plan, these operational innovations helped optimize patient care in the days following Sandy.

Social workers who would typically see up to ten patients/day had to assist approximately 200 patients by November 1, as patients sought help because they were unable to return to their “flooded, waterless and powerless homes” (26).

No time for red-tape

Following the decision to evacuate, residents, nurses, and other hospital support staff at NYU Langone and Bellevue were incredibly anxious. Hospital administrators assured the staff that no one would lose their job. The surge of patients at the other hospitals would require an expanded workforce to care for all the additional patients. Sending providers from the flood-affected hospitals to the receiving hospitals seemed to be the logical solution.

FIGURE 4: Evacuations in New York City

	Hospitals	Nursing Homes	Adult Care Facilities	TOTAL
Patients evacuated, re-evacuated and repatriated	1,379	3,102	1,520	6,001
Pre-storm evacuation of ventilator dependent patients	579	57	49	685
Healthcare facilities that lost power during the storm	9	43	21	73
Healthcare facilities that operated using a generator	5	32	12	49
Healthcare facilities that remain partially-closed [†]	3	0	0	3
Healthcare facilities that remain fully closed [†]	0	4	1	5
HCFs requiring post-storm evacuations (5,316 persons)	6	18	12	36
HCFs within NYC that received patients (4,436 persons)**	45	73	18	136
HCFs outside NYC that received patients (30 persons)**	0	4	1	5

[†] Figures as of April 1, 2013
^{**} Note: many of these patients were evacuated more than once. First evacuations were emergent, so not all patients went to the most appropriate HCF. Second evacuations were from shelters to more appropriate HCFs. Third transport was to repatriate patients back to their original facility (if it was still operational).
^{***} Note: 7 special medical needs shelters received 1,523 persons

Source: Diglio, M., Benedetto, N. A., & Raneri, J. (2013). Retrieved from http://www.nycremsco.org/images/articlesserver/Sandy_Article-1305JEMS32-39.pdf Accessed April 1 2016.

The New York City Health and Hospitals Corporation (HHC), now branded New York Health + Hospitals, was formed in 1969 and operates 11 hospitals across the city, including some of the nation's oldest public hospitals. In addition, three large hospital systems, including New York-Presbyterian, Mount Sinai Health System, and North Shore - LIJ Health System (now Northwell Health), control the majority of hospitals in the New York Greater area. Each system had its own set of rules and regulations around physician recruitment and credentialing. The process would routinely take several weeks; even months. Hospitals were now being asked to expedite the credentialing process to facilitate physicians that had traveled with the transferred patients on the night of the storm to care for their patients in the new host facilities (2).

Mount Sinai, on the upper east side of Manhattan, was one such hospital. Between 1am and 5pm, the hospital received 57 patients in its PACU (Post Anesthesia Care Unit). The

majority were critically ill ICU-bound patients. Nine patients went to the labor and delivery ward. For NYU patients, the hospital switched to its “downtime” operational procedures replacing the electronic medical record with paper charts. The pharmacy was allowed to enter orders into the automated dispensing systems under “downtime” provisions. The State allowed emergency credentialing and approval for the NYU providers to practice at Mt. Sinai. An additional set of “read-only” access users were created by Mt. Sinai’s IT department for NYU staff to access patient records. Within 30 hours of arrival, the patients were transferred to their final in-patient locations.

On Wednesday, October 31, Bellevue began evacuation. Phone communication was lost, and Mt. Sinai did not know how many patients to expect during this second wave. They created “virtual patient units” in their EMR, and re-purposed existing physical wards to accommodate the incoming patients. Additional printers were made available for printing identity bands for patients, and labels for laboratory samples. Hand-scrawled bed numbers in this newly assigned unit coincided with the bed numbers in the “virtual unit” created in the EMR. Medical students were recruited as runners. Though the new unit did not eventually receive many patients, it served as an overflow unit during the subsequent flu season (peak season December to February) that continued to overwhelm the inpatient bed capacity of New York City,

The credentialing process for NYU staff at Beth Israel was delayed due to protracted negotiations between the two hospitals. The over-worked staff at Beth Israel would only get some respite when Bellevue re-opened its emergency department weeks later.

Coordinating Response

The Healthcare Facility Evacuation Center (HEC)

The Department of Health activated the Healthcare Facility Evacuation Center (HEC), a Department of Health-run entity set up to coordinate the evacuation, shelter-in-place, and repatriation of healthcare facilities in conjunction with other response agencies (27). It is responsible for finding beds, arranging transport and giving guidance to receiving facilities (28). It coordinates these processes with the DOH, the OEM, the Greater New York Hospital Association (GNYHA), the Health and Hospitals Corporation (HHC), the Veterans Administration, the NY State Office of Mental Health and various nursing home associations. It coordinates transport via FDNY, the Regional EMS Council, the Metropolitan Transport Authority (MTA), the Taxi and Limousine Commission (TLC) and the NYC Department of Education.

The HEC was in the midst of consolidating lessons learned from Hurricane Irene. It had finalized its Command and Control plans, and its Transportation logistics. But HEC’s facility was itself not completed and its plans on finance, repatriation and data systems were only partially completed. While the HEC was largely responsible for coordination of safe inter-hospital evacuations and transfers, the unique demands of Sandy compelled HEC to expand its scope of services significantly. The HEC found itself coordinating dialysis centers, fueling for emergency vehicles and generators, procuring interim housing, supporting home care staff, providing logistics to health care facilities including meals and equipment, and tracking patients until a better system was put in place. In all, the HEC coordinated the emergency evacuation of over 2,000 patients (6).

After Sandy, HEC released a set of guidelines and online resources (eFINDS) to help health care facilities optimize HEC's use during disasters, allowing HEC to focus on its core mission of coordinating bed-matching, transportation and shelter-in-place directives. eFINDS can be found at <http://www.oasas.ny.gov/pio/eFINDS/>.

EMS

The Bureau of EMS in New York is the country's largest Fire Department-based EMS system and contributes 67% of the ambulances on New York's 911 network (29). A majority of the remaining 33% are considered volunteer ambulances and are provided by hospitals across the city. FDNY EMS is responsible for all mass casualty incidents across the city. Its annual call volume is over 1.3 million (29).

Several local FDNY ambulances could not reach their fueling stations and were out of commission. Others had low clearances and could not navigate the flooded roads. The lack of familiarity of out-of-state EMS providers with routes to closest hospitals, especially during the various road closures and diversions, contributed to patients ending up at wrong hospitals.

In the immediate aftermath of Sandy (and the blackout), FDNY responded to calls for rescuing the many people who were trapped in elevators across downtown Manhattan. The elderly called for assistance with navigating stairs. Owing to road closures, widespread power failures, unlit roads, and the long walks up and down stairwells, many of these rescue calls took upwards of three hours to respond to, completely saturating the department's capacity to respond promptly. Provider fatigue was substantial in the initial days after Sandy (2).

OEM and FEMA

On October 26, the New York State OEM activated the Emergency Operations Center to serve as the coordination nucleus for all emergency response activities (27). Thousands of response personnel would converge in the area from multiple agencies across the country. During peak deployment, there were 212, 282 personnel from 23 agencies (30). In addition, 1,061 volunteers from 29 states responded to Sandy. FEMA deployed 1200 personnel for reconnaissance in affected neighborhoods (31). It also activated the Surge Capacity Force, which allowed volunteers from the Department of Homeland Security to rapidly deploy to disaster-affected areas.

Within three days, FEMA had provided 1.9 million meals and distributed 1.3 million liters of water (31). FEMA established 147 shelters in conjunction with the American Red Cross. The Temporary Sheltering Assistance program facilitated the relocation of displaced residents from shelters to hotels. So that those with homes but without power could return home sooner, FEMA's Sheltering and Temporary Essential Power (STEP) Program assisted the city in paying contractors to perform emergency repairs on their homes (31). In total, 11,531 emergency repairs were facilitated in New York City and Long Island (30). Estimates of people totally displaced by Sandy range from 30-40,000.

New York after Sandy

Manhattan only saw two deaths from Hurricane Sandy. No deaths were reported due to hospital blackouts or transfers. Yet the prolonged impact of the storm on NYC hospital systems compromised care for months to come. Beth Israel, for example, saw a 15% increase in patients brought via ambulances leaving the ED without being seen by providers (26). All EDs in Manhattan saw a steep rise in volume that continued through February, the end of the peak flu season, and did not return to a pre-Sandy baseline for long.

The show goes on

While one of the more enduring images of Sandy was the blackout in downtown Manhattan, storm damage was particularly devastating in the borough of Queens. A day after the storm, a massive fire spread through Breezy Point, engulfing over a hundred homes (32). Breezy Point has roughly 2800 homes, 1500 of which were damaged by the flood waters. Far Rockaway is a coastal community with a large underserved population, where initial aid was provided by local community efforts. According to several investigative media reports, police, disaster response agencies and power companies were largely absent in the Far Rockaways in the days following the storm (33)(34).

Thousands of homes in the neighboring Rockaway peninsula were also destroyed in the storm. Clean up and restoration of beaches along the Rockaway shores cost the city over \$140 million in just the first year following Sandy (35). Bureaucratic and logistical hurdles delayed the reconstruction process. One year after Sandy, shops remained closed and burned buildings stood on empty lots (35).

The New York Stock Exchange closed for two days - a first since 1888 (36). JFK and Newark airports re-opened on October 31. La Guardia airport had suffered some damage in the storm and took two weeks to be fully operational again.

Power was restored to lower Manhattan in stages, with most electricity restored by November 3 (11). Responding to public pressure and growing criticism, Mayor Bloomberg reluctantly cancelled the New York City Marathon (37). By November 3, 80% of the subway system had been restored. Though New York City public schools reopened on November 5, 80 schools were too damaged to meet this re-opening date. Polling booths for the US Presidential elections, scheduled on November 6, were relocated or combined (36).

Over one hundred hotels lost power (and business) in downtown Manhattan. Tourism losses were substantial and compounded by the cancellation of the NYC Marathon. The Statue of Liberty did not open to tourists for another eight months, not until July 4, 2013 (38).

New York City hospitals incurred an estimated cost of one billion dollars associated with the emergency response, and were expected to pay an additional billion dollars in repair and mitigation. In the weeks following the storm, the hospitals lost about USD 70 million per week (6). See Exhibit 1

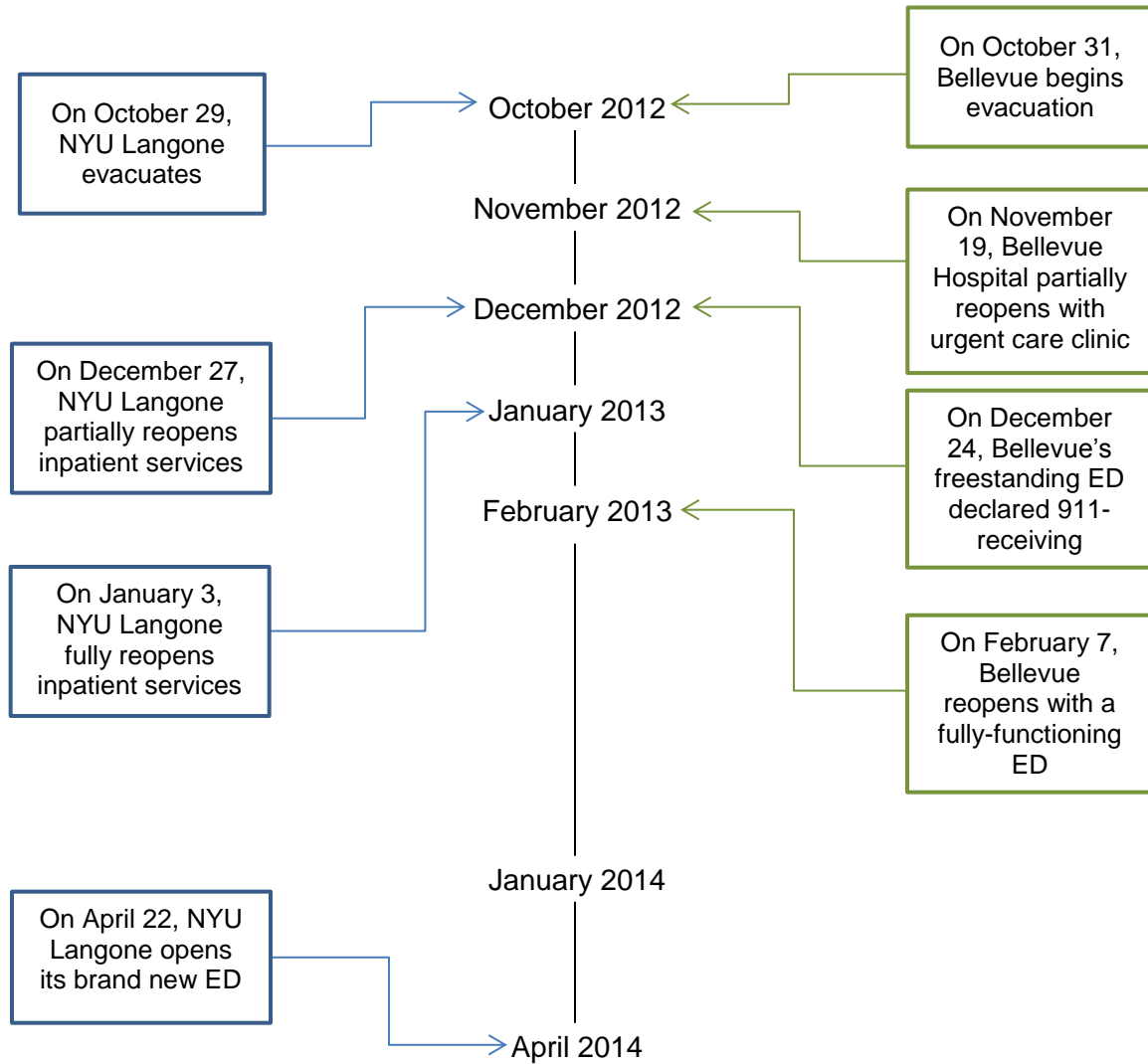
The estimated assessment of damage in New York City was \$15 billion, including damage to homes, businesses, infrastructure, the healthcare system, and other areas of the city (38). See Exhibit 2.

Bellevue reopens

It would be many months before New York City would return to normal life. The destitute that sought routine care at Bellevue Hospital found it hard to seek care elsewhere. Responding to their needs, Bellevue first opened its urgent care center on November 19th, transformed it into a free-standing ED, and finally declared it a 911 receiving center on December 24th (19). Patients that accessed these services were the most vulnerable among New Yorkers - those that “did not have an inlet into the healthcare system” (39). These patients had delayed seeking care because they could not seek care elsewhere or did not know how to. They had missed clinic appointments. Though the free-standing ED was to only receive non-critical patients by ambulances, many that arrived at their door were critically ill because of delayed access to care. Though these patients knew that Bellevue was closed they came to the ED because they considered it “their hospital” and did not know where else to go. Physicians in the Bellevue ED, unable to always find ICU beds in other hospitals to which to transfer these patients, resuscitated and cared for many patients in the Bellevue ED for sustained periods of time (39).

Bellevue re-opened on February 7, 2013, 99 days after it had been forced to close.

EXHIBIT 1: NYU Lagone and Bellevue operation timeline



Adapted from Adalja, A. A., Watson, M., Bouri, N., Minton, K., Morhard, R. C., & Toner, E. S. (2014a). Absorbing citywide patient surge during Hurricane Sandy: A case study in accommodating multiple hospital evacuations. *Annals of Emergency Medicine*, 64(1), 1–9. <http://doi.org/10.1016/j.annemergmed.2013.12.010>

EXHIBIT 2: Damage Assessment Estimates in USD millions

Categories	NYC	Counties					Total by Category
		Suffolk	Nassau	Westchester	Rockland	Other Counties ¹	
Government Response & Repair	486.0	144.0	257.1	17.0	16.2	707.0	1,627.3
Housing	4,738.0	833.0	4,016.0	50.0	35.0	-	9,672.0
Business	4,512.1	492.4	486.8	400.6	90.0	18.1	6,000.0
Infrastructure	1,130.0	25.8	1,086.5	32.4	-	6,133.7	8,408.4
Health	2,799.0	3.0	43.0	-	-	236.0	3,081.0
Parks & Environment	300.0	100.7	265.0	27.0	-	101.2	793.9
Other ²	1,080.0	186.0	448.2	0.8	2.5	10,584.8	12,302.3
Total	\$15,045.1	\$1,784.9	\$6,602.6	\$527.8	\$143.7	\$17,780.8	\$41,884.9

Source: U.S. Department of Commerce. (2013). *Economic Impact of Hurricane Sandy*. Retrieved from <http://www.esa.doc.gov/sites/default/files/sandyfinal101713.pdf>

ADDITIONAL READINGS

An assessment of Manhattan's hospital response to Sandy

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4110437/>

Hospital Emergency Preparedness and Response During Superstorm Sandy

<http://oig.hhs.gov/oei/reports/oei-06-13-00260.asp>

A Stronger, More Resilient New York

http://s-media.nyc.gov/agencies/sirr/SIRR_spreads_Hi_Res.pdf

EXERCISE

It is Hurricane season again.

Which hospitals in your city are vulnerable to severe weather events? What events? What are the hospitals' vulnerabilities?

What is the contingency plan for electricity and water?

What are the communication channels within and among hospitals in case of a disaster event requiring the evacuation of a hospital?

What preparedness and mitigation steps must hospitals in your city undertake to ensure adequate communication, transport and redistribution of personnel between hospitals? What exists? What does not? And how will you address these gaps?

In case of a severe crippling storm like Hurricane Sandy, who in your city would be among the most vulnerable? How will you identify, protect, assist or rescue them? What measures can your city undertake to minimize their vulnerability?

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