Effects of the August 2003 blackout on the New York City healthcare delivery system: A lesson for disaster preparedness

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Background: **On August 14, 2003, the United States and Canada suffered the largest power failure in history. We report the effects of this blackout on New York City's healthcare system by examining the following: 1) citywide 911 emergency medical service (EMS) calls and ambulance responses; and 2) emergency department (ED) visits and hospital admissions to one of New York City's largest hospitals.**

Methods: **Citywide EMS calls and ambulance responses were categorized by 911 call type. Montefiore Medical Center (MMC) ED visits and hospital admissions were categorized by diagnosis and physician-reviewed for relationship to the blackout. Comparisons were made to the week pre- and postblackout.**

Results: **Citywide EMS calls numbered 5,299 on August 14, 2003, and 5,021 on August 15, 2003, a 58% increase ($p < .001$). During the blackout, there were increases in "respiratory" (189%; $p < .001$), "cardiac" (68%; $p = .016$), and "other" (40%; $p < .001$) EMS call categories, but when expressed as a percent of daily totals, "cardiac" was no longer significant. The MMC-ED reflected this surge with only "respiratory" visits significantly increased (expressed as percent of daily total visits; $p < .001$). Respiratory device failure (mechanical ventilators, positive pressure breathing assist devices, nebulizers, and oxygen compressors) was responsible for the greatest burden (65 MMC-ED visits, with 37 admissions) as compared with 0 pre- and postblackout.**

Conclusions: **The blackout dramatically increased EMS and hospital activity, with unexpected increases resulting from respiratory device failures in community-based patients. Our findings suggest that current capacity to respond to public health emergencies could be easily overwhelmed by widespread/prolonged power failure(s). Disaster preparedness planning would be greatly enhanced if fully operational, backup power systems were mandated, not only for acute care facilities, but also for community-based patients dependent on electrically powered lifesaving devices. (Crit Care Med 2005; 33[Suppl.]:S96–S101)**

Key Words: power failure; blackout; healthcare utilization; mechanical ventilators; respiratory failure

On Thursday, August 14, 2003, an electrical power failure of unprecedented proportion affected the northeastern United States and Canada. New York City (NYC) and its 13 million residents and workers suffered a blackout (complete power outage) at 4:00 pm, the beginning of the evening rush hour, with gradual restoration of power over the next day. Emergency medical service (EMS) and acute care hospitals, our first and second responders, are critical elements of any city's disaster preparedness planning. During this blackout, both experienced substantial demands, with increases in 911 calls, EMS ambulance responses, and hospital patient visits.

NYC last suffered citywide blackouts in 1965 and 1977. After the 1965 blackout, NY State regulations required mandatory backup power systems for its hospitals and long-term care facilities (1, 2). In the July 1977 blackout, emergency backup generators again failed at several hospitals (3–5). At Bellevue Hospital, a major trauma center, the emergency department (ED) was closed and 15 patients on mechanical ventilation were manually ventilated with bag–valve–mask devices by rotating staff; two patient deaths may have resulted (3, 4).

Since 1977, advances in medical care, communication, and information systems have greatly increased the power needs of a modern hospital. In the last decade, changes in healthcare delivery have encouraged the redistribution of substantial numbers of chronically ill patients dependent on electrically powered life-saving devices (mechanical ventilators, positive pressure breathing assist devices, nebulizers, oxygen compressors, and dialysis) to the community, living at home or in long-term chronic care facilities. Disaster preparedness planning for power failures must consider not only the modern acute care hospital, but also community-based patients dependent on electrically powered life-saving devices. This problem is made even more urgent when one considers that blackouts not only result from power failures, but also may occur during other major disasters (e.g., hurricanes, earthquakes, explosions, etc). Yet, despite heightened interest in disaster planning since September 11, 2001, we could find no published analyses, other than anecdotal reports in the lay press (3–5), on the impact of a widespread power failure on a modern municipal healthcare system. To highlight the impact of our healthcare system's increased electrical dependence on

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disaster preparedness planning, we report the effects of the August 2003 citywide blackout on NYC's healthcare delivery system by examining the following: 1) 911 EMS calls and ambulance responses for the entire city; and 2) ED visits and hospital admissions to Montefiore Medical Center (MMC), one of the city's largest hospitals.

METHODS

With approval from our institutional research review board, data from the NYC Fire Department EMS computerized ambulance dispatch and the MMC health information management systems were analyzed and MMC medical charts were reviewed. Daily 911 EMS call totals were categorized by NYC Fire Department EMS call types as follows: "cardiac" (cardiac arrest and diagnoses, including nontraumatic chest pain), "respiratory" (difficult breathing, asthma, status asthmaticus, chronic obstructive pulmonary disease, other respiratory diagnoses but *not* upper or lower tract infections unless associated with difficulty breathing), "trauma" (injury, sprains, strains, contusion, concussion, lacerations, fractures, burns, trauma, motor vehicle accident, pedestrian struck), "heat-related" (heat exhaustion, heat stroke, dizziness related to the heat), and "other." All 911 EMS calls require an ambulance response, but not all responses require hospital transport. The numbers of EMS ambulance transports were presented as citywide totals to all 911 receiving hospitals and to MMC alone. MMC-ED visits (all referral sources, adult and children) were classified by International Classification of Diseases, 9th revision diagnosis code (6) and categorized by NYC Fire Department EMS call types for comparison purposes. For 911 EMS calls, EMS transports, MMC-ED visits, and MMC hospital admissions, average daily totals during the blackout (August 14 and 15, 2003) were compared with the week pre- and postblackout. Length of stay was calculated for MMC-ED visits in hours (registration to discharge) and for MMC admissions in days (numerical difference between the admission and discharge date starting on the day of ED registration). Patients admitted and discharged on the same day were considered to have a 1-day length of stay. To correct for variations in activity, the number of EMS call types by category, EMS transports, MMC-ED visits by diagnostic category, and MMC hospital admissions were each expressed as a percent of the daily totals. For these outcomes, the daily average during the blackout was compared with averages in the week pre- and postblackout by analysis of variance. Significance was defined as $p < .05$.

MMC-ED and hospital records for the 48 hrs postblackout (August 14, 2003, 4 pm, to August 16, 2003, 4 pm) were also physician-reviewed and attributed to the blackout only if a causal relationship was documented in the medical record. Electrically powered respiratory devices included only mechanical ventilators, positive pressure breathing assist devices, nebulizers, oxygen compressors, and tracheal suctioning equipment. Fatalities at MMC were reviewed to determine whether they were blackout-related. In addition, respiratory care suppliers and long-term care facilities within the MMC catchment area were surveyed for daily census, backup power capabilities, and activity during the blackout.

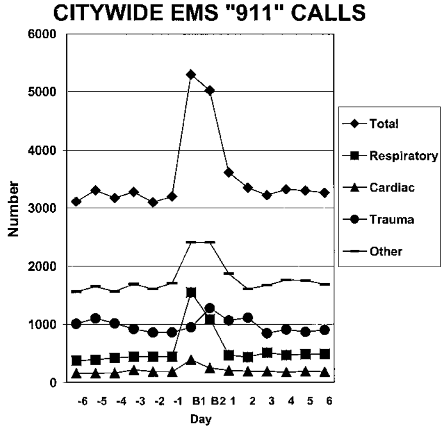

Figure 1. Citywide emergency medical service (*EMS*) calls numbered 5,299 on day 1 of the blackout (*B1*) and 5,021 on day 2 of the blackout (*B2*), a significant increase of 58% (mean, 5,100; $p < .001$) when compared with daily averages in the pre- and postblackout periods (means, 3,168 preblackout and 3,358 postblackout). When citywide daily averages for calls by category were compared during the blackout with the pre- and postblackout periods, there were significant increases in "respiratory" (189%; $p < .001$), "cardiac" (68%; $p = .016$), and "other" (40%; $p < .001$). However, when expressed as a percent of total EMS calls, "cardiac" calls were no longer significantly increased.

RESULTS

Citywide EMS calls numbered 5,299 on August 14, 2003, and 5,021 on August 15, 2003, a significant increase of 58% (mean, 5,100; $p < .001$) when compared with daily averages in the pre- and postblackout periods (means, 3,168 preblackout and 3,358 postblackout; Fig. 1). When citywide daily averages for calls by category were compared during the blackout with the pre- and postblackout periods, there were significant increases in "respiratory" (189%; $p < .001$), "cardiac" (68%; $p = .016$), and "other" (40%; $p < .001$) (Fig. 1). The increase in "trauma" calls was not significant (17%; $p = .271$). Despite relatively mild temperatures (72–83°F; U.S. Weather Service, personal communication), "heat-related " calls, although few, increased by sevenfold, from a daily average of 3 calls pre- and postblackout to 26 and 24 calls on August 14, 2003, and August 15, 2003 ($p < .001$). When the number of EMS calls by category were expressed as a percent of the total number of EMS calls that day, the increases in "respiratory" ($p < .001$) and "other" ($p = .027$) categories remained significant when the daily average during the blackout was compared with the daily averages in the pre- and postblackout periods. Similar findings were found in all five boroughs of NYC, including the Bronx (Fig. 2).

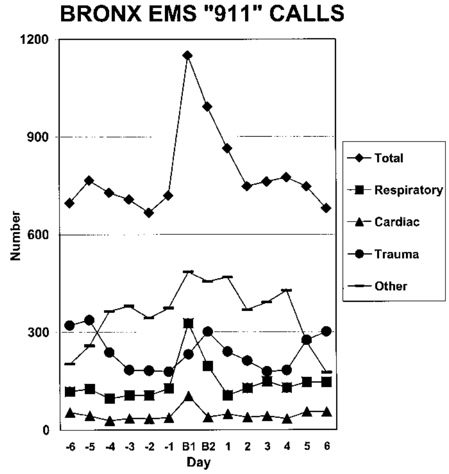

Figure 2. Emergency medical service (EMS) calls in the Bronx (Montefiore Medical Center is located in this borough of New York City) numbered 1,150 on day 1 of the blackout (*B1*) and 993 on day 2 of the blackout (*B2*), a significant increase of 44% (mean, 1,072; $p < .001$) when compared with daily averages in the pre- and postblackout periods (means, 716 preblackout and 777 postblackout). When citywide daily averages for calls by category were compared during the blackout with pre- and postblackout periods, there were significant increases in "respiratory" (118%; $p = .022$) and "cardiac" (96%; $p = .032$), and "trauma" (34%; $p = .042$). However, when expressed as a percent of total EMS calls, "cardiac" and "trauma" calls were no longer significantly increased.

Citywide EMS transports to acute care hospitals numbered 2,545 on August 14, 2003, and 2,877 on August 15, 2003, for an average daily increase of 9% ($p = .128$) as compared with daily averages during the pre- and postblackout periods (means: 2,509 preblackout, 2,711 during blackout, and 2,486 postblackout). When transports were expressed as percent of total calls, there was actually a substan-

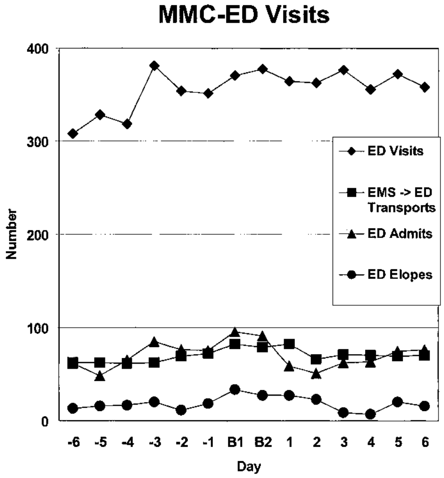

Figure 3. Montefiore Medical Center (*MMC*) emergency department (*ED*) visits (all referral sources; children and adult) numbered 370 on day 1 of the blackout (*B1*) and 377 on day 2 of the blackout (*B2*), for only a 6% increase (mean, 374; $p = .065$) as compared with daily averages of 340 and 365 in the pre- and postblackout periods. MMC admissions numbered 95 on B1 and 91 on B2, for a 40% increase (mean, 93; $p = .024$) as compared with daily averages of 68 and 64 in the pre- and postblackout periods. EMS transports to the MMC emergency department during the blackout increased by 18% (mean, 81; $p = .039$) as compared with pre- and postblackout periods. Emergency department elopements (patients registered, triaged, and seen by a physician but leaving without treatment) during the blackout increased by 83% (mean, 30; $p = .035$) as compared with pre- and postblackout periods. These comparisons remained significant when the numbers were expressed as percent of total MMC emergency department visits.

tial decrease from daily averages of 70% during the pre- and postblackout periods to 50% during the blackout ($p < .001$). This was the result of an increase in the numbers of "patients not found or gone" when EMS arrived, from a daily average of 15% of total calls in the week pre- and post blackout periods to 23% during the blackout ($p < .001$). There were no significant changes (percent of total calls) in other nontransport categories (e.g., patient refused transport, EMS unit canceled, EMS unit only present to assist other unit, or "dead on arrival").

MMC-ED visits (all referral sources; children and adult) numbered 370 on August 14, 2003, and 377 on August 15, 2003, for only a 6% increase (mean, 374; $p = .065$) as compared with daily averages of 340 and 365 in the pre- and postblackout periods (Fig. 3). MMC admissions (all referral sources, adult and children) numbered 95 on August 14, 2003, and 91 on August 15, 2003, for a 40% increase (mean, 93; $p = .024$) as compared with daily averages of 68 and 64 in the pre- and postblackout periods (Fig. 3). This comparison remained significant when the number of admissions were expressed as percent of total MMC-ED visits (32% increase; $p = .017$). Elopements from the ED (patients registered, triaged, and seen by a physician but leaving without treatment) during the blackout numbered 33 and 27 on August 14, 2003, and August 15, 2003, respectively, for an 83% increase (mean, 30; $p = .035$) as compared with daily averages of 16 and 17 in the pre- and postblackout periods. This comparison remained significant when the number of elopements were expressed as percent of total MMC-ED visits (74% increase; $p = .021$).

When daily averages for MMC-ED visits by diagnosis category were compared during the blackout with pre- and postblackout periods, there were significant increases in "respiratory" (74% increase; $p < .001$) and "trauma" visits (49% increase; $p = .012$). "Heat stress" visits were few but increased from daily averages of 0 cases pre- and postblackout to nine cases on August 14, 2003, and one case on August 15, 2003 ($p = .01$). When the number of MMC-ED visits by category were expressed as a percent of the total number of MMC-ED visits that day, only the increase in "respiratory" visits ($p < .001$) remained significant when the daily average during the blackout was compared with the daily averages in the pre- and postblackout periods (Fig. 4).

Medical records for all MMC-ED visits and MMC-admissions during the 48 hrs postblackout period were physician-reviewed for documented causal relationships to the blackout. Community-based chronically ill patients with respiratory device failure were responsible for the greatest burden (65 MMC-ED visits, of which 37 patients required MMC admission) as compared with 0 pre- and postblackout (Tables 1 and 2). Other blackout-related diagnoses resulted in 44 patients requiring an MMC-ED visit, of which only seven patients required admission (Tables 1 and 2). For respiratory device failure, adults (nearly all elderly) outnumbered pediatric patients, and median length of stay in the ED or hospital was only one day (Tables 1 and 2), indicating a rapid turnaround, but also the need for additional resources (administrative, social work, nursing, and private

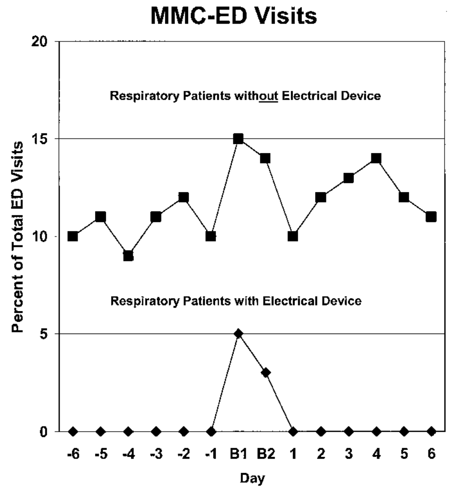

Figure 4. If the number of Montefiore Medical Center (*MMC*) emergency department (*ED*) visits by category were expressed as a percent of the total number of MMC emergency department visits that day, only the increase in "respiratory" visits ($p < .001$) remained significant when the daily average during the blackout was compared with the daily averages in the pre- and postblackout periods. "Respiratory" visits for patients who require electrical devices (mechanical ventilators, bilevel positive airway pressure assistance, nebulizers, and oxygen by concentrators) accounted for 5% and 3% of MMC emergency department visits on day 1 (*B1*) and day 2 (*B2*) of the blackout. These patients represented the greatest burden to the emergency department and hospital with 65 patients requiring an MMC emergency department visit, of which 37 of the 65 patients required admission.

ambulances) for return transports to their original care locations.

In cases with extended ED management rather than hospital admission, the decision not to admit was unrelated to illness acuity but instead was based on the following: 1) administrative needs to distribute impact according to available staff/beds; and 2) time of arrival, i.e., late arrivals remained in the MMC-ED because news reports suggested that power restoration was imminent. A physician reviewed all hospital mortalities occurring during this period. None of the deaths were attributable to the blackout, and there was no significant change in the number of hospital deaths compared with the average rate in August 2004.

Most MMC outpatients who are dependent on respiratory equipment receive their supplies from a single vendor. The ten mechanically ventilated patients are supplied with a 24-hr battery backup system. Nevertheless, two of the ten went to the hospital concerned that backup

Table 1. Montefiore Medical Center emergency department (MMC-ED) visits—blackout-related August 14–15, 2003

	MMC-ED Visits,[a] Median (Range)					
	Pediatric			Adult		
Reason	No.	Age (Yrs)	Length of Stay (Hrs)	No.	Age (Yrs)	Length of Stay (Hrs)
Respiratory device						
Mechanical ventilator	1	1.5	24	1	82	6
Oxygen	0	—	—	12	76 (39–103)	16 (6–45)
Nebulizer ± oxygen	7	3 (1.5–14)	7 (2–9)	4	78 (68–95)	18 (15–42)
Pressure assist (bilevel positive airway pressure)	0	—	—	2	44 (38–49)	18 (12–24)
Respiratory suction	1	13	2	0	—	M
Respiratory device stats	9	3 (1.5–14)	7 (2–24)	19	75 (38–103)	16 (6–45)
Other						
Dialysis	1	17	13	2	56 (52–60)	9 (7–11)
Heat-related	1	3	2	9	70 (21–92)	7 (3–21)
Trauma	2	17	10 (6–13)	10	46 (38–75)	7 (2–28)
Psychiatric	1	11	7	0	—	—
Chest pain while trapped	0	—	—	1	38	4
Medication-related†	1	4	3	9	49 (20–88)	13 (5–24)
Other stats	6	14 (3–17)	6 (2–13)	31	48 (20–92)	8 (2–28)
Totals	15	4 (1.5–17)	7 (2–24)	50	65 (20–103)	11 (2–45)

[a]ED visits excludes admissions so total ED burden equals ED visits plus hospital admissions; [b]medication-related = unable to find/reach medications or unable to obtain tests needed to adjust medications (e.g., warfarin).

power would be inadequate. For this vendor, all 1,220 patients requiring home oxygen are supplied with electric-powered oxygen concentrators and backup oxygen cylinders (M80 oxygen cylinders at 2 L/min last 12 hrs). On the night of the blackout, 243 M80 cylinders were delivered emergently, a 156% increase when compared with an average daily delivery of 95 M80 cylinders.

In the MMC catchment area, there are six long-term care facilities with a combined census of 164 mechanically ventilated patients on August 14, 2003 (18–40 patients per facility). Apparently, backup generators were available, but mechanical problems and adequate fuel supplies limited their usefulness in some locations. At least 15 patients from long-term care facility(s) were transported to acute care hospitals in the Bronx. More transports would have occurred if the blackout had continued and emergency fuel supplies were limited or unavailable.

DISCUSSION

On August 14, 2003, a power failure cascaded through eight states, becoming the largest blackout in U.S. history. NYC

Table 2. Montefiore Medical Center (MMC) hospital admissions—blackout-related August 14–15, 2003

	MMC Hospital Admissions, Median (Range)					
	Pediatric			Adult		
Cause	No.	Age (Yrs)	Length of Stay (Days)	No.	Age (Yrs)	Length of Stay (Days)
Respiratory device						
Mechanical ventilator	2	8 (1.5–15)	1	7	72 (26–87)	1 (1–2)
Oxygen	1	7	1	9	85 (66–93)	1 (1–12)
Nebulizer ± oxygen	6	7 (0.5–12)	2 (1–3)	7	72 (40–89)	3 (1–5)
Pressure assist (bilevel positive airway pressure)	2	5	1	3	60 (43–68)	2 (1–4)
Respiratory suction	0	—	—	0	—	—
Respiratory device stats	11	5 (0.5–15)	1 (1–3)	26	74 (26–93)	1 (1–12)
Other						
Dialysis	0	—	—	1	71	3
Heat-related	0	—	—	0	—	—
Trauma	0	—	—	3	91 (84–91)	5 (4–7)
Psychiatric	0	—	—	1	61	13
Chest pain while trapped	0	—	—	2	79 (70–88)	3 (1–4)
Medication-related[a]	0	—	—	0	—	—
Other stats	0			7	84 (61–91)	4 (1–13)
Totals	11	5 (0.5–15)	1 (1–3)	33	69 (26–93)	1 (1–13)

[a]Medication-related = unable to find/reach medications or unable to obtain tests needed to adjust medications (e.g., warfarin).

suffered a citywide blackout at 4:00 pm, the beginning of evening rush hour. Municipal resources (Mayor's Office, Office of Emergency Management, Police, Fire, and EMS) were quickly mobilized. By all accounts, disaster plans implemented by government, financial institutions, and private industry were successful, in large-part as a result of lessons learned from prior blackouts, the World Trade Center attack, and the coordinated response to recent biologic threats: anthrax, smallpox, and severe acute respiratory distress syndrome (SARS). Communication to the public was rapid and well-conceived, crime did not increase, and critical computer systems were not significantly disrupted.

During the blackout, EMS and hospital activity surged dramatically, in large part as a result of unexpected increases in calls/visits from community-based patients dependent on electrically powered lifesaving respiratory care devices. It is likely that "heat-related" calls and hospital visits would have also significantly increased if not for a relatively mild night for NYC in mid-August. NYC EMS calls increased from a daily average of 3,274 in the weeks pre- and postblackout to 5,299 on August 14, 2003, and 5,021 on August 15, 2003, a 62% and 53% increase, respectively. "Respiratory" call types showed the greatest increase (189%). During the blackout, MMC-ED visits increased by only 6% but "respiratory" visits increased by 74%, mostly as a result of an influx of community-based patients dependent on electrically powered respiratory devices. These patients came from homes without backup power or from long-term care facilities with inadequate backup power. This increased patient acuity along with the news that power would not be restored until the next day, resulting in a 40% increase in MMC hospital admissions. Of the 65 MMC-ED visits for blackout-related respiratory device failure, 57% were admitted and the remaining patients received lengthy ED treatment, avoiding admission only when news reports indicated imminent power restoration on day 2. MMC hospital records indicate that it is rare to have even a single patient admission for respiratory device failure.

This was not the first citywide blackout because power outages occur for many reasons, including natural and manmade disasters. Despite prior occurrences, we could find no study in the medical literature examining the effects of a blackout on a city's healthcare delivery system. Isolated power failures to a surgical operating room (7) and intensive care units (8, 9) have been reported, demonstrating the need for backup power systems. After the 1965 NYC blackout, NY State regulated mandatory power backup systems for its hospitals and long-term care facilities (1). Twelve years later, during the July 1977 blackout, there were still failures of emergency diesel-powered generators at several NYC hospitals (3–5). In response to this and other emergencies, standards for hospital power backup systems were improved and instituted at local, state, and national levels (1, 2).

Yet, over the last decade, advances in medical care, communication, and information systems have greatly increased the electrical power needs of acute and chronic care hospitals. Uninterrupted electrical power is now an absolute requirement for the care of critically ill patients. Our success in treating the critically ill has created a large and growing group of chronically ill patients dependent on electric power for varying degrees of life support. With increasing frequency, these patients now live in their own homes or in long-term care facilities.

Electrically powered medically necessary or lifesaving devices include not only respiratory care equipment, but also dialysis, cardiac support, arrhythmia monitoring, enteral and parenteral nutrition, and intravenous medication pumps. In a power failure, community-based patients requiring respiratory care devices are extremely vulnerable, whereas patients depending on other electrically powered medical devices remain relatively unharmed unless power failures are prolonged for days. Patients on mechanical ventilators living at long-term care facilities are the most vulnerable because they have the lowest performance status and complex medical/nursing needs.

Our findings clearly demonstrate the impact of a power failure on increased resource utilization of EMS resources and acute care hospitals. For chronically ill patients, EMS and hospitals are the current default transport and care sites, respectively. In the months before and after the blackout, mean EMS response time to calls prioritized as potentially life-threatening was approximately 6:50 mins and for all calls 8:14 mins. During the 2 blackout days, EMS response times were significantly impacted, and at times were as much as 100% greater, depending on call priority, with the highest priority calls receiving resources first. Increased response times were the result of 1) the almost 60% increase in number of calls received, 2) the number of ventilator-dependent patients requiring transport from facilities with failure or imminent failure of electrical backup power, 3) a proportionally small increase in the number of ambulances available (EMS units were added as capacity allowed and approximately 50 mutual aide units were deployed), and 4) travel delays (gridlock at key intersections, nonfunctioning traffic signals and decreased driving speed by EMS crews as a safety precaution for large numbers of street walkers, and darkness from nonfunctioning street lights). Despite the increase in the number of calls or ambulance responses, the number of transports actually decreased. The EMS transport paradigm was not altered during the blackout. Instead, the decrease in transports was explained by an increase in number of "patients not found or gone" when EMS arrived, especially for low-priority calls, perhaps as a result of the longer response times experienced.

The greatest source of increased demand on MMC was by community-based chronically ill patients needing electricity to power essential respiratory support devices, especially those on mechanical ventilators. For example, early in the morning of August 15, MMC was asked to accept 15 chronically patients on chronic mechanical ventilation from a local nursing home because their backup generator fuel supply was nearly exhausted and could not be replenished. Given the already high demand on available bed and ventilator capacity, MMC accepted seven patients, whereas the remaining were transferred to other local hospitals. Throughout the blackout, MMC received additional inquiries from acute care hospitals and long-term care facilities about existing capacity to accept transfers of acute and chronically ill mechanically ventilated patients. Contingency plans were made, although capacity was already severely strained. Fortunately, power was restored and other transfers were unnecessary. If power disruption had continued, such patients from home and long-term care facilities would have quickly overloaded this and other acute care hospitals.

Although we did not study the blackout's impact on other NYC hospitals, we believe that MMC-ED visit and admission data reasonably reflect patient activity in other hospitals. Similar trends for daily variations in EMS calls, ambulance responses, and transports were found, whether analyzed for the entire city or by any single NYC borough such as the Bronx. During the blackout, NYC hospitals relied on backup diesel-powered generators, leaving nonessential equipment underpowered or nonfunctional. At least six NYC hospitals and five long-term care facilities reported generator failures (intermittent or complete), and during those time periods, mechanically ventilated patients depended on battery-powered backup internal to the ventilator, manual ventilation by hospital staff, or transfer by ambulance to other facilities (10). Typically, the NY State Patient Occurrence and Tracking System (a mandatory statewide reporting system for hospitals and nursing homes on patient safety issues) receives zero to two reports of device failure. On August 14, 2003, there were 43 reports of device failures from healthcare facilities in NY State. Details are not yet available, but NY State has convened a workgroup to review power failure preparedness, including emergency generator capacity (NY State Department of Health, personal communication).

MMC was the only NYC hospital with an on-site, self-sufficient, cogeneration plant that regularly supplies electric power to the hospital at all times, supplemented as needed by public utilities. During the blackout, MMC remained fully powered by its own cogeneration plant. There were no disruption in services, although elective surgical and procedure cases were canceled as a precaution. MMC's cogeneration plant has a total capacity 14 MW, consisting of one gas turbine (5 MW) and five diesel engines (two of which are for backup). It produces both electricity and steam from turbine and engine exhaust (waste heat), hence the term cogeneration, producing two forms of power from one source of fuel combustion, in our model, gas or oil.

Since September 11, 2001, the NYC healthcare system, particularly acute care hospitals, has been extensively trained to respond to disasters, particularly terrorist events. Anthrax bioterrorism cases in October 2001, the spread of SARS in 2003, and the recent smallpox vaccination program have further conditioned our healthcare system to accept a central role in disaster response. The Department of Health and Human Services, Homeland Security, the Centers for Disease Control and Prevention, the NYC Department of Health and Mental Hygiene, the NYC Fire Department's EMS, and hospital trade groups such as the Greater New York Hospital Association have organized medical disaster planning sessions and drills to improve our response to nuclear, biologic, and chemical disasters. What this blackout made all too clear is that the success of our modern healthcare system, both during day-to-day activities and during disasters, depends on an uninterrupted electrical power supply operating at full or near-full capacity. Furthermore, just as our electrical grid was shutdown by seemingly distant problems, our acute healthcare system was similarly affected by "distant" problems, i.e., those in the long-term care setting. Even with full electrical power, MMC did not have the staff, spare ventilators, or bed availability to accept both the expected flows of acutely ill patients from the ED and chronically ill, ventilator-dependent patients from home or long-term care facilities. Our data demonstrate that the blackout posed a severe test to the capacity of healthcare first responders (EMS) and second responders (acute care hospitals) in NYC. The ability of our healthcare system to respond to a prolonged blackout or to a simultaneous second event would have been severely constrained because EMS and hospitals (ED, inpatient, and critical care beds) were already at near-full capacity with little reserve.

Because many disasters, natural or unnatural, would be expected to compromise electrical power, disaster preparedness planning must account for medically needed electrical power requirements in healthcare facilities and the community. To maintain the capacity of our public health infrastructure to respond to acute medical needs in a disaster, backup power systems must be available for community-based patients and chronic care facilities, without reliance on acute care responders. Assuring an adequate power supply for acute and chronic healthcare needs must be considered a central component of future public health disaster planning.

Given these data from NYC suggesting that current health-related power backup systems can be overwhelmed, threatening our overall disaster response, we suggest that public health disaster planning include the following: 1) educating all healthcare providers (acute, chronic, and home-based) about the extent of their current backup power supplies and the need for maintaining and improving this supply; 2) mandating acute and chronic healthcare facilities to have backup power adequate to supply clinical demands for at least 48 hrs; 3) mandate health facilities to have backup systems for communication and computerized medical information systems; 4) to regularly update and test these backup systems at full clinical load; 5) through economic incentives, encourage healthcare facilities to install cogeneration plants; 6) require home-based patients who are dependent on electrically powered lifesaving devices to have a backup system capable of lasting for at least 24 hrs; 7) develop a registry, available to the local hospital and municipal authorities, of patients dependent on electrically powered lifesaving devices; and 8) a coordinated blackout disaster plan for the resupply of fuel during prolonged blackouts and/or the redistribution of patients (hospital and community-based) to sites with power in the event backup systems fail.

Healthcare institutions must learn the same lessons from this blackout that financial institutions have apparently learned from prior blackouts: disaster preparedness planning must include assurance of uninterrupted power to the entire healthcare system, including not only hospitals, but long-term care facilities and outpatients dependent on electrically powered lifesaving devices.

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