Health Impacts of Power Outages and Warm Weather on Food Safety

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Report Summary

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Abstract

Climate change could potentially increase the frequency of power outages due to severe weather events and increased demand during hotter summers. New York City has a large concentration of high-rise buildings and significant dependence on a mass transit system which could heighten the risk of power outage health impacts, especially among the most at-risk populations, such as older adults or people who use electric medical equipment. In addition, power outages, and hot weather that occurs with or without outages, provide an opportunity for increased food spoilage and foodborne illness. A better understanding of current risks, including the health impacts of smaller-scale outages, preparedness in at-risk populations, and hot weather effects on gastrointestinal illness and restaurant food safety, may help inform preparedness and educational materials. This project consisted of four research components: (1) time-series analysis of the acute impacts of major and localized power outages on morbidity and mortality outcomes; (2) a telephone survey of NYC residents to understand power outage preparedness; (3) time-series analysis of the impacts of ambient temperature on the emergency department (ED) visits for gastrointestinal illnesses and restaurant food safety violations during the warm season (May–September); and (4) focus groups of NYC restaurant operators to understand their experiences with hot weather and power outages. The analysis of power outages replicated the 2003 citywide outage impacts on mortality reported in past studies but also found large impacts of major localized outages in the warm season, with relative risks comparable to that of the citywide event, albeit with less precision, in multiple health outcomes, including respiratory hospitalizations and all-cause deaths. In the pooled analysis of smaller local outages during the cold months, associations were found for all-cause deaths and cardiovascular hospitalizations. Results from the telephone survey suggested that—although concern about power outages was higher among older adults and households with someone requiring assistance with daily activities or dependent on electric medical equipment—preparedness was still low for some of these at-risk groups. Based on our findings, and with feedback from our partners, we conducted a poster and postcard campaign to increase preparedness among people who use electric medical equipment in selected, high-risk neighborhoods. The analysis of gastrointestinal ED visits found that daily maximum temperature during the warm season was associated with this outcome, especially among children (age 5–17). In the analysis of ambient temperature and restaurant inspections data, higher temperature was associated with cold-food holding violations and no or insufficient refrigerated or hot holding equipment violations, which was consistent with refrigeration breakdowns described by restaurant

operators in the focus groups. These findings support a possible mechanism for the increased risk of gastrointestinal illness on hotter days since holding cold foods at warmer temperatures could increase the growth of foodborne pathogens. Focus group participants also expressed the need for more concise guidance on impacts due to hot weather and power outages. These findings can inform emergency planning and climate adaptation for current and future heat and power outage events in NYC.

Keywords

Power outages, hospitalizations, mortality, preparedness, hot days, acute gastroenteritis, food safety

Acknowledgments

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1 Background

Climate change is expected to increase average summer temperatures, as well as the frequency of heat-waves and severe storms (IPCC 2007; Diffenbaugh, Scherer, and Trapp 2013). With these changes, there may be a greater occurrence of power outages due to higher electricity demands in the summer and storm-related damage to energy infrastructure (Horton et al. 2010). Power outages can greatly impact public health. Without adaptation, future health impacts of power outages may increase as the climate changes.

New York City has experienced considerable impacts due to power outages. Superstorm Sandy was a major coastal storm that hit NYC on October 29, 2012 disrupting one-third of the city's electric generating capacity and other vital infrastructure (The City of New York 2013). Over two million city residents lost power and many remained without power, water, and heat for an extended period of time (The City of New York 2013). The August 14–15, 2003 outage originated in Ohio due to equipment failure and cascaded throughout the Northeastern United States, affecting NYC's 8 million residents (U.S.–Canada Power System Outage Task Force 2004). This citywide outage disrupted potable water pumping equipment and elevators compromising the safety of water and stranding residents in the city's large concentration of high-rise buildings (Marx et al. 2006; Beatty et al. 2006).

Some significant power outages in NYC have been confined to smaller areas. On July 6, 1999, all 68,888 electricity customers (more than 200,000 residents) in the Washington Heights electric grid network lost power for 18 hours (Office of the Attorney General 2000). Beginning on July 17, 2006, 65,000 customers (174,000 residents) in the Long Island City electric grid network had no power for nine days (New York State Assemby Queens Task Force 2007; Department of Public Service 2007). These non-citywide outages coincided with extreme heat events when power usage is typically at its peak (New York City Emergency Management 2016); however, winter month outages from wind, ice, and snow can also occur.

In recent years, the understanding of the health effects produced by major power outages has grown. Previous studies reported significant increases of carbon monoxide poisonings during power outages associated with the incorrect use of devices for generating electricity, heating, and cooking during hurricanes and major winter storms. (Chen et al. 2013; Damon et al. 2013; Muscatiello et al. 2010). Large-scale outages may exacerbate chronic health conditions as evidenced by increased all-cause mortality (Anderson and Bell 2012) and respiratory hospitalizations (Lin et al. 2011) during the

2003 outage. A loss of air conditioning or heating during power outages that occur on very hot or cold days may increase the risk of heat- and cold-related illnesses and exacerbate chronic conditions (Seltenrich 2015). It is possible that smaller-scale power outages pose similar risks as larger outages; however, information on smaller-scale events is limited.

Power outages at any scale can have greater health effects in the most vulnerable residents. As demonstrated in studies of the 2003 outage and Superstorm Sandy (Lin et al. 2011; Prezant et al. 2005; Gotanda et al. 2015; Lee et al. 2016), older adults, people who rely on a caregiver to perform daily activities, and those who depend on electric medical equipment are frequently at greater risk.

Power outages also provide an opportunity for increased food spoilage and foodborne illness by compromising refrigeration. In NYC, during the 2003 outage, emergency department visits for diarrhea, sales of antidiarrheal medication, and gastrointestinal illnesses as causes of worker absenteeism increased (Marx et al. 2006). Hot weather occurring with or without a power outage may also make it harder to maintain safe temperatures for potentially hazardous foods.

To support climate adaptation strategies, evidence-based research is needed. Quantitative and qualitative analyses were conducted to better understand current risks, which may help inform preparedness and outreach for future warmer summers and power outage events in NYC. The aims of the study were to (1) examine the health impacts of citywide and localized outages in NYC using known outage events and additional warm- and cold-weather outages identified from the New York State Public Service Commission (NYSPSC) data, (2) assess power outage preparedness in NYC adults, especially vulnerable populations, (3) examine hot weather impacts on acute gastroenteritis as defined by Scallan et al. (Scallan et al. 2011) and restaurant food safety violations identified from NYC restaurant inspection data (City of New York), and (4) understand restaurant operators' experiences with hot weather and power outages.

The overall design used Poisson time series regression with distributed lags (Gasparrini 2011) to understand the acute impacts of power outages and ambient temperature distributed over multiple days prior to the occurrence of hospitalization or death. For these analyses, the unit of analysis was a person. This approach was additionally used to estimate the short-term effects of ambient temperature on food safety violations in which restaurant inspection was the unit of analysis. A survey and focus groups were conducted to understand power outage preparedness and restaurant operator hot weather and power outage experiences. All study protocols were approved by the NYC Department of Health and Mental Hygiene (DOHMH) Institutional Review Board. Further details of the methods and findings summarized in this report are available in three journal publications (Dominianni, Lane, Johnson, et al. 2018; Dominianni, Lane, Ahmed, et al. 2018; Dominianni, Ahmed, Johnson, et al. 2018).

2 Health Impacts of Power Outages in NYC

2.1 NYC Power Outages

Power outage data was available for 89 NYC electric grid networks identified from the NYSPSC data from January 2002 to June 2014. NYSPSC regulates the utilities which are required to report the number of customers (electricity meters) without power. The electric grid networks consisted of underground networks and overhead load areas. Those that overlapped within the same geography were combined (hereafter “network”). The final analytic number of networks was 66 (Figure 1).

Figure 1. Boundaries of the 66 NYC Electric Grid Networks

Typically, only a fraction of customers in the involved network(s) had no power so that a threshold of number of customers without power was used to define network-level outages. Warm (May–September) outage days were defined as at least 1,000 electricity customers without power at any point. Cold (October–April) outage days were defined as at least 75 electricity customers without power because there were fewer outages during the cold season. Superstorm Sandy-related outages were excluded because isolating the effects of power outages from the effects of the hurricane was beyond the scope of the analysis. In addition, networks with low exposure (≤1 outage) or small health outcome counts (mean daily count <1) were excluded. Twelve events were identified as warm-weather outages impacting 1,014 to 481,420 electricity customers within one to 16 networks on any given day, and 106 events were identified as cold-weather outages impacting 78 to 25,909 electricity customers within one to 24 networks on any given day.

Public reports were used to identify documented outages not captured in the NYSPSC data (New York State Assemby Queens Task Force 2007; U.S.–Canada Power System Outage Task Force 2004; Office of the Attorney General 2000). This included the 1999 power outage which affected all of the Washington Heights network on July 6-–7; the 2003 power outage which affected all NYC networks on August 14–15; and the 2006 power outage which affected part of the Long Island City network, for which the boundaries of the impacted area were identified during July 17–26. The entire population of the involved area or networks were affected, so on these dates, the areas were coded as having outages.

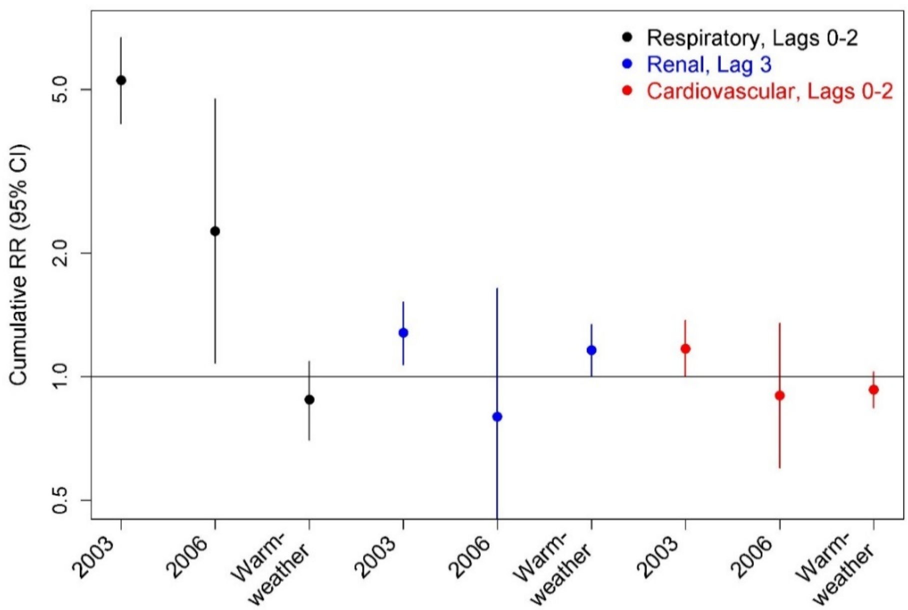
Power outage exposure was assigned to the individual-level health data by geocoding residential addresses to a tax parcel number and then assigning to one of the 66 electric grid networks.

2.2 Warm-Season Outages and Hospitalizations

The New York State Department of Health's Statewide Planning and Research Cooperative System (SPARCS) (New York State Department of Health) was used to identify NYC residents admitted through a NYC emergency department and hospitalized between 2000 and 2013. The 2006 localized outage was positively associated with hospitalizations for respiratory illnesses (Cumulative Relative Risk [CRR] over lags 0 through 2: 2.26, 95% CI: 1.08, 4.74) as can be seen in Figure 2. The effects of warm-weather outages identified from NYSPSC were estimated for each network and then pooled by meta-analysis methods (Viechtbauer 2010). An association was observed between these outages and renal hospitalizations at lag 3 only (RR: 1.16, 95% CI: 1.00, 1.34). Both associations were observed with the 2003 citywide outage (CRR of respiratory hospitalizations: 5.26, 95% CI: 4.13, 6.70; RR of renal hospitalizations: 1.28, 95% CI: 1.07, 1.52). The 2003 citywide outage showed a modest increase in risk of cardiovascular disease (CVD) hospitalizations (CRR over lags 0-2 = 1.17, 95% CI: 1.00, 1.37), while the 2006 outage and pooled outages were not associated with this outcome. The 1999 localized outage could not be assessed with hospitalizations because data was not available prior to 2000.

Figure 2. Impact of the 2003, 2006, and Pooled, Warm-Weather Outages on Hospitalizations

Models adjusted for day of week, holiday, year, temperature effects and within-season temporal trends. CRRs were estimated by summing the lag-specific contributions for CVD and respiratory hospitalizations. The relative risk at lag 3 only is shown for renal hospitalizations since there was no indication of multiday effects.

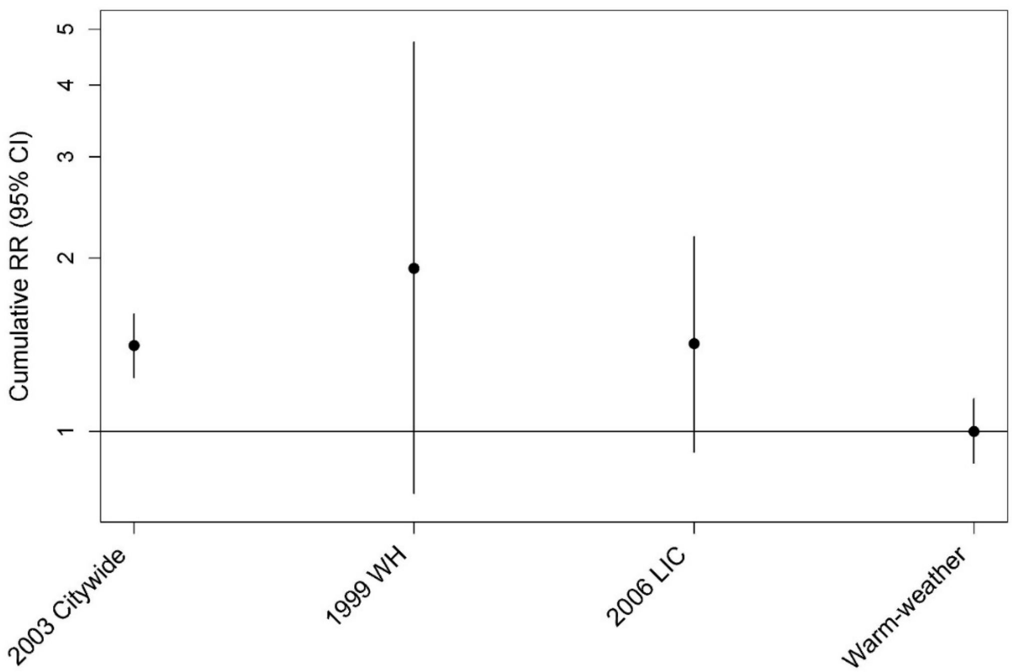


2.3 Warm-Season Outages and Mortality

All deaths among NYC residents between 1997 and 2014 were obtained from the NYC DOHMH Office of Vital Statistics and categorized as all-cause mortality. The magnitude of risks for all-cause mortality with the localized 1999 and 2006 outages were comparable, if not greater (CRR [95% CI] at lags 0 through 1: 1.92 [0.78, 4.75] and 1.42 [0.92, 2.18], respectively) as seen in Figure 3, to the citywide outage (CRR at lags 0 through 1: 1.41, 95% CI: 1.24, 1.60), though not statistically significant (likely due to small daily counts). The pooled, warm-weather outages were not associated with all-cause mortality.

Figure 3. Impact of the 2003, 1999, 2006 and Pooled, Warm-Weather Outages on All-Cause Mortality

Models adjusted for day of week, holiday, year, temperature effects and within-season temporal trends. CRRs were estimated by summing the effects at lags 0 through 1.



2.4 Cold-Season Outage Health Impacts

Cold-weather outages, which were pooled across networks, were associated with greater mortality (CRR over lags 0 through 1: 1.06, 95% CI: 1.01, 1.12) and cardiovascular disease hospitalizations (CRR over lags 0 through 1: 1.14, 95% CI: 1.03, 1.26).

2.5 Public Health Implications

These findings suggest that localized power outages can impact health considerably. The 1999 and 2006 localized outages presented similar challenges as the citywide outage, such as exposure to warm temperatures worsened by lack of air conditioning, impaired transit systems and elevators, and increased stress associated with not having power. Even though fewer people were without power, those with underlying health conditions may have experienced worse effects. The additional warm-weather outages that occurred throughout NYC over the last decade may have not been severe enough to impact mortality but may have increased the risk of hospitalization for renal illnesses. Increased heat exposure and physical exertion (Bouchama and Knochel 2002), as well as disruptions in dialysis appointments (Lempert and Kopp 2013), may have worsened renal outcomes. Cold-weather outages were associated with all-cause mortality and cardiovascular disease hospitalizations possibly due to increased exposure to lower indoor temperatures, which may exacerbate chronic health conditions (Lin, Soim, et al. 2016). It must be noted that the study was limited by simple assignments of health outcomes at residential addresses to the networks that experienced power outages. Without individual or household-level data on the location of outages, it could not be determined if the subject who had an adverse outcome was home at the time of the outage or had alternative sources of power. These limitations could have masked potential associations or biased results.

3 Power Outage Preparedness among NYC Adults

3.1 Random Digit Dial Survey

Having critical items of an emergency preparedness plan (Federal Emergency Management Agency 2017), especially for the most vulnerable, may reduce impacts by helping people to shelter in place. This includes a working flashlight, three-day supply of non-perishable food and drinking water, extra medications, and backup power supply for medical equipment. Developing a plan to identify exit routes from homes and neighborhoods, and meeting spots for all household members (New York City Office of Emergency Management 2014) is another important component of preparedness for events that may require evacuation. For people who are electric-dependent, preparedness also includes signing up with their utility company to receive notification before a power outage (Trento and Allen 2014). There have been few studies on preparedness where power outages have been exclusively assessed as the hazard (Sato et al. 2013; Zidek et al. 2014; Sakashita, Matthews, and Yamamoto 2013). It also remains unclear the extent utility notification programs for electric-dependent customers are used.

Power outage preparedness was assessed in NYC adults using a random sample telephone survey administered by Baruch College Survey Research. A total of 887 NYC residents responded to the survey between November 18 and December 23, 2016. Approximately half of the surveys were conducted on a landline (47% *vs.* 53% on cell phone) and most were conducted in English (91% *vs.* 9% conducted in Spanish). Data were weighted to the U.S. 2010 Census population data for age, sex, race, Hispanic origin and borough for New York City adults. The majority of respondents lived in Brooklyn (30%), followed by Queens (28%), Manhattan (20%), Bronx (16%) and Staten Island (5%). Approximately half of the respondents were women (53%), 60% were between 18 and 49 years old, and 34% reported themselves as White, non-Hispanic, all comparable to the 2010 Census data for adult New Yorkers (New York City Department of Health and Mental Hygiene).

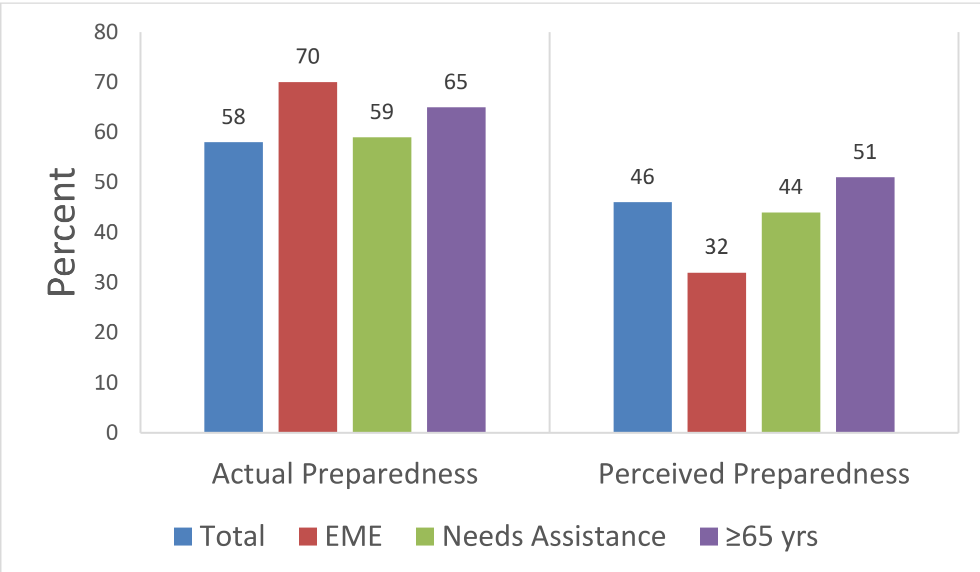
3.2 Vulnerable Populations

Three subpopulations were defined as higher risk. A quarter of the respondents reported having a household member who needed assistance with daily activities, such as eating, bathing or dressing, and would require help leaving the house during a power outage; 17% were older adults (≥65 years old); and 9% said there was someone in their household who depended on electric medical equipment (EME).

3.3 Power Outage Preparedness and Concerns

The majority of respondents reported having a working flashlight (89%), 71% had a three-day supply of food that wouldn't spoil, and 59% had a three-day supply of drinking water. However, only 58% of respondents reporting having all three preparedness items and only 46% perceived their households as prepared (Figure 4). Actual preparedness tended to be higher among respondents with household members who depended on EME (70%) and older adults (65%). Respondents with EME-dependent household members had a lower perception of preparedness (32%).

Figure 4. Actual and Perceived Power Outage Preparedness among Total and Vulnerable Respondents



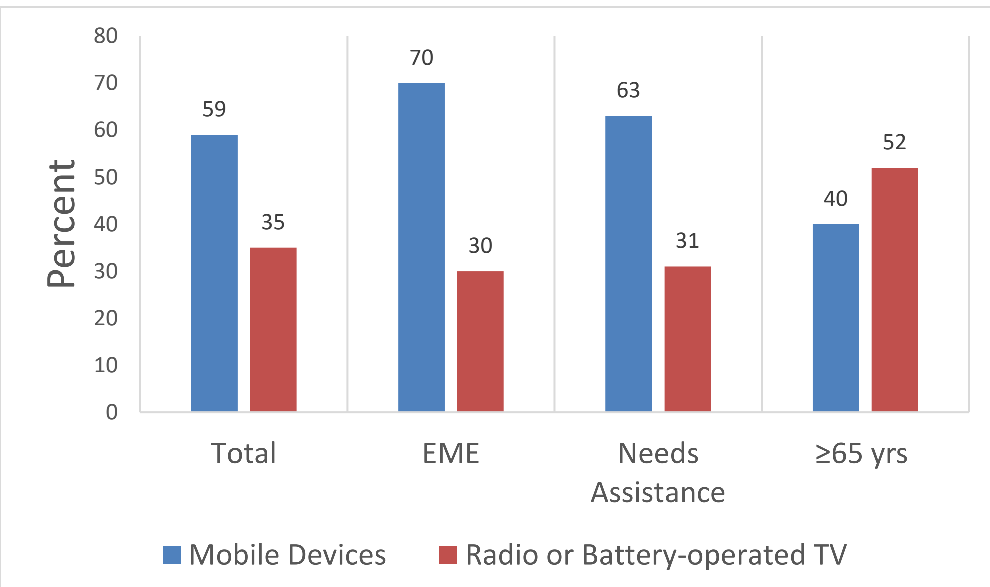
A little less than half of the respondents expressed being very or somewhat concerned that power outages could cause injury or illness to themselves or someone in their household (46%). These concerns were greater among respondents with household members who depended on EME (74%), respondents with household members who needed assistance with daily activities (65%), and older adults (54%).

For vulnerable populations, a power outage could present more challenges (Molinari et al. 2017), which might make them perceive a greater risk compared to the non-vulnerable population; however, having concerns about power outages does not necessarily translate into greater preparedness, suggesting there are barriers to obtaining and maintaining basic preparedness supplies. Respondents with EME-dependent household members were more likely to have all three basic preparedness items but a much lower perception of preparedness, indicating the understanding that weathering an outage is much more complex than stocking up on basic supplies. Caregivers of family members with other medical needs and requiring assistance may also face additional challenges in preparedness (Bagwell et al. 2016; Baker and Baker 2010).

3.4 Getting Information During a Power Outage

Most respondents reported using a mobile device, such as a mobile phone, tablet or laptop (59%) as seen in Figure 5. Mobile devices tended to be the preferred means of getting information among most vulnerable groups, although older adults tended to prefer radios or battery- or generator-operated televisions (52%). A loss of power could make it difficult to charge the devices and disrupt services. Mobile devices can be a useful resource to widely reach residents prior to an outage, but the messaging must be clear, in multiple languages, and easy to find especially if sent through links in texts. Other means of accessing information during an outage should be clearly stated in the messages that go out prior to an outage.

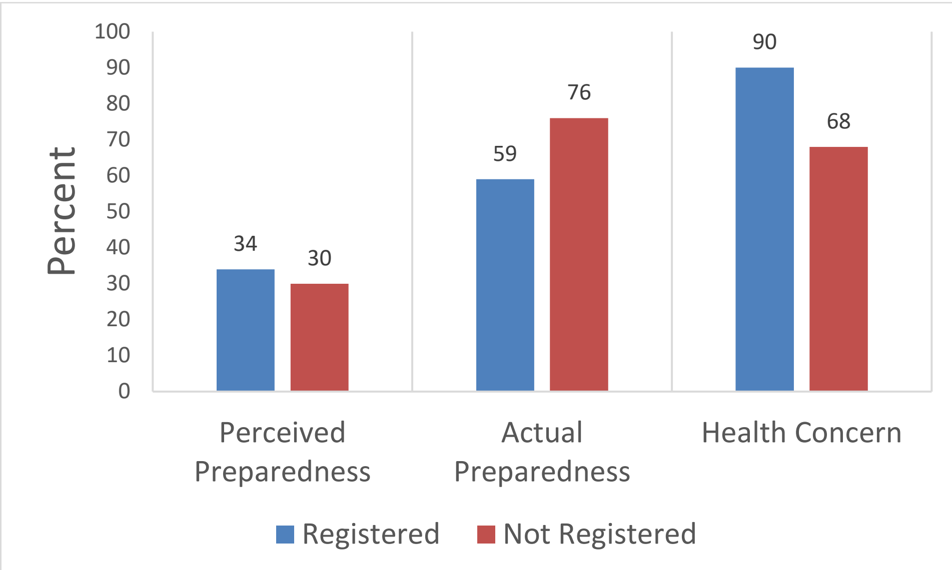
Figure 5. Getting Information During a Power Outage among Total and Vulnerable Respondents



3.5 Awareness of Utility Power Outage Notification Programs

Among respondents who reported having someone in their household dependent on electrically powered medical equipment, only 40% (n=25) said that person was registered with a utility company to receive notification before a power outage. These respondents expressed greater concern about health (90% *vs.* 68%, p=0.04) as seen in Figure 6, which may be motivating registration. However, there tended to be a lower level of preparedness among these respondents (59% *vs.* 76%, p=0.34).

Figure 6. Power Outage Preparedness and Concerns among Respondents with and without Registered Electric Medical Equipment Dependent Household Members



3.6 Additional Vulnerability

Multifamily buildings, including walk-ups and those with elevators, were the most common residence type (56%); however, all vulnerable populations were more likely to live in multifamily buildings (70% of respondents with household members who depended on EME; 67% of respondents with household members who needed assistance with daily activities; 64% of older adults). Living in a multifamily building may present additional challenges for vulnerable populations, especially if they live on higher floors. They may lose access to safe drinking water and the water may also be harder to reach due to impaired pumping equipment and elevators (Beatty et al. 2006). Community-based programs that encourage people to check on their vulnerable neighbors can help promote power outage safety among those whom emergency responders cannot easily reach.

3.7 Public Education Campaign Targeted to People Who Use Electric Medical Equipment

The findings from this survey highlighted the importance of encouraging preparedness among all households with electric medical equipment users, regardless of whether they have signed up with their utility company. In response, and with feedback from our partners, a public education campaign was developed with a special focus on people who use electric medical equipment and live in neighborhoods at greater risk of power outages. The goal of the campaign was to increase enrollment in utility programs and increase power outage preparedness, including keeping and maintaining backup batteries for medical equipment. Posters and postcards were distributed to local vendors in twenty-two NYC zip codes. Thirty dialysis centers identified in these zip codes were also provided with postcards to distribute to patients.

4 Hot Weather, Gastrointestinal Illnesses, and Food Safety

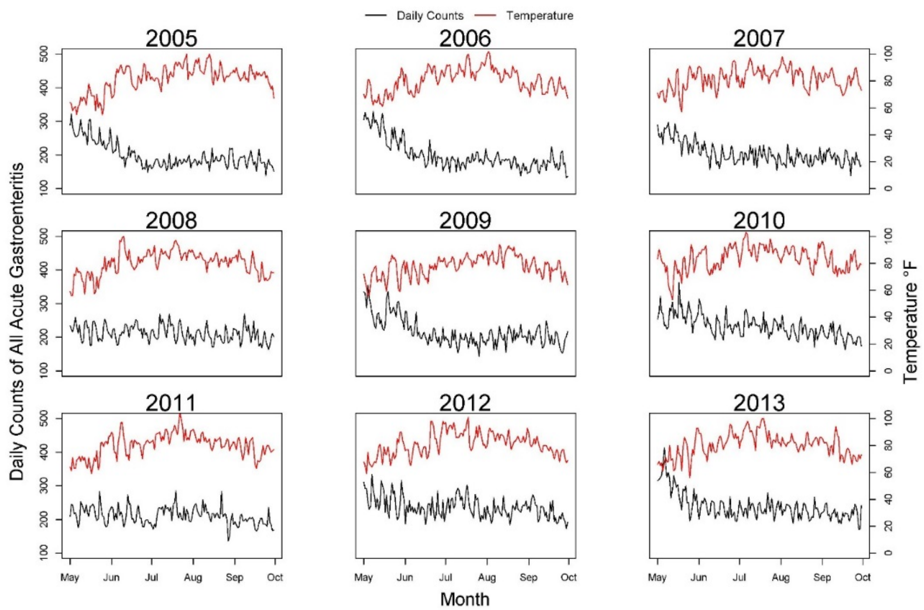
4.1 Hot weather and emergency department visits for gastrointestinal illnesses

Potentially hazardous food held at ambient temperatures between 41°F and 140°F can cause foodborne pathogen proliferation (U.S. Department of Agriculture Food Safety and Inspection Service 2011). Several studies have shown that higher ambient air temperature is associated with an increased incidence of gastrointestinal infections (Carlton et al. 2016; Lin, Sun, et al. 2016), including foodborne diseases, such as salmonellosis and campylobacteriosis.

To understand the association between temperature and gastrointestinal illness in NYC, emergency department visits for acute gastroenteritis were obtained from SPARCS (New York State Department of Health). Cases were restricted to NYC residents who were treated and released from or hospitalized in NYC hospitals. A total of 298,341 emergency department visits for acute gastroenteritis were identified between May 2005 and September 2013, most of which were treat and release visits (83%). Just over half of the visits were among women (56%). The majority of visits were among those between 18 and 64 years old (52%), followed by 0- to 4-year-olds (25%), 5- to17-year-olds (14%), and those 65 years or older (10%).

Daily maximum temperature for NYC was obtained from the National Oceanic and Atmospheric Administration, National Centers for Environmental Information using the NYC station at LaGuardia Airport. The median/maximum temperature was 82°F (min–max: 53-104°F), and the 95th percentile value was 94°F. There was no clear pattern observed between daily counts of acute gastroenteritis ED visits and maximum temperature (Figure 7).

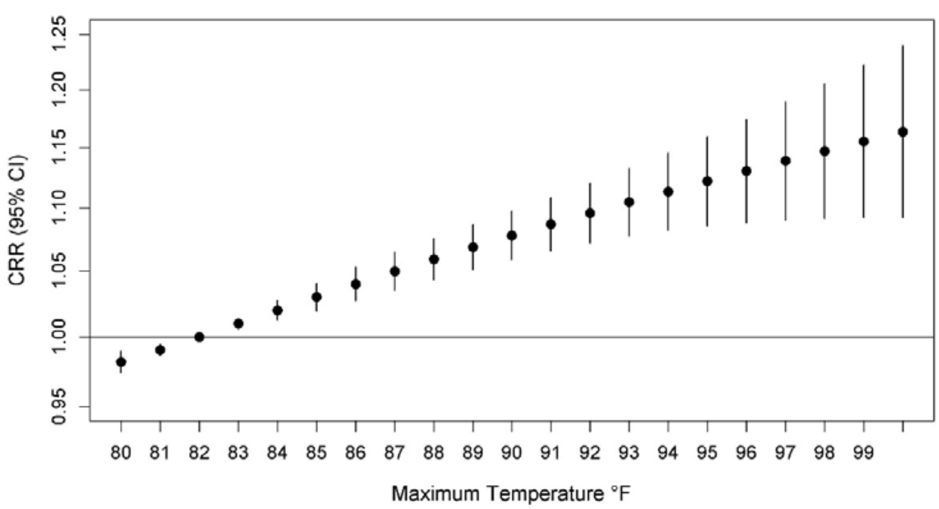
Figure 7. Temporal Patterns of Acute Gastroenteritis ED Visits during May 2005–September 2013



After controlling for within-season temporal trends, a positive association between maximum temperature and total acute gastroenteritis ED visits was observed over 0 through 10 lag days (Figure 8). The CRR when 94°F days (warm season hot day) were compared to 82°F days (normal warm season day) was 1.11 (95% CI: 1.08, 1.15). The observed positive association in NYC is consistent with studies conducted in New York State (Lin, Sun, et al. 2016) and elsewhere (Carlton et al. 2016).

Figure 8. Impact of Maximum Temperature on ED Visits for Acute Gastroenteritis

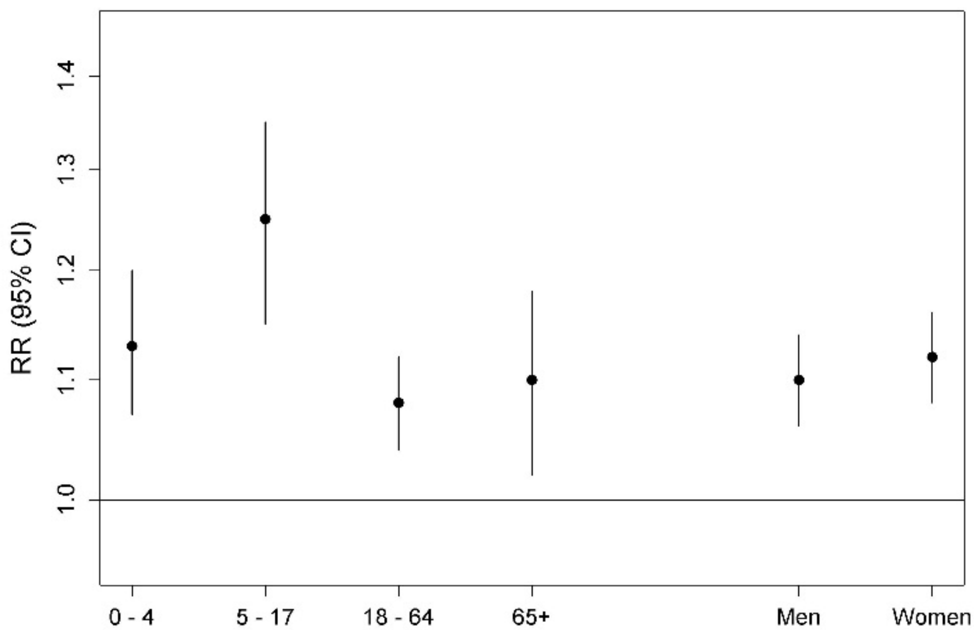
Models adjusted for day of week, holiday, year, and within-season temporal trends. The cumulative relative risks and 95% confidence intervals represent the sum of each lag day's effect up until lag day 10.



While all age groups showed increased risk of acute gastroenteritis ED visits, the risk was strongest among children between the ages of five and 17 (CRR at lags 0 through 10 [95% CI]: 1.25 [1.15, 1.35]) as seen in Figure 9. Young children are more vulnerable to infectious diseases due to weakened immune responses (Balbus and Malina 2009); however, the risk was lower among the youngest children, suggesting there may be additional behaviors among older children that increase their risk. There was no difference in the association between maximum temperature and total acute gastroenteritis by sex.

Figure 9. Impact of Maximum Temperature on ED Visits for Acute Gastroenteritis by Age and Sex

Models adjusted for day of week, holiday, year, and within-season temporal trends.



4.2 Hot Weather and Food Safety Violations

In 2015, the restaurant setting was associated with approximately 60% of reported foodborne disease outbreaks in the United States (Centers for Disease Control and Prevention (CDC) 2017). Inadequate temperature and time control of potentially hazardous food are some of the contributing factors of foodborne illness in restaurants (Gould et al. 2013; Angelo et al. 2017). Warmer temperatures may compromise refrigeration making it hard to maintain temperatures below 41°F for cold holding of potentially hazardous foods. Cooling of food prepared for later service, which must be done rapidly from 140°F to 70°F within two hours and to 41°F within an additional four hours in a refrigerator or ice bath (New York City Department of Health and Mental Hygiene 2017), may also be impacted. As the temperature rises due to climate change and extreme heat events occur more frequently (Horton et al. 2015), restaurants may face additional challenges in maintaining safe temperatures for potentially hazardous food, which could increase the risk of foodborne illness. However, there is limited information on the effects of hot weather on restaurant food safety.

Food safety violations were identified from NYC food service establishment inspection data. The analysis included initial inspections conducted by the NYC DOHMH during May 2011–September 2015, excluding inspections in establishments with minimal on-site preparation of food. A total of 64,661 inspections were conducted among 29,614 restaurants during this period. The median number of initial inspections per restaurant was two (min–max: 1-7). On average, 84.5 (standard deviation: 59.1) initial inspections were conducted daily. Most of the restaurants were located in Manhattan (38%), followed by Brooklyn (25%), Queens (23%), Bronx (10%), and Staten Island (4%), reflecting the geographic distribution of all NYC food service establishments. The majority were non-chain restaurants (90%). Less than half were quick service establishments (46%), followed by full-service restaurants or diners (38%).

Three violation types related to food holding temperature were examined. Cold-food holding above 41°F violations were most commonly issued (n=29,254), followed by hot-food item held below 140°F violations (n=13,499), and insufficient refrigeration or hot-holding equipment, which are grouped as one violation (n=1,095).

The median/maximum temperature during May 2011–September 2015 was 82°F (min–max: 56–104°F). The 95th percentile of maximum temperature was 93°F. Violations for cold-food holding and insufficient refrigerated or hot-holding equipment were more likely to be cited on hot days compared with cool days (RR [95% CI]: 1.27 [1.23-1.31] and 3.26 [2.72-3.91], respectively) as seen in Table 1.

Table 1. Crude Rate Ratios (RR) and 95% Confidence Interval (CI) for Temperature-Related Food Safety Violations on Hotter Days

	Cool Days[a]	Hot Days[b]
Inspections (n)	37,557	4,007
Cold-Food Holding Violations		
n	15,993	2,163
RR (95 % CI)[c]	1.00 (reference)	1.27 (1.23, 1.31)
Insufficient Equipment[d] Violations		
n	440	153
RR (95 % CI)[c]	1.00 (reference)	3.26 (2.72, 3.91)
Hot-Food Holding Violations		
n	8,061	817
RR (95 % CI)[c]	1.00 (reference)	0.95 (0.89 1.01)

[a] Cool days were identified as days were the maximum temperature was ≤ the median value of daily maximum temperature (56-82°F).

[b] Hot days were identified as days where the maximum temperature was ≥ the 95th percentile value of daily maximum temperature (93-104°F).

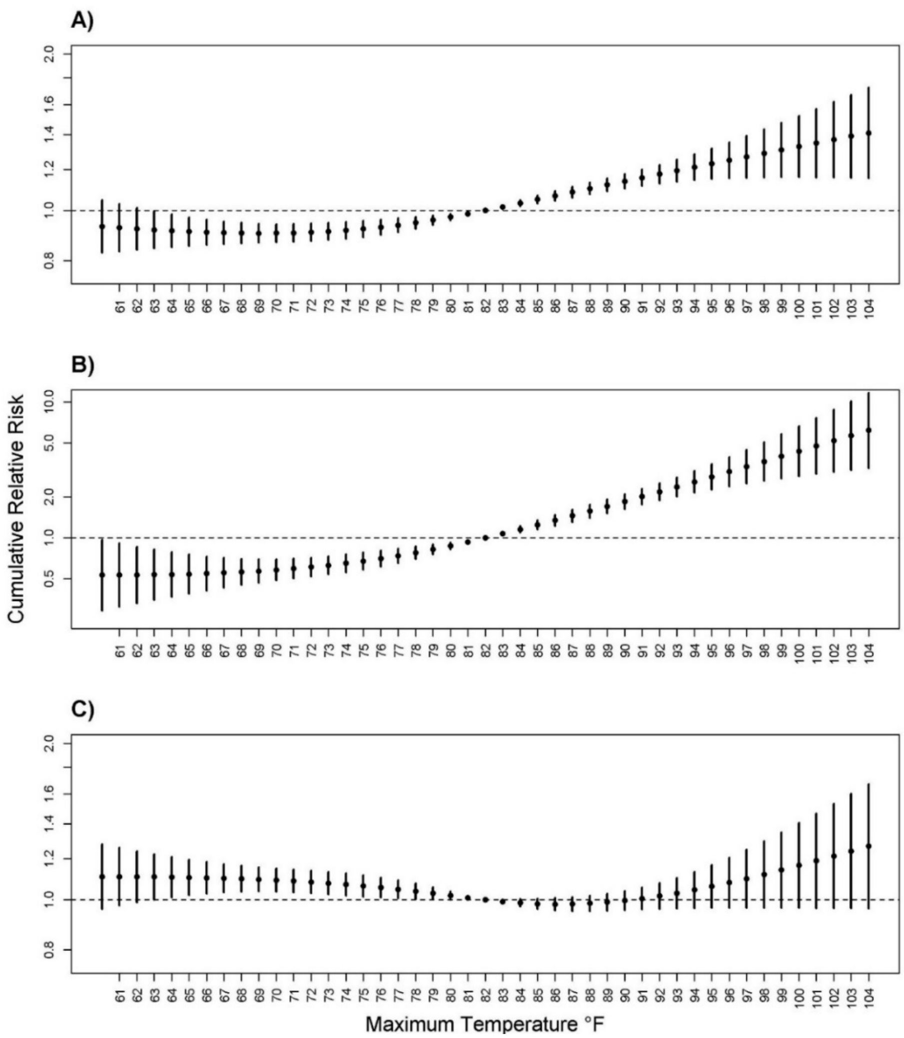
[c] Rate of violations on hot days divided by rate of violations on cool days.

[d] Insufficient equipment included refrigeration and hot holding equipment.

These associations remained after controlling for temporal trends (CRR [95% CI] of violations for cold-food holding at 93°F days *vs.* 82°F days: 1.19 [1.14, 1.25] and insufficient refrigeration or hot-holding equipment: 2.37 [2.02, 2.79]) as seen in Figures 10A and 10B. Hot-food holding violation rates increased at the highest temperatures (CRR at 96°F: 1.08, 95% CI: 0.96-1.21) as seen in Figure 10C and temperatures below 80°F (CRR at 64°F: 1.11, 95% CI: 1.01-1.21). These findings suggest hotter temperatures may compromise cold holding, possibly by straining refrigeration. It is unclear why hot-food holding violations would increase on hotter days. It is not expected that higher temperatures would directly affect hot-holding equipment, but it is possible that holding temperatures are lowered to minimize heat in the kitchen on very hot days.

Figure 10. Impact of Maximum Temperature on Food Safety Violations

Models adjusted for day of week, holiday, year, and daily number of inspections. The cumulative relative risks and 95% confidence intervals represent the sum of each lag day's effect up until lag day 3 on violations for (a) cold-food item held above 40°F, (b) insufficient or no refrigerated or hot-holding equipment, and (c) hot-food item not held at 140°F or higher.



5 Hot Weather and Power Outage Experience among NYC Restaurant Operators

5.1 Focus Group Participant Recruitment and Characteristics

Two focus groups with owners and managers of the (1) high- and (2) low-performing restaurants were conducted to assess awareness of hot weather and power outage impacts on kitchen operations. These were conducted in collaboration with ICF International and Zebra Strategies in winter 2017. Using NYC inspection data, participants were recruited from non-chain, full-service restaurants or diners that were currently operating and had at least two initial inspections during May 2011–September 2015. Performance was based on the restaurants' average initial inspection scores.

A total of 17 people, eight in the high-performing group and nine in the low-performing group, agreed to participate in the discussions. Approximately half of the focus group participants were men (n=9, 53%) and 76% were White (n=13). Five (29%) of the participants reported being solely responsible for running the kitchen, while the remaining shared decision-making responsibilities.

5.2 Maintaining Cold Foods below 41°F during Hot Weather

All operators cited refrigeration issues as a common problem during hot weather: "Refrigerators always break in the summer." During hotter weather, refrigerators must work harder to keep food cold and are more likely to break down. Additionally, the warmer ambient temperature may cause the temperature in the refrigerator to rise faster as doors are opened and closed. However, it may take time for refrigerator temperatures to noticeably rise. While operators from both groups described checking refrigerator thermometers, there was variation in how frequently these were checked, which may prevent them from being able to recognize and respond promptly to breakdowns. The restaurant operators described ways of managing refrigeration problems after the fact rather than using a preventive approach, including moving food to colder refrigeration units or adding ice to the refrigerators to keep temperatures low. Some higher performers additionally move food from the front to the back of the refrigerator and run the air conditioners to help the refrigerators.

5.3 Other Hot Weather Impacts

One operator expressed concern about higher temperatures in the delivery truck affecting food safety. Three operators also described general challenges with deliveries arriving close to the lunch hour, mentioning that they spend their limited time ensuring that the bill is correct rather than monitoring food temperature. These findings suggest that multiple points along the supply chain, including food transport, may be impacted by warmer temperatures (Hall, D'Souza, and Kirk 2002).

Operators said that cooling down procedures did not change during hot weather, although one operator mentioned that food may take a little longer to cool and another described using more ice. In general, knowledge of cooling time varied and most operators did not describe monitoring temperature over time. This practice has been observed in previous studies (Green and Selman 2005; Brown et al. 2012), which may result in a lower level of awareness of hot weather effects on cooling.

The discussions did not provide an explanation for why hot-food holding violations increase on very hot days, and there was no indication that holding temperatures are lowered. When probed about this, one operator suggested “attention and focus is more on keeping the things cold than keeping the things hot.”

5.4 Previous Power Outage Experience

Power outage experiences for some operators ranged from minor local construction to the more severe Superstorm Sandy. None had emergency plans, and all said they use “common sense” or “prior experiences.” The higher performers described throwing food out, although there was effort to save food, particularly expensive meats and fish. One lower performer would throw food out if the outage was long, but there was generally greater emphasis on saving food, such as moving to a freezer that might stay colder for longer. These findings may point to differences between the two groups, perhaps related to the cost of throwing food out. There was variation in knowledge of cutoff times for throwing food out, inconsistent use of thermometers to check temperatures, and one operator mentioned using taste to determine if food had spoiled, suggesting there was limited knowledge of food safety during power outages. Both groups mentioned sending food to other restaurants, and in general, nearby restaurants provided resources during emergencies, such as space in refrigerators or ice.

No participant from either group said they were aware of preparedness resources for power outages or hot weather. After reading guidelines developed for restaurants impacted by Superstorm Sandy, most operators felt the information was common sense. However, both groups liked the idea of having emergency information readily available as a checklist in an emergency.

6 Conclusions

This study demonstrated that localized power outages can have comparable magnitude of effects on health (i.e., relative risk) as a citywide event. The 2006 outage, which affected part of the Long Island City network, was associated with respiratory hospitalizations, consistent with the citywide 2003 outage. The 2006, as well as the 1999 outages may also have had substantial effects on mortality. The health effects of power outages were not limited to warm-weather outages. Localized power outages that occurred during the cold months may impact mortality, as well as hospitalizations for cardiovascular disease. Results from the survey suggested that although concern about power outages was higher among older adults—and households with someone requiring assistance with daily activities or dependent on electric medical equipment—preparedness was still low for some of these at-risk groups. There was also an indication of low awareness of utility company power outage notification programs. These findings led to the development of a power outage awareness campaign aimed at increasing utility program enrollment and power outage preparedness among people who use electric medical equipment.

Higher temperature was associated with cold-food holding violations and no or insufficient refrigerated or hot-holding equipment violations, possibly reflecting refrigeration breakdowns that were commonly reported by restaurant operators during focus group discussions. These findings support a possible mechanism for the increased risk of gastrointestinal illness on hotter days since holding cold foods at warmer temperatures could increase the growth of foodborne pathogens. Focus group participants also expressed the need for more guidance on hot weather and power outages to be delivered concisely.

Higher average temperatures as well as increased intensity and frequency of heat waves are expected under future climate change. Power outages may also occur more often, due to storms or stress on the electric system. These findings can inform emergency planning and climate adaptation for current and future heat and power outage events.

7 Recommendations

1. Efforts to ensure that the electric grid is resilient to climate change should be continued in order to protect public health. The finding that the localized power outages can impact adverse health outcomes highlights the need to develop climate change resiliency and mitigation plans that address neighborhood-specific vulnerabilities and infrastructures.
2. Local health departments can benefit from the use of non-traditional data sources to improve understanding of health risks, including vulnerability assessments. This study highlights how a data source intended for non-health purposes can be used in combination with traditional health data sources to bolster epidemiological studies. Findings from these epidemiological studies can be used to inform larger city resiliency and planning efforts.
3. The study identified a need for timely and finer-level power outage data. Researchers can link finer-scale outage exposures to health data to validate results from this study with the availability of building-level power outage data. Real-time collection of data could also support emergency responses to outage events.
4. Additional research is needed to understand how individuals, particularly at-risk individuals, perceive, experience, and respond to power outages. This includes understanding influences on preparedness behavior and barriers that may limit the ability to stay safe. Findings could identify or improve strategies to promote power outage preparedness. However, funding is needed to support this research.
5. Collaboration among partners such as utility companies, healthcare providers and electric medical equipment vendors and manufacturers is needed to discuss how to expand power outage preparedness efforts among at-risk populations. This includes government agency management and public health agencies working with vendors and non-profit providers to develop a unified message and guidance to provide to clients.
6. To reach potentially at-risk individuals, information on emergency preparedness and utility outage notification programs can be integrated into trainings for staff who provide visiting home and case management services. For example, home-health aides routinely interact with clients who may have difficulty staying cool during a hot-weather power outage or use electric medical equipment. These clients may also have limited resources or social contacts to assist in developing a preparedness plan. They could inform clients that they can sign up for utility notification programs if they are dependent on electric medical equipment, and check that items such as backup batteries for medical equipment, water, and non-perishable food are present.
7. Providing simple guidelines to restaurant operators on safely keeping or discarding food in the event of a power outage may be useful. Restaurant operators should also consider developing an emergency plan for power outages, which can be communicated to staff. Both the guidelines and emergency plan should be easily accessible during a power outage.

8. Restaurants should have a preventive maintenance plan for refrigeration equipment to ensure safe food temperatures are maintained during hot weather, when such equipment may be stressed. In addition, an operator can keep food at the appropriate temperature during the summer months by using a staging refrigerator so that walk-in refrigerators remain closed most of the day; place ice baths in the refrigerators; schedule deliveries earlier or later in the day when the temperature is lower; reject food that arrives out of temperature or on a non-refrigerated truck; and most importantly, monitor the temperature of all refrigeration and hot-holding equipment every three to four hours at a minimum.
9. Estimating the financial costs of health impacts associated with power outages could help inform policies related to climate adaptation. Current assessments of power outage impacts often focus on commercial economic loss. Integrating the costs of health consequences can provide a more complete assessment of the financial repercussions of power outages.

8 Bibliography

Anderson, G. B., and M. L. Bell. 2012. 'Lights out: impact of the August 2003 power outage on mortality in New York, NY', Epidemiology, 23: 189-93.

Angelo, K. M., A. L. Nisler, A. J. Hall, L. G. Brown, and L. H. Gould. 2017. 'Epidemiology of restaurant-associated foodborne disease outbreaks, United States, 1998-2013', Epidemiol Infect, 145: 523-34.

Bagwell, H. B., R. Liggin, T. Thompson, K. Lyle, A. Anthony, M. Baltz, M. Melguizo-Castro, T. Nick, and D. Z. Kuo. 2016. 'Disaster Preparedness in Families With Children With Special Health Care Needs', Clin Pediatr (Phila), 55: 1036-43.

Baker, L. R., and M. D. Baker. 2010. 'Disaster preparedness among families of children with special health care needs', Disaster Med Public Health Prep, 4: 240-5.

Balbus, J. M., and C. Malina. 2009. 'Identifying vulnerable subpopulations for climate change health effects in the United States', J Occup Environ Med, 51: 33-7.

Beatty, M. E., S. Phelps, M. C. Rohner, and M. I. Weisfuse. 2006. 'Blackout of 2003: public health effects and emergency response', Public Health Rep, 121: 36-44.

Bouchama, A., and J. P. Knochel. 2002. 'Heat stroke', N Engl J Med, 346: 1978-88.

Brown, L. G., D. Ripley, H. Blade, D. Reimann, K. Everstine, D. Nicholas, J. Egan, N. Koktavy, D. N. Quilliam, and E. HS-Net Working Group. 2012. 'Restaurant food cooling practices', J Food Prot, 75: 2172-8.

Carlton, E. J., A. P. Woster, P. DeWitt, R. S. Goldstein, and K. Levy. 2016. 'A systematic review and meta-analysis of ambient temperature and diarrhoeal diseases', Int J Epidemiol, 45: 117-30.

Centers for Disease Control and Prevention (CDC). 2017. Surveillance for Foodborne Disease Outbreaks, United States, 2015, Annual Report.

Chen, B. C., L. K. Shawn, N. J. Connors, K. Wheeler, N. Williams, R. S. Hoffman, T. D. Matte, and S. W. Smith. 2013. 'Carbon monoxide exposures in New York City following Hurricane Sandy in 2012', Clin Toxicol (Phila), 51: 879-85.

City of New York. 'New York City restaurant inspection results. NYC open data', Accessed March 16, 2016. https://nycopendata.socrata.com.

Damon, S. A., J. A. Poehlman, D. J. Rupert, and P. N. Williams. 2013. 'Storm-Related Carbon Monoxide Poisoning: An Investigation of Target Audience Knowledge and Risk Behaviors', Soc Mar Q, 19: 188.

Department of Public Service. 2007. Department of Public Service Staff Report on its Investigation of the July 2006 Equipment Failures and Power Outages in Con Edison’s Long Island City Network in Queens County, New York. February 2007.

Diffenbaugh, N. S., M. Scherer, and R. J. Trapp. 2013. 'Robust increases in severe thunderstorm environments in response to greenhouse forcing', Proc Natl Acad Sci U S A, 110: 16361-6.

Dominianni, C., K. Lane, M. Ahmed, S. Johnson, Kelvey W. Mc, and K. Ito. 2018. 'Hot Weather Impacts on New York City Restaurant Food Safety Violations and Operations', J Food Prot: 1048-54.

Dominianni, C., K. Lane, S. Johnson, K. Ito, and T. Matte. 2018. 'Health Impacts of Citywide and Localized Power Outages in New York City', Environ Health Perspect, 126: 067003.

Dominianni, C., M. Ahmed, S. Johnson, et al. 2018. 'Power Outage Preparedness and Concern among Vulnerable New York City Residents', J of Urban Health. DOI: https://doi.org/10.1007/s11524-018-0296-9

Federal Emergency Management Agency. 2017. 'Build an Emergency Supply Kit', Accessed May 10, 2017. https://www.ready.gov/build-a-kit.

Gasparrini, A. 2011. 'Distributed Lag Linear and Non-Linear Models in R: The Package dlnm', J Stat Softw, 43: 1-20.

Gotanda, H., J. Fogel, G. Husk, J. M. Levine, M. Peterson, K. Baumlin, and J. Habboushe. 2015. 'Hurricane Sandy: Impact on Emergency Department and Hospital Utilization by Older Adults in Lower Manhattan, New York (USA)', Prehosp Disaster Med, 30: 496-502.

Gould, L. H., I. Rosenblum, D. Nicholas, Q. Phan, and T. F. Jones. 2013. 'Contributing factors in restaurant-associated foodborne disease outbreaks, FoodNet sites, 2006 and 2007', J Food Prot, 76: 1824-8.

Green, L.R., and C. Selman. 2005. 'Factors impacting food workers' and managers' safe food preparation practices: A qualitative study', Food Protection Trends, 25: 981-90.

Hall, G. V., R. M. D'Souza, and M. D. Kirk. 2002. 'Foodborne disease in the new millennium: out of the frying pan and into the fire?', Med J Aust, 177: 614-8.

Horton, R., D. Bader, Y. Kushnir, C. Little, R. Blake, and C. Rosenzweig. 2015. 'New York City Panel on Climate Change 2015 Report. Chapter 1: Climate observations and projections', Ann N Y Acad Sci, 1336: 18-35.

Horton, R., C. Rosenzweig, V. Gornitz, D. Bader, and M. O'Grady. 2010. 'Climate risk information: climate change scenarios and implications for NYC infrastructure. New York City Panel on Climate Change', Ann N Y Acad Sci, 1196: 147-228.

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Lee, D. C., S. W. Smith, B. G. Carr, K. M. Doran, I. Portelli, C. R. Grudzen, and L. R. Goldfrank. 2016. 'Geographic Distribution of Disaster-Specific Emergency Department Use After Hurricane Sandy in New York City', Disaster Med Public Health Prep, 10: 351-61.

Lempert, K. D., and J. B. Kopp. 2013. 'Hurricane Sandy as a kidney failure disaster', Am J Kidney Dis, 61: 865-8.

Lin, S., B. A. Fletcher, M. Luo, R. Chinery, and S. A. Hwang. 2011. 'Health impact in New York City during the Northeastern blackout of 2003', Public Health Rep, 126: 384-93.

Lin, S., A. Soim, K. A. Gleason, and S. A. Hwang. 2016. 'Association Between Low Temperature During Winter Season and Hospitalizations for Ischemic Heart Diseases in New York State', J Environ Health, 78: 66-74.

Lin, S., M. Sun, E. Fitzgerald, and S. A. Hwang. 2016. 'Did summer weather factors affect gastrointestinal infection hospitalizations in New York State?', Sci Total Environ, 550: 38-44.

Marx, M. A., C. V. Rodriguez, J. Greenko, D. Das, R. Heffernan, A. M. Karpati, F. Mostashari, S. Balter, M. Layton, and D. Weiss. 2006. 'Diarrheal illness detected through syndromic surveillance after a massive power outage: New York City, August 2003', Am J Public Health, 96: 547-53.

Molinari, N. A., B. Chen, N. Krishna, and T. Morris. 2017. 'Who's at Risk When the Power Goes Out? The At-home Electricity-Dependent Population in the United States, 2012', J Public Health Manag Pract, 23: 152-59.

Muscatiello, N. A., G. Babcock, R. Jones, E. Horn, and S. A. Hwang. 2010. 'Hospital emergency department visits for carbon monoxide poisoning following an October 2006 snowstorm in western New York', J Environ Health, 72: 43-8.

New York City Department of Health and Mental Hygiene. 'Epiquery: NYC Interactive Health Data System - Census 2010. '. http://nyc.gov/health/epiquery.

New York City Department of Health and Mental Hygiene. 2017. Article 81 of the NYC Health Code: Food Preparation and Food Establishments.

New York City Emergency Management. 2016. 'Utility Disruptions', Accessed October 27, 2016. https://www1.nyc.gov/site/em/ready/utility-disruptions.page.

New York City Office of Emergency Management. 2014. 'Ready New York. Preparing for Emergencies in New York City', Accessed May 19, 2017. http://www1.nyc.gov/assets/em/downloads/pdf/household_guide.pdf.

New York State Assemby Queens Task Force. 2007. Report Concerning the July 2006 Power Outage in Consolidated Edison's Service Territory. January 30, 2007.

New York State Department of Health. Statewide Planning and Research Cooperative System (SPARCS), 2002-2013 (Data Update: July 2014).

Office of the Attorney General. 2000. Con Edison's July 1999 Electric Service Outages: A report to the people of the state of NY. March 9, 2000.

Prezant, D. J., J. Clair, S. Belyaev, D. Alleyne, G. I. Banauch, M. Davitt, K. Vandervoorts, K. J. Kelly, B. Currie, and G. Kalkut. 2005. 'Effects of the August 2003 blackout on the New York City healthcare delivery system: a lesson for disaster preparedness', Crit Care Med, 33: S96-101.

Sakashita, K., W. J. Matthews, and L. G. Yamamoto. 2013. 'Disaster preparedness for technology and electricity-dependent children and youth with special health care needs', Clin Pediatr (Phila), 52: 549-56.

Sato, K., R. Morita, K. Tsukamoto, N. Sato, Y. Sasaki, M. Asano, Y. Okuda, H. Miura, M. Sano, T. Kosaka, H. Watanabe, T. Shioya, and H. Ito. 2013. 'Questionnaire survey on the continuity of home oxygen therapy after a disaster with power outages', Respir Investig, 51: 9-16.

Scallan, E., R. M. Hoekstra, F. J. Angulo, R. V. Tauxe, M. A. Widdowson, S. L. Roy, J. L. Jones, and P. M. Griffin. 2011. 'Foodborne illness acquired in the United States--major pathogens', Emerg Infect Dis, 17: 7-15.

Seltenrich, N. 2015. 'Between Extremes: Health Effects of Heat and Cold', Environ Health Perspect, 123: A275-80.

The City of New York. 2013. A Stronger, More Resilient New York. Chapter 6: Utilities. June 11, 2013.

Trento, L., and S. Allen. 2014. 'Hurricane Sandy nutrition support during disasters', Nutr Clin Pract, 29: 576-84.

U.S. - Canada Power System Outage Task Force. 2004. Final Report on the August, 14, 2003 Blackout in the United States and Canada: Causes and Recommendations. April 2004.

U.S. Department of Agriculture Food Safety and Inspection Service. 2011. '"Danger Zone" (40 °F - 140 °F)', Accessed April 18, 2017. https://www.fsis.usda.gov/shared/PDF/Danger_Zone.pdf.

Viechtbauer, W. 2010. 'Conducting meta-analyses in R with the metafor package,' Journal of Statistical Software, 36:1-48.

Zidek, C., E. West, J. Holmes, and M. Crytzer. 2014. 'A survey comparison of rural versus urban residents and household preparedness', Home Healthc Nurse, 32: 420-9.

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