ORIGINAL RESEARCH

Spatial Shift in the Utilization of Mental Health Services After Hurricane Sandy Among New York City Residents Enrolled in Medicaid

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ABSTRACT

Objective: Closure of several New York City (NYC) hospitals after Hurricane Sandy caused an unanticipated, extended surge in patient demand at open hospitals. This study identified hospitals with a significant increase in mental-health-related emergency department, inpatient, and outpatient visits from Medicaid patients displaced by Hurricane Sandy.

Methods: NYC Medicaid patients were classified into non-mutually-exclusive geographic categories corresponding to residence in areas served by Bellevue Hospital Center and Coney Island Hospital, the hurricane impact area, and all of NYC. For each geographic region, we compared the observed to the expected number of service visits in the 6 months after the storm. The expected number of visits was calculated from 2-year trends in mental health claims.

Results: Twenty-four facilities in all 5 NYC boroughs experienced patient redistribution from storm-affected areas. Eighteen facilities had a concurrent surge in total Medicaid patients, which suggested that redistribution had a greater impact on resource use at these locations.

Conclusions: The redistribution of Medicaid patients after Hurricane Sandy increased mental health service utilization at facilities not near flooded areas. Our findings can aid in surge capacity planning and thereby improve the continuity of mental health care after a natural disaster. (*Disaster Med Public Health Preparedness.* 2016;10:420-427)

Key Words: emergency preparedness, Hurricane Sandy, Medicaid, mental health, statistical process control

Hurricane Sandy made landfall in the greater New York City (NYC) area on October 29, 2012. Flooding and power outages caused several NYC hospitals to close and evacuate patients to neighboring facilities. Receiving hospitals anticipated an increase in patients immediately after Hurricane Sandy but were less prepared for the surge in patients that persisted for several months after the storm.[1-3] Government agencies, researchers, and health care facilities need easy-to-use applications to aid in planning for disaster-related patient surges. Statistical process control is a statistical method that uses past data to create decision rules about whether a process is changing over time.[4] Emergency planners can use statistical process control to better understand variation in health service utilization before and after a disaster and thereby improve resource planning to meet increased patient demand.

Persons with low income are particularly vulnerable to natural disasters owing to baseline health disparities,

lack of financial resources, and reliance on safety net hospitals.[5,6] To ensure that individuals in all social groups can recover from a natural disaster, it is important to incorporate socioeconomic factors—like public health care insurance—into disaster planning efforts.[7] Hurricane Sandy led to the suspension of emergency department (ED) and inpatient services for weeks or months at Bellevue Hospital Center (BHC), Coney Island Hospital (CIH), and New York University Langone Medical Center (NYULMC). BHC and CIH are public hospitals that serve large numbers of publicly insured and uninsured persons.[8,9] NYULMC is privately owned and less than 20% of ED patients are insured through Medicaid.[10] Patients who exclusively used the ED at a public hospital (BHC) or private hospital (NYULMC) before Hurricane Sandy were more likely to be redistributed to public and private hospitals, respectively, after the storm.[7] The same study also found that open hospitals closest to BHC and NYULMC were more likely to receive patients from closed EDs. Lee and colleagues

provided valuable insights on the redistribution of ED patients after Hurricane Sandy, but less is known about individuals seeking inpatient, outpatient, and mental health (MH) treatment.

Psychological stress from natural disasters can cause or exacerbate MH conditions such as depression and post-traumatic stress disorder.[11,12] A disruption in MH services can cause inconvenience or distress for patients seeking care for new-onset post-storm psychiatric symptoms or any other cause. To ensure the continuity of hospital operations and achieve the best patient outcomes in the aftermath of a natural disaster, health care facilities need the ability to accommodate more patients than they would on a daily basis, ie, surge capacity.[13] Hospitals that received evacuees from closed hospitals were prepared for an immediate post-storm surge in patients.[14] At some hospitals the precautionary measures implemented were based on experiences during Hurricane Irene,[3] which had a weak acute effect and no extended effect on health service utilization.

Every natural disaster is different and surge capacity plans should accommodate multiple levels of patient demand. This study applied statistical process control methods to 2-year trends in Medicaid MH claims to identify hospitals that experienced a significant increase in service use after Hurricane Sandy. These hospitals have the highest risk of a patient surge when there was an expectation of severe coastal flooding. Thus, our findings can enhance surge capacity planning for low-income patients. The statistical process control method we demonstrate can be easily implemented by public health agencies and health facilities to plan surge capacity for disasters of varying magnitudes. The limiting factor is access to past patient census data with which one can estimate future utilization.

METHODS
Data Source
Medicaid claims data were obtained from the New York State Medicaid Data Warehouse and were accessed via the Salient Interactive Miner software (SIM; Salient Management Company, Horseheads, NY). SIM contains Medicaid enrollment data and Medicaid claims for New York State residents.

Study Population
Medicaid patients with claims for MH-related ED, inpatient, or outpatient services from January 1, 2010, to April 30, 2013, were eligible for inclusion in the study. Claims with the following *International Classification of Diseases, 9th Revision, Clinical Modification* codes in the primary diagnosis field were selected for analysis: 295-297.99, 298-298.99, 300-302.99 (excluding 302.52), 306-309.99, and 311-314.99 (code definitions in Appendix A in the online data supplement). Current Procedure Terminology codes and Ambulatory Patient Groups rate codes were used to exclude claims for substance use disorder treatment. One claim per patient per service date was included in the analysis of ED/outpatient visits. Similarly, one claim per patient per discharge date was included in the analysis of inpatient hospitalizations.
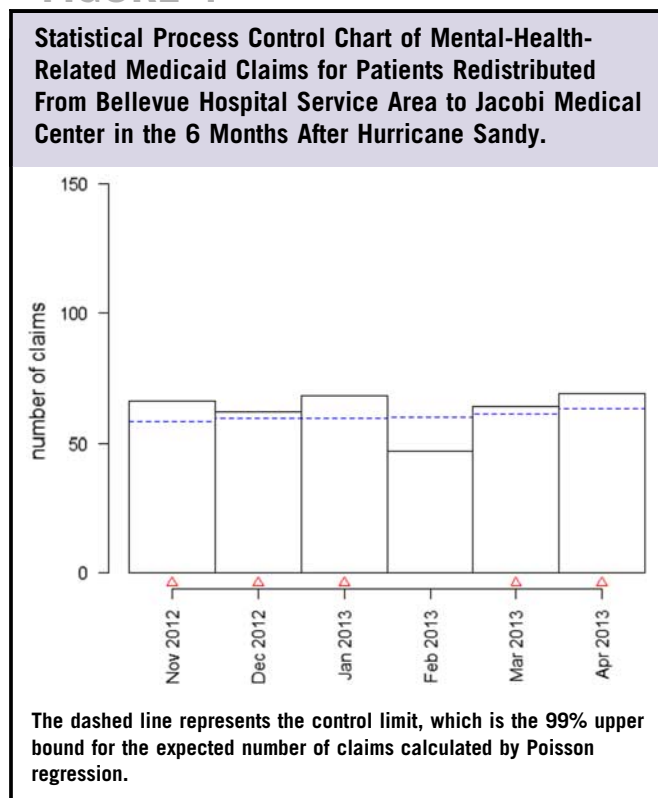
To observe a shift in MH service use among NYC Medicaid patients due to Hurricane Sandy, we compared monthly claim counts before and after the storm made landfall. Claims were classified into geographic regions based upon the residential zip code of the patient. The geographic regions included all New York City zip codes, the Hurricane Sandy impact area, and the service areas for BHC and CIH (Appendix B in the online data supplement). This study did not assess patient redistribution from the NYULMC service area because NYULMC admitted so few Medicaid patients in the 2 years before the storm (about 14 patients per month for a given MH service). The Hurricane Sandy impact area consists of zip codes with 30% or more of the population in the Hurricane Sandy inundation zone as defined by the Federal Emergency Management Agency Modeling Task Force 3-meter hindcast model of storm surge inundation. The population inside and outside of the inundation zone was estimated from the 2010 census. Service areas for closed hospitals were defined by residential zip codes associated with 75% of MH-related claims during the 6 months immediately preceding Hurricane Sandy (April 1, 2012, through September 30, 2012).

Statistical Analysis
For a given hospital, we compared the number of observed to expected patients admitted from the 4 selected geographic regions of the city. To reduce inflated type I error associated with performing multiple statistical tests, a confidence level of 99% was used to assess statistical significance. In addition, we analyzed only those hospitals most likely to receive patients from a storm-affected region. ED and inpatient claims with service or discharge dates in November and December 2012 were used to rank hospitals by service use. Due to reoccupancy of storm-damaged facilities, ED claims from the BHC service area and outpatient claims from any of the areas under study were ranked for service dates in November 2012. Selected hospitals represented 60% or more of claims among patients admitted from a given catchment area. Facilities that were infrequently used by patients during suspension of services at BHC and CIH (ie, did not fall within the 60% threshold) are listed as "not tested" in the tables. Hospitals and community health centers were included in the analysis of outpatient utilization.

The method presented by Farrington et al[15] was used to compare the observed to expected claim counts in the 6 months following the hurricane. The Farrington method implements a Poisson regression model to calculate the expected number of claims in a given month after Hurricane Sandy given the observed number of claims during the same

FIGURE 1

Statistical Process Control Chart of Mental-Health-Related Medicaid Claims for Patients Redistributed From Bellevue Hospital Service Area to Jacobi Medical Center in the 6 Months After Hurricane Sandy.

The dashed line represents the control limit, which is the 99% upper bound for the expected number of claims calculated by Poisson regression.

month in previous years. Claims data from January 1, 2010, to September 30, 2012, provided the historical time points. A 4-week time window before and after each historical month under analysis was used in the calculation of expected claim counts. Hospitals with claims greater than the upper bound of the 99% confidence interval for the expected number of claims were considered to have had a statistical increase in the number of Medicaid patients. Analysis of Medicaid utilization trends and the production of control charts was performed in R 3.2.2 using package "surveillance." Figure 1 shows a control chart for utilization of inpatient services during the 6 months after the storm by persons who lived in the BHC service area. The dotted line marks the control limit, ie, the upper bound of the 99% confidence interval for the expected number of claims.

The Institutional Review Board of the New York City Department of Health and Mental Hygiene approved this study.

RESULTS
Trends in Mental Health Service Utilization
There was 4.3% growth in the number of MH ED visits per month by NYC Medicaid patients from 2010 to 2013. Among patients from all geographic areas, there were 145,046 ED visits and 79,918 unique patients from January 1, 2010, to April 30, 2013. At hospitals that closed as a result of the

hurricane, ED visits declined sharply after October 2012. Apparent disruptions in service persisted for 2 months at BHC and for at least 6 months at CIH (Figure 2).

The use of psychiatric inpatient services by NYC Medicaid patients increased by 1.6% from 2010 to 2013. During the 42-month study period, there were 109,986 MH hospitalizations and 56,388 unique persons treated. After the hurricane, there was an apparent disruption in service utilization for 4 months at BHC and 3 months at CIH (Figure 3).

MH-related outpatient visits by Medicaid patients grew by 5.7% from 2010 to 2013. Among the total Medicaid population, there were 3,264,080 visits and 187,887 distinct Medicaid patients treated during the 42-month study period. At hospitals that closed due to the storm, apparent outpatient service disruptions were observed for 2 months after the storm at BHC and for 1 month after the storm at CIH (Figure 4).

Redistribution of Medicaid Patients
After Hurricane Sandy, 11 NYC hospitals experienced an increase in MH-related ED visits from Medicaid patients who lived in any region of the city ("NYC Medicaid Patients," Table 1). At each of these facilities, the increase in total Medicaid patients was coincident with an increase in patients admitted from the Hurricane Sandy impact area and closed hospital service areas. The percentage increase in visits over the duration of the patient surge ranged from 30% to 98% depending on the hospital (Table 1). These data suggest that hospital closures and the dispersal of persons from storm-affected regions of the city contributed to an overall surge in Medicaid patient volume at hospitals that remained open.

When the patient pool was not restricted to a particular area, 3 hospitals experienced a 25% to 95% increase in inpatient admissions ("NYC Medicaid Patients," Table 2). These hospitals also experienced greater than the expected number of admissions from the Hurricane Sandy impact area and closed hospital service areas. Two hospitals (Maimonides and Kings County) had an increase in admissions from storm-affected areas but no increase in total Medicaid admissions (Table 2). In these cases, we found no evidence that redistribution caused by the storm contributed to an increase in patient volume above conventional capacity (ie, care as usually provided at the facility).[13]

Four hospitals experienced an increase in outpatient visits among Medicaid patients from the citywide patient pool and the Hurricane Sandy impact area and closed hospital service areas (Table 3). Bayley Seton Hospital on Staten Island had the greatest increase in outpatient visits (249%), which was likely due to its location within the Hurricane Sandy impact zone.

FIGURE 2

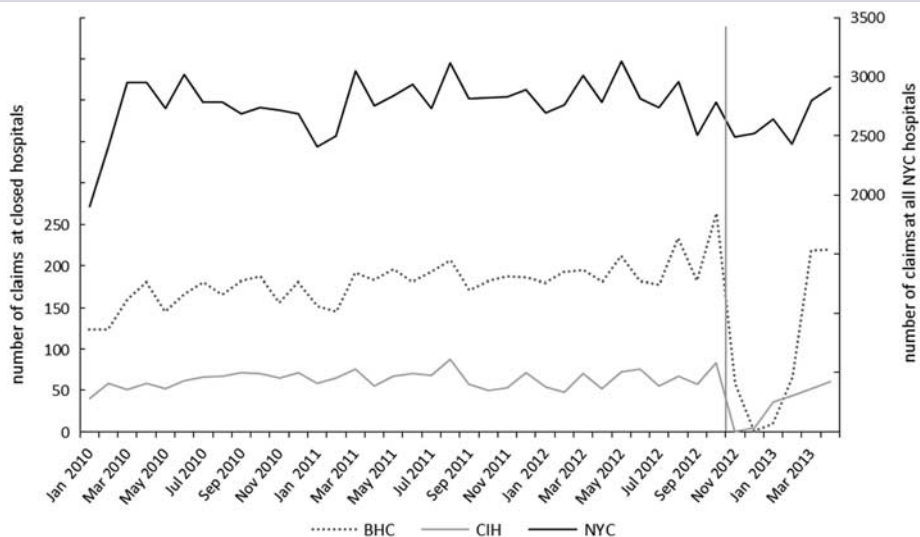**Mental-Health-Related Emergency Department Visits Among New York City Medicaid Patients and Patients at Hospitals That Closed After Hurricane Sandy.**
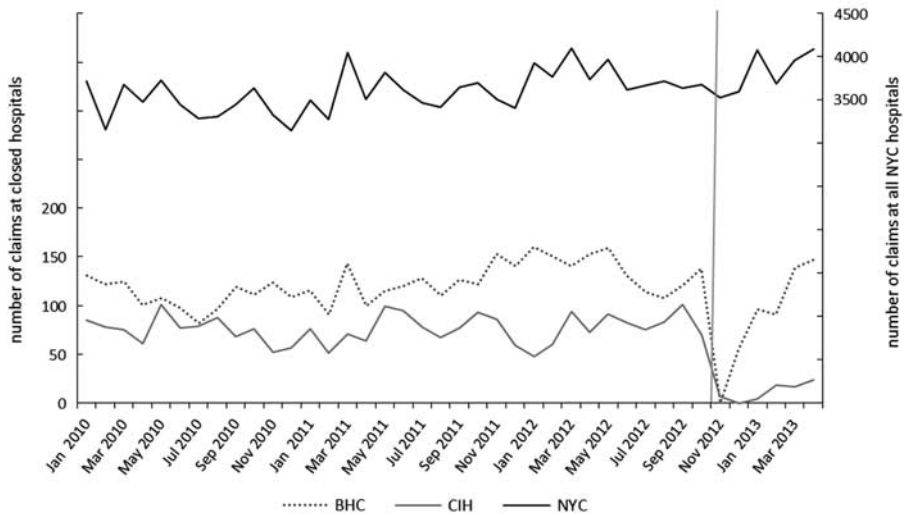
The gray vertical line marks the month Hurricane Sandy made landfall. Abbreviations: BHC, Bellevue Hospital Center; CIH, Coney Island Hospital; NYC, New York City.

FIGURE 3

**Mental-Health-Related Inpatient Hospitalizations Among New York City Medicaid Patients and Patients at Hospitals That Closed After Hurricane Sandy.**

The gray vertical line marks the month Hurricane Sandy made landfall. Abbreviations: BHC, Bellevue Hospital Center; CIH, Coney Island Hospital; NYC, New York City.

FIGURE 4

Mental-Health-Related Outpatient Visits Among New York City Medicaid Patients and Patients at Health Care Facilities That Closed After Hurricane Sandy.
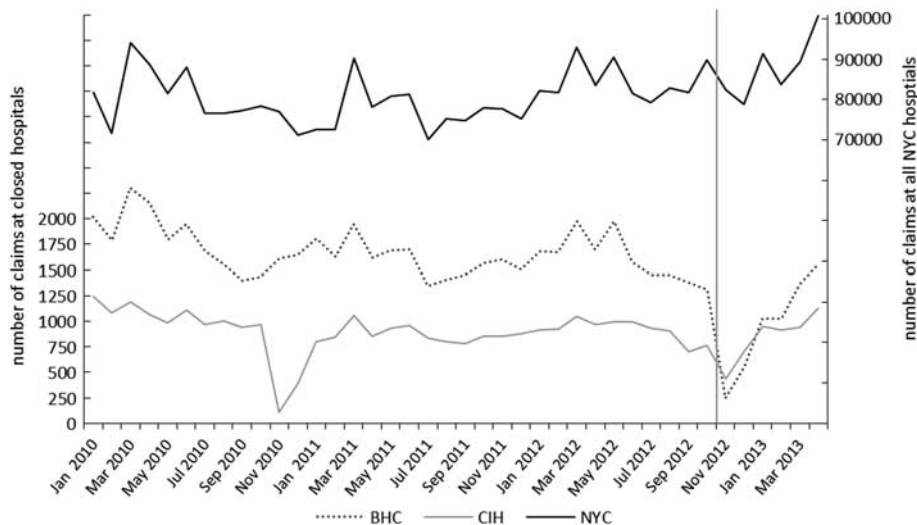
The gray vertical line marks the month Hurricane Sandy made landfall. Abbreviations: BHC, Bellevue Hospital Center; CIH, Coney Island Hospital; NYC, New York City.

TABLE 1

Health Facilities With Greater Than the Expected Number of Emergency Department Medicaid Mental Health Visits After Hurricane Sandy[a]

| | NYC Medicaid Patients | | Area of Patient Residence | | |
| | | | BHC Service Area | CIH Service Area | Hurricane Sandy Impact Area |
Facility	No. of Months[b]	Percentage difference,[c] %	No. of months	No. of months	No. of months
Brookdale Hospital	1	47	0	2	2
Jacobi Medical Center	1	36	1	0	0
Kings County Hospital	0	—	—	1	0
Lutheran Medical Center	2	94	1	6	5
Maimonides Medical Center	4	54	0	4	4
Metropolitan Hospital Center	1	82	1	0	0
Montefiore Moses	6	95	6	0	1
Mount Sinai Beth Israel	2	98	2	0	1
New York Methodist Hospital	1	84	1	0	0
St. Barnabas Hospital	1	40	2	0	0
St. John's Episcopal Hospital	1	68	3	0	2
Woodhull Medical and Mental Health Center	5	30	3	1	0

[a]Abbreviations: BHC, Bellevue Hospital Center; CIH, Coney Island Hospital; NYC, New York City. Dashed line indicates not tested.

[b]Number of months facilities experienced an increase in Medicaid claims.

[c]Percentage increase between the number of claims after the storm and the mean number of claims in the 2 years before the storm for those months with greater than the expected number of claims. The percentage difference was calculated for facilities where increase in total Medicaid patients was coincident with an increase in patients admitted from the Hurricane Sandy impact area and closed hospital service areas.

DISCUSSION

Two-year trends in ED, inpatient, and outpatient Medicaid MH claims showed variability in claims per month, a gradual increase in the number of claims over time, and a steep decline in claims that lasted for 1 to 4 months after the storm at closed hospitals. Redistribution of patients from closed hospitals was observed at 24 health care facilities located in all 5 boroughs of NYC. Thus, Hurricane Sandy

TABLE 2

Health Facilities With Greater Than the Expected Number of Inpatient Medicaid Mental Health Hospitalizations After Hurricane Sandy[a]

| | NYC Medicaid Patients | | Area of Patient Residence | | |
| | | | BHC Service Area | CIH Service Area | Hurricane Sandy Impact Area |
Facility	No. of Months[b]	Percentage difference,[c] %	No. of months	No. of months	No. of months
Holliswood Hospital	1	25	0	0	2
Jacobi Medical Center	3	39	5	0	0
Kings County Hospital	0	—	0	1	1
Kingsbrook Jewish Medical Center	1	95	1	0	1
Maimonides Medical Center	0	—	—	2	2

[a]Abbreviations: BHC, Bellevue Hospital Center; CIH, Coney Island Hospital; NYC, New York City. Dashed line indicates not tested.

[b]Number of months facilities experienced an increase in Medicaid claims.

[c]Percentage increase between the number of claims after the storm and the mean number of claims in the 2 years before the storm for those months with greater than the expected number of claims. The percentage difference was calculated for facilities where an increase in total Medicaid patients was coincident with an increase in patients admitted from the Hurricane Sandy impact area and closed hospital service areas.

TABLE 3

Health Facilities With Greater Than the Expected Number of Outpatient Medicaid Mental Health Visits After Hurricane Sandy[a]

| | NYC Medicaid Patients | | Area of Patient Residence | | |
| | | | BHC Service Area | CIH Service Area | Hurricane Sandy Impact Area |
Facility	No. of Months[b]	Percentage difference,[c] %	No. of months	No. of months	No. of months
Elmhurst Hospital	1	21	1	0	2
Harlem Hospital	0	—	0	—	1
Montefiore Moses	0	—	1	—	—
Mount Sinai Beth Israel	1	24	1	0	0
Mount Sinai Roosevelt	1	35	1	0	1
RUMC Bayley Seton Hospital	6	249	0	0	6
Union Community Health Center	0	—	0	2	0

[a]Abbreviations: BHC, Bellevue Hospital Center; CIH, Coney Island Hospital; NYC, New York City; RUMC, Richmond University Medical Center. Dashed line indicates not tested.

[b]Number of months facilities experienced an increase in Medicaid claims.

[c]Percentage increase between the number of claims after the storm and the mean number of claims in the 2 years before the storm for those months with greater than the expected number of claims. The percentage difference was calculated for facilities where increase in total Medicaid patients was coincident with an increase in patients admitted from the Hurricane Sandy impact area and closed hospital service areas.

had a substantial impact on MH service utilization across the entire city.

At Montefiore Hospital Moses Campus, the patient surge from the Hurricane Sandy impact area continued for the entire 6-month follow-up period. This may indicate long-term displacement of some physician practices, selection of a new provider by patients with storm-related service disruptions, or redistribution of patients from community-based providers who closed their facilities due to the hurricane. It is also possible that there was an increase in demand for MH services from residents of storm-affected areas. The Medicaid claims data do not allow us to distinguish between these 4 possibilities.

At the Montefiore Hospital Moses campus, the persistence of ED patient relocations was not readily explained by the duration of hospital closures. We observed redistribution of ED patients from the BHC service area for 6 months after the storm; however, at BHC, ED claims returned to pre-hurricane levels by December 2012. Given the suspension of inpatient services at BHC, hospital administrators sought to reduce the number of ED visits that might lead to inpatient admission.[16] Thus, the prolonged redistribution of ED patients may be the result of coordination between BHC and emergency medical services to exclude ambulance patients with emotional disturbance. Lee and colleagues found that persons who visited the BHC ED for medical or MH services prior to Hurricane Sandy were most frequently redistributed to Mount

Sinai Beth Israel (24%), Metropolitan Hospital Center (18%), and Woodhull Medical and Mental Health Center (10%) after the storm.[7] In the current study, there was a significant redistribution of Medicaid MH patients from the BHC service area to these same hospitals.

Eighteen facilities had a concurrent increase in claims from the citywide Medicaid patient pool and patients from one or more storm-affected regions. Of these hospitals, 4 were publicly owned (Elmhurst Hospital, Metropolitan Hospital Center, Jacobi Medical Center, and Woodhull Medical and Mental Health Center). Given that the majority of patients at public hospitals in NYC are either uninsured or insured through Medicaid, it is likely that the storm had a substantial impact on resource use at these hospitals. It was rare for a hospital to have a patient surge in more than one service area. Mount Sinai Beth Israel was the only hospital to experience an increase in ED and outpatient volume. Jacobi Medical Center was the only hospital with an increase in ED and inpatient volume.

Limitations

First, hospital service areas were defined as the most frequent zip codes among patients who visited closed hospitals in the 6 months before Hurricane Sandy. This method assumes the likelihood that an individual in a given zip code seeks care at a given facility does not change over time. Second, we found yearly growth in utilization of ED, inpatient, and outpatient MH services. It is possible that the increase in MH claims after Hurricane Sandy is attributable to secular trends rather than redistribution of patients from closed hospitals. For example, in 2012 the Patient Portability and Affordable Care Act (PL 111-148) increased the number persons eligible for Medicaid benefits.

CONCLUSIONS

In the next 50 years, it is expected that the coastal areas of NYC will experience a 7- to 12-inch rise in sea level and a doubling of the population that lives in the flood zone.[17,18] As a result, less severe storms will have greater destructive potential. While every effort should be made to strengthen health care facilities against catastrophic flooding, there are limits to the infrastructure improvements that can be carried out. For example, building code regulations prevent some facilities from moving fuel pumps above ground.[14] Statistical process control can identify the location of patient surges and thereby improve planning of the staff, facilities, and equipment necessary to provide continuity of care after a natural disaster. After Hurricane Sandy, 24 hospitals from all 5 boroughs of NYC experienced a storm-related surge in Medicaid MH visits. Given a Sandy-like flood event with persistent disruptions in health care service delivery, the surge needs at a hospital may outstrip their response capabilities. Thus, the facilities identified in this study should be given high priority for support from government agencies and mutual aid partners.

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Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/dmp.2016.58

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