



Lack of access to medical care during Hurricane Sandy and mental health symptoms

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ABSTRACT

Destruction caused by natural disasters compromises medical providers' and hospitals' abilities to administer care. Hurricane Sandy was particularly devastating, resulting in massive disruptions of medical care in the region. This study aimed to determine whether a lack of access to medical care during Hurricane Sandy was associated with posttraumatic stress disorder (PTSD) symptoms and other mental health/substance abuse outcomes. A secondary aim was to examine whether having a chronic illness moderates those associations. Self-reported medical access and mental health symptomatology were obtained from New York City and Long Island residents ($n = 1669$) following Hurricane Sandy under the Leaders in Gathering Hope Together project (10/23/2013–2/25/2015) and Project Restoration (6/5/2014–8/9/2016). Multivariable logistic regressions were utilized to determine the relationship between lack of access to medical care and mental health outcomes. Of the 1669 participants, 994 (59.57%) were female, 866 (51.89%) were white, and the mean age was 46.22 (SD = 19.2) years old. Those without access to medical care had significantly higher odds of showing symptoms of PTSD (AOR = 2.71, CI = [1.77–4.16]), as well as depression (AOR = 1.94, CI = [1.29–2.92]) and anxiety (AOR = 1.61, CI = [1.08–2.39]) compared to those with access. Lack of access to care was associated with a 2.12 point increase in perceived stress scale score (SE = 0.63). The interaction between having a chronic illness and lack of access to medical care was not significantly associated with any outcomes. The findings emphasize the importance of making medical care more accessible to patients, both chronically and acutely ill, during natural disasters to benefit their physical as well as their mental health.

1. Introduction

Hurricane Sandy hit the New York area on October 29, 2012, becoming the second costliest hurricane in United States history at the time (Roberts and Lyles, 2012; Blake et al., n.d.). Over 8 million residents of the New York metropolitan area lost power (Ben-Ezra et al., 2014) and the cost of infrastructure damages sustained in New York City totaled \$19 billion (Blake et al., n.d.). Natural disasters compromise hospitals' abilities to administer care due to electricity loss, property damage, and transportation/delivery issues, obstructing patients' access to physicians and critical equipment (Kessler, 2007; Rath

et al., 2007; Ryan et al., 2015; Smith, 2005; Tsuboya et al., 2016). Hurricane Sandy was particularly devastating, resulting in massive disruptions of medical care in the region (Ben-Ezra et al., 2014; Heptulla et al., 2016; Kelman et al., 2015; Lurie et al., 2015; Murakami et al., 2015; Redlener and Reilly, 2012).

Studies have found that specific demographic factors, including lack of insurance (Greenough et al., 2008) and low socioeconomic status (Heptulla et al., 2016; Abdel-Kader and Unruh, 2009; Lempert and Kopp, 2013), can increase one's likelihood of experiencing a disaster-related disruption in medical care (Kessler, 2007). During Hurricanes Katrina (Arrieta et al., 2009) and Sandy (Department of Health and

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<https://doi.org/10.1016/j.pmedr.2018.04.014>

Received 16 January 2018; Received in revised form 26 March 2018; Accepted 21 April 2018

Available online 24 April 2018

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Human Services, n.d.). A substantial proportion of hospitals were either lost or severely damaged, and the majority reported experiencing significant challenges to administering care. Following Hurricanes Isabel and Sandy, the number of emergency department visits to actually plummeted on the day of each disaster (Smith, 2005; Kim et al., 2016).

While the impacts of restricted access to medical care during and after a natural disaster on physical health are well established, there is a dearth of literature on the consequences of limited health care access on mental health in the context of a natural disaster (Tsuboya et al., 2016; Hyre et al., 2007; Sirey et al., 2016). Several studies have found that traumatic experiences during natural disasters can lead to negative mental health symptoms such as anxiety, depression, posttraumatic stress disorder (PTSD) and substance abuse, although little is known about the specific impact of lack of access to medical care on these outcomes (Tsuboya et al., 2016; Hyre et al., 2007; Abramson et al., 2010; Beaudoin, 2011; Boscarino et al., 2014; Galea et al., 2005; Gros et al., 2012; Leon et al., 2007; Lieberman-Cribbin et al., 2017; Neria et al., 2007; Schwartz et al., 2015a; Schwartz et al., 2015b; Schwartz et al., 2016; Zwiebach et al., 2010). Individuals suffering from chronic illnesses are particularly vulnerable to losing access to medical care during a disaster (Kelman et al., 2015; Rath et al., 2007; Abdel-Kader and Unruh, 2009; Lempert and Kopp, 2013). In the aftermath of Hurricane Katrina, Rath et al. (2007) found that 58.4% of chronically ill participants experienced a disruption in medical care, compared to 38.3% of non-chronically ill participants.

This study aims to test the hypothesis that lack of access to medical care during Hurricane Sandy is associated with an increased likelihood of showing symptoms of perceived stress, depression, anxiety, PTSD, and substance abuse. The secondary study aim is to examine whether having a chronic illness moderates those associations.

2. Methods

2.1. Participants and procedure

The data was collected by combining two cross-sectional studies that examined the impact of Hurricane Sandy exposure on mental health. The first study, Leaders in Gathering Hope Together (Project LIGHT), ran from 10/23/2013 to 2/25/2015 and included participants from Nassau and Suffolk Counties of Long Island, Queens, and Staten Island. Recruitment for the second study, Project Restoration (PR), ran from 6/5/2014 to 8/9/2016 and focused exclusively on residents of the Rockaways in Queens, NY. Both studies utilized convenience sampling where interested potential participants approached the research booth at a variety of locations, such as street fairs, libraries, and supermarkets. Eligible participants completed a self-report survey and were given \$15 as compensation. Exclusion criteria were not speaking English or Spanish, having cognitive impairments that prevented a participant from providing informed consent, being under the age of 18, or not living in Long Island or New York City during Hurricane Sandy. For PR, participants also had to have been living in the Rockaways at the time of Hurricane Sandy. The study sample included 1669 participants (Project LIGHT $n = 658$, PR $n = 1011$).

2.2. Measures

2.2.1. Independent variable

Participants' degree of exposure to the hurricane was measured using a 30-item checklist derived from exposure tools used in previous studies on Hurricanes Andrew (Norris et al., 1999) and Katrina (Harville et al., 2010) and other disaster studies (Schwartz et al., 2015a; Schwartz et al., 2015b; Schwartz et al., 2016). It included items that related to both personal losses and property losses. Participants were asked to check off each exposure they experienced specifically during Hurricane Sandy. On the checklist, participants indicated whether or not they had been unable to access necessary medical care during the

hurricane; lack of access to medical care was then used as a dichotomized variable in all analyses. Participants were also asked whether a health care professional had ever told them that they had any of the following chronic illnesses: heart disease, high cholesterol, coronary artery disease, having a prior stroke, coronary heart failure, hypertension, type II diabetes, insulin dependent diabetes, osteoarthritis, osteoporosis, Parkinson's disease, autoimmune thyroid disease, tuberculosis, and "other". For each disease, participants indicated "Yes", "No", or "I Don't Know". The presence of at least one chronic illness was used as a dichotomized variable, and all "I Don't Know" responses were considered as missing for all analyses ($n = 12$, 0.72%).

2.2.2. Outcome variables

The primary outcome was symptoms of PTSD. Secondly we studied symptoms of anxiety, depression, and perceived stress. The self-reported Posttraumatic Stress Disorder Checklist Specific (PCL-S), a validated (Weathers et al., 1993) 17-item checklist widely used in previous disaster studies (Gros et al., 2012; Leon et al., 2007; Schwartz et al., 2015a; Schwartz et al., 2015b; Schwartz et al., 2016; Harville et al., 2010; Pietrzak et al., 2013; Hyre et al., 2008), was used to assess PTSD symptoms. In this case, each item in the checklist asked if participants experienced a certain PTSD symptom specifically when thinking about Hurricane Sandy. PTSD symptom scores range from 17 to 85. In all analyses, PTSD was treated as a dichotomized variable, with scores of at least 30 indicating probable PTSD (Weathers et al., 1993). Anxiety and depression symptoms were assessed by summing responses of the first two and last two questions of the Patient Health Questionnaire (PHQ-4), respectively. The PHQ-4 is a validated tool (Kroenke et al., 2009) and has been used in prior studies (Schwartz et al., 2015a; Schwartz et al., 2015b; Schwartz et al., 2016; Pietrzak et al., 2013; Anastario et al., 2008). Summed scores range from 0 to 6 and were dichotomized at ≥ 3 as an indicator of probable anxiety or probable depression (Kroenke et al., 2009). Perceived stress was defined as a continuous variable by summing the 10 items, including reversed coding, of the Perceived Stress Scale (PSS), which is validated (Cohen et al., 1983) and has been used in previous disaster studies (Hyre et al., 2008). PSS scores range from 0 to 40.

The substance use variables evaluated were substance abuse, smoking, and alcohol misuse. According to the National Institute on Drug Abuse (NIDA), participants were categorized as engaging in substance abuse if they were using illegal drugs or prescription drugs for non-indicated purposes at least monthly in the past year (Abuse NID, n.d.). If participants indicated that they currently smoked, they were categorized as current smokers (Tobacco Questions for Surveys - WHO, n.d.). Per the National Institute on Alcohol Abuse and Alcoholism (NIAAA) guidelines, male participants were categorized as engaging in alcohol misuse if they drank at least 5 drinks in a day on a monthly basis; females were classified as engaging in alcohol misuse if they drank at least 4 drinks (Drinking Levels Defined, n.d.).

2.2.3. Additional study variables

Participants answered questions about their demographics, including their age, gender, race (white or other), ethnicity (Hispanic or non-Hispanic), and education level (completed high school or above/did not complete high school). The elapsed time since Hurricane Sandy was measured as the time in months between Sandy's landfall and survey completion. Those who answered that they had been diagnosed with a mental health condition before Hurricane Sandy were classified as having a history of mental illness. Participants also indicated whether they had medical insurance and, if so, their insurance provider. Participants' medical insurance status was classified into four categories (no insurance, government provider [Medicaid/Medicare], private provider, and other/unknown provider). Hurricane exposure score was defined as the number of items checked off on the hurricane exposure checklist, not including a lack of access to medical care.

2.2.4. Statistical analysis

Chi-square tests were performed to evaluate the associations between those with and without medical care access and each categorical study variable; if small expected sizes were present, Fisher's exact tests were performed instead. In addition, the frequencies and percentages for each categorical variable are reported and stratified based on medical care access. For each normally distributed continuous study variable, *t*-tests compared those with and without access to medical care. Alternatively, Wilcoxon Rank Sum tests were conducted for non-normally distributed continuous variables. Mean ± standard deviation (SD) or median (Med) and interquartile range (IQR) were reported for each continuous variable.

The association between a lack of access to medical care and each categorical outcome was assessed using separate multivariable logistic regression models. Substance abuse was not modeled due to a high percentage of incomplete analysis data (12.50%). The models adjusted for the following factors: gender, race, level of education, Hispanic ethnicity, prior mental health history, age, insurance, elapsed time since Hurricane Sandy, and hurricane exposure score. Adjusted odds ratios (AOR), 95% confidence intervals (CI), *p*-values, and *c*-statistics are reported. A multivariable linear regression model was used to examine the association between PSS score and a lack of access to medical care, using the same adjustments. Adjusted parameter estimates (*B*), standard errors (SE), *p*-values, and coefficient of determination (*R*²) were reported for this model. The interaction between chronic illness and a lack of access to medical care was also modeled without adjustment. All multivariable analyses used data from at least 92.80% of the participants. Results with a *p*-value < 0.05 were considered significant. SAS software, version 9.4 was used for all statistical analyses (SAS Institute, Cary, NC, USA).

3. Results

3.1. Univariable analysis

Of the 1669 study participants, 994 (59.57%) were female, and 866 (51.89%) were white. The mean age was 46.22 (SD = 19.2) years old. One-hundred and fifty-six participants (9.34%) were unable to access necessary medical care during Hurricane Sandy, and 700 (42.25%) indicated that they had at least one chronic illness. Among the 156 participants who lost access to medical care, 87 (55.77%) had at least one chronic illness; in fact, a significantly higher percentage of the chronically ill lost access to medical care (12.43%) than those without chronic illnesses (7.00%, Table 1). Furthermore, a significantly greater proportion of males lost access to medical care than females (11.14% vs. 8.15%), and a similar trend was seen between those who did not complete high school (13.78%) versus those who did (8.60%, Table 1). Among groups with different insurance plans, the highest proportion who lost access to medical care were those with government insurance (12.85%), followed by other/unknown (10.63%), no insurance (9.94%), and private insurance (6.69%); this disparity between all three groups was statistically significant (Table 1). In pairwise comparisons with Bonferroni correction, lack of access to medical care was significantly higher among those with government vs. private insurance (*p* = 0.0036). No other pairs were significant.

There were significant associations between a lack of access to medical care and mental health symptoms after the storm (Table 2). Specifically, those who lacked access to medical care had a higher percentage of symptoms of our primary outcome of PTSD (70.51% vs. 28.87%), as well as depression (44.23% vs. 22.24%) and anxiety (45.51% vs. 26.08%) than those with access to medical care. Likewise, those who lacked access to medical care had significantly higher mean PSS scores (Mean ± SD: 19.7 ± 7.26) than those who did not (15.99 ± 7.22). There was no significant association between a lack of medical care access and alcohol misuse or substance abuse; however, a higher proportion of those who lacked medical care access were current

Table 1
Percentage (%) of lack of access to medical care, according to study population characteristics^a.

Variable	Category	Lack access to medical care		<i>p</i> -Value ^c
		Yes (N = 156)	No (N = 1513)	
		No. (%)	No. (%)	
Gender	Male	75 (11.14%)	598 (88.86%)	0.039
	Female	81 (8.15%)	913 (91.85%)	
Race	White	72 (8.45%)	780 (91.55%)	0.21
	Other	81 (10.25%)	709 (89.75%)	
Ethnicity	Not Hispanic	122 (9.13%)	1214 (90.87%)	0.59
	Hispanic	31 (10.13%)	275 (89.87%)	
Education	< HS ²	35 (13.78%)	219 (86.22%)	0.010
	≥ HS	117 (8.60%)	1243 (91.40%)	
Insurance	None	18 (9.94%)	163 (90.06%)	0.007
	Government	50 (12.85%)	339 (87.15%)	
	Private	46 (6.69%)	642 (93.31%)	
	Other/Unknown	42 (10.63%)	353 (89.37%)	
Study	LIGHT ^b	34 (5.17%)	624 (94.83%)	< 0.001
	Project	122 (12.07%)	889 (87.93%)	
	Restoration			
Prior mental health history	No	101 (8.31%)	1114 (91.69%)	0.014
	Yes	55 (12.28%)	393 (87.72%)	
Chronic illness	No	67 (7.00%)	890 (93.00%)	< 0.001
	Yes	87 (12.43%)	613 (87.57%)	

Variable	Mean (SD) ^b	Mean (SD) ^b	<i>p</i> -Value ^c
Age (years)	48.88 (16.11)	45.94 (19.48)	0.070
Elapsed time since Hurricane Sandy (months)	27.57 (11.34)	25.99 (11.12)	0.11
Hurricane exposure score	9.81 (4.88)	4.51 (3.85)	< 0.001

^a Numbers may not add to total due to missing values in each characteristic.
^b HS = high school; LIGHT = Leaders in Gathering Hope Together; SD = standard deviation.
^c *p*-value from Chi-square tests for categorical variables, two sample *t*-test for age and Mann-Whitney Rank sum test for Hurricane to Questionnaire Date and Hurricane Exposure score.

smokers than those with medical care access.

3.2. Multivariable analysis

From the multivariable models (Tables 3, 4), a lack of access to medical care was significantly associated with increased odds of each of the four mental health symptoms: PTSD, anxiety, depression, and PSS score. Those without access to medical care were associated with significantly increased odds of showing symptoms of PTSD (AOR = 2.71, CI = [1.77–4.16]), as well as depression (AOR = 1.94, CI = [1.29–2.92]) and anxiety (AOR = 1.61, CI = [1.08–2.39]), and were associated with a 2.12 point increase in PSS score (SE = 0.63) than those with adequate access to medical care. A lack of medical care access was not significantly associated with alcohol misuse or smoking. Having at least one chronic illness was not found to be associated with PTSD or depression. However, having a chronic illness was associated with significantly higher odds of probable anxiety (AOR = 1.57, CI = [1.17–2.10]) and significantly higher PSS scores (B = 0.94, *t* = 2.24) as opposed to those without chronic illnesses. There was a significant positive association between having a history of mental health difficulties and showing symptoms of PTSD (AOR = 3.08, CI = [2.35–4.02]), depression (AOR = 3.50, CI = [2.68–4.56]), and anxiety (AOR = 2.60, CI = [2.02–3.34]) after the hurricane; those with prior mental health difficulties also reported a 4.02-point increase in PSS score (SE = 0.40). Increased exposure to Hurricane Sandy and a

Table 2
Percentage (%) of mental health symptoms and substance abuse, according to access to medical care^a.

Variable	Category	Lack access to medical care		p-Value ^c
		Yes (N = 156)	No (N = 1513)	
		No. (%)	No. (%)	
Depression symptoms	No	87 (55.77%)	1175 (77.76%)	< 0.001
	Yes	69 (44.23%)	336 (22.24%)	
Anxiety symptoms	No	85 (54.49%)	1117 (73.92%)	< 0.001
	Yes	71 (45.51%)	394 (26.08%)	
PTSD symptoms	No	46 (29.49%)	1074 (71.13%)	< 0.001
	Yes	110 (70.51%)	436 (28.87%)	
Alcohol misuse	No	93 (59.62%)	943 (62.41%)	0.49
	Yes	63 (40.38%)	568 (37.59%)	
Smoking	No	101 (64.74%)	1168 (77.76%)	< 0.001
	Yes	55 (35.26%)	334 (22.24%)	
Substance Abuse	No	115 (80.99%)	1180 (83.87%)	0.38
	Yes	27 (19.01%)	227 (16.13%)	

Variable	Mean (SD) ^b	Mean (SD) ^b	p-Value ^c
PSS score	19.7 (7.26)	15.99 (7.22)	< 0.001

^a Numbers may not add to total due to missing values in each characteristic.
^b SD = standard deviation.
^c p-value from Chi-square tests for categorical variables, two sample t-test for PSS score.

Table 3
Adjusted Odds Ratios (AOR) between mental health symptoms and lack of access to medical care, adjusted for study variables^a.

Effect	Depression symptoms	Anxiety symptoms	PTSD symptoms	Alcohol misuse	Smoking
	AOR ^{b,c} (95% CI ^b)	AOR ^{b,c} (95% CI ^b)	AOR ^{b,c} (95% CI ^b)	AOR ^{b,c} (95% CI ^b)	AOR ^{b,c} (95% CI ^b)
Lack medical care (yes vs. no)	1.94** ([1.2–2.92])	1.61* ([1.08–2.39])	2.71*** ([1.77–4.16])	0.91 ([0.6–1.35])	1.35 ([0.8–2.07])
Chronically Ill (yes vs. no)	1.2 ([0.8–1.62])	1.57** ([1.17–2.10])	1.34 ([1.00–1.79])	1.08 ([0.8–1.42])	0.97 ([0.7–1.33])
Gender (female vs. male)	1.25 ([0.9–1.63])	1.32* ([1.03–1.70])	1.1 ([0.85–1.42])	0.67** ([0.5–0.84])	0.59*** ([0.4–0.76])
Race (Non-white vs. White)	1.63** ([1.2–2.18])	1.21 ([0.92–1.58])	2.21*** ([1.66–2.94])	0.86 ([0.6–1.10])	2.06*** ([1.5–2.78])
Education (≥ HS vs. < HS) ^b	0.64** ([0.4–0.89])	0.7* ([0.51–0.97])	0.58** ([0.42–0.81])	1.06 ([0.7–1.45])	0.38*** ([0.2–0.53])
Prior mental health history (yes vs. no)	3.5*** ([2.6–4.56])	2.6*** ([2.02–3.34])	3.08*** ([2.35–4.02])	1.28 ([1.0–1.63])	3.29*** ([2.5–4.34])
Ethnicity (Hispanic vs. Not Hispanic)	1.7** ([1.2–2.40])	1.34 ([0.97–1.86])	2.06*** ([1.46–2.91])	0.62** ([0.4–0.85])	0.87 ([0.5–1.28])
Insurance (public vs. none)	1.03 ([0.6–1.66])	1.04 ([0.67–1.63])	0.82 ([0.52–1.30])	0.59* ([0.3–0.89])	0.74 ([0.4–1.18])
Insurance (private vs. none)	0.8 ([0.5–1.26])	0.88 ([0.58–1.33])	0.58* ([0.38–0.89])	0.74 ([0.5–1.08])	0.68 ([0.4–1.05])
Insurance (other/unknown vs. none)	0.92 ([0.5–1.47])	0.81 ([0.52–1.27])	0.89 ([0.57–1.39])	0.58** ([0.3–0.87])	0.84 ([0.5–1.32])
Age (years)	1.00 ([0.9–1.01])	0.98*** ([0.98–0.99])	1.00 ([0.99–1.01])	0.97*** ([0.9–0.98])	1.00 ([0.9–1.01])
Elapsed time since Hurricane Sandy (months)	1.00 ([0.9–1.01])	1.00 ([0.99–1.01])	1.00 ([0.99–1.01])	1.03*** ([1.0–1.04])	1.02* ([1.0–1.03])
Hurricane exposure score	1.06** ([1.0–1.09]) c = 0.723 ^b N = 1556	1.06*** ([1.03–1.10]) c = 0.698 ^b N = 1556	1.19*** ([1.15–1.23]) c = 0.787 ^b N = 1556	1.05** ([1.0–1.08]) c = 0.691 ^b N = 1557	1.04* ([1.0–1.08]) c = 0.749 ^b N = 1548

^a Assessed by separate multivariable logistic regressions; each model adjusted for gender, race, level of education, Hispanic ethnicity, prior mental health history, age, insurance, elapsed time since Hurricane Sandy, and hurricane exposure score.
^b HS = high school; AOR = adjusted odds ratio; CI = confidence interval; c = c statistic.
^c * p < 0.05, ** = p < 0.01, *** = p < 0.001.

Table 4
Adjusted parameter estimates of perceived stress score according to several study variables^a.

Effect	Perceived stress	
	Adj. B ^{b,c} (SE ^b)	t ^b
Lack medical care (yes vs. no)	2.12** (0.6)	3.35
Chronically Ill (yes vs. no)	0.94* (0.4)	2.24
Gender (female vs. male)	1.81*** (0.4)	5.01
Race (Non-white vs. White)	0.7 (0.4)	1.79
Education (≥ HS vs. < HS) ^b	−0.96 (0.5)	−1.95
Prior mental health history (yes vs. no)	4.02*** (0.4)	10.1
Ethnicity (Hispanic vs. Not Hispanic)	0.67 (0.5)	1.36
Insurance (public vs. none)	−1.53* (0.7)	−2.29
Insurance (private vs. none)	−1.8** (0.6)	−2.93
Insurance (other/unknown vs. none)	−1.53* (0.7)	−2.34
Age (Years)	−0.08*** (0)	−7.02
Elapsed time since Hurricane Sandy (months)	−0.004 (0)	−0.28
Hurricane exposure score	0.21*** (0.1)	4.66
R ² = 0.16 ² N = 1556		

^a Assessed by multivariable linear regression; model adjusted for chronic illness, gender, race, level of education, Hispanic ethnicity, prior mental health history, age, insurance, elapsed time since Hurricane Sandy, and hurricane exposure score.
^b HS = high school; Adj. B = adjusted parameter estimate; SE = standard error; t = t value; R² = coefficient of variation.
^c * p < 0.05, ** = p < 0.01, *** = p < 0.001.

Table 5
Odds ratios between mental health symptoms and lack of access to medical care by chronic illness status.

Outcome	Effect	OR	95% CI		p-Value for interaction
Depression symptoms					
Interaction between Access to Medicine and Chronic Illness					
Chronically Ill = No	Lack Medical Care (Yes vs. No)	2.19	1.29	3.70	0.3592
Chronically Ill = Yes	Lack Medical Care (Yes vs. No)	3.03	1.92	4.80	
Lack Medical Care = No	Chronically Ill (Yes vs. No)	1.26	0.99	1.62	
Lack Medical Care = Yes	Chronically Ill (Yes vs. No)	1.75	0.91	3.36	
Anxiety symptoms					
Interaction between Access to Medicine and Chronic Illness					
Chronically Ill = No	Lack Medical Care (Yes vs. No)	2.00	1.20	3.35	0.5485
Chronically Ill = Yes	Lack Medical Care (Yes vs. No)	2.47	1.57	3.90	
Lack Medical Care = No	Chronically Ill (Yes vs. No)	1.25	0.99	1.58	
Lack Medical Care = Yes	Chronically Ill (Yes vs. No)	1.54	0.81	2.94	
PTSD symptoms					
Interaction between Access to Medicine and Chronic Illness					
Chronically Ill = No	Lack Medical Care (Yes vs. No)	5.55	3.28	9.39	0.9821
Chronically Ill = Yes	Lack Medical Care (Yes vs. No)	5.59	3.37	9.27	
Lack Medical Care = No	Chronically Ill (Yes vs. No)	1.44	1.15	1.81	
Lack Medical Care = Yes	Chronically Ill (Yes vs. No)	1.46	0.73	2.91	
Alcohol misuse					
Interaction between Access to Medicine and Chronic Illness					
Chronically Ill = No	Lack Medical Care (Yes vs. No)	0.82	0.49	1.36	0.0436
Chronically Ill = Yes	Lack Medical Care (Yes vs. No)	1.66	1.05	2.62	
Lack Medical Care = No	Chronically Ill (Yes vs. No)	0.61	0.49	0.76	
Lack Medical Care = Yes	Chronically Ill (Yes vs. No)	1.24	0.65	2.39	
Smoking					
Interaction between Access to Medicine and Chronic Illness					
Chronically Ill = No	Lack Medical Care (Yes vs. No)	1.35	0.78	2.35	0.1017
Chronically Ill = Yes	Lack Medical Care (Yes vs. No)	2.48	1.55	3.97	
Lack Medical Care = No	Chronically Ill (Yes vs. No)	0.93	0.72	1.19	
Lack Medical Care = Yes	Chronically Ill (Yes vs. No)	1.70	0.86	3.37	
Perceived stress					
Intercept		B = 16.08	SE = 0.24	t = 66.42	< 0.0001
Lack Medical Care (Yes vs. No)		B = 2.85	SE = 0.91	t = 3.12	0.0019
Chronically Ill (Yes vs. No)		B = -0.26513360	SE = 0.38	t = -0.70	0.4847
Interaction between Access to Medicine and Chronic Illness		B = 1.41	SE = 1.23	t = 1.14	0.2535

lack of a high school education were both significantly positively associated with having symptoms of each of the mental health outcomes. Being of Hispanic ethnicity was significantly associated with increased odds of symptoms of PTSD (AOR = 2.06, CI = [1.46–2.91]) and depression (AOR = 1.70, CI = [1.20–2.40]). Females were associated with significantly higher odds of symptoms of anxiety (AOR = 1.32, CI = [1.03–1.70]) and higher PSS scores (t = 5.01) than males (Tables 3, 4).

The interaction between chronic illness and lack of access to medical care was tested and found not to be significantly associated with any outcomes (Table 5). Therefore, further modeling analyses regarding this relationship were not conducted.

4. Discussion

This study is among the first to evaluate the associations between lack of access to medical care and mental health outcomes during Hurricane Sandy. While a few studies have been conducted on the association between a lack of access to medical care and depression in different natural disasters (Tsuboya et al., 2016; Hyre et al., 2007; Sirey et al., 2016), none, to our knowledge, have examined the association with PTSD and other mental health issues in the context of Hurricane Sandy, specifically. Our study indicates that those who lost access to medical care during the hurricane had significantly greater odds of showing symptoms of PTSD, stress, depression, and anxiety. These results are consistent with the limited previous studies on various natural disasters (Tsuboya et al., 2016; Hyre et al., 2007; Sirey et al., 2016).

We found no significant association between losing access to medical care and alcohol or smoking. While little has been studied about

this association, an association between general exposure to natural disasters and substance abuse has been reported (Beaudoin, 2011). Given that other studies have found that the relationship between trauma and substance abuse can be mediated by mental health difficulties (Jaquier et al., 2014; Khoury et al., 2010; Sullivan et al., 2009), it is also possible that mental health symptoms can mediate the impact of a lack of access to medical care on substance abuse in a similar manner. Future research should investigate this potential mediating effect.

The interaction between chronic illness and a lack of access to medical care was non-significant for all outcomes, indicating that having a chronic illness did not moderate the relationship between a lack of access to medical care and mental health symptoms. While experiencing chronic illness was not associated with PTSD and depression, it was associated with symptoms of anxiety and perceived stress. Previous studies support the current study's finding that being chronically ill is not associated with the development of PTSD or depression after a hurricane (Sirey et al., 2016; Boscarino et al., 2014). As a result of these factors, those who lost access to medical care have similar odds of developing mental health difficulties, regardless of whether or not they are chronically ill. Anxiety and stress, however, have historically been associated with cardiovascular diseases (Player and Peterson, 2011); considering that the majority of chronically ill respondents had a cardiovascular condition, this may account for the increased odds of showing symptoms of anxiety and perceived stress among the chronically ill.

Similar to previous studies, this study suggests that male gender (Greenough et al., 2008), the presence of a preexisting medical condition (Kelman et al., 2015; Rath et al., 2007) and lower socioeconomic

status (Heptulla et al., 2016; Abdel-Kader and Unruh, 2009; Lempert and Kopp, 2013) are associated with increased odds of losing access to medical care during a hurricane. While previous studies indicate that a lack of insurance coverage is also a risk factor for losing access to medical care (Greenough et al., 2008), this study found that those with government insurance plans were the most likely to experience disruptions in care. This may be because a far greater proportion of those with government insurance (58.87%) were chronically ill than of those without any insurance (25.97%) in our study population. Since the chronically ill were found to be more likely to lose access to medical care in both this study and previous studies (Kelman et al., 2015; Rath et al., 2007), this resulted in a higher proportion of government-insured respondents that lost access to medical care. This effect was enhanced by the fact that those with governmental insurance are generally of lower socioeconomic status (Medalia JCSC, 2014), which is a significant predictor of losing access to medical care (Heptulla et al., 2016; Abdel-Kader and Unruh, 2009; Lempert and Kopp, 2013).

These findings, along with other studies' findings, emphasize the importance of making medical care more accessible to patients, both chronically and acutely ill, during natural disasters to benefit both their physical (Kelman et al., 2015; Lurie et al., 2015; Ryan et al., 2015; Kario et al., 2003) and mental health (Tsuboya et al., 2016; Hyre et al., 2007; Sirey et al., 2016). This could be done by increasing emergency preparedness to ensure that all people in affected areas have adequate medication and are fully aware of their medical facilities' evacuation plans.

This study's findings should be interpreted in the context of its limitations. As this is a cross-sectional study, the participants' mental health was not assessed before the hurricane, barring longitudinal analysis beginning before the hurricane. The model attempts to account for this by adjusting for participants' prior mental health history in all multivariable analyses. Additionally, respondents indicated whether or not they currently had chronic illnesses rather than whether they did prior to Hurricane Sandy. Due to convenience sampling, individuals with lower socioeconomic status, more exposure to the hurricane, and more mental health difficulties may have been more likely to agree to participate, as all participants were given financial compensation, and all PR participants were offered linkage to appropriate mental health care. Further, although we assess temporary displacement, individuals who were displaced permanently out of the region of study would not be included in the study nor would individuals who died potentially due to hurricane-related causes, leading to additional selection bias whereas data from highly affected individuals would not be included. Efforts were made, however, to match the demographics of the sample to the general population. In both cohorts, our samples closely matched the 2010 United States Census data on race and ethnicity. However, for project LIGHT, the sample were slightly older and more female than the general population. Recognizing these differences, the recruitment strategy was altered during LIGHT and also PR to recruit more men and young people in places like gyms and after-work events. Additionally, although we were able to consider the roles of education and health insurance status, some potentially important other sociodemographic variables which may play a role in lack of access to care such as social support, previous healthcare access and income were not assessed in the current study so their potential role as confounders in the models could not be assessed. Moreover, the mental health assessment tools used in this study are not diagnostic in nature; the widely-used, validated tools (Weathers et al., 1993; Kroenke et al., 2009; Cohen et al., 1983) are a convenient, reliable alternative for assessing symptoms of mental health difficulties among participants, but they are not meant to diagnose a mental health disorder (Leon et al., 2007; Schwartz et al., 2015a; Schwartz et al., 2015b; Schwartz et al., 2016; Harville et al., 2010; Pietrzak et al., 2013; Hyre et al., 2008; Anastario et al., 2008). Further, the lack of imprecision of the mental health outcome measures and the variability in completion of measures in terms of time since the hurricane also potentially conflates early versus late onset of symptoms

as well as transient versus persistent symptoms, however a previous study using data from a subset of participants in this study who completed measures at two time points does indicate some persistence in PTSD symptoms, in particular (Schwartz et al., 2017). Finally, since surveys were administered up to 4 years after the hurricane, there is a potential for recall bias.

5. Conclusions

This study finds that experiencing a lack of access to medical care due to Hurricane Sandy is significantly associated with an increased odds of developing symptoms of PTSD, anxiety, depression, and perceived stress. While those who lacked access to medical care were disproportionately chronically ill, having a chronic illness did not significantly moderate the relationship between a lack of medical care access and mental health. In light of these findings, measures should be taken to provide ample mental health care to those who are unable to access necessary medical care during future natural disasters.

Acknowledgments Conflict of interest statement

The authors have no conflicts of interest to declare. Funding

This work was supported by the Centers for Disease Control and Prevention under award number U01-TP000573-01 (PI: Emanuela Taioli, <http://www.cdc.gov/grants/>) as well as a private gift to Northwell Health (PI: Rebecca Schwartz).

References

- Abdel-Kader, K., Unruh, M.L., 2009. Disaster and end-stage renal disease: targeting vulnerable patients for improved outcomes. *Kidney Int.* 75 (11), 1131–1133. <http://dx.doi.org/10.1038/ki.2009.12>.
- Abramson, D.M., Park, Y.S., Stehling-Ariza, T., Redlener, I., 2010. Children as bellwethers of recovery: dysfunctional systems and the effects of parents, households, and neighborhoods on serious emotional disturbance in children after hurricane Katrina. *Disaster Med. Public Health Prep.* 4 (S1). <http://dx.doi.org/10.1001/dmp.2010.7>.
- Abuse NID. The NIDA Quick Screen. NIDA. <https://www.drugabuse.gov/publications/resource-guide-screening-drug-use-in-general-medical-settings/nida-quick-screen>. Accessed June 20, 2017.
- Anastario, M.P., Larrance, R., Lawry, L., 2008. Using mental health indicators to identify postdisaster gender-based violence among women displaced by hurricane Katrina. *J. Women's Health* 17 (9), 1437–1444. <http://dx.doi.org/10.1089/jwh.2007.0694>.
- Arrieta, M.I., Foreman, R.D., Crook, E.D., Icenogle, M.L., 2009. Providing continuity of care for chronic diseases in the aftermath of Katrina: from field experience to policy recommendations. *Disaster Med. Public Health Prep.* 3 (03), 174–182. <http://dx.doi.org/10.1097/dmp.0b013e3181b66ae4>.
- Beaudoin, C.E., 2011. Hurricane Katrina: addictive behavior trends and predictors. *Public Health Rep.* 126 (3), 400–409. <http://dx.doi.org/10.1177/003335491112600314>.
- Ben-Ezra, M., Goodwin, R., Palgi, Y., et al., 2014. Concomitants of perceived trust in hospital and medical services following Hurricane Sandy. *Psychiatry Rep.* 220 (3), 1160–1162. <http://dx.doi.org/10.1016/j.psychres.2014.08.012>.
- Blake E, Kimberlain T, Berg R, Cangialosi J, Beven J. Tropical Cyclone Report: Hurricane Sandy: National Hurricane Center. http://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf. Accessed June 20, 2017.
- Boscarino, J.A., Hoffman, S.N., Adams, R.E., Figley, C.R., Solikhah, R., 2014. Mental health outcomes among vulnerable residents after hurricane Sandy: implications for disaster research and planning. *Am. J. Disaster Med.* 9 (2), 107–120. <http://dx.doi.org/10.5055/ajdm.2014.0147>.
- Cohen, S., Kamarck, T., Mermelstein, R., 1983. A global measure of perceived stress. *J. Health Soc. Behav.* 24 (4), 385–396.
- Department of Health and Human Services <https://oig.hhs.gov/oei/reports/oei-06-13-00260.pdf>. Accessed date: 20 June 2017.
- Drinking Levels Defined National Institute on Alcohol Abuse and Alcoholism. <https://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/moderate-binge-drinking>. Accessed date: 20 June 2017.
- Galea, S., Nandi, A., Vlahov, D., 2005. The epidemiology of post-traumatic stress disorder after disasters. *Epidemiol. Rev.* 27 (1), 78–91. <http://dx.doi.org/10.1093/epirev/mxi003>.
- Greenough, P.G., Lappi, M.D., Hsu, E.B., et al., 2008. Burden of disease and health status among hurricane Katrina-displaced persons in shelters: a population-based cluster sample. *Ann. Emerg. Med.* 51 (4), 426–432. <http://dx.doi.org/10.1016/j.annemergmed.2007.04.004>.
- Gros, D.F., Price, M., Gros, K.S., Paul, L.A., McCauley, J.L., Ruggiero, K.J., 2012. Relations between loss of services and psychiatric symptoms in urban and non-urban settings following a natural disaster. *J. Psychopathol. Behav. Assess.* 34 (3), 343–350. <http://dx.doi.org/10.1007/s10862-012-9290-9>.
- Harville, E.W., Xiong, X., Smith, B.W., Pridjian, G., Elkind-Hirsch, K., Buekens, P., 2010.

- Combined effects of Hurricane Katrina and Hurricane Gustav on the mental health of mothers of small children. *J. Psychiatr. Ment. Health Nurs.* 18 (4), 288–296. <http://dx.doi.org/10.1111/j.1365-2850.2010.01658.x>.
- Heptulla, R., Hashim, R., Johnson, D.N., et al., 2016. Evaluating emergency preparedness and impact of a hurricane sandy in pediatric patients with diabetes. *Disaster Mil. Med.* 2 (1). <http://dx.doi.org/10.1186/s40696-016-0012-9>.
- Hyre, A.D., Cohen, A.J., Kutner, N., Alper, A.B., Muntner, P., 2007. Prevalence and predictors of posttraumatic stress disorder among hemodialysis patients following hurricane Katrina. *Am. J. Kidney Dis.* 50 (4), 585–593. <http://dx.doi.org/10.1053/ajkd.2007.07.013>.
- Hyre, A.D., Benight, C.C., Tynes, L.L., Rice, J., Desalvo, K.B., Muntner, P., 2008. Psychometric properties of the hurricane coping self-efficacy measure following Hurricane Katrina. *J. Nerv. Ment. Dis.* 196 (7), 562–567. <http://dx.doi.org/10.1097/nmd.0b013e31817d016c>.
- Jaquier, V.C.A., Flanagan, J.C., Sullivan, T.P., 2014. Anxiety and posttraumatic stress symptom pathways to substance use problems among community women experiencing intimate partner violence. *Anxiety Stress Coping* 28 (4), 445–455. <http://dx.doi.org/10.1080/10615806.2014.968562>.
- Kario, K., Bruce, S.M., Thomas, G.P., 2003. Disasters and the heart: a review of the effects of earthquake-induced stress on cardiovascular disease. *Hypertens. Res.* 26 (5), 355–367. <http://dx.doi.org/10.1291/hypres.26.355>.
- Kelman, J., Finne, K., Bogdanov, A., et al., 2015. Dialysis care and death following hurricane Sandy. *Am. J. Kidney Dis.* 65 (1), 109–115. <http://dx.doi.org/10.1053/ajkd.2014.07.005>.
- Kessler, R.C., 2007. Hurricane Katrina's impact on the care of survivors with chronic medical conditions. *J. Gen. Intern. Med.* 22 (9), 1225–1230. <http://dx.doi.org/10.1007/s11606-007-0294-1>.
- Khoury, L., Tang, Y.L., Bradley, B., Cubells, J.F., Ressler, K.J., 2010. Substance use, childhood traumatic experience, and posttraumatic stress disorder in an urban civilian population. *Depress. Anxiety* 27 (12), 1077–1086. <http://dx.doi.org/10.1002/da.20751>.
- Kim, H., Schwartz, R.M., Hirsch, J., Silverman, R., Liu, B., Taioli, E., 2016. Effect of hurricane Sandy on Long Island emergency departments visits. *Disaster Med. Public Health Prep.* 10 (03), 344–350. <http://dx.doi.org/10.1017/dmp.2015.189>.
- Kroenke, K., Spitzer, R.L., Williams, J.B., Lowe, B., 2009. An ultra-brief screening scale for anxiety and depression: the PHQ-4. *Psychosomatics* 50 (6), 613–621. <http://dx.doi.org/10.1176/appi.psy.50.6.613>.
- Lempert, K.D., Kopp, J.B., 2013. Hurricane Sandy as a kidney failure disaster. *Am. J. Kidney Dis.* 61 (6), 865–868. <http://dx.doi.org/10.1053/ajkd.2013.03.017>.
- Leon, K.A., Hyre, A.D., Ompad, D., Desalvo, K.B., Muntner, P., 2007. Perceived stress among a workforce 6 months following hurricane Katrina. *Soc. Psychiatry Psychiatr. Epidemiol.* 42 (12), 1005–1011. <http://dx.doi.org/10.1007/s00127-007-0260-6>.
- Lieberman-Cribbin, W., Liu, B., Schneider, S., Schwartz, R., Taioli, E., 2017. Self-reported and FEMA flood exposure assessment after hurricane Sandy: association with mental health outcomes. *PLoS One* 12 (1). <http://dx.doi.org/10.1371/journal.pone.0170965>.
- Lurie, H., Finne, K., Worrall, C., et al., 2015. Early dialysis and adverse outcomes after hurricane Sandy. *Am. J. Kidney Dis.* 66 (3), 507–512. <http://dx.doi.org/10.1053/ajkd.2015.04.050>.
- Medalia JCSC. Data. Health Insurance in the United States: 2013. <https://www.census.gov/data/tables/2014/demo/health-insurance/p60-250.html>. Published September 16, 2014. Accessed August 25, 2017.
- Murakami, N., Siktel, H.B., Lucido, D., Winchester, J.F., Harbord, N.B., 2015. Disaster preparedness and awareness of patients on hemodialysis after hurricane Sandy. *Clin. J. Am. Soc. Nephrol.* 10 (8), 1389–1396. <http://dx.doi.org/10.2215/cjn.10181014>.
- Neria, Y., Nandi, A., Galea, S., 2007. Post-traumatic stress disorder following disasters: a systematic review. *Psychol. Med.* 38 (04). <http://dx.doi.org/10.1017/s0033291707001353>.
- Norris, F.H., Perilla, J.L., Riad, J.K., Kaniasty, K., Lavizzo, E.A., 1999. Stability and change in stress, resources, and psychological distress following natural disaster: findings from hurricane Andrew. *Anxiety Stress Coping* 12 (4), 363–396. <http://dx.doi.org/10.1080/10615809908249317>.
- Pietrzak, R.H., Ness, P.H.V., Fried, T.R., Galea, S., Norris, F.H., 2013. Trajectories of posttraumatic stress symptomatology in older persons affected by a large-magnitude disaster. *J. Psychiatr. Res.* 47 (4), 520–526. <http://dx.doi.org/10.1016/j.jpsychires.2012.12.005>.
- Player, M.S., Peterson, L.E., 2011. Anxiety disorders, hypertension, and cardiovascular risk: a review. *Int. J. Psychiatry Med.* 41 (4), 365–377.
- Rath, B., Donato, J., Duggan, A., et al., 2007. Adverse health outcomes after hurricane Katrina among children and adolescents with chronic conditions. *J. Health Care Poor Underserved* 18 (2), 405–417. <http://dx.doi.org/10.1353/hpu.2007.0043>.
- Redlener, I., Reilly, M.J., 2012. Lessons from Sandy — preparing health systems for future disasters. *N. Engl. J. Med.* 367 (24), 2269–2271. <http://dx.doi.org/10.1056/nejmp1213486>.
- Roberts A, Lyles T. Superstorm Sandy: By the Numbers. CNN. <http://www.cnn.com/2012/10/30/us/sandy-by-the-numbers/>. Published October 31, 2012. Accessed June 20, 2017.
- Ryan, B., Franklin, R.C., Burkle, F.M., et al., 2015. Identifying and describing the impact of cyclone, storm and flood related disasters on treatment management, care and exacerbations of non-communicable diseases and the implications for public health. *PLoS Curr.* <http://dx.doi.org/10.1371/currents.dis.62e9286d152de04799644dcca47d9288>.
- Schwartz, R.M., Sison, C., Kerath, S.M., et al., 2015a. The impact of hurricane Sandy on the mental health of New York area residents. *Am. J. Disaster Med.* 10 (4), 339–346. <http://dx.doi.org/10.5055/ajdm.2015.0216>.
- Schwartz, R., Liu, B., Sison, C., et al., 2015b. Study design and results of a population-based study on perceived stress following hurricane Sandy. *Disaster Med. Public Health Prep.* 10 (03), 325–332. <http://dx.doi.org/10.1017/dmp.2015.157>.
- Schwartz, R.M., Rothenberg, P., Kerath, S.M., Liu, B., Taioli, E., 2016. The lasting mental health effects of hurricane Sandy on residents of the rockaways. *J. Emerg. Manag.* 14 (4), 269–279. <http://dx.doi.org/10.5055/jem.2016.0292>.
- Schwartz, R.M., Gillezeau, C.N., Liu, B., Lieberman-Cribbin, W., Taioli, E., 2017. Longitudinal impact of hurricane sandy exposure on mental health symptoms. *Int. J. Environ. Res. Public Health* 14 (9).
- Sirey, J.A., Berman, J., Halkett, A., et al., 2016. Storm impact and depression among older adults living in hurricane Sandy-affected areas. *Disaster Med. Public Health Prep.* 11 (01), 97–109. <http://dx.doi.org/10.1017/dmp.2016.189>.
- Smith, C.M., 2005. Regional impact of hurricane Isabel on emergency departments in coastal southeastern Virginia. *Acad. Emerg. Med.* 12 (12), 1201–1205. <http://dx.doi.org/10.1197/j.aem.2005.06.024>.
- Sullivan, T.P., Cavanaugh, C.E., Buckner, J.D., Edmondson, D., 2009. Testing posttraumatic stress as a mediator of physical, sexual, and psychological intimate partner violence and substance problems among women. *J. Trauma. Stress.* <http://dx.doi.org/10.1002/jts.20474>.
- Tobacco Questions for Surveys - WHO World Health. http://www.who.int/tobacco/surveillance/en_tfi_tqs.pdf, Accessed date: 20 June 2017.
- Tsuboya, T., Aida, J., Hikichi, H., et al., 2016. Predictors of depressive symptoms following the great East Japan earthquake: a prospective study. *Soc. Sci. Med.* 161, 47–54. <http://dx.doi.org/10.1016/j.socscimed.2016.05.026>.
- Weathers, F., Litz, B., Herman, D., Huska, J.A., Keane, T.M., 1993. The PTSD checklist (PCL): reliability, validity, and diagnostic utility. In: *Proceedings of the Annual Convention of the International Society for Traumatic Stress Studies*, (San Antonio, TX, USA).
- Zwiebach, L., Rhodes, J., Roemer, L., 2010. Resource loss, resource gain, and mental health among survivors of hurricane Katrina. *J. Trauma. Stress.* 23 (6), 751–758. <http://dx.doi.org/10.1002/jts.20579>.