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Cumulative Effects of the Gulf Oil Spill and Other Disasters on Mental Health Among Reproductive-Aged Women: The Gulf Resilience on Women's Health Study

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Objective: To test whether effects of multiple (up to 5) disasters on mental health responses were cumulative (additive effects), or whether an earlier disaster produced sensitization (higher) or habituation (lower) responses to a later one. **Method:** The Gulf Resilience on Women's Health study interviewed 1,366 southern Louisiana women regarding their exposure to Hurricanes Katrina, Rita, Gustav, and Ike and the Gulf oil spill (measured several ways), and administered validated measures of symptoms of depression and posttraumatic stress disorder (PTSD). Multiple linear and logistic regression with disaster exposures entered singly, combined, and as an interaction were used to model mental health. **Results:** Both exposure to the oil spill and hurricane disaster were associated with likely depression and PTSD, consistent with a cumulative model, but we did not find statistical interactions that would suggest sensitization or habituation. When results were examined with continuous symptom measures of depression and PTSD, they were similar, with the exception that exposure to the oil spill and experiencing illness or injury because of the hurricane disaster showed a significant interaction ($p < .05$) in a manner consistent with a sensitization effect when predicting PTSD symptoms. The results of this study point mainly to a cumulative risk for the mental health effects of multiple disasters, although some indication of sensitization occurred among those with particularly severe experiences. There was no evidence for habituation. **Conclusions:** These findings may guide efforts to assist those in regions experiencing multiple disasters that occur in close sequence.

Clinical Impact Statement

This study examined a sample of young, largely low-income, southern Louisiana women, most of whom had experienced multiple hurricanes as well as the Gulf oil spill. We found that experience of multiple disasters was associated with an increased level of symptoms of depression and posttraumatic stress disorder (PTSD). Habituation, where people become accustomed to disaster after experiencing them, was not observed, but there was also only limited evidence for sensitization, whereby people who have experienced previous disasters react more strongly to new disasters than would be expected.

Keywords: disaster, depression, posttraumatic stress disorder, cumulative

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Trauma has long-lasting effects on mental health. Those who experience more traumatic events and major life events are at increased risk of depressive and anxiety disorders in an essentially dose-response manner (Bifulco, Bernazzani, Moran, & Ball, 2000; Turner & Lloyd, 2004). Depressive or posttraumatic stress symptoms also raise the risk of encountering future traumas (for instance, by predisposing to entering into relationships that turn abusive [Cogle, Resnick, & Kilpatrick, 2009b], or by limiting the energy and executive function needed to prepare for or evacuate from a natural disaster); thus, leading to chronic or relapsing mental illness (Lowe, Walsh, Uddin, Galea, & Koenen, 2014). Many individuals who experience traumatic events do not develop subsequent psychopathology, however, and several trauma-related factors have been identified as predisposing to the development of psychopathology.

Models of Effects of Multiple Traumas

Several models of the effects of multiple traumatic exposures on mental health can be identified (see Figure 1). Perhaps the most straightforward is a *cumulative* model: multiple traumas are associated with worsened mental health in a dose-response fashion. Multiple lifetime traumas are associated with psychosis (Shevlin, Houston, Dorahy, & Adamson, 2008), anxiety disorders, posttraumatic stress disorder (PTSD; Schumm, Briggs-Phillips, & Hobfoll, 2006), and depression (Liu et al., 2015; Turner & Lloyd, 2004; Vinkers et al., 2014). However, at least one study suggests that cumulative experiences of adversity are associated with poorer mental health primarily because those who experienced the most trauma also experienced the most severe traumas (Schilling, Aseltine, & Gore, 2008).

A second possible theoretical approach to the effects of multiple traumas is a *sensitization* model whereby those with a previous experience of disaster would be at risk for greater psychopathology after subsequent disasters as compared with those who have not had a previous exposure. This is consistent with PTSD, where related and unrelated events may trigger memories and flashbacks to the original trauma. In this second model, the total amount of effects on health after a later disaster is greater than that which would be expected from a simple cumulative model. Evidence for this model includes previous work indicating that previous direct and indirect exposures to collective trauma events (e.g., Superstorm Sandy, Sandy Hook, and 9/11) were associated with in-

creased acute stress responses after the Boston Marathon bombing, among a representative sample in both Boston and New York (Seery, Holman, & Silver, 2010). Other studies indicate that childhood adversity predisposes to developing depression (Hammen, Henry, & Daley, 2000; McLaughlin, Conron, Koenen, & Gilman, 2010) and PTSD (Cogle, Resnick, & Kilpatrick, 2009a) in response to life events. In addition, physiologically, the hypothalamic-pituitary-adrenal (HPA) axis appears to be primed for hyperresponsiveness in PTSD/trauma survivors, with the negative feedback loop not working as it does in normal controls (Yehuda, 2001).

A third model of disaster response is *habituation* (sometimes also defined as *resilience* or *toughening*). In this case, people who live through multiple disasters can become inoculated, habituated, or better at coping, improving their ability to adjust to subsequent disasters with little or no additional distress. Therefore, the total effect of multiple disasters is less than that which would be expected from a cumulative model. Evidence for this model includes studies finding that a moderate amount of lifetime adversity is associated with lower global distress and posttraumatic stress symptoms (Seery et al., 2010) and higher resistance to stress and pain, compared with low or high adversity (Seery, Leo, Lupien, Kondrak, & Almonte, 2013). Also, studies of the effects of minor daily stressors have found that, after a certain point, additional stressors do not worsen mood, with the exception of interpersonal conflicts (Bolger, DeLongis, Kessler, & Schilling, 1989). Physiologically, depression, in particular, is associated with a blunted rather than hyperresponsive HPA axis response to repeated stress (Burke, Fernald, Gertler, & Adler, 2005; Miller, Chen, & Zhou, 2007).

Disaster as Trauma

Community-level disasters may differ in some important ways from other types of individual trauma. The traumatic events that have the strongest effect on mental health (particularly PTSD) include rape, intimate partner violence, sexual abuse, physical assault, and robbery (Frans, Rimmo, Aberg, & Fredrikson, 2005; Hapke, Schumann, Rumpf, John, & Meyer, 2006; Sumner, Wong, Schetter, Myers, & Rodriguez, 2012), although experiencing emotional abuse in childhood can be as damaging as physical abuse (Spinazzola et al., 2014). Disasters may increase risk of such interpersonal trauma (Harville, Taylor, Tesfai, Xu Xong, & Buekens, 2011; Keenan, Marshall, Nocera, & Runyan, 2004; Schumacher et al., 2010). Disasters also lead to secondary stressors, such as financial issues, which can linger for years and affect mental health adversely (Cerdá et al., 2013). On the other hand, humans have experienced disaster for millennia. Even nonhuman primates show behavioral flexibility to adapt to the aftermath of disasters (Schaffner, Rebecchini, Ramos-Fernandez, Vick, & Aureli, 2012). Disasters are normally experienced in the presence of others, and the aftermath of disasters can be a time when a community pulls together for support (Dezecache, 2015), unlike, for example, child abuse or sexual assault, which can be very isolating (Gracia & Musitu, 2003). People who have experienced multiple traumas do not generally rank the disaster as the most traumatic event in their lives (Harville, Jacobs, & Boynton-Jarrett, 2015), nor does natural disaster cause as strong effects on mental health as social violence (Kumar & Fonagy, 2013). Disasters are probably less likely to be

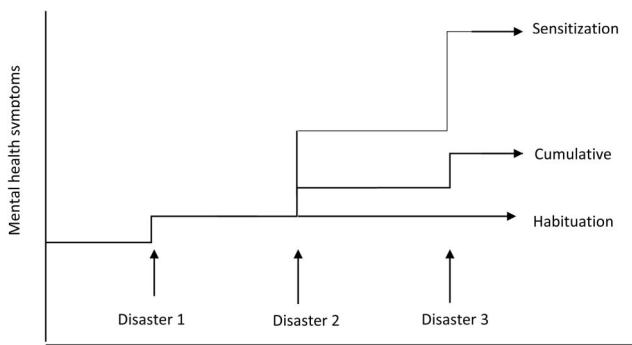


Figure 1. Conceptual model of possible effects of multiple disasters on mental health.

perceived as a betrayal or as a cause for self-blame than other types of trauma (Greening, Stoppelbein, & Docter, 2002; Owens & Chard, 2006), and such cognitive appraisals by survivors may partially mediate the relationship between trauma and psychopathology (Klest, Freyd, & Foynes, 2013; Martin, Cromer, DePrince, & Freyd, 2013).

Although the effects of exposure to a single disaster on mental health have been well-characterized (Norris, Friedman, & Watson, 2002; Norris, Friedman, Watson et al., 2002), the effects of multiple disasters are less clear, as only a few studies have examined the effects of combined disasters. In a study of a Chilean earthquake and subsequent tsunami, separate components (earthquake, tsunami, and postdisaster looting) were examined as predictors of mental health; the authors found that specific aspects of disaster were associated with worse mental health (loss, injury, and death), but cumulative exposure (discrete numbers of disasters) was not (Garfin, Silver, Ugalde, Linn, & Inostroza, 2014). In our previous study of the combined effect of Hurricanes Gustav and Katrina on 102 women, a cumulative effect was generally observed when considering severity of exposures, with more severe experience of both hurricanes being associated with higher depressive and PTSD symptoms (Harville, Xiong, et al., 2011). For a few aspects of Gustav (the length of time the house was without power, for instance), an interaction was found with exposure to Katrina, with the combined effect being worse than would be predicted from the individual effects; this effect was stronger for PTSD symptoms than depression symptoms (Harville, Xiong et al., 2011).

These three distinct models of the effects of multiple trauma exposure have not been widely applied to disaster research. Southern Louisiana has been exposed to a number of disasters in recent years, most notably Hurricane Katrina, but also Hurricanes Rita, Ike, Gustav, and Isaac, and widespread Mississippi flooding in 2011. In 2010, the Gulf of Mexico oil spill caused extensive environmental damage and had major economic effects among those dependent on deep-water drilling, fishing, or tourism. In the aftermath of the Gulf of Mexico oil spill, mental health was identified as a high priority public health concern in vulnerable Gulf Coast communities (Goldstein, Osofsky, & Lichtveld, 2011). We explored the effects of the oil spill on mental health (depression and posttraumatic stress symptoms) among those with varying degrees of exposure to previous disasters.

Method

The GROWH study is a cohort study of the effects of the Gulf oil spill on reproductive health and general health of women of reproductive age. From 2011–2016, women were recruited from prenatal, health, and women, infants, and children (WIC) clinics, from community colleges, and at community events, throughout southeastern Louisiana, targeting the parishes most strongly impacted by the oil spill. Women were eligible if they lived in the region at the time of the oil spill, were 18–45 years old, and spoke English, Spanish, or Vietnamese. Pregnant participants needed to be <37 weeks' gestation and carrying a singleton pregnancy. Women were recruited and interviewed by trained research staff, and completed written questionnaires. This analysis incorporates data on 1,366 women who completed the interview, mean age 28.9 (*SD* 6.5), 62% Black, and 29% White. There were 387 (28%) who were pregnant at the time of the interview, while 41% had been

pregnant within the last 2 years (see Table 1). Interactions with pregnancy status were examined and results did not differ by whether the woman was pregnant or not, nor was pregnancy status a predictor of the mental health outcomes; therefore, the results were combined across all groups.

Measures

Oil spill experience was measured with questions from several sources, including questions about: (a) a participant's involvement in work on the clean-up and contact with oil, taken from the Gulf Workers' Study (National Institutes of Health, GuLF Study, n.d.); (b) direct exposure to the oil spill, taken from studies performed after the Exxon Valdez spill (Palinkas, Downs, Petterson, & Russell, 1993); (c) the social and economic effects of the oil spill, from a previous study (GUMBO, R03 NR012052); and (d) involvement in litigation, after Exxon Valdez studies (Palinkas et al., 1993;

Table 1
Southern Louisiana Women Participating in a Study of Disaster Exposure, 2011–2016 (n = 1,366)

Participant characteristic	<i>N</i>	%
Age		
18–25	430	32.9
>25–30	378	28.6
>30–35	261	19.7
>35	253	19.1
Parity		
Nulliparous	145	11.2
Parous	1,151	88.8
Married/living with partner		
Yes	515	39.2
No	800	60.8
Race		
White	375	28.9
Black	810	62.4
Other	114	8.9
Income		
<=\$20K	595	45.9
>\$20K–40	431	33.3
>\$40	270	20.8
Smoke in last 2 years		
Yes	379	28.1
No	971	71.9
BMI, categorized		
>=20	81	6.3
>20–25	295	22.9
>30–35	332	25.8
>35	580	45.0
Parish of residence		
Jefferson	540	41.1
Lafourche	92	7.0
Orleans	273	20.8
Plaquemines	143	10.9
St. Bernard	100	7.6
St. Charles	11	.8
Terrebonne	127	9.7
Other	80	2.1
Time since last pregnancy		
Never pregnant	36	2.6
Currently pregnant	387	28.3
0–2 years	553	40.5
>2–5 years	193	14.1
>5+	197	14.4

Picou, Marshall, & Gill, 2004). Confirmatory factor analysis was used to group the 17 questions asked into categories of exposure: financial/income consequences; direct contact with oil; oil spill-related trauma (damage to people or own property); loss of use of the coast (damage to areas where one or one's family fishes, boats, or goes to the coast or beach); and involvement in litigation. Involvement in litigation was not related to mental health in this dataset and was, therefore, omitted from further analysis. In addition, separate variables for any exposure to the oil spill (0 vs. 1) and total exposure to the oil spill (sum of the above individual experiences—money, direct contact, trauma, loss of use, and litigation, weighted equally; theoretical range was 0 to 10; range in this sample was 0 to 9).

Natural disaster experience was measured with 12 questions, based on a study of Hurricane Andrew (Norris, Perilla, Riad, Kaniasty, & Lavizzo, 1999). Women were asked individually about Hurricanes Katrina (2005), Rita (2005), Ike (2008), Gustav (2008), and the Mississippi flooding of 2011. Hurricane Isaac, which hit in 2012, was added during data collection. For this analysis, only the hurricanes that occurred before the oil spill were included. Total hurricane experience was a sum of the number of disaster experiences across these four disasters (up to 15 per disaster, range 0–60; median in the study was 10). This measure has been associated with poorer mental health and birth outcomes in previous studies (Harville, Xiong, Pridjian, Elkind-Hirsch, & Buekens, 2009; Xiong et al., 2010) and factor analysis has been conducted (Harville, Xiong et al., 2011) to group the questions for similar aspects of exposure, creating three disaster exposure categories: (a) damage (some or more “damage to house,” “house flooded,” some or greater “impact of hurricane,” and some or greater “total impact on belongings of other people”), (b) perceived/experienced danger (“felt life in danger,” “walked in floodwater,” and “saw someone die”), and (c) illness/injury to self or others (“experienced illness/injury,” “someone in household experienced illness/injury,” “someone near died,” and “someone else important experienced illness/injury”). An additional question asked whether the respondent had evacuated for the disaster. Damage, danger, and illness have all been associated with depression and PTSD in previous analysis, but evacuation has not (Harville et al., 2015). The overall hurricane variable was the total number of experiences endorsed for each disaster, summed across the different disasters, and the subcategories (damage, danger, and illness/injury) used the number of experiences in those subcategories endorsed for each disaster, summed across the different disasters.

Mental health. The Edinburgh Postnatal Depression Index (EDS) was used to assess symptoms of depression (Cox, Holden, & Sagovsky, 1987). This scale was originally designed to address postnatal depression, but has been validated for use in pregnant and nonpregnant samples (Bergink et al., 2011; Cox et al., 1987; Matijasevich et al., 2014; Murray & Cox, 1990). This scale focuses on cognitive and affective symptoms rather than somatic ones, and shows good consistency with other general depression scales, such as the Center for Epidemiologic Studies-Depression (CES-D) and Beck Depression Inventory (BDI; Chaudron et al., 2010; Tandon, Cluxton-Keller, Leis, Le, & Perry, 2012). Probable depression was defined as EDS score greater than 12, which is estimated as the best cut-off for indicating likely depression (Eberhard-Gran, Eskild, Tambs, Opjordsmoen, & Samuelsen, 2001). PTSD symptoms

where measured with the Posttraumatic Checklist (PCL), which asks about symptoms related to any stressful experience and is based on the *Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition (DSM-IV)* criteria for PTSD (Weathers, Litz, Herman, Huska, & Keane, 1993). PTSD symptoms were dichotomized at scores greater than 50, which has been shown to perform well as a cut-off relative to clinical diagnosis (Weathers et al., 1993; Weathers, Ruscio, & Keane, 1999). Previous research indicates that those who experience traumas that lead to increased or new psychopathology are more likely to experience subsequent traumas (Bifulco et al., 2000; Lowe et al., 2014; Stein et al., 2002), which means that excluding those with prior symptoms biases the population and the relationship. Therefore, we did not exclude those with a prior diagnosis. Also, some populations are less likely to seek treatment, even when it is available, in response to negative experiences and mental health, so exclusions based on diagnosis would likely lead to differential participations of groups (Ward, Mengesha, & Issa, 2014).

Analysis

The statistical analysis was carried out in the following five steps from the simplest model to the most complex model. First, bivariate log-Poisson regression model with robust variance was conducted to predict the relative risk of likely depression and PTSD for each individual aspect of oil exposure and overall disaster exposure. Next, confounders (age, education, income, marital status, pregnancy status, race, smoking, Body Mass Index [BMI; prepregnant, if applicable]), chosen based on a directed acyclic graph (Textor, Hardt, & Knuppel, 2011) indicating expected causal relationships with exposure and outcome, were entered into the models from the first step. For missing values in covariates, multiple imputation, which can take into account uncertainty because of missing data, was used to impute the missing values. Ten data sets were imputed using Monte Carlo Markov Chain methods in proc mi in SAS (v 9.3), and combined estimates calculated with proc mianalyze. Most frequently missing was BMI (6%). These models tested whether the individual disaster exposure was related to mental health.

Third, log-Poisson models were constructed incorporating the confounders, oil spill experience, and disaster experience. If the cumulative model was true, both oil spill and disaster experience should continue to contribute to the risk of the outcome.

Fourth, the models were extended to incorporate an interaction between oil spill experience and disaster experience (dichotomized at the median), to examine whether the data were consistent with a sensitization (or habituation) effect. Risk ratios for the effect of oil spill exposure on mental health outcomes in those above and below the median of total disaster exposure are presented. Finally, the cumulative and interactive models were analyzed again with individual aspects of disaster exposure, rather than total disaster exposure.

Secondary analyses examined alternate model forms and variable specifications: additive-scale models (risk difference and continuous outcome measures) and continuous disaster exposure variables; results were similar except where otherwise indicated.

Because the data were collected cross-sectionally, we were concerned that those who were suffering from mental health symptoms might be more likely to report exposure to disaster, but not

actually be more exposed (reverse causation or state dependence; Turner & Lloyd, 2004). This can be conceived as a problem in classification, with the interview questions measuring exposure differentially in those who have the outcome and those who do not. Therefore, using the method of Fox, Lash, and Greenland (2005), we examined a range of sensitivity, specificity, and correlations between the sensitivity and specificity for cases and noncases. Fairly extreme assumptions were required to reduce or eliminate the associations seen, suggesting that such misclassification is probably not the explanation for the results (details, Appendix 1 in supplementary material). Procedures in this study were approved by the Institutional Review Boards of Tulane University, WIC, and Ochsner Clinics, and all participants provided written informed consent.

Results

The study population was predominantly young, low-income, and Black (see Table 1). The vast majority was exposed to at least one natural disaster and usually multiple disasters (see Table 2), with property damage and evacuation being the most common experiences. The most commonly reported negative effect of the oil spill was financial, followed by damage to the coast or water that the participants used (see Table 2). A smaller proportion had been in direct contact or was involved with litigation. Oil spill exposure was significantly ($p < .05$) more common among women who were older, not pregnant, parous, married, not Black, of higher-income, smokers, and who lived near the coast (data not shown). There were 214 women (16%) who met the criterion for depression and 83 (6%) for PTSD. Depression and PTSD were significantly more common among those who were lower-income, who smoked, and had either 0 or ≥ 3 total pregnancies.

Consistent with a cumulative model, both exposure to oil spill and disaster exposure were associated with depression and PTSD, individually and additively (see Table 3). For instance, both high total exposure (aRR 1.65, 1.14–2.39) and overall disaster exposure (aRR 1.038, 1.026–1.050 per indicator of exposure) were independently associated with increased risk of depression, and of

Table 2
Description of Disaster Experience of Sample

Disaster exposure	N	%
Oil spill		
Worked on cleanup	99	7.3
Used area along the coast	384	29.1
Property lost/damaged	40	3.0
Oil spill directly affected hunting, fishing, gathering	405	30.4
Someone close to you injured or killed	39	2.9
Direct contact with oil	257	18.9
Financial effect	674	51.5
I have been contacted by attorneys.	134	10.0
I believe that I need legal representation to deal with the oil spill	192	14.4
I have had unpleasant experiences or memories of the litigation	142	11.2
Natural disaster exposure		
Exposed to Katrina	1,160	93.5
Exposed to Rita	818	67.7
Exposed to Gustav	848	70.1
Exposed to Ike	578	48.0

Table 3
Relationship Between Natural Disaster Exposure, Oil Spill Exposure, and Mental Health, Cumulative Model

Disaster exposure	Depression				PTSD					
	Unadjusted		Adjusted ^a		Unadjusted		Adjusted ^a			
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI		
Any exposure	1.09	[1.05–1.13]	1.75	[1.30–2.36]	1.04	[1.01–1.07]	1.79	[1.10–2.90]	1.77	[1.05–2.98]
Overall disaster exposure	1.08	[1.03–1.13]	1.53	[1.17–2.01]	1.06	[1.02–1.09]	2.09	[1.35–3.23]	1.037	[1.016–1.059]
High income loss	1.12	[1.06–1.18]	1.66	[1.24–2.23]	1.04	[1.00–1.08]	1.41	[.87–2.29]	2.03	[1.33–3.08]
Overall disaster exposure	1.11	[1.01–1.21]	1.56	[.96–2.55]	1.04	[.98–1.11]	1.50	[.70–3.21]	1.038	[1.018–1.059]
Direct contact with oil	1.10	[1.05–1.14]	1.76	[1.34–2.36]	1.05	[1.02–1.08]	2.00	[1.25–3.21]	1.60	[1.00–2.59]
Overall disaster exposure	1.00		1.00		1.00		1.00		1.039	[1.018–1.060]
Traumatic/property loss	1.48	[1.03–2.11]	1.24	[.90–1.69]	1.07	[.58–1.94]	1.15	[.66–2.00]	1.17	[.56–2.46]
Overall disaster exposure	1.62	[1.80–2.41]	1.35	[.96–1.90]	1.96	[1.10–3.50]	1.85	[1.07–3.20]	1.044	[1.023–1.065]
Loss of use of coast, etc.	2.61	[1.75–3.89]	2.24	[1.60–3.14]	2.44	[1.29–4.65]	2.44	[1.36–4.37]	2.22	[1.40–3.53]
Overall disaster exposure	1.00		1.00		1.05	[1.02–1.08]	2.00	[1.25–3.21]	1.041	[1.020–1.062]
Total exposure	1.00		1.00		1.00		1.00		1.00	
Low	1.48	[1.03–2.11]	1.24	[.90–1.69]	1.07	[.58–1.94]	1.15	[.66–2.00]	1.17	[.64–2.16]
Medium-low	1.62	[1.80–2.41]	1.35	[.96–1.90]	1.96	[1.10–3.50]	1.85	[1.07–3.20]	1.66	[.92–3.01]
Medium-high	2.61	[1.75–3.89]	2.24	[1.60–3.14]	2.44	[1.29–4.65]	2.44	[1.36–4.37]	2.28	[1.20–4.32]
High	1.00		1.00		1.05	[1.02–1.08]	2.00	[1.25–3.21]	1.037	[1.016–1.058]
Overall disaster exposure	1.038	[1.026–1.050]	1.038	[1.026–1.050]	1.038 ^b	[1.026–1.050]	1.038 ^b	[1.026–1.050]	1.038	[1.026–1.050]

Note. RR = relative risk; CI = confidence interval; PTSD = posttraumatic stress disorder.

^a Adjusted for age, Body Mass Index, Black, income, gravidity, education, partnership status, and smoking. ^b Relative risk per experience of disaster.

PTSD (aRRs 2.28, 1.20–4.32; 1.037, 1.016–1.058, respectively.) This same pattern—both oil spill exposure and disaster exposure predicting depressive and PTSD symptoms—was found for income loss because of the oil spill, direct contact with oil, and loss of use of the coast.

The evidence for an interaction of the two exposures and, thus, for a sensitization or habituation model, was not strong (see Table 4), with the strength of the association between the oil spill and the mental health outcomes remaining relatively constant regardless of previous exposure to disaster. Examining alternative measures of disaster exposure resulted in similar conclusions (data not shown). When results were examined with continuous symptoms measures of depression and PTSD, results similarly indicated a cumulative but not interactive effect, with the exception that exposure to the oil spill (measured several ways) and experiencing illness or injury because of disaster had a significant interaction ($p < .05$) predicting PTSD symptoms synergistically or in a compounded manner (Table 1 in supplementary material).

Discussion

In this study of a special population that had been highly exposed to disasters of many kinds, data were most consistent with a cumulative rather than a sensitization model. Exposure to natural disasters and the oil spill were each individually and additively associated with worse mental health, but there was no evidence of interaction of exposures, with one exception: illness/injury because of disaster in-

teracted synergistically with oil spill exposure to predict PTSD symptoms (although the interaction was not particularly statistically strong). Some studies of trauma and PTSD distinguish “assaultive” traumas (those related to actual or threatened bodily violation) from “nonassaultive” traumas (that include natural disasters; Lowe et al., 2014). Although by this definition the data in this manuscript deal entirely with nonassaultive traumas, illness/injury have stronger physical effects than property damage or evacuation, and so our results would, broadly, fit that framework.

Limitations of the study include use of screening instruments rather than formal diagnosis, self-report of disaster exposure, and a population not representative of the entire region. Perhaps the biggest concern is whether the observed correlations represent a likely causal relationship between disaster outcome and depression/PTSD, or whether those with mental illness or symptomatology are more likely to report experiences of disaster, even if their experience was in fact similar to other people’s. Our analysis suggests that this is likely to explain no more than a small part of the association. A sensitivity analysis indicated that reporting would have had to be substantially differential (much more than is plausible) between cases and noncases for differential reporting to be the cause of the associations seen (Appendix 1 in supplementary material). In addition, most of the disaster-related events that were queried were concrete actions and events, which were probably less vulnerable to reporting bias than subjective impressions.

Table 4
Relationship Between Natural Disaster, Oil Spill Exposure, and Mental Health, Interactive Model

Estimated effect of the given oil spill measure, within strata of disaster exposure	Depression			PTSD		
	RR ^a	95% CI	<i>p</i> for interaction	RR ^a	95% CI	<i>p</i> for interaction
Any exposure to oil spill, high disaster exposure stratum	1.40	[.99–1.96]	.99	1.55	[.85–2.82]	.31
Any exposure to oil spill, low disaster exposure stratum	1.31	[.84–2.04]		2.54	[1.06–6.09]	
High income loss because of oil spill, high disaster exposure stratum	1.25	[.92–1.69]	.33	1.66	[.99–2.77]	.16
High income loss because of oil spill, low disaster exposure stratum	1.53	[.95–2.46]		3.02	[1.35–6.77]	
Direct contact with oil, high disaster exposure stratum	1.43	[1.05–1.97]	.39	1.45	[.84–2.49]	.25
Direct contact with oil, low disaster exposure stratum	1.75	[1.04–2.92]		2.44	[1.08–5.50]	
Traumatic/property loss because of oil spill, high disaster exposure stratum	1.61	[1.03–2.51]	.68	1.51	[.69–3.33]	.56
Traumatic/property loss because of oil spill, low disaster exposure stratum	1.16	[.44–3.09]		.70	[.11–4.43]	
Loss of use of coast, etc. because of oil spill, high disaster exposure stratum	1.54	[1.12–2.13]	.93	1.96	[1.10–3.47]	.43
Loss of use of coast, etc., because of oil spill, low disaster exposure stratum	1.49	[.94–2.38]		2.97	[1.21–7.29]	
Total exposure to oil spill						
High disaster exposure stratum						
Low	Ref			^b		
Medium-low	1.01	[.67–1.54]	.31			
Medium-high	1.16	[.77–1.74]	.85			
High	1.56	[1.02–2.40]	.26			
Low disaster exposure stratum						
Low	Ref					
Medium-low	1.40	[.82–2.36]				
Medium-high	1.12	[.56–2.24]				
High	2.24	[1.08–4.62]				

Note. RR = relative risk; CI = confidence interval; PTSD = posttraumatic stress disorder.

^a Adjusted for age, Body Mass Index, Black, income, gravidity, education, partnership status, smoking. ^b Failed to converge.

In interpreting these results, the study population—young women—must be kept in mind. Generally, studies find that women have a stronger mental health reaction to disaster than men, while differences by age are inconsistent (Norris et al., 2002). It is possible that the cumulative or sensitization effects would, therefore, be stronger in women than in a comparable sample of men, but we cannot demonstrate that. The sample was unselected with respect to exposure or clinical outcomes (i.e., it is not specifically designed to study those who were seeking restitution for oil-spill-related losses, or reported for mental health screening) and thus is more representative than many similar studies, although the overall region is highly disaster-exposed. Compared with the overall population of births in these parishes, this population is younger and more Black (Louisiana Department of Health, 2015); it is also generally poor. Overall, this population is vulnerable. Disaster does not affect all populations equally, even within a geographic area. Poverty and racism may put women at risk for a depression and PTSD (Bryant-Davis, Ullman, Tsong, Tillman, & Smith, 2010; Paranjape, Sprauve-Holmes, Gaughan, & Kaslow, 2009), and lifetime trauma exposure has been found to be very common among low-income Black women (Dailey, Humphreys, Rankin, & Lee, 2011). Living in a disadvantaged or dangerous neighborhood may interact with negative life experiences to increase susceptibility to depression (Cutrona et al., 2005). A longitudinal study of a similar demographic group after Hurricane Katrina found that poor mental health before the storm was particularly important in predicting high risk of posttraumatic stress symptoms and psychological distress after Katrina (Paxson, Fussell, Rhodes, & Waters, 2012). Black women may define their experiences differently than the (White, male, and educated) mental health establishment, which may influence both their coping strategies as well as limiting their access to mental health services—for instance, one study of older Black women found they were likely to regard depression as a natural consequence of life experiences and something to be persevered through (Ward et al., 2014). Follow-up for mental health issues after disaster may need to consider previous trauma exposures rather than previous diagnosis when trying to reach those at risk for psychopathology, as well as reaching out across the population rather than expecting those who need help to seek care.

Conclusions

The results of this study support most strongly a cumulative risk model for the effects of multiple disasters, although the sensitization and habituation models may need to be investigated in other populations. This finding warns against the complacency of expecting those living in disaster-prone areas to be unaffected by disasters. At the same time, it suggests that mental health responses to future disasters in such areas are not likely to be disproportionately severe, and encourages study of outreach strategies that reach all those who need mental health assistance, as well as factors that lead to resilient communities.

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