

The 2010 Deepwater Horizon Oil Spill: The Trauma Signature of an Ecological Disaster

James M. Shultz, MS, PHD

Lauren Walsh, MPH

Dana Rose Garfin, PHD

Fiona E. Wilson, PHD

Yuval Neria, PHD

Abstract

The 2010 Deepwater Horizon “British Petroleum (BP)” oil spill was a mega-disaster characterized as the petroleum industry’s largest-volume marine oil spill in history. Following a “wellhead blowout” that destroyed the drilling platform, 4.9 million barrels of petroleum flowed into the Gulf of Mexico over 87 days and the spill expanded to cover 68,000 square miles of sea surface. However, despite the expansive scope of the event, systematic surveys of affected coastal populations found only modest effects on mental health and substance abuse. An established trauma signature (TSIG) methodology was used to examine the psychological consequences in relation to exposure to the unique constellation of hazards associated with the spill. A hazard profile, a matrix of psychological stressors, and a “trauma signature” summary for the affected Gulf Coast population—in terms of exposure to hazard, loss, and change—were created specifically for this human-generated ecological disaster. Psychological risk characteristics of this event included: human causation featuring corporate culpability, large spill volume, protracted duration, coastal contamination from petroleum products, severe ecological damage, disruption of Gulf Coast industries and tourism, and extensive media coverage. The multiple impact effect was

Address correspondence to James M. Shultz, MS, PHD, Sunny Isles Beach, FL, USA. Phone: +1-305-2199011. Email: jamesmichaelshultz@gmail.com.

James M. Shultz, MS, PHD, Center for Disaster and Extreme Event Preparedness (DEEP Center), University of Miami Miller School of Medicine, 251 174 St. #2319, Sunny Isles Beach, FL, 33160, USA. Phone: +1-305-2199011. Email: jamesmichaelshultz@gmail.com

Lauren Walsh, MPH, Johns Hopkins University Bloomberg School of Public Health, Department of Environmental Health Sciences, 615 N Wolfe St, Baltimore, MD, USA. Email: walshlulu@gmail.com

Dana Rose Garfin, PHD, Department of Psychology and Social Behavior, 4201 Social and Behavioral Sciences Gateway, University of California, Irvine, Irvine, CA, USA. Email: dgarfin@uci.edu

Fiona E. Wilson, PHD, Department of Clinical and Health Psychology, University of Edinburgh, Edinburgh, Scotland, UK. Email: fiona.e.wilson@nhslothian.scot.nhs.uk

Yuval Neria, PHD, Department of Psychiatry and The New York State Psychiatric Institute, Columbia University, 1051 Riverside Dr., New York, NY, USA. Email: ny126@columbia.edu

Journal of Behavioral Health Services & Research, 2014. 58–76. © 2014 National Council for Behavioral Health. DOI 10.1007/s11414-014-9398-7

notable due to prior exposure of the region to Hurricane Katrina. These stressors were counterbalanced by the relative absence of other prominent risks for distress and psychopathology. Coastal residents did not experience significant onshore spill-related mortality or severe injury, shortages of survival needs, disruption of vital services (health care, schools, utilities, communications, and transportation), loss of homes, population displacement, destruction of the built environment, or loss of social supports. Initial acute economic losses were partially offset by large-sum BP payments for cleanup and recovery of the coastal economy. Not only did Gulf Coast populations display remarkable resilience in the face of daunting challenges, the behavioral health impact of the Deepwater Horizon spill appears to have been blunted by the absence of major evidence-based risks for psychological distress and disorder; the exemplary response, and the infusion of economic resources.

Introduction

On 20 April 2010, an explosion and fire occurred on the *Deepwater Horizon*, a floating deep-sea oil-drilling platform, operated by Transocean and leased to British Petroleum's (BP) Macondo Prospect in the Gulf of Mexico.¹⁻³ The inferno blazed for 36 h, destroying the platform, claiming the lives of 11 oil rig workers, and severely injuring 17 others. The charred superstructure collapsed and sank into the Gulf, producing a "wellhead blowout" as the oil inlet disconnected at a seafloor depth of 5,100 ft. Over the subsequent period of 87 days, before the wellhead was successfully capped on 15 July 2010, more than 4.9 million barrels of petroleum (210,000,000 US gal; 780,000 m³) flowed into the Gulf.⁴ Although surpassed by the spill volumes of the 1910 Lakeview Oil Company "gusher" in Kern County, California (an on-land spill)⁵ and the 1991 Gulf War oil spill and inferno unleashed in Kuwait by invading Iraqi forces,⁶ the *Deepwater Horizon* surpassed all previous petroleum industry marine oil spills and created an ecological mega-disaster.¹⁻³

In terms of disaster classification, the *Deepwater Horizon* spill may be characterized as a nonintentional anthropogenic (human-generated) technological disaster involving a hazardous materials spill (petroleum and dispersant chemicals) that generated severe ecological impact.^{7,8} Human-generated technological disasters have the potential to create significant risk for psychological distress and a range of mental health consequences equaling and often exceeding the effects produced by natural disasters.¹⁰⁻¹⁴ Adding to the fact of human causation, the investigation by the Presidentially appointed National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling determined that the spill was preventable.¹ As the event unfolded, US President Barack Obama declared: "This oil spill is the worst environmental disaster America has ever faced... Make no mistake: we will fight this spill with everything we've got for as long as it takes. We will make BP pay for the damage their company has caused. And we will do whatever's necessary to help the Gulf Coast and its people recover from this tragedy."¹⁵

Given the anthropogenic nature, the scale, and the magnitude of this event, the disaster behavioral health (DBH) consequences of the *Deepwater Horizon* oil spill were anticipated to feature prominently among the public health effects. Supported by earmarked "behavioral health" funding from BP,¹⁶ the Substance Abuse and Mental Health Services Administration (SAMHSA) and the Centers for Disease Control and Prevention (CDC) set out to document the mental health and substance abuse effects using large, representative samples of coastal residents in the oil spill-affected states of Louisiana, Mississippi, Alabama, and Florida.¹⁷ Surprisingly, findings were modest and equivocal, prompting the authors to conclude that the behavioral health impact of the spill was not as "widespread" as expected throughout the spill-impacted Gulf coast.¹⁷

In the present study, an established methodology of trauma signature (TSIG) analysis¹⁸⁻³¹ was applied to this landmark ecological disaster. TSIG analyses have been conducted on a wide

spectrum of disasters, including natural,^{20–25} nonintentional technological, hybrid,^{26,27} and intentionally-perpetrated^{28–31} variants. In the present case study, TSIG analysis sheds light on the counterintuitive finding that a hazardous materials spill of epic proportions apparently caused only moderate behavioral health effects for the general population of the affected states.

DBH consequences of oil spills: review of the literature. As previously reviewed in detail,^{17,32} DBH consequences have been routinely documented along with physical health effects after oil spill disasters.^{32–36} Mental health effects were investigated in the 1996 *Sea Empress* oil tanker spill in Wales^{37,38} and the 2002 sinking of the *Prestige* oil tanker off the coast of Galicia, Spain.^{39–41} However, the richest source of behavioral health literature, prior to the *Deepwater Horizon* event, focused on the 1989 *Exxon Valdez* tanker spill in Prince William Sound, Alaska.^{42–49} Strong parallels have been drawn by the researchers who investigated the *Exxon Valdez* disaster, linking their lessons learned to the *Deepwater Horizon* spill.^{50–52} Now, several years since the rupture of the *Deepwater Horizon* wellhead, the DBH literature specific to this event continues to accrue.^{53–65}

One of the most pronounced concerns for Gulf Coast residents was the “multiple exposure” effect.^{7,8,66–74} The geographic region most affected by the *Deepwater Horizon* oil spill included the same Gulf Coast counties that were most devastated by Hurricane Katrina in 2005.^{75–78} The possible compounding effect of successive “hits” from both disaster events had been widely speculated to elevate risks for significant psychological consequences.^{53,59,79–82} Indeed, a study of individuals living in the Louisiana parishes (counties) that received the heaviest shoreline petroleum contamination showed a statistically significant association between level of prior impact from Hurricane Katrina and the likelihood of symptoms of posttraumatic stress following *Deepwater Horizon*.⁵⁹

The psychological impacts of oil spill disasters can persist for years following the event.^{48,49} One year following the *Exxon Valdez* spill, for example, there were significant increases in rates of anxiety disorder, posttraumatic stress disorder (PTSD), and depression among residents with a high level of exposure to the spill and its cleanup efforts.⁴⁴ Elevated levels of depression, intrusive stress, avoidance, and family conflict continued to be evident 8 years post-spill.⁴⁹ Additional community-level consequences persisted for decades. Long-term damage to the ecosystem affected families and communities economically and socially. For example, some families whose livelihoods depended on the natural environment were forced to relocate or live apart because of the ecological damage caused by the spill.⁴⁹

The degree and duration of exposure to petroleum products and dispersant chemicals may predict the presence and severity of psychological stress and distress. Of particular interest for investigation is petroleum exposure for the oil spill cleanup workers in relation to mental health.^{83–87} For example, following the *Exxon Valdez* spill, exposed cleanup workers had significantly higher rates of generalized anxiety disorder, PTSD, and major depression compared with nonexposed controls.⁴⁴

Recent studies have examined the health and psychological consequences of the *Deepwater Horizon* spill.^{53–65} Four months after the spill, the Louisiana Department of Children and Family Services funded a study to implement a mental health needs assessment in the four most impacted Louisiana parishes.⁵⁹ Despite the limitations of using a nonrepresentative convenience sample, findings were instructive: respondents who expressed concerns about the oil spill or who had experienced occupational, family, or social disruptions due to the spill, had higher scores on scales of posttraumatic stress, depression, and anxiety symptoms—after controlling for Hurricane Katrina impact, place satisfaction, and individual rebound resilience.⁵⁹ A survey of residents in Mobile County, Alabama found higher levels of spill-related psychological stress in respondents who indicated that the spill posed threats to their economic future, family health, and family finances and in survey participants with commercial ties to natural resources and direct exposure to oil and contaminants.⁵² These results were shown to be comparable to the mental health impacts observed

following the *Exxon Valdez* oil spill, further validating the importance of understanding the risk factors commonly associated with social and psychological consequences of oil spill disasters.⁵²

Upon request from the states of Alabama and Mississippi, the CDC conducted the Community Assessment for Public Health Emergency Response (CASPER) survey in the immediate aftermath of the spill in 2010 and replicated the survey in 2011.^{61,62} Using questions from the Behavioral Risk Factor Surveillance Survey (BRFSS) to provide 2009 pre-spill comparisons, investigators surveyed representative samples of the populations of coastal Mississippi counties and Baldwin and Mobile counties in Alabama. Respondents in the CASPER sample self-reported higher proportions of physically and mentally “unhealthy” days, limited activity days, and depressive symptoms immediately post-spill in 2010 compared with 2009 pre-spill BRFSS data for the two states.^{61,62} By 2011, these proportions had all decreased markedly toward baseline but remained above 2009 levels.⁶² Following the 2011 replication, authors concluded, “These results suggest that mental health services are still needed, particularly in households experiencing decreased income since the oil spill.”⁶²

Acknowledging the importance of psychosocial health effects during oil spill disasters, BP’s Trust Fund reparations to the Gulf Coast specifically designated \$52 million for behavioral health, with \$42 million apportioned to four Gulf Coast states and \$10 million directed to SAMHSA to conduct research and programming.^{16,88,89} Joining forces with the CDC, SAMHSA used some of these resources to conduct survey research with representative samples of residents in 32 coastal counties across the four affected states of Louisiana, Mississippi, Alabama, and Florida.¹⁷ To assess effects of the oil spill on substance use, SAMSHA added 2,000 interviews in these states to the ongoing National Survey on Drug Use and Health (NSDUH). A critical design element was the ability to compare substance use rates for pre- and post-spill time periods. NSDUH results showed modest past-month increases in marijuana and alcohol use. There were also increased self-reports of depression and suicidal thoughts and plans, but only among 18–25-year olds. There were no pre-spill/post-spill differences in cigarette use, nonmedical use of pain relievers, substance use disorder, psychological distress, any mental illness, serious mental illness, suicide attempts, or utilization of mental health services.¹⁷

Simultaneously, to examine behavioral and mental health effects, CDC fielded the Gulf States Population Survey (GSPS), a telephone survey of 38,000 residents, comparing persons living in coastal and noncoastal counties within each of the four states. Persons living in coastal counties more commonly reported decreased income or job loss due to the spill. However, there were no differences between coastal county and noncoastal county residents in terms of chronic mental or physical health conditions or health behaviors.¹⁷ SAMHSA and CDC co-authors summarized their findings with the statement, “...this mixed picture could indicate that the behavioral health impact of the Gulf Coast oil spill may not be widespread across the entire population of the counties most affected by the spill” (p. 4).¹⁷

TSIG analyses presented here were intended to bring perspective to these important but somewhat unexpected findings of nominal mental health and substance abuse effects at the level of the affected region.

Methods

TSIG analysis^{18–31} was applied to examine the psychological and mental health effects of the *Deepwater Horizon* oil spill.¹⁸ TSIG analysis is defined as “an evidence-based method that examines the interrelationship between population exposure to a disaster, extreme event, or complex emergency, and the inter-related physical and psychological consequences for the purpose of providing timely, actionable guidance for effective DBH support that is organically tailored and targeted to the defining features of the event.”¹⁸

Briefly, for each individual disaster event, TSIG analysis looks at disaster survivors' exposures to empirically documented risk factors for psychological distress and mental health disorders.⁹⁻¹⁴ Consistent with the Disaster Ecology Model,^{7,8} which forms the theory base for TSIG analysis, the assumption is that each disaster exposes the affected population to a novel constellation of "forces of harm." In turn, forces of harm are subcategorized into exposures to hazards, losses, and changes. Once defined, the disaster's unique "signature" of exposure risks may serve as a key predictor of needs for mental health and psychosocial support.¹⁸ Unlike the current *post hoc* case study conducted several years after the spill, when TSIG analysis is performed in "real time," as a disaster is unfolding, results can be used to guide the immediate, on-scene DBH response.¹⁸

The TSIG analyses reported here entailed the following steps: retrieval and synthesis of published reports describing the *Deepwater Horizon* oil spill to produce a hazard profile; review of the scientific literature on evidence-based risk factors for psychological distress and mental health disorders for persons exposed to technological disasters and especially oil spills; enumeration of spill-specific exposures and stressors; creation of a TSIG summary, based on the estimated psychological severity of exposures to hazards, losses, and changes; and identification of major psychological risk factors that were present or absent in this event.

Hazard profile (Table 1). TSIG hazard profiles use an epidemiologic approach to disaster description that incorporates hazard, person, place, and time dimensions. Type of disaster was based on classification schemes used by the Centre for Research on the Epidemiology of Disasters (CRED)⁹⁰ and the World Association for Disaster and Emergency Medicine.⁹¹

Table 1
Deepwater Horizon Oil Spill: Hazard Profile

Event characteristic	<i>Deepwater Horizon "BP" oil spill</i>
Event description	
Event definition	Nonintentional anthropogenic (human-generated) technological disaster involving a hazardous materials spill (petroleum and dispersant chemicals) that generated severe ecological impact
Industry description	"Wellhead blowout"
Spill characteristics	
Hazardous materials	Petroleum: Louisiana Light Crude Chemical dispersant: "Corexit"
Volume of spill	4.9 million barrels (210,000,000 US gallons; 780,000 m ³)
Surface area of spill	68,000 square miles; 176,120 km ²
Magnitude	Largest-volume marine oil spill in history
Dispersant volume	1.84 million US gallons; 7,000 m ³
Place	
Location	Gulf of Mexico near Mississippi River Delta, USA
Coordinates	28° 44' 17.30" N, 88° 21' 57.40" W
Coastline affected	Gulf of Mexico coastline for states of Louisiana, Mississippi, Alabama, Florida: 32 coastal counties with direct contamination
Depth of wellhead	Seafloor: 5,100 ft (1, 555 m) below surface (~1 mile)
Time	
Date/time: explosion	20 April 2010 09:45 CDT (14:45 GMT): time of initial explosion
Date: wellhead capped	15 July 2010
Duration of flow	87 days

Table 2

Deepwater Horizon Oil Spill: Onshore Disaster Exposure and Stressor Matrix in Relation to Categories of Exposure

Type of exposure	Disaster exposures and stressors
Hazard	<p>Scale, scope, and duration: largest petroleum industry marine oil spill in history</p> <p>Multiple exposure effect: prior exposure to Hurricane Katrina, economic crisis</p> <p>Preventable human causation with corporate culpability</p> <p>Prolonged negative media coverage elevated sense of risk</p> <p>Uncertain future health effects</p> <p>Additional exposures:</p> <p>Contact with petroleum, dispersants, and contaminants</p> <p>Direct exposure to oil and petroleum products (especially cleanup/recovery workers)</p> <p>Direct exposure to dispersant chemicals (especially cleanup/recovery workers)</p> <p>Exposure to smoke from burning oil (especially cleanup/recovery workers)</p> <p>Exposure to odors/vapors</p> <p>Direct contamination of Gulf Coast products</p> <p>Fear of contamination</p> <p>Stressors of working on cleanup/recovery crews</p> <p>Working in personal protective equipment (PPE)</p> <p>Heat stress</p> <p>Direct exposures to petroleum, dispersants, contaminants, and smoke/vapors</p> <p>Ecological impacts</p> <p>Visible harm/death to wildlife</p> <p>Visible harm to shoreline ecosystems</p> <p>Below-the-surface harm to ecosystems</p> <p>Fears about effects on Gulf Coast ecology</p>
Loss	<p>Multiple loss effects (compounding losses from Katrina, global economic crisis, oil spill)</p> <p>Losses sustained by area economy and Gulf Coast industries</p> <p>Job loss, unemployment, and competitive disadvantage</p> <p>Gulf Coast economic losses</p> <p>Fishing industry losses:</p> <p>Closure of fishing areas</p> <p>Loss of fish and shellfish stocks</p> <p>Stigmatization of seafood products</p> <p>Tourism industry losses</p> <p>Beach contamination</p> <p>Closed beaches</p> <p>Decreased tourism</p> <p>Closure of area hotels, restaurants, and related industries</p> <p>Other impacted Gulf industries:</p> <p>Real estate</p> <p>Oil/petroleum industry jobs</p> <p>Other Gulf water-dependent industries</p> <p>Losses sustained by Gulf ecosystems:</p> <p>Visible loss/damage to fragile ecosystems</p> <p>Visible loss/harm to wildlife and vegetation</p> <p>Fear of reduction/extinction of endangered species</p>

Table 2

(continued)

Type of exposure	Disaster exposures and stressors
Change	Stigmatization of Gulf Coast region and Gulf Coast products (seafood, fish products) Change in employment patterns: Job loss, reduced hours, unemployment in Gulf industries Job creation for cleanup and recovery operations Introduction of new coastal technologies Media presence and focus Media stories focusing on anxiety, loss, and stress Major changes to Gulf Coast economy

Review of the literature on psychological risk factors for oil spills. The disaster mental health literature on human population exposure to oil spills was searched to identify evidence-based risk factors. A summary of this literature was presented in the introduction.

Exposure and stressor matrix (Table 2). Based on review of the scientific literature and news accounts, a table was constructed of disaster stressors experienced by Gulf Coast citizens during the impact phase of the *Deepwater Horizon* oil spill. The resulting “stressor matrix” classifies exposures to hazards, losses, and changes.

TSIG summary (Table 3). A composite TSIG summary table was constructed, displaying the most significant evidence-based psychological risk factors, grouped under the headings of hazard, loss, and change. The table presents exposure severity ratings for these risk factors. The ratings use order-of-magnitude (10-fold) differences between adjacent categories. Based on CRED’s database of international disaster events, dating from 1900 to the present,⁹⁰ ratings of “extreme” for a specific risk factor are reserved for disasters that produce consequences at that order of magnitude only several times every 50 to 100 years. “Very severe” ratings reflect the order-of-magnitude threshold reached with a frequency of 1 or several times within a 10- to 20-year period, while “severe” ratings occur 1 or several times within a 3- to 5-year period.

Psychological risk factors: present or absent (Table 4). Considering the evidence-based disaster risk factors that most strongly and consistently predict psychological distress and impairment,^{9–13} Table 4 contrasts those risk factors that were present and prominent with those that were absent or minimal during the *Deepwater Horizon* oil spill.

Results

Results of the TSIG analyses are presented in Tables 1, 2, 3, and 4 and summarized here.

Hazard profile (Table 1). The hazard profile presents the event description including the disaster classification and the time of onset, duration, volume of petroleum products and chemical dispersants released, geographic location, surface spread, and coastal populations affected. The *Deepwater Horizon* spill was the largest-volume marine petroleum spill in history.

Table 3
Deepwater Horizon Oil Spill: Trauma Signature Summary

Risk factors for psychological distress and mental disorders	Deepwater Horizon oil spill characteristics	Exposure severity			
		Low	Moderate	Severe	Very severe
Exposure to hazards	100,000 coastal dwellers and 45,000 cleanup workers	Low	Moderate	Severe	Very severe
Direct petroleum product/dispersant exposure	400,000 Gulf Coast population	<10,000	≥10,000	≥100,000	≥10 million
Minimal exposure to spill products		Low	Moderate	Severe	Extreme
Strong fear reactions	Very few persons experienced sense of threat to life	<10,000	≥10,000	≥100,000	≥10 million
perceived life threat	No life-threatening onshore injuries due to spill	Low	Moderate	Severe	Extreme
Severe, life-changing physical injury	Coastal cleanup workers: ~1,000.	<100	≥100	≥1,000	≥10,000
Minor ailment requiring medical attention	Infirmary visits/month for 8 months	Low	Moderate	Severe	Extreme
Witnessing death or severe harm to humans	Several onshore suicides/no life-threatening injuries due to spill	Low	Moderate	Severe	Extreme
Witnessing grotesque scenes: dead wildlife	500,000 Gulf Coast population	<1,000	≥1,000	≥10,000	≥1 million
Exposure to post-impact severe environment	All infrastructure remained intact.	Low	Moderate	Severe	Extreme
Multiple high-intensity impacts	All vital services operational	<1,000	≥1,000	≥10,000	≥1 million
Human-generated contribution	Coastal populations in 32 counties; others in the states	Low	Moderate	Severe	Extreme
	Totally human-generated event	<10,000	≥10,000	≥100,000	≥10 million
		Low	Moderate	Severe	Extreme
Exposure to loss					Very severe
Mortality	Several onshore suicides due to spill (11 deaths on oil rig)	Low	Moderate	Severe	Extreme
Bereavement	Few onshore deaths. 50 first-line relatives of 11 dead oil workers	Low	Moderate	Severe	Extreme
Loss of primary dwelling	No or very few losses of primary dwellings	Low	Moderate	Severe	Extreme
Severe financial losses	Estimated severe losses for 200,000 workers	Low	Moderate	Severe	Extreme
National financial losses	Billions in costs, but all paid by BP	<10,000	≥10,000	≥100,000	≥1 million
		Low	Moderate	Severe	Extreme
Exposure to change					Very severe
Evacuation/displacement/relocation to shelters	Very few or no evacuations with long term displacement	Low	Moderate	Severe	Extreme
		<1,000	≥1,000	≥10,000	≥1 million

Table 3
(continued)

Risk factors for psychological distress and mental disorders	Deepwater Horizon oil spill characteristics	Exposure severity				
		Low	Moderate	Severe	Very severe	Extreme
Loss of essential services	No loss of essential services	Low	Moderate ≥10,000	Severe ≥100,000	Very severe ≥1 million	Extreme ≥10 million
Disruption of critical infrastructure	No damage to vital infrastructure	Low	Moderate ≥10,000	Severe ≥100,000	Very severe ≥1 million	Extreme ≥10 million
2010 impact on Gulf Coast industries	Severe impact on tourism, fishing, shellfish, and oil industries	Low	Moderate	Severe	Very severe	Extreme
2011–present impact on Gulf Coast Industries	Rapid recovery: tourism, fishing, shellfish, and oil industries	Low	Moderate	Severe	Very severe	Extreme
Enduring ecological impact	Severe, extreme, and enduring	Low	Moderate	Severe	Very severe	Extreme

Table 4

Deepwater Horizon Oil Spill: Psychological Risk Factors for Gulf Coast Residents: Comparison of Risk Factors that were Present/Prominent vs. Absent/Minimal

Types of exposure	Present and prominent	Absent or minimal
Hazard	Human-generated hazardous materials event Preventable human causation Expansive scale, scope, and duration Exposure to hazardous materials Multiple impact event (Katrina, economic crisis, BP oil spill) Contamination of Gulf waters, coastlines, and beaches Damage to machinery and equipment Extreme ecological damage Witnessing harm to wildlife, vegetation, habitat, and ecosystems Current, future health fears Negative media publicity	Severe, life-changing injury Single or multiple injuries to loved ones Witnessing harm to other humans Fear of life threat for self or loved ones Fear of injurious harm for self or loved ones Evacuation/sheltering Need for rescue Entrapment Extreme fear or panic reactions Exposure to undetectable hazards
Loss	Short-term severe impact on Gulf economy Impacts on specific Gulf Coast industries (e.g., tourism and fishing) Family economic hardships Job loss or reduced income Fears regarding economy Short-term loss of access to beach/coastal recreational areas Small number of episodes of self-harm	Mass mortality Single or multiple deaths of loved ones Traumatic bereavement Complicated grief Separation from loved ones Long-term negative economic impacts Long-term family economic hardships Loss of home Loss of basic necessities Loss of vital services
Change	Fears regarding stigma Fears regarding changes to lifestyle	Displacement Loss of critical infrastructure Structural destruction

Exposure and stressor matrix (Table 2). Psychological stressors were subdivided into those related to exposures to hazards, losses, and changes. Regarding hazards, in addition to defining features of the event (large scale, multiple exposure effect, human causation, negative media publicity, and uncertain future health effects), the stressors were those of direct contact with petroleum and related products, environmental/ecological damage, and rigors of working on the cleanup crews. Loss-related stressors included the “multiple loss effect,” losses for specific Gulf industries and the broader economy of the area, and ecosystem impacts. Change-associated stressors included stigma of the area and its products, changes in employment patterns and opportunities (including the introduction of new technologies), and the protracted presence of media.

TSIG summary (Table 3). The TSIG summary contrasts the major evidence-based psychological risk factors, subsumed under the categories of exposures to hazards, losses, and changes, and ranked according to “exposure severity.” Exposure severity is highly variable, ranging from low to extreme; however, it is notable that the majority of the risk factors have a ranking of “low” or

“moderate” severity. The use of the severity rankings allows this table to display the contrasts between the psychological risk factors in play and not in play.

Psychological risk factors: prominent and absent (Table 4). The table presents lists of exposures and stressors that are known to be evidence-based risk factors for psychological distress and disorders divided into two groups: those that were present and prominent during the *Deepwater Horizon* oil spill and those that were absent or minimal. Psychological risk factors are classified into exposures to hazards, losses, and changes.

Prominent psychological risk factors that were clearly present during the *Deepwater Horizon* oil spill were the defining features of the event: large scale, multiple exposure effect, human causation, negative media publicity, and uncertain future health effects. Equally important is the litany of risk factors that were absent. Onshore, throughout the *Deepwater Horizon* oil spill, Gulf Coast residents did not experience: mass mortality, life-changing injury, witnessing harm to other humans, fear of life threat, exposure to undetectable hazardous materials, loss of homes, displacement, separation from loved ones, widespread physical destruction in the community, disruption of critical infrastructure and vital services, or lack of basic necessities.

Discussion

Risk factors for psychological consequences: present and prominent

TSIG analysis examines both the distinguishing features that set a disaster event apart as well as the presence and degree of severity of known risk factors for psychological distress and mental health consequences. More than most disaster events, in the case of the *Deepwater Horizon* oil spill, it was possible to dichotomize exposures into those that were present or absent, “in play” or “not in play.”

Five defining characteristics that predicted the likelihood of significant DBH effects will be discussed: (1) expansive scale and prolonged duration, (2) multiple exposure effect, (3) preventable human causation, (4) prolonged negative media publicity, and (5) the uncertain future health effects.

Expansive scale and prolonged duration. The *Deepwater Horizon* disaster was the petroleum industry’s largest-volume marine oil spill.^{1,4,92} For Gulf Coast residents, the ominously expanding oil spill created significant stress. Aerial and satellite photos, and animations of the expanding oil slick, added to the distressing imagery. As the oil reached the coastline, the ecological damage to plant and animal species, and to fragile wetlands habitats, became grotesquely visible. Photographic and video images repeatedly displayed waterfowl, shrouded in a coating of viscous oil, struggling and perishing along the coastline.^{93,94}

Multiple exposure effect. The brunt of the *Deepwater Horizon* oil spill was borne by many of the same Gulf Coast residents who had experienced the wrath of Hurricane Katrina in 2005 and strong tropical cyclones in 2008.⁵⁹ Meanwhile, these coastal citizens were in the throes of the most severe global economic crisis in 80 years at the time the oil platform exploded.⁹⁵

Research indicates that multiple high-intensity impacts are more stressful than an encounter with a singular event.^{7,8,66–74} Exposure to prior adverse experiences or traumatic events appears to sensitize people to react more negatively following subsequent trauma.^{70–72} The Adverse Child Experiences (ACE) study has found robust correlations between cumulative exposure to adversity in childhood and deleterious physical and mental health outcomes in adulthood.⁷³ Additionally, childhood exposure to a natural disaster predicted elevated symptom levels for common mental disorders in adulthood.⁶⁸ Prior exposure to violence predicted poorer mental health following the impact of a natural disaster, the 1988 earthquake in Armenia.⁷¹

The spill struck the economic heart of the coastal Deep South, with strongest effects experienced in the tourism,⁹⁶ fin fishing, shellfish culture,⁹⁷ and energy/petroleum industries. The instantaneous and severe impact on the marketability of Gulf Coast products and services set in motion strong fears that stigmatization of the region would threaten the viability of coastal livelihoods long term.

Preventable human causation. The *Deepwater Horizon* explosion and oil spill represented a cataclysmic failure of human technology.¹⁻³ Although contingency plans for hazardous materials spills had been previously developed, none took into consideration uncontrolled spillage from an offshore well, rather than a vessel or onshore facility.^{2,4} Human negligence, lack of foresight, cavalier disregard for predictable risks, and corporate culpability were prominently on display.¹⁻³ Such hallmarks of a human-generated disaster magnified the psychological reactions.⁹⁻¹³

Prolonged negative media publicity. Media personalities converged on the Gulf Coast, with network news anchors frequently broadcasting live from the Gulf shoreline. The coverage of the event was extensive, ever-present, and protracted. With story lines focusing on BP's share of the blame, the media scrutiny was investigative and intense. Media stories "stirred the pot," playing on the coastal anxieties regarding economic ruin, lasting damage, and stigma, as newscasters presented a series of personal tales of hardship. The *Deepwater Horizon* spill maintained "top story" status for 14 consecutive weeks, an unparalleled feat in the annals of disaster journalism.⁹⁸ Forty-seven percent of news coverage focused on impact, cleanup, and containment; 27% dealt with BP's role and culpability; and 17% dealt with the Obama administration response.⁹⁸

An ocean-floor camera was installed to visualize the illuminated, spewing wellhead and cable news networks displayed a 24/7 real-time, screen-within-a-screen image of the seafloor gusher. Broadcasting the prolonged, relentless accumulation of petroleum product both on the surface and submerged in the ocean depths amplified the sense of threat. Only when the wellhead was capped were the underwater cameras turned off, and abruptly, the *Deepwater Horizon* media coverage dissipated.

Uncertain future health effects. Scientists have begun to examine the range of possible health consequences of significant exposures to the chemical constituents of petroleum and dispersant products and aerosols, including various forms of cancer, neurological disorders, and special susceptibilities for persons with genetic polymorphisms.⁹⁹ Rumors of harmful exposure to vapors and aerosols were fairly common in the early weeks and some coastal residents sought medical consultations for symptoms they believed to be related to contact with oil washing ashore or breathing foul-smelling air. However, the great majority of residents factually perceived that the spill did not pose threat to life or threat of severe bodily harm. Ongoing surveillance will be critical to monitor the health status of Gulf residents, especially the cleanup workers.⁹⁹

Protective factors buffering psychological consequences

Several opposing forces may have counterbalanced the psychological risk factors described above. First, some prominent disaster risk factors that strongly predict psychological distress and impairment were not present in the *Deepwater Horizon* oil spill. Second, the nature of the disaster allowed the infrastructure of coastal communities to remain intact. Third, the disaster response was exemplary. Fourth, substantial BP financing was made available to underwrite losses, pay for the cleanup efforts, and support Gulf Coast economic recovery.

Absence of powerful psychological trauma risk factors. Juxtaposed against the psychological effects related to the enormity of this ecological catastrophe was a pronounced absence of a number of major psychological risk factors that predict severe psychological consequences across a range of disasters

and extreme events. Importantly, the expression of distress and the risks for severe disaster-related psychopathology may have been diminished because Gulf Coast residents did not experience acute threats to their lives and physical integrity. The following powerful stressors—common predictors of psychopathology—were not in play during this event: mass mortality, life-changing injury, witnessing harm to other humans, fear of exposure to invisible or undetectable agents, and fear of death or grievous harm to self or loved ones.

This finding, presented in two compare/contrast columns in Table 4, is also powerfully portrayed in the traumatic signature summary appearing in Table 3. Notice that the majority of the exposure severity ratings for the *Deepwater Horizon* oil spill are “low” or “moderate.” This contrasts starkly with previously published TSIG analyses of other mega-disaster events: the 2010 Haiti earthquake (natural disaster),²⁰ the 2011 Great East Japan Disaster (hybrid disaster),²⁶ and the protracted armed conflict in Colombia leading to massive internal displacement (intentional anthropogenic disaster);³¹ all have a preponderance of exposure severity ratings—for the same risk factors—in the “very severe” and “extreme” categories.

Apart from 11 deaths associated with the conflagration onboard the *Deepwater Horizon* drilling platform, and anecdotal reports of possible spill-related suicides,¹⁰⁰ there were very few onshore civilian deaths clearly attributable to the oil spill. Apart from the 17 serious injuries sustained by workmen on the oil rig, there were almost no life-threatening injuries associated with the spill.

Individuals who were most likely to experience oil-spill-associated health effects were the 45,000 persons who comprised the Gulf cleanup workforce. Although cleanup crews were outfitted with personal protective equipment (PPE), a proportion of workers did not comply with the donning and wearing of the protective gear and enforcement was variable. The most common ailments that prompted a visit to the infirmary were heat stress, respiratory complaints, skin conditions related to contact with petroleum and dispersant products, sprains, and similar non-life-threatening, non-life-changing conditions.^{81,83,84,97}

The health effects for Gulf Coast cleanup workers, including possible psychological outcomes, are being carefully monitored. The National Institute of Environmental Health Sciences (NIEHS), part of the National Institutes of Health, has embarked on the Gulf Long-term Follow-up Study (GuLF Study), described as, “the largest study ever conducted on the potential health effects associated with an oil spill, with nearly 33,000 participants.”¹⁰¹ This follows the initial surveillance of Gulf workers during their tours of duty by the Department of Labor’s Occupational Safety and Health Administration (OSHA), working in close cooperation with investigators from the National Institute for Occupational Safety and Health (NIOSH) and the Office of the Assistant Secretary for Preparedness and Response (ASPR).¹⁰²

Throughout the *Deepwater Horizon* oil spill, the hazardous materials tended to be observable to the senses. Unlike other human-generated chemical, radiological, or biological agent events, the *Deepwater Horizon* spill did not generally expose citizens unknowingly to dreaded hazards that were colorless, odorless, unseen, and undetected.

The boundaries of petroleum product and dispersant chemical contamination were restricted to the Gulf waters and coastal shorelines, so most citizens of the affected states had limited or no direct exposure.¹⁷ Typically, coastal residents could see the oil and contaminants and avoid contact. Persons who were engaged in the cleanup operations received training and were provided with PPE. The GuLF Study currently provides ongoing surveillance for the majority of cleanup workers who opted to join the study; their exposures and health outcomes will be carefully monitored to provide insights into potential long-term health—and mental health—effects.^{101,102}

An exceptional feature of the *Deepwater Horizon* oil spill was the fact that, because there was limited onshore physical harm to humans, the psychological effects could be prioritized and isolated for focused investigation. This research opportunity coincided with the availability of earmarked BP funding for behavioral health research^{16,88,89} to produce the well-designed and carefully executed mental health and substance abuse surveys conducted by SAMHSA and CDC.¹⁷

In summary, major psychological risk factors, particularly those relating to physical harm, were not prominently in play. There was almost no onshore spill-related mortality or severe injury. Coastal residents did not experience realistic fears of life threat for self or others. Most were not directly exposed to hazardous petroleum products. With minimal physical harm, the importance of studying the behavioral health effects of the oil spill was recognized, well-funded, and rigorously investigated.¹⁷

Intact coastal community infrastructure. During 2010, there were serious spill-related economic impacts on fishing, tourism, and other industries dependent on the Gulf waters. Nevertheless, despite the effects on Gulf ecosystems and industries, community infrastructure remained operational throughout the spill. There was no major structural damage, destruction of the built environment, or loss of homes. Persons were not evacuated, displaced, relocated, or separated from loved ones. There was minimal disruption of essential services. Major components of critical infrastructure such as communications, transportation, utilities, schools, and health care (including mental health care) operated at full capacity. Gulf residents did not lack for basic necessities.

Therefore, this additional set of risk factors commonly seen in natural disasters—and especially evident when Hurricane Katrina collided with the Gulf coast—was not a factor during the *Deepwater Horizon* oil spill. Furthermore, perhaps one of the strongest assets that buffered the effects of the spill was the deep and abiding community attachment that pervades the Gulf Coast cultures.^{64,65}

Exemplary disaster response. Local and national disaster response assets performed exceptionally well.^{1,2} Disaster response was swift, efficient, and a model of command and control. The US President was rapidly on-scene, the acclaimed FEMA Administrator brought the full force of his agency's response to bear, and the Coast Guard spearheaded the incident command structure.^{1,2} The media and the general public were apprised of each new development. The response instilled confidence and the responders were welcomed as they guided a technologically savvy and coordinated set of cleanup and recovery operations.

Financial injection and economic rebound. BP was actively engaged operationally and financially in all aspects of the response to stop the flow of petroleum, limit ecological damage while the spill was in process, and clean up the Gulf. This brought an infusion of funding, talent, and technology. Funding was prioritized for projects with favorable prospects for rapidly boosting the local economies.¹⁰³ A number of the Gulf industries most affected by the spill appear to be flourishing. For example, the 1-year restriction on fishing allowed the fish stocks to reach record numbers and after a major downturn in 2010, tourism rebounded to profitability with record numbers of visitors by 2011 thanks in part to very effective promotion and beachside renovation. The timing was also fortuitous; the forward economic momentum in the Gulf coincided with the ongoing upturn of a mending economy. All in all, the Gulf Coast experienced an innovative, multi-strategy, resilience-enhancing response buoyed by substantial funding. The timing and speed of the economic turnaround was noted by the SAMHSA/CDC investigators as a possible factor explaining what appears to be robust community mental health throughout the region.¹⁷

TSIG analysis

TSIG analysis continues to evolve as a methodology. The ultimate goal is to develop a system that operates in real-time to rapidly inform mental health and psychosocial support (MHPSS) based on conversion of early and available disaster intelligence into actionable guidance. The present study is one of a series of case studies developed to provide perspective on important disaster

events globally and to create the platform for advancing the science of TSIG analysis.^{18–31} Researchers from five continents have participated on this series of TSIG case studies. Numerous additional “TSIGs” are underway and a Delphi process is planned for 2014 to further refine TSIG methodology based on input from an interested cadre of international DBH experts.

At present, limitations in TSIG analyses also reflect limitations in the field of DBH. These include the needs to better define and quantify exposures, and to translate exposures (to hazards, losses, and changes) into empirical predictions of likely psychological outcomes. For example, the exposure severity ratings are an early and inexact approach to enhancing quantification and their refinement will be a focus of Delphi discussions. For the present study, TSIG analysis provided a framework for examining the defining features of the *Deepwater Horizon* oil spill and identifying the evidence-based psychological risk factors that were present and absent during this event.

Implications for Behavioral Health

The *Deepwater Horizon* oil spill was—and is—an ecological disaster of daunting magnitude that struck the Gulf Coast of the United States as its citizens still struggled to recover from Hurricane Katrina while weathering a severe economic recession. Behavioral health impact has been a consequential feature of previous oil spill disasters. Specific to the *Deepwater Horizon* spill, surveys fielded in heavily impacted communities (some including cohorts previously assembled to study the psychological effects of Hurricane Katrina) initially documented increased symptoms of distress, anxiety, posttraumatic stress, and depression^{52–63,103} although reported symptom levels diminished substantially by 2011.^{61,62} By contrast, the well-designed SAMHSA/CDC surveys employing large, representative population-based samples drawn from the four spill-affected states, and focusing on mental health and substance use indicators, did not find widespread behavioral health impacts from this technological disaster.¹⁷ Although the *Deepwater Horizon* spill may be rated as a mega-disaster in terms of ecological impact, this event does not appear to have produced geographically pervasive, severe, and enduring behavioral health effects.

The SAMHSA/CDC surveys represent a one-time opportunity to take a broad, objective, and systematic view of a disaster in a manner that reveals the geographic boundaries of psychological impact. The *Deepwater Horizon* oil spill was the rare disaster event with a culpable party, BP, both able and incentivized to fully underwrite the containment, the cleanup, the recovery, and the scientific studies that would monitor the health and environmental effects. Even as the BP-funded SAMHSA/CDC surveys were underway, BP was pumping economic resources into the region. When applied to disaster stress, Hobfoll’s conservation of resources (COR) theory posits that “people strive to retain, protect, and build resources and that what is threatening to them is the potential or actual loss of these valued resources.”¹⁰⁴ It is reasonable to assume that the stressors associated with 2010 economic impacts of the spill on the Gulf economy were at least partially redressed as economic resources were made available and as many Gulf industries rebounded (sometimes surpassing pre-spill levels of profitability by 2011 and beyond).¹⁰⁵ Of course, it will be critical to examine the degree of “saturation” of the recovery at the county, community, and family levels to determine whether some have not shared the collective benefits.

The behavioral health implications are clear. Despite the expansive dimensions of the *Deepwater Horizon* spill and the yet-unknown long-term effects on Gulf Coast ecology, (1) the extent of physical human harm appears to be limited, (2) the initial resource loss appears to have been significantly replenished at the regional level, and (3) large, well-conducted studies demonstrate that the “behavioral health impact” is neither severe nor widespread across the area.

Conflict of Interest: There are no conflicts of interest declared.

References

1. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. Deepwater: The Gulf Oil Disaster and the Future of Offshore Drilling: A Report to the President. January 2011. Available at: http://www.oilspillcommission.gov/sites/default/files/documents/DEEPWATER_ReporttothePresident_FINAL.pdf. Accessed 31 January 2014.
2. United States Coast Guard. *On-scene Coordinator Report: Deepwater Horizon Oil Spill: Submitted to the National Response Team*, September, 2011. Available at: http://www.uscg.mil/foia/docs/dwh/fosc_dwh_report.pdf. Accessed 31 January 2014.
3. British Petroleum (BP). *Deepwater Horizon Accident Investigation Report*. September 8, 2010. Available at: http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/incident_response/STAGING/local_assets/downloads_pdfs/Deepwater_Horizon_Accident_Investigation_Report.pdf. Accessed 31 January 2014.
4. McNutt M, Camilli R, Guthrie G, et al. *Assessment of Flow Rate Estimates for the Deepwater Horizon / Macondo Well Oil Spill*. National Incident Command, Interagency Solutions Group, Flow Rate Technical Group Spill, U.S. Department of Interior, March 10, 2011. Available at: <http://www.doi.gov/deepwaterhorizon/loader.cfm?csModule=security/getfile&PageID=237763>. Accessed 31 January 2014.
5. Rintoul W, Hodgson SF. *Drilling Through Time: 75 Years with California's Division of Oil and Gas*. Sacramento: Department of Conservation, Division of Oil and Gas. 1990. pp.13–15.
6. Hosny K, Dhari A. Environmental impact of the Gulf War: an integrated preliminary assessment. *Environmental Management*. 1993; 17(4):557–562. doi:10.1007/BF02394670.
7. Shultz JM, Espinel Z, Galea S, Reissman DE. Disaster ecology: implications for disaster psychiatry. In RJ Ursano, CS Fullerton, L Weisaeth, B Raphael (Eds.). *Textbook of Disaster Psychiatry*. Cambridge, UK: Cambridge University Press. 2007. pp. 69–96.
8. Shultz JM, Espinel Z, Flynn BW, et al. *DEEP PREP: All-Hazards Disaster Behavioral Health Training*. Disaster Life Support Publishing, Tampa, Florida, 2007.
9. Norris FH, Friedman MJ, Watson PJ, et al. 60,000 disaster victims speak: Part I. An empirical review of the empirical literature, 1981–2001. *Psychiatry*. 2002; 65:207–39. doi:10.1521/psyc.65.3.207.20173
10. Norris FH, Friedman MJ, Watson PJ. 60,000 disaster victims speak: Part II. Summary and implications of the disaster mental health research. *Psychiatry*. 2002; 65:240–60. doi:10.1521/psyc.65.3.240.20169
11. Norris FH, Byrne CM, Diaz E, Kaniasty K. *Risk Factors for Adverse Outcomes in Natural and Human-Caused Disasters: A Review of the Empirical Literature. A National Center for PTSD Fact Sheet*. National Center for PTSD, Department of Veterans Affairs, 2007. Available at: <http://www.georgiadisaster.info/MentalHealth/MH12%20ReactionsafterDisaster/Risk%20Factors.pdf>. Accessed 31 January 2014.
12. Norris FH, Wind LH. The experience of disaster: trauma, loss, adversities, and community effects. In: Neria Y, Galea S, Norris FH (eds.) *Mental Health and Disasters*. Cambridge, UK: Cambridge University Press. 2009. pp. 7–28.
13. Neria Y, Nandi A, Galea S, 2008. Posttraumatic stress disorder following disasters: a systematic review. *Psychological Medicine*. 2008; 38(4):467–480.
14. Shultz JM, Neria Y, Allen A, Espinel Z. *Psychological impacts of natural disasters*. In: Bobrowsky, P. (ed.), *Encyclopedia of Natural Hazards*. Dordrecht, Heidelberg, London, New York: Springer Publishing, 2013. pp. 779–791.
15. Reuters. Full Text of President Obama's BP Oil Spill Speech. June 15, 2010. Available at: <http://www.reuters.com/article/2010/06/16/us-oil-spill-obama-text-idUSTRE65F02C20100616>. Accessed 31 January 2014.
16. Ramseur JL, Hagerty CL. *Deepwater Horizon Oil Spill: Recent Activities and Ongoing Developments*. Congressional Research Office. CRS Report for Congress. 7-5700. January 31, 2013. Available at: <http://www.fas.org/srg/crs/misc/R42942.pdf>. Accessed 31 January 2014.
17. Substance Abuse and Mental Health Services Administration and Centers for Disease Control and Prevention. *Behavioral Health in the Gulf Coast Region Following the Deepwater Horizon Oil Spill*, HHS Publication No. (SMA) 13-4737, Rockville, MD; Atlanta, GA: Substance Abuse and Mental Health Services Administration and Centers for Disease Control and Prevention, 2013. Available at: <http://www.samhsa.gov/data/nsduh/nsduh-gsps-gulf-coast.pdf>. Accessed 31 January 2014.
18. Shultz JM, Neria Y. Trauma signature analysis: state of the art and evolving future directions. *Disaster Health*. 2013; 1(1):4–8.
19. Shultz JM, Neria Y, Espinel Z, Kelly F. Trauma signature analysis: evidence-based guidance for disaster mental health response. 17th World Congress on Disaster & Emergency Medicine, Beijing, China, 31 May 2011. *Prehospital and Disaster Medicine*. 2011; 26(Suppl. 1): s4
20. Shultz JM, Marcelin LH, Madanes S, et al. The trauma signature: understanding the psychological consequences of the Haiti 2010 earthquake. *Prehospital and Disaster Medicine*. 2011; 26(5):353–366.
21. Shultz JM, Marcelin LH, Espinel Z, et al. Haiti earthquake 2010: psychosocial impacts. In: Bobrowsky, P. (ed.), *Encyclopedia of Natural Hazards*. Dordrecht: Springer Publishing, 2013.
22. Shultz JM, McLean A, Herberman Mash HB, et al. Mitigating flood exposure: reducing disaster risk and trauma signature. *Disaster Health*. 2013; 1(1):30–44. doi:10.4161/dish.23076
23. Neria Y, Shultz JM. Mental health effects of Hurricane Sandy: characteristics, potential aftermath, and response. *JAMA*. 2012; 308(24):2571–2572. doi:10.1001/jama.2012.110700.
24. Shultz JM, Neria Y. The trauma signature of Hurricane Sandy: a meteorological chimera. Online at: *The 2x2 Project*. Columbia University, Mailman School of Public Health, Department of Epidemiology. Published 14 November 2012. Available at: <http://the2x2project.org/the-trauma-signature-of-hurricane-sandy/>
25. Shultz JM, Walsh L, O'Sullivan T. Psychological impact of Superstorm Sandy: the trauma signature. 18th World Congress on Disaster & Emergency Medicine, Manchester, United Kingdom, 29 May 2013. *Prehospital and Disaster Medicine*. 2013; 28(Suppl. 1): s162
26. Shultz JM, Forbes D, Wald D, et al. Trauma signature of the Great East Japan Disaster provides guidance for the psychological consequences of the affected population. *Disaster Medicine and Public Health Preparedness*. 2013; 7(2):201–214. doi:10.1017/dmp.2013.21

27. Shultz JM, Kelly F, Forbes D, et al. Triple threat trauma: evidence-based mental health response for the 2011 Japan disaster. *Prehospital and Disaster Medicine*. 2011; 26(3):141-145.
28. Shultz JM, Cohen A. Sandy Hook Elementary school shooting: the trauma signature. 18th World Congress on Disaster & Emergency Medicine, Manchester, United Kingdom, 31 May 2013. *Prehospital and Disaster Medicine*. 2013; 28(Suppl. 1): s163
29. Migline V, Shultz JM. Psychosocial impact of the Russian invasion of Georgia in 2008. 17th World Congress on Disaster & Emergency Medicine, Beijing, China, 1 June 2011. *Prehospital and Disaster Medicine*. 2011; 26(Suppl. 1): s110
30. Espinel Z, Shultz JM. Trauma exposure in internally displaced women in Colombia: psychological intervention. 8th World Congress on Disaster & Emergency Medicine, Manchester, United Kingdom, 29 May 2013. *Prehospital and Disaster Medicine*. 2013; 28(Suppl. 1): s167
31. Shultz JM, Wilson FE, Araya R., et al. Internally-displaced "victims of armed conflict" in Colombia: the trajectory and trauma signature of displacement. *Disaster Health*. 2014; 2(1):1-15.
32. Golstein BD, Osofsky HJ, Lichtveld MY. The Gulf oil spill. *New England Journal of Medicine*. 2011; 364(14):1334-1348.
33. Campbell D, Cox D, Crum J, et al. Initial effects of the grounding of the tanker Braer on health in Shetland. *BMJ*. 1993; 307:1251-1255.
34. Janjua NZ, Kasi PM, Nawaz H, et al. Acute health effects of the Tasman Spirit oil spill on residents of Karachi, Pakistan. *BMC Public Health*. 2006; 6:84.
35. Sim MS, Jo IJ, Song HG. Acute health problems related to the operation mounted to clean the Hebei Spirit oil spill in Taean, Korea. *Marine Pollution Bulletin*. 2010; 60:51-57.
36. Aguilera F, Mendez J, Pasaro E, Laffon B. Review on the effects of exposure to spilled oils on human health. *Journal of Applied Toxicology*. 2010; 30:291-301.
37. Lyons RA, Temple JM, Evans D, et al. Acute health effects of the Sea Empress oil spill. *Journal of Epidemiology and Community Health*. 1999; 53:306-310.
38. Gallacher J, Bronstering K, Palmer S, et al. Symptomatology attributable to psychological exposure to a chemical incident: a natural experiment. *Journal of Epidemiology and Community Health*. 2007; 61:506-12.
39. Carrasco JM, Perez-Gomez B, Garcia-Mendizabal MJ, et al. Health-related quality of life and mental health in the medium-term aftermath of the prestige oil spill in Galiza (Spain): a cross-sectional study. *BMC Public Health*. 2007; 7:245.
40. Sabucedo JM, Arce C, Ferraces MJ, et al. Psychological impact of the Prestige catastrophe. *International Journal of Clinical Health Psychology*. 2009; 9:105-116.
41. Sabucedo JM, Arce C, Senra C, et al. Symptomatic profile and health-related quality of life of persons affected by the Prestige catastrophe. *Disasters*. 2010; 34:809-820.
42. Palinkas LA, Russell J, Downs MA, Petterson JS. Ethnic differences in stress, coping, and depressive symptoms after the Exxon Valdez oil spill. *Journal of Nervous and Mental Disorders*. 1992; 180:287-295.
43. Palinkas LA, Downs MA, Petterson JS, Russell J. Social, cultural, and psychological impacts of the Exxon Valdez oil spill. *Human Organization*. 1993; 52(1):1-13.
44. Palinkas LA, Petterson JS, Russell J, Downs MA. Community patterns of psychiatric disorders after the Exxon Valdez oil spill. *American Journal of Psychiatry*. 1993; 150(10):1517-1523.
45. Picou S, Arata C. Chronic impacts of the Exxon Valdez oil spill. In: *Coping with Technological Disasters*. Prince William Sound Regional Citizens' Advisory Council. 1997; J2-J42.
46. Gill DA, Picou JS. Technological disaster and chronic community stress. *Society and Natural Resources*. 1998; 11:795-815.
47. Arata CM, Picou JS, Johnson GD, McNally TS. Coping with technological disaster: an application of the conservation of resources model to the Exxon Valdez oil spill. *Journal of Traumatic Stress*. 2000; 13(1):23-39. doi:10.1023/a:1007764729337
48. Palinkas L, Petterson JS, Russell JC, Downs MA. Ethnic differences in symptoms of post-traumatic stress after the Exxon Valdez oil spill. *Prehospital and Disaster Medicine*. 2004; 19(1):102-112.
49. Picou JS, Formichella C, Marshall BK, Arata C. Community impacts of the Exxon Valdez oil spill: A synthesis and elaboration of social science research. In: SR Braund SR, J Kruse J (Eds.). *Synthesis: Three Decades of Research on Socioeconomic Effects Related to Offshore Petroleum Development in Coastal Anchorage, AK*. MMS OCS Study No. 2009-006. May 2009, pp. 279-307.
50. Ritchie LA, Gill DA, Picou JS. The BP disaster as an Exxon Valdez rerun. *Contexts*. 2011; 10(3):30-35. doi:10.1177/1536504211418454
51. Palinkas LA. A conceptual framework for understanding the mental health impacts of oil spills: Lessons from the Exxon Valdez oil spill. *Psychiatry*. 2012; 75(3):203-222.
52. Gill DA, Picou JS, Ritchie LA. The Exxon Valdez and BP oil spills: a comparison of initial social and psychological impacts. *American Behavioral Scientist*. 2012; 56(1):3-23.
53. Abramson D, Redlener I, Stehling-Ariza T, et al. *Impact on Children and Families of the Deepwater Horizon Oil Spill: Preliminary Findings of the Coastal Population Impact Study*. National Center for Disaster Preparedness Research Brief 2010_08. New York NY: Columbia University Mailman School of Public Health. 2010, pp. 1-19. Available at: <http://academiccommons.columbia.edu/catalog/ac:128195>. Accessed 31 January 2014.
54. Witters D. *Gulf Coast residents worse off emotionally after BP oil spill*. September 28, 2010. Available at: <http://www.gallup.com/poll/143240/gulf-coastresidents-worse-off-emotionally-oil-spill.aspx>. Accessed 31 January 2014.
55. Devi S. Anger and anxiety on the Gulf Coast. *The Lancet*. 2010; 376(9740):503-504. doi:10.1016/s0140-6736(10)61237-8
56. Slomski A. Experts focus on identifying, mitigating potential health effects of Gulf oil leak. *JAMA*. 2010; 304(6):621-624. doi:10.1001/jama.2010.1053
57. Solomon GM, Janssen S. Health effects of the Gulf oil spill. *JAMA*. 2010; 304(10):1118-1119.
58. Osofsky HJ, Palinkas LA, Galloway JM. Mental health effects of the Gulf oil spill. *Disaster Medicine and Public Health Preparedness*. 2010; 4(4):273-276.
59. Osofsky HJ, Osofsky JD, Hansel TC. Deepwater horizon oil spill: mental health effects on residents in heavily affected areas. *Disaster Medicine and Public Health Preparedness*. 2011; 5(4):280-286.
60. Safina C. The 2010 Gulf of Mexico oil well blowout: a little hindsight. *PLoS Biology*. 2011; 9(4):e1001049.
61. Buttke D, Vagi S, Bayleyegn T, et al. Mental health needs assessment after the Gulf Coast oil spill—Alabama and Mississippi, 2010. *Prehospital and Disaster Medicine*. 2012; 27(5):1-8.

62. Buttke D, Vagi S, Schnall A, et al. Community assessment for public health emergency response (CASPER) one year following the Gulf Coast oil spill: Alabama and Mississippi, 2011. *Prehospital and Disaster Medicine*. 2012; 27(6):496-502.
63. Grattan LM, Roberts S, Mahan Jr. WT, et al. The early psychological impacts of the Deepwater Horizon oil spill on Florida and Alabama communities. *Environmental Health Perspectives*. 2009; 119:838–843. doi:10.1289/ehp.1002915
64. Cope MR, Slack T, Blanchard TC, Lee MR. Does time heal all wounds? Community attachment, natural resource employment, and health impacts in the wake of the BP Deepwater Horizon disaster. *Social Science Research*. 2013; 42:872-881.
65. Lee MR, Blanchard TC. Community attachment and negative affective states in the context of the BP Deepwater Horizon disaster. *American Behavioral Scientist*. 2012; 56(1):24-47. doi:10.1177/0002764211409384
66. Butler AS, Panzer AM, Goldfrank LR. *Preparing for the Psychological Consequences of Terrorism: A Public Health Approach*. Institute of Medicine Committee on Responding to the Psychological Consequences of Terrorism, Board of Neuroscience and Behavioral Health. Washington, D.C.: National Academies Press, 2003.
67. Acierno R, Ruggiero KJ, Galea S, et al. Psychological sequelae resulting from the 2004 Florida hurricanes: implications for postdisaster intervention. *American Journal of Public Health*. 2007; 97:S103–S108. doi:10.2105/AJPH.2006.087007
68. McFarlane AC, Van Hooff M. Impact of childhood exposure to a natural disaster on adult mental health: 20-year longitudinal follow-up. *British Journal of Psychiatry*. 2009; 195:142-148. doi:10.1192/bjp.bp.108.054270
69. Pietrzak RH, Southwick SM, Tracy M, et al. Posttraumatic stress disorder, depression, and perceived needs for psychological care in older persons affected by Hurricane Ike. *Journal of Affective Disorders*. 2012; 138(1-2):96–103. doi:10.1016/j.jad.2011.12.018.
70. Breslau N, Chilcoat HD, Kessler RC, Davis GC. Previous exposure to trauma and PTSD effects of subsequent trauma: results from the Detroit area survey of trauma. *American Journal of Psychiatry*. 1999; 156(6):902–907.
71. Goenian AK, Naarian LM, Pynoos RS, et al. Posttraumatic stress reactions after a single and double trauma. *Acta Psychiatrica Scandinavica*. 1994; 90, 214-221.
72. Turner RJ, Lloyd DA. Lifetime traumas and mental health: the significance of cumulative adversity. *Journal of Health and Social Behavior*. 1995; 36(4):360–76.
73. Felitti VJ, Anda RF, Nordenberg D, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse Childhood Experiences (ACE) Study. *American Journal of Preventive Medicine*. 1998; 14(4):245–258.
74. Seery MD, Holman EA, Silver RC. Whatever does not kill us: cumulative lifetime adversity, vulnerability, and resilience. *Journal of Personality and Social Psychology*. 2010; 99:1025–1041.
75. Galea S, Brewin CR, Gruber M, et al. Exposure to hurricane-related stressors and mental illness after Hurricane Katrina. *Archives of General Psychiatry*. 2007; 64:1427-1434.
76. Gheyntchi A, Joseph L, Gierlach E, et al. The dirty dozen: twelve failures of the Hurricane Katrina response and how psychology can help. *American Psychologist*. 2007; 62(2):118-130.
77. Kessler RC, Galea S, Gruber MJ, et al. Trends in mental illness and suicidality after Hurricane Katrina. *Molecular Psychiatry*. 2008; 13:374-384.
78. Kronenberg ME, Hansel TC, Brennan AM, et al. Children of Katrina: lessons learned about postdisaster symptoms and recovery patterns. *Child Development*. 2010; 81:1241-1259.
79. Yun K, Lurie N, Hyde PS. Moving mental health into the disaster-preparedness spotlight. *New England Journal of Medicine*. 2010; 363:1193-1195.
80. Kennedy MS. Another tragedy on the Gulf Coast. *American Journal of Nursing*. 2010; 110(9):7. doi:10.1097/1001.NAJ.0000388241.0000398740.0000388245a.
81. Nelson R. Adding insult to injury: Five years after Katrina. *American Journal of Nursing*. 2010; 110(9):19-21. doi:10.1097/01.NAJ.0000388256.34180.06
82. Voelker R. Memories of Katrina continue to hinder mental health recovery in New Orleans. *JAMA*. 2010; 304(8):841-843. doi:10.1001/jama.2010.1193
83. Suarez B, Lope V, Perez-Gomez B, et al. Acute health problems among subjects involved in the cleanup operation following the Prestige oil spill in Asturias and Cantabria (Spain). *Environmental Research*. 2005; 99:413-424.
84. King BS, Gibbins JD. *Health Hazard Evaluation of Deepwater Horizon Response Workers*. Health Hazard Evaluation Report HETA 2010-0115 & 2010-0129-3138. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, August, 2011.
85. Reardon S. Ten months after deepwater horizon: picking up the remnants of health data. *Science*. 2011; 331:1252.
86. Michaels D, Howard J. Review of the OSHA-NIOSH response to the Deepwater Horizon oil spill: Protecting the health and safety of cleanup workers. *PLOS Currents Disasters*. 2012 Jul 18. Edition 1. doi:10.1371/4fa83b7576b6e
87. National Institute for Occupational Safety and Health (NIOSH). *Deepwater Horizon response: NIOSH voluntary roster of Deepwater Horizon response workers*. 2010. Available at: <http://cdc.gov/niosh/topics/oilspillresponse/workerroster.html>. Accessed 31 January 2014.
88. Hyde PS. Coping with the oil spill. *SAMHSA News*. 2010; 18(4):2.
89. Blank K. Oil spill response: making behavioral health a top priority. *SAMHSA News*. 2010; 18(4):1,3-4
90. Centre for Research on the Epidemiology of Disasters. EM-DAT: The International Disaster Database. <http://www.emdat.be>. Accessed 31 January 2014.
91. World Association of Disaster and Emergency Medicine (WADDEM). *Health Disaster Management: Guidelines for Evaluation and Research*. <http://www.wadem.org/guidelines.html>. Accessed 31 January 2014.
92. National Oceanic and Atmospheric Administration Education Resources. *Gulf Oil Spill*. March 19, 2013. Available at: http://www.education.noaa.gov/Ocean_and_Coasts/Oil_Spill.html. Accessed 31 January 2014.
93. National Oceanic and Atmospheric Administration. *Deepwater Horizon Ocean Response Imagery*. Available at: <http://oceanservice.noaa.gov/deepwaterhorizon/images.html#9>. Accessed 31 January 2014.
94. Animal Planet. *Animals Covered in Oil: Gulf Oil Spill Pictures*. Available at: <http://animal.discovery.com/wild-animals/animals-covered-in-oil-pictures.htm>. Accessed 31 January 2014.

95. Yale Global Online: A Publication of the MacMillan Center. *Global Financial Crisis*. Available at: <http://yaleglobal.yale.edu/content/global-economic-crisis>. Accessed 31 January 2014.
96. CRED: *Conversations for Responsible Economic Development. Tourism Industry Impacts: The Deepwater Horizon Spill*. Available at: <http://credbc.ca/tourism-industry-impacts-the-deepwater-horizon-spill/>. Accessed 31 January 2014.
97. Upton H. *The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry*. Congressional Research Service. CRS Report for Congress. February 17, 2011. Available at: <http://www.fas.org/sgp/crs/misc/R41640.pdf>. Accessed 31 January 2014.
98. Pew Research Center Journalism Project Staff. *100 Days of Gushing Oil – Media Analysis and Quiz/Eight Things to Know About How the Media Covered the Gulf Disaster*. August 25, 2010. Available at: <http://www.journalism.org/2010/08/25/100-days-gushing-oil/>. Accessed 31 January 2014.
99. Diaz JH. The legacy of the Gulf oil spill. Analyzing acute public health effects and predicting chronic ones in Louisiana. *American Journal of Disaster Medicine*. 2011; 6(1):5-22.
100. Los Angeles Times. *Gulf oil spill: Boat captain, despondent over spill, commits suicide*. June 23, 2010. Available at: <http://latimesblogs.latimes.com/greenspace/2010/06/gulf-oil-spill-boat-captain-despondent-over-spill-commits-suicide.html>. Accessed 31 January 2014.
101. National Institute of Environmental Health Sciences. *The GuLF STUDY: The Gulf Long-term Follow-up Study*. Available at: <http://www.niehs.nih.gov/research/atniehs/labs/epi/studies/gulfstudy/>. Accessed 31 January 2014. Home page for GuLF Study: <http://www.gulfstudy.nih.gov/>
102. Occupational Safety and Health Administration. *Update on OSHA Activities to protect oil spill workers in the Gulf*. August 31, 2010. Available at: <https://www.osha.gov/oilspills/oilspill-activity-update.html>. Accessed 31 January 2014.
103. Research Triangle Institute International. *Literature, Web, and Media Review of the Behavioral Health Impacts of the Deepwater Horizon Gulf Oil Spill: Draft Report* (Report prepared for the Substance Abuse and Mental Health Services Administration, under Contract No. 283-05-0092, Project No. 9523). Research Triangle Park, NC: RTI International. 2010.
104. Hobfoll SE. Conservation of resources: a new attempt at conceptualizing stress. *American Psychologist*. 1989; 44(3):513–524.
105. Talk of the Nation with Neil Cohen. *After the spill: the environment and economy of the Gulf*. National Public Radio. February 28, 2013. Available at: <http://www.npr.org/2013/02/28/173167436/after-the-spill-the-environment-and-economy-of-the-gulf>. Accessed June 13, 2013.