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Exploring heterogeneity and correlates of depressive symptoms in the Women and Their Children's Health (WaTCH) Study

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Abstract

Introduction—Oil spill exposures are associated with increased levels of depression, which is often measured using continuous scores or dichotomous cut points on screening tools in population-based studies. Latent profile analysis can overcome analytic limitations such as 1) masking of heterogeneity in outcomes among people within dichotomous categories and 2) loss of information about symptom patterns among those with the same continuous score. This study examined variation in depressive symptoms and assessed the associations between depressive symptomatology and oil spill exposure, socioeconomic risk factors, and social capital.

Methods—Between 2012 and 2014, we interviewed 2852 women in southeastern Louisiana. We performed latent profile analysis then tested the adjusted associations between sociodemographic characteristics, oil spill exposure and latent class membership.

Results—Results indicated a three-class solution in which classes varied by symptom severity as the best fit. The strongest associations were among women with the most severe depressive symptoms, who were less educated, were more economically vulnerable, and had the least social support compared to women with no depressive symptoms.

Limitations—This study is limited by its cross-sectional design and the self-reported nature of exposures and depressive symptoms, but results are consistent with prior literature.

Conclusions—Our results support the conventional use of screening tools to estimate depressive symptomatology. Nevertheless, the identification of subgroups within study participants highlights an important finding: the subgroups were comprised of characteristically different women with varying levels of depressive symptoms, a discovery that would have been overlooked if the CES-D was used conventionally.

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Keywords

Disaster; Women's health; Depression; Latent profile analysis; Socioeconomic status; Vulnerable populations

1. Introduction

Since the early 1900s the number of technological disasters has increased from just one in 1902 to an average of 36 per year since 2000, affecting a record high of over 550,000 people per continent in the Americas in 2003 (Guha-Sapir et al., 2015). When a technological disaster occurs, people often experience several stressful life events concurrently, including economic loss, physical and mental trauma, and community social capital declines subsequent to disaster. Thus, it is essential to examine disasters as major stressful life events and their association with human health outcomes.

Experiencing a stressful life event is one of the strongest predictors of depression (Kendler et al., 2002; Kessler, 1997). Depression, characterized by depressed mood, feelings of guilt, worthlessness, helplessness, hopelessness, and other somatic symptoms, is one of the most common psychiatric disorders affecting adults in the United States (APA, 2013; CDC, 2011) with the lifetime risk at approximately 17% (Yen and Kaplan, 1999). It is associated with a variety of long-term health consequences, including worse physical and social functioning, poor perceived current health, chronic pain (Wells et al., 1989), and is often comorbid with highly prevalent chronic diseases including heart disease, diabetes, hypertension, stroke, obesity, Alzheimer's disease, and cancer (Penninx et al., 2013). The seriousness of the comorbidities with depression further highlights the importance of prevention and control of depression. Furthermore, understanding the effect of stressful life events on depression is especially important in women due to the consistent association between female gender and depression (CDC, 2010; Ko et al., 2012; Pratt and Brody, 2008; SAMHSA, 2012, 2013) where the prevalence in women is approximately two times higher than in men (Nolen-Hoeksema, 2001).

The Deepwater Horizon Oil Spill (DHOS) was a technological disaster that affected many people living near the 1100 miles (1770 km) of oil-polluted shoreline along the Gulf Coast of the United States including Louisiana residents (Pallardy, 2015). In addition to the physical impact on the ecosystem, the DHOS had dire effects on the economy through its impact on essential industries in Louisiana. More than one third of the Gulf was closed for fishing; 8000 to 12,000 workers were temporarily unemployed due to a six month moratorium on offshore drilling; and tourism suffered due to fears of oil contamination (Pallardy, 2015). Evidence supports that oil spill exposures resultant from technological disaster are associated with poor mental health outcomes, including increased levels of depression (Fan et al., 2015; Kim et al., 2013; Osofsky et al., 2011; Palinkas et al., 1993), which could be due not only to acute stress associated with exposure to the oil, but also to such consequences of the disaster as financial loss, community and life disruptions, and the recovery process.

Prior population-based studies examining mental health effects of oil spills have used screening tools to measure depressive symptoms either continuously (Drescher et al., 2014; Morris et al., 2013; Palinkas et al., 1992) or dichotomously (Fan et al., 2015; Kim et al., 2013; Lyons et al., 1999; Osofsky et al., 2011; Palinkas et al., 1993). Use of dichotomous outcomes, however, results in loss of information and power to detect true associations (Lagakos, 1988) and masking of severity or heterogeneity in outcomes among people within categories (Breslow NE, 1980). Alternatively, continuous scores may provide information about symptom severity but will not provide information about patterns of symptoms among individuals within the same severity level. Latent profile analysis (LPA) is a method that can overcome the analytic limitations ensuing from using either continuous or dichotomous measurement of depressive symptoms.

LPA categorizes people into homogenous subgroups based on their response patterns to observed variables; thus, the heterogeneity between groups is attributable to differences in response patterns. Previous LPA studies using the Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977) each identified at least three unique latent classes based on depressive symptomatology (Hybels et al., 2011; Hybels et al., 2013; Mora et al., 2012) among elderly populations; but, none focused on a community sample of female residents of a geographic area vulnerable to disaster. The Women and Their Children's Health (WaTCH) Study was designed to assess the effects of the DHOS on the physical and mental health of southeastern Louisiana women and children. Using WaTCH data, this will be the first analysis to apply LPA to assess heterogeneity in depressive symptoms using the CES-D and to estimate correlates of these symptoms within a vulnerable population of female residents of a region previously experiencing disaster.

The aim of the current study is to examine heterogeneity in depressive symptoms and test the associations between depressive symptoms and oil spill exposure, socioeconomic status (SES), and social capital among women enrolled in the WaTCH Study. We hypothesize that LPA will identify several depressive symptom presentation subtypes (e.g., somatic symptoms, negative affect, etc.) among WaTCH study participants, and we expect to characterize at least three unique latent classes among the respondents. We will test the hypothesis that WaTCH women in the class with the most severe presentations of depressive symptoms report greater DHOS exposure, more socioeconomic risk factors, and lower social capital than women with less severe patterns of depressive symptoms.

2. Methods

2.1. Study design

The WaTCH Study is a prospective cohort of women residing in the seven coastal parishes of southeastern Louisiana (Orleans, St. Bernard, Jefferson, Plaquemines, Lafourche, Terrebonne and St. Mary). Between 2012 and 2014, women were recruited from preexisting lists of phone numbers for individuals and households using an address-based sampling frame supplied by Marketing Systems Group, providing nearly 100% coverage of all households in each parish.

Individual and household addresses and phone numbers were randomly selected from lists of census tracts from five of the seven parishes (St. Bernard, Plaquemines, Lafourche, Terrebonne, and St. Mary Parishes). Individuals from the two larger urban parishes (Orleans and Jefferson Parishes), were undersampled to achieve greater numbers of participants from the smaller parishes. All potential study participants were mailed an invitation to participate. Potential participants were called a week later and screened for eligibility. If the potential participant was eligible, verbal consent was obtained, and data were collected by trained telephone interviewers. Telephone interviews were approximately 60 min in length. Volunteers were also accepted into the study if they met eligibility criteria. The overall response rate, based on American Association for Public Opinion Research *Standard Definitions,* was acceptable at 45% (The American Association for Public Opinion Research, 2011).

Study data were collected and managed using REDCap electronic data capture tools hosted at the Epidemiology Data Center at the Louisiana State University Health Sciences Center School of Public Health (Harris et al., 2009). REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources. The study protocol was approved by the Louisiana State University Health Sciences Center Institutional Review Board.

2.2. Study population

Inclusion criteria were female gender, being between 18 and 80 years of age, and residing in one of the seven coastal Louisiana parishes listed above at the time of the DHOS (April 20, 2010).

2.3. Outcome, exposures, and covariates

2.3.1. Depressive symptomatology—Depressive symptomatology was assessed by the CES-D, a widely used 20-item self-report screening tool suitable for use in the general population due to its high internal consistency, reliability, and construct validity that hold in various racial, age, income, and gender subgroups (Knight et al., 1997; Radloff, 1977). During the telephone interview, trained interviewers followed the original CES-D format and asked participants to report symptoms felt in the past week (e.g., depressed mood, guilt, worthlessness, helplessness, psychomotor retardation, loss of appetite, sleep disturbance) using a 4-point Likert scale. Response options range from *rarely or none of the time* (0) to *most or all of the time* (3). Positive mood items (i.e., feelings of being as good as other people, hopefulness, happiness, and enjoyment of life) were reverse coded. Each of the 20 items served as a continuous indicator in LPA.

2.3.2. Exposures—Nine items were used to estimate individual economic, physical, and environmental exposure to the DHOS. Participants reported environmental and physical exposures comprising of: participation in DHOS cleanup; the DHOS affecting recreational activities; physical damage to commercial fishing areas as a result of the DHOS; other

property damage or loss due to the DHOS or its cleanup; frequency and severity of smelling the oil; and any other contact with the oil. Reports of economic exposure included items assessing income loss due to the DHOS, amount affected in comparison to others in the community, and the influence of the DHOS on household finances. Each item was binary (yes/no) or nominal and assigned a reference group. Though there have been no prior validation studies of these questions assessing oil spill exposure, five of the nine questions were asked in prior oil spill studies (Fan et al., 2015), including research evaluating the impacts of the Exxon Valdez Oil Spill of 1989 (Palinkas et al., 1992, 1993). Other oil spill studies have also used similar questions to assess oil spill exposure (Drescher et al., 2014; Osofsky et al., 2011).

Socioeconomic status exposures of interest included education (college or beyond, high school, less than high school); annual household income in the year prior to the DHOS (less than $20,000; $20,001–$40,000; $40,001–$60,000; and over $60,000); and current employment (yes/no). We also measured social capital constructs (Appendix A, Table 6) including: five items measuring *perceived social support*; twelve items assessing neighborhood *social cohesion*; five items estimating *social control*; and nine forms of *neighborhood participation*. Sums of scores for perceived social support, social cohesion, social control, and neighborhood participation were calculated and treated as continuous variables and higher scores indicate higher levels of these variables.

2.3.3. Covariates—We constructed causal models through directed acyclic graphs (Greenland et al., 1999) using prior literature to identify potential confounders. Variables examined for confounding purposes included: months between the DHOS and interview date; age; race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Other (i.e. Asian/Pacific Islander, American Indian/Native American, and Latina/Hispanic of any race)); marital status (married/living with a partner and single/divorced/separated/widowed); and self-efficacy. We measured self-efficacy using the 10-item General Self-Efficacy Scale (Schwarzer, 1995), where a composite score was summed and treated as a continuous variable with higher scores indicating higher self-efficacy. Alcohol use (moderate/heavy drinker vs. non-drinker) and cigarette smoking (former, current, and never smoker) were also considered as potential confounders. Moderate and heavy drinkers were combined due to the small prevalence of heavy drinkers (n=2) who drank five or more drinks on the same occasion on each of five or more days in the past 30 days (SAMHSA, 2015).

2.3.4. Statistical analysis—The baseline WaTCH cohort consisted of 2852 women; however, 62 women were excluded due to missing values on all 20 CES-D items. As a result, the analytic sample included 2790 women. We estimated distributions of the exposure, outcome, and covariates in the study population. There were a total of 899 women who had missing data for any exposure variable or covariate. These women were significantly different from women with no missing values. They were more likely to be non-White and non-married; to have socioeconomic risk factors including lower education, lower pre-DHOS household income; and be currently unemployed. Additionally, women with missing values also had higher scores on the CES-D, were more exposed to the smell of the oil, and had lower perceived social support, higher social cohesion, and lower social

control than women with no missing values. Therefore, in order to reduce potential selection bias resulting from excluding women significantly different from those included in the analytic sample, we performed multiple imputation and included all 2790 women in the subsequent analysis. There were 21 variables including exposures and covariates in the multiple imputation model. Approximately 68% of the study population had no missing values and the maximum number of missing values for all other participants was eight. Multiple imputation and subsequent analyses were performed using MPlus, version seven (Muthén LK, 1998–2012).

We assumed that the data were missing at random and generated the recommended 20 datasets sufficient for multiple imputation analysis (Graham et al., 2007). During the analysis phase, parameter estimates were averaged over the imputed datasets. Standard errors were computed by averaging the squared standard errors across the datasets and averaging the parameter estimate variation between datasets (Muthén LK, 1998–2012).

In LPA and subsequent logistic regression, we employed the three-step method to mixture modeling (Asparouhov and Muthén, 2014). The LPA model was estimated using full maximum likelihood estimation with robust standard errors. Participants were assigned to latent classes based upon their responses to CES-D items and posterior probabilities for their most likely class membership. We chose the best fitting model based on the model fit statistics and a smallest class size of 6–8%. The model fit comparison statistics included: log likelihood; Aikaike's Information Criteria (AIC); Bayesian Information Criterion (BIC) and sample-size adjusted BIC (Henson et al., 2007); entropy; and the Lo Mendell Rubin Likelihood Ratio Test (LMR-LRT) (Lo et al., 2001). Lower values of the log likelihood, AIC, BIC, and sample-size adjusted BIC indicate good model fit. Entropy measures class separation based on each individual's probability of belonging to each class. A value closest to one indicates high entropy. A non-significant p-value of the LMR-LRT, indicates that compared to the k class model, the $k-1$ class model is the best fit for the data (Nylund et al., 2007).

Once we identified the best class solution, chi square tests and t-tests were used to identify significant crude associations between class membership and exposure variables. To test the adjusted associations between latent classes, DHOS exposure, socioeconomic risk factors, and social capital, we performed multinomial logistic regression with baseline logits adjusting for months between the DHOS and interview date, race, education, age, marital status, and self-efficacy. Alcohol and tobacco use did not change other parameter estimates by more than 10%; therefore, they were not included in the final model. In order to avoid erroneously rejecting a true null hypothesis, we calculated the Benjamini and Hochberg corrected significance level for multiple comparisons (Benjamini and Hochberg, 1995). As a result, alpha was set at 0.01.

3. Results

Among the 2790 WaTCH women included in the analysis with known values, the majority were White (56.8%), with a mean age of 45.7 years (SD 12.0), had at least a high school education (88.3%), were married (63.0%), and had high levels of perceived social support

(Table 1). The most frequent DHOS exposures included income loss (26.3%), the DHOS affecting the household's recreational hunting and fishing activities (34.4%), and a negative influence of the DHOS on household finances (37.9%). The average CES-D score was 11.8 (SD 12.5) (Table 2). The CES-D items with the highest levels of endorsement included: *I felt everything I did was an effort* (22.1% of women reporting the symptom most or all of the time); *My sleep was restless* (22.1% of women reporting the symptom most or all of the time); and *I had trouble keeping my mind on what I was doing* (14.5% of women reporting the symptom most or all of the time).

All model fit statistics indicate the three-class solution as the best fit to the data (Table 3). In order to confirm the three-class solution, successive fit tests were implemented up to the eight-class solution (not shown) to compare the k class model to the $k-1$ class model. The three-class solution remained the best fit for the data. Further support for the three-class solution includes the high posterior probabilities of class membership for the three classes (0.99 for class one, 0.94 for class two, and 0.99 for class three) and the average probability of individuals belonging to a different class was low 0–0.05).

Results of LPA show latent classes varied by symptom severity (Fig. 1). Class one, consisting of approximately 69% of the study population, experienced virtually no depressive symptoms. Class two, consisting of approximately 20% of the study population experienced rare to occasional depressive symptoms on average. Class three, consisting of approximately 11% of the study population, experienced moderate to severe depression symptoms on average.

The three latent classes had strikingly different compositions of women (Table 4). There was a greater frequency of DHOS exposure as severity of depressive symptoms increased. Women with moderate to severe depressive symptoms (Class 3) more frequently experienced income loss (31.8% vs. 29.1% (Class 2) vs. 24.6% (Class 1), two-sided P=0.01) and reported high smell exposure to the oil (29.5% vs. 21.0% (Class 2) vs. 13.8% (Class 1), $p < 0.001$). Class membership was also associated with pre-DHOS annual household income, with 46.7% of women with moderate to severe depressive symptoms having annual income less than $20,000 compared to 35.0% of women with rare to occasional depressive symptoms and 18.6% of women with no depressive symptoms ($p < 0.001$). Women with moderate to severe depressive symptoms were also less likely to be currently employed (37.2% vs. 52.3% (Class 2) vs. 64.2% (Class 1), $p < 0.001$). They too had the lowest levels of all forms of social capital. Of note, the average CES-D scores for women with rare to occasional and moderate to severe symptoms were well above the common cutoff value of 16 (Table 4), demonstrating the variation of symptom severity between groups that would have been missed if the CES-D was measured dichotomously.

Multinomial logistic regression comparing the higher depressive symptom profiles to the lowest symptom profile indicates significant differences between latent classes after controlling for confounding (Table 5). The strongest association after adjustment for months between the DHOS and interview date, race, education, age, marital status, and self-efficacy was among women with moderate to severe depressive symptoms, who were 3.08 times as likely (99% confidence interval (CI): 1.45, 6.59) to have less than a high school education

than women with no depressive symptoms. Furthermore, women with moderate to severe depressive symptoms were 2.21 times as likely to be currently unemployed as women with virtually no depressive symptoms after adjustment (99% CI: 1.44, 3.39). Though there was no significant difference in DHOS exposure between women with rare to occasional depressive symptoms and women with virtually no depressive symptoms, women with moderate to severe depressive symptoms were more likely to have high frequency and severity of smelling oil (adjusted odds ratio (aOR): 2.08; 99% CI: 1.26, 3.43). Additionally, as severity of depressive symptomatology increased, perceived social support significantly decreased after adjustment.

3.1. Sensitivity analysis

In a post-hoc sensitivity analysis, we performed multivariate linear regression and multivariate logistic regression on the imputed data in order to assess associations when measuring the CES-D continuously and dichotomously (Appendix A). After adjustment for multiple comparisons, in addition to risk factors identified in multinomial logistic regression, higher CES-D score, measured continuously, was also associated with influence of the DHOS on household finances and lower social cohesion (Appendix A, Table 7). Results from the logistic regression models after multiple imputation yielded similar statistically significant, but attenuated, results to those found in multinomial logistic regression (Appendix A, Table 8).

We also examined associations between depressive symptomatology and exposures of interest if we had used listwise deletion rather than multiple imputation. On average, the result was stronger but non-significant associations between exposures and experiencing rare to occasional depressive symptoms (Appendix A, Table 9). However, the associations between membership to the subgroup with moderate to severe depressive symptoms and the exposures including smelling oil, education, and annual household income were attenuated in the logistic model using listwise deletion. Though attenuated, these results were in the same direction and numerically similar to results of the model using imputed variables. The small variation in results between models using multiple imputation and listwise deletion indicate that it was safe to keep the missing at random assumption. Though this assumption cannot be tested, consistency in results between the imputed and non-imputed models support missing at random, coupled with the added strength of increased power to detect true associations supports the use of multiple imputation in this analysis.

4. Discussion

In this study, we hypothesized that LPA would reveal heterogeneity in depressive symptomatology and expected to find at least three subgroups among the respondents. The data supported the presence of three subgroups; however, it indicated that the three subgroups represent degrees of depressive symptom severity rather than three distinct depressive symptom patterns. Nevertheless, the identification of these three subgroups highlights an important finding: women with higher levels of depressive symptoms (i.e., women in classes two and three) had average CES-D scores well above the clinically significant cut-off value. Using the conventional dichotomous cut-off on the CES-D, women

with significantly different characteristics would have been combined, thus masking their differences in depressive symptomatology severity and other characteristics. We identified higher DHOS exposure, more socioeconomic risk factors, and lower social capital as being associated with latent profile membership to the subgroup with the most depressive symptom severity.

The results of this study are consistent with results found in previous literature. In elderly populations, Hybels et al. identified latent classes of depressive symptomatology that differed by symptom severity when using CES-D indicators in LPA (Hybels et al., 2011, 2013). Our findings are also consistent with their findings of an inverse association between depressive symptom severity and perceived social support (Hybels et al., 2011; Mora et al., 2012). Additionally, unemployment was strongly associated with moderate to severe depressive symptoms. Our findings are consistent with the buffering model of social support which shows that stress resulting from loss (e.g., unemployment) or other life events increase depressive symptomatology, with social support acting as a buffer in this process (Aneshensel and Stone, 1982). Lack of social support to buffer the effect of experiencing other stressors, may lead to increases in experiencing depressive symptoms.

Two of the DHOS exposures that were measured were associated with depressive symptomatology in the LPA: property loss, though results should be interpreted with caution, and frequency and severity of smelling oil. Further research of the mechanism behind the smell association is warranted. Another future direction of research is examining how symptom profiles are associated with clinical diagnoses of depression determined by clinical interviews with psychiatrists or psychologists.

4.1. Limitations

There are several limitations to the current analysis. The cross-sectional nature of this study prevents causal interpretations of the data; however, we will be able to reassess these results using longitudinal data in the future. Secondly, there is often stigmatization of persons with mental illness that could influence participants' reports of depressive symptoms (Pompili et al., 2003). Due to negative perceptions of people with mental illness, women may have been less likely to report depressive symptoms to interviewers; however, this would not likely vary by any of the exposures of interest. Therefore, current results may be attenuated. Thirdly, though participants recalled DHOS exposure that occurred prior to the assessment of current depressive symptoms, women with depressive symptoms could have had history of depression, which increases the risk of recurrent depressive episodes (Holden et al., 2013), and their current report of symptoms may be a recurrence unrelated to DHOS exposure or other characteristics measured in this study. We did not have data on previous diagnoses or experiences of depression, thus there is a possibility of residual confounding in the association between the exposures and depressive symptoms. However, social capital and socioeconomic status are consistently associated with poor mental health in the literature (Hybels et al., 2011; Kendler et al., 2002; Kessler, 1997; Kessler et al., 2003; Kim and Durden, 2007; Mora et al., 2012; Noble, 2005), which supports the validity of these results despite the possibility of residual confounding. An additional limitation is that exposures were based on self-report, and recall may have been biased; however, errors in recall should

be small due to the salient memories evoked (e.g., lost income, participating in cleanup activities, socioeconomic status).

4.2. Strengths

Despite the limitations, there are several strengths to the current analysis. To date, this is the first LPA using the CES-D that focuses specifically on a population of female residents of a vulnerable region in the United States. The CES-D also had higher internal consistency in this population (Cronbach's Alpha=0.93) than in previous studies, supporting its validity (Knight et al., 1997; Lewinsohn et al., 1997). Additionally, using the three-step LPA method has advantages over the traditionally used one-step method. Often, the one-step method can be biased, while the three-step method overcomes these limitations (Asparouhov and Muthén, 2014). An added strength is that we performed an assessment of a variety of potential oil spill exposures beyond the scope of exposure assessments done in prior studies of the mental health effects of oil spills (Fan et al., 2015; Kim et al., 2013; Lyons et al., 1999; Morris et al., 2013; Osofsky et al., 2011; Palinkas et al., 1992, 1993).

Moreover, we implemented more robust assessment of and control for many potential confounders than prior studies of oil spill exposure and mental health (Fan et al., 2015; Kim et al., 2013; Lyons et al., 1999; Morris et al., 2013; Osofsky et al., 2011; Palinkas et al., 1992, 1993). In addition to direct physical exposure, we were also able to assess a variety of economic oil spill exposures. Economic impacts have been found to be one of the most significant predictors of poor mental health in people affected by oil spills (Fan et al., 2015).

Furthermore, the sensitivity analyses supported the strength of using multiple imputation in this analysis. Women excluded from analysis in listwise deletion were more likely to have higher depression, have smelled the oil, and had more socioeconomic risk factors. As compared to logistic regression after multiple imputation, logistic regression after listwise deletion generally resulted in attenuated estimates when comparing the most severe depressive symptom subgroup to the subgroup with no depressive symptoms. These results are plausible because listwise deletion removed women with more socioeconomic risk factors, higher prevalence of some DHOS exposures, and the highest CES-D scores. Therefore, the use of multiple imputation adds strength to this analysis by reducing potential selection bias.

4.3. Conclusions

Results of the current study identified latent classes of individuals with different levels of depressive symptomatology. Though most oil spill exposures were not associated with depressive symptomatology, women with the most severe symptoms had lower education and income, had a higher prevalence of unemployment, and had the least perceived social support, suggesting that interventions targeting and protecting women in low socioeconomic positions may be the best approach to mitigating mental health effect of disaster. Programs such as higher education support, employment assistance, and community capacity building may reduce the mental health impacts of disaster-related stress in high risk female residents in regions vulnerable to disaster. These findings are especially important as technological

advancements and climate change increase the number of people at risk of experiencing disaster both in the United States and globally.

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References

Aneshensel CS, Stone JD. Stress and depression: a test of the buffering model of social support. Arch Gen Psychiatry. 1982; 39:1392–1396. [PubMed: 7149899]

APA. Diagnostic and Statistical Manual of Mental Disorders. 5. American Psychological Association; Washington, DC: 2013.

Asparouhov T, Muthén B. Auxiliary variables in mixture modeling: three-step approaches using Mplus. Struct Equ Model: A Multidiscip J. 2014; 21:329–341.

Benjamini Y, Hochberg Y. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J R Stat Soc Ser B (Methodol). 1995; 57:289–300.

Breslow, NE., Day, NE. Statistical methods in cancer research. Volume I - The analysis of case-control studies. IARC scientific publications; 1980. p. 5-338.

CDC. Morbidity and Mortality Weekly Report (MMWR). Centers for Disease Control and Prevention; 2010. Current Depression Among Adults – United States, 2006 and 2008; p. 1229-1235.

CDC. MMWR Morb Mortal Wkly Report. Centers for Disease Control and Prevention; 2011. Mental illness surveillance among adults in the United States; p. 1-30.

Drescher CF, Schulenberg SE, Smith CV. The deepwater horizon oil spill and the Mississippi Gulf coast: mental health in the context of a technological disaster. Am J Orthopsychiatry. 2014; 84:142–151. [PubMed: 24826930]

Fan AZ, Prescott MR, Zhao G, Gotway CA, Galea S. Individual and community-level determinants of mental and physical health after the deep-water horizon oil spill: findings from the Gulf states population survey. J Behav Health Serv Res. 2015; 42:23–41. [PubMed: 25124651]

Graham JW, Olchowski AE, Gilreath TD. How many imputations are really needed? Some practical clarifications of multiple imputation theory. Prev Sci: Off J Soc Prev Res. 2007; 8:206–213.

Greenland S, Pearl J, Robins JM. Causal diagrams for epidemiologic research. Epidemiol (Camb Mass). 1999; 10:37–48.

Guha-Sapir, D., Below, R., Hoyois, P. EM-DAT: The CRED/OFDA International Disaster Database. Universite Catholique de Louvain; Brussels, Belgium: 2015.

Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap) – a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009; 42:377–381. [PubMed: 18929686]

Henson JM, Reise SP, Kim KH. Detecting mixtures from structural model differences using latent variable mixture modeling: a comparison of relative model fit statistics. Struct Equ Model: A Multidiscip J. 2007; 14:202–226.

Holden KB, Bradford LD, Hall SP, Belton AS. Prevalence and correlates of depressive symptoms and resiliency among African American women in a community-based primary health care center. J Health Care Poor Under. 2013; 24:79–93.

Hybels CF, Landerman LR, Blazer DG. Latent subtypes of depression in a community sample of older adults: can depression clusters predict future depression trajectories? J Psychiatr Res. 2013; 47:1288–1297. [PubMed: 23806578]

Hybels CF, Blazer DG, Landerman LR, Steffens DC. Heterogeneity in symptom profiles among older adults diagnosed with major depression. Int Psychogeriatr IPA. 2011; 23:906–922.

Kendler KS, Gardner CO, Prescott CA. Toward a comprehensive developmental model for major depression in women. Am J Psychiatry. 2002; 159:1133–1145. [PubMed: 12091191]

Kessler RC. The effects of stressful life events on depression. Annu Rev Psychol. 1997; 48:191–214. [PubMed: 9046559]

Kessler RC, Berglund P, Demler O, et al. The epidemiology of major depressive disorder: results from the national comorbidity survey replication (ncs-r). JAMA. 2003; 289:3095–3105. [PubMed: 12813115]

Kim J, Durden E. Socioeconomic status and age trajectories of health. Soc Sci Med. 2007; 65:2489–2502. (1982). [PubMed: 17765375]

Kim YM, Park JH, Choi K, Noh SR, Choi YH, Cheong HK. Burden of disease attributable to the Hebei spirit oil spill in Taean, Korea. BMJ Open. 2013; 3:e003334.

Knight RG, Williams S, McGee R, Olaman S. Psychometric properties of the centre for epidemiologic studies depression scale (CES-D) in a sample of women in middle life. Behav Res Ther. 1997; 35:373–380. [PubMed: 9134792]

Ko JY, Farr SL, Dietz PM, Robbins CL. Depression and treatment among U.S. pregnant and nonpregnant women of reproductive age, 2005–2009. J Women's Health. 2012; 21:830–836. (2002).

Lagakos SW. Effects of mismodelling and mismeasuring explanatory variables on tests of their association with a response variable. Stat Med. 1988; 7:257–274. [PubMed: 3353607]

Lewinsohn PM, Seeley JR, Roberts RE, Allen NB. Center for epidemiologic studies depression scale (CES-D) as a screening instrument for depression among community-residing older adults. Psychol Aging. 1997; 12:277–287. [PubMed: 9189988]

Lo Y, Mendell NR, Rubin DB. Testing the number of components in a normal mixture. Biometrika. 2001; 88:767–778.

Lyons RA, Temple JM, Evans D, Fone DL, Palmer SR. Acute health effects of the sea empress oil spill. J Epidemiol Community Health. 1999; 53:306–310. [PubMed: 10396538]

Mora PA, Beamon T, Preuitt L, DiBonaventura M, Leventhal EA, Leventhal H. Heterogeneity in depression symptoms and health status among older adults. J Aging Health. 2012; 24:879–896. [PubMed: 22491993]

Morris JG Jr, Grattan LM, Mayer BM, Blackburn JK. Psychological responses and resilience of people and communities impacted by the deepwater horizon oil spill. Trans Am Clin Climatol Assoc. 2013; 124:191–201. [PubMed: 23874022]

Muthén, LK., MB. Mplus User's Guide. 7. Muthén & Muthén; Los Angeles, CA: 1998–2012.

Noble RE. Depression in women. Metabolism. 2005; 54:49–52.

Nolen-Hoeksema S. Gender differences in depression. Curr Dir Psychol Sci. 2001; 10:173–176.

Nylund KL, Asparouhov T, Muthén BO. Deciding on the Number of classes in latent class analysis and growth mixture modeling: a Monte Carlo simulation study. Struct Equ Model: A Multidiscip J. 2007; 14:535–569.

Osofsky HJ, Osofsky JD, Hansel TC. Deepwater horizon oil spill: mental health effects on residents in heavily affected areas. Disaster Med Public Health Prep. 2011; 5:280–286. [PubMed: 22146666]

Palinkas LA, Russell J, Downs MA, Petterson JS. Ethnic differences in stress, coping, and depressive symptoms after the Exxon Valdez oil spill. J Nerv Ment Dis. 1992; 180:287–295. [PubMed: 1583472]

Palinkas LA, Petterson JS, Russell J, Downs MA. Community patterns of psychiatric disorders after the Exxon Valdez oil spill. Am J Psychiatry. 1993; 150:1517–1523. [PubMed: 8379557]

Pallardy, R. Deepwater Horizon Oil Spill of 2010. Encyclopaedia Britannica Inc; 2015.

Penninx BW, Milaneschi Y, Lamers F, Vogelzangs N. Understanding the somatic consequences of depression: biological mechanisms and the role of depression symptom profile. BMC Med. 2013; 11:129. [PubMed: 23672628]

Pompili M, Mancinelli I, Tatarelli R. Stigma as a cause of suicide. Br J Psychiatry. 2003; 183:173–174.

Pratt LA, Brody DJ. Depression in the United States household population, 2005–2006. NCHS data brief. 2008:1–8.

Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. Appl Psychol Meas. 1977; 1:385–401.

SAMHSA. Substance Use and Mental Disorders in the New Orleans-Metairie-Kenner MSA. The NSDUH Report: Metro Brief. 2012

SAMHSA. Results from the 2012 National Survey on Drug Use and Health: Mental Health Findings, NSDUH Series H-47. Substance Abuse and Mental Health Services Administration; Rockville, MD: 2013.

SAMHSA. Substance Use Disorders. 2015.

Schwarzer, RJM. Generalized self-efficacy scale. In: Weinman, J.SW, Johnston, M., editors. Measures in Health Psychology: A User's Portfolio. Causal and Control Beliefs. NFER-NELSON; Windsor, UK: 1995. p. 35-37.

The American Association for Public Opinion Research. Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys. 7. 2011.

Wells KB, Stewart A, Hays RD, Burnam MA, Rogers W, Daniels M, Berry S, Greenfield S, Ware J. The functioning and well-being of depressed patients. Results from the medical outcomes study. JAMA. 1989; 262:914–919. [PubMed: 2754791]

Yen IH, Kaplan GA. Poverty area residence and changes in depression and perceived health status: evidence from the Alameda county study. Int J Epidemiol. 1999; 28:90–94. [PubMed: 10195670]

Appendix A

See Tables 6–9.

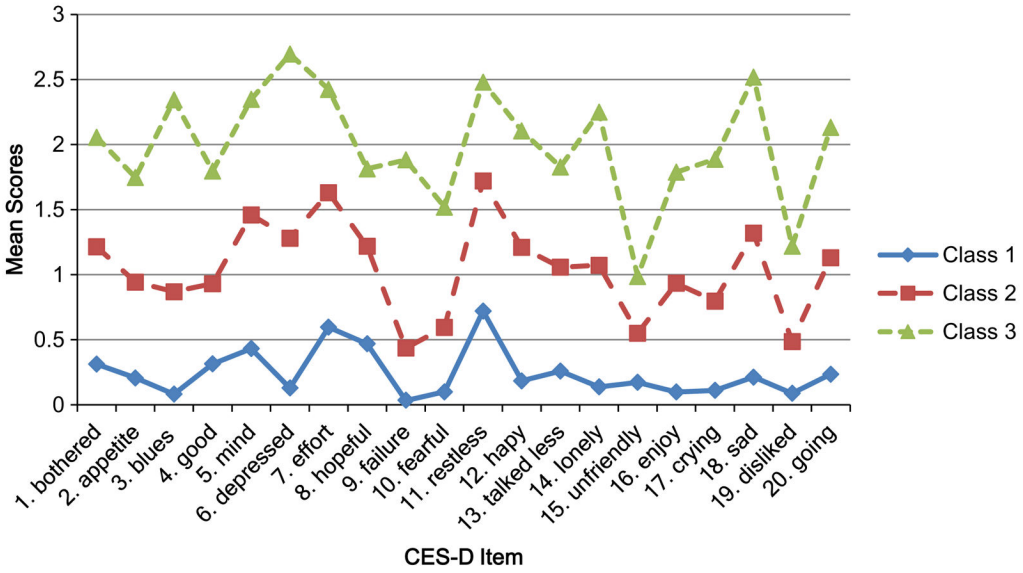

Fig. 1.

Class membership associated with depressive symptom profiles in the WaTCH Study, Louisiana, 2012–2014 (N=2790).

Table 1

Women and Their Children's Health (WaTCH) Study population characteristics, Louisiana, 2012–2014 (N=2790).

	n	(%)	Range	Missing
Race				40 *
Non-Hispanic White	1562	56.80		
Non-Hispanic Black	956	34.76		
Other (Multiracial, Hispanic, Other Races)	232	8.44		
Age (mean, SD)	45.67	11.996	18–80	
Education				7 *
Less than High School	326	11.71		
High School Graduate	1650	59.29		
College or beyond	807	29.00		
Annual Household Income				201 *
≤ $20,000	645	24.91		
$20,001–$40,000	542	20.93		
$40,001–$60,000	416	16.07		
≥ $60,001	986	38.08		
Marital Status				4 *
Married/Living with Partner	1754	62.96		
Never Married/Separated/Divorced/Widowed	1032	37.04		
Currently Employed	1562	59.12		148 *
Current Regular Drinker	180	21.00		116 *
DHOS Exposure				
Income loss due to DHOS	729	26.26		14
Participated in DHOS cleanup activities	55	1.97		
Affected recreational hunting/fishing activities	952	34.37		20
Physical damage to commercial fishing areas	188	6.78		19
Property Loss/Damage due to DHOS or cleanup	70	2.51		3
Frequency and Severity of Smelling Oil				136 *
None	1663	62.66		
Low	282	10.63		
Medium	259	7.76		
High	450	16.96		
Other contact with oil	608	22.01		27
Hit harder than others	164	6.01		59
Somewhat/very negative influence on finances	1043	37.93		40
	Mean	**SD**		
Months since DHOS	38.28	4.668	27–53	
Perceived Social Support Score	4.19	1.273	0–5	113 *
General Self Efficacy Scale Score	34.14	4.781	10–40	62

	n	(%)	Range	Missing
Social Cohesion Score	9.59	2.559	0–12	288 *
Informal Social Control Score	16.81	3.162	5–20	173 *
Neighborhood Participation Score	1.19	1.562	0–9	4
CES-D Score	11.76	12.457	0–58	60 *

Center for Epidemiologic Studies Depression Scale (CES-D); Deepwater Horizon Oil Spill (DHOS).

* Significant difference between women with missing and non-missing values, $p < 0.05$.

Table 2

Distribution of endorsement of symptoms during the past week in the WaTCH Study, Louisiana, 2012–2014 (N=2790).

	Mean	SD	Missing	% of respondents endorsing symptom			
CES-D Item				**0***	**1***	**2***	**3***
1. I was bothered by things that donot usually bother me.	0.68	0.964	3	59.35	21.28	11.23	8.14
2. I did not feel like eating; my appetite was poor.	0.52	0.920	3	70.36	14.53	7.75	7.36
3. I felt that I could not shake off the blues even with help from my family or friends.	0.48	0.900	4	72.43	14.29	5.92	7.36
4. I felt that I was just as good as other people. **	0.60	1.039	14	71.58	7.74	10.05	10.63
5. I had trouble keeping my mind on what I was doing.	0.84	1.089	4	53.63	22.79	9.08	14.50
6. I felt depressed.	0.64	1.000	3	64.08	18.69	6.60	10.62
7. I felt that everything I did was an effort.	1.00	1.217	3	51.85	18.19	7.89	22.07
8. I felt hopeful about the future. **	0.76	1.108	6	63.22	9.81	14.30	12.68
9. I thought my life had been a failure.	0.31	0.782	2	82.93	8.61	2.80	5.67
10. I felt fearful.	0.35	0.766	5	77.88	13.90	3.38	4.85
11. My sleep was restless.	1.11	1.184	4	43.07	24.73	10.12	22.07
12. I was happy. **	0.60	0.965	2	68.01	10.98	14.28	6.74
13. I talked less than usual.	0.59	0.992	5	68.11	15.01	6.75	10.13
14. I felt lonely.	0.55	0.976	4	70.06	14.39	5.71	9.83
15. People were unfriendly.	0.34	0.750	15	79.03	12.76	3.86	4.36
16. I enjoyed life. **	0.45	0.889	2	76.72	7.14	10.65	5.49
17. I had crying spells.	0.44	0.837	3	72.80	16.22	5.13	5.85
18. I felt sad.	0.68	0.974	3	58.67	23.82	7.97	9.54
19. I felt that people disliked me.	0.29	0.723	15	82.59	10.23	2.85	4.32
20. I could not get “going.”	0.62	0.961	7	63.17	21.06	6.47	9.31

Center for Epidemiologic Studies Depression Scale (CES-D); Deepwater Horizon Oil Spill (DHOS); Standard Deviation (SD); Women and Their Children’s Health Study (WaTCH).

* Response options included: rarely or none of the time (0); some or a little of the time (1); occasionally or moderate amount of time (2); and most or all of the time (3).

** Positive items were reverse coded.

Table 3

Comparison of model fit statistics for latent class solutions in the WaTCH Study, Louisiana, 2012–2014 (N=2790).

Number of classes	Log likelihood	AIC	BIC	SSA-BIC	Entropy	Smallest class, %	LMR-LRT P-value
1 Class	−75,703.47	151,486.94	151,724.29	151,597.20			
2 Classes	−65,421.56	130,965.11	131,327.07	131,133.26	0.977	20.39	< 0.001
3 Classes	−63,101.87	126,367.73	126,854.30	126,593.76	0.957	10.65	0.02
4 Classes	−62,235.60	124,677.20	125,288.38	124,961.12	0.953	7.03	0.07

Aikaike’s Information Criteria (AIC); Bayesian Information Criteria (BIC); Lo Mendell Rubin Likelihood Ratio Test (LMR-LRT); Sample size adjusted Bayesian Information Criteria (SSA-BIC).

Table 4

Characteristics for each latent class of depressive symptomatology in the WaTCH Study, Louisiana, 2012–2014 (N=2790).

Depressive symptoms	Class 1 (N=1928) None		Class 2 (N=565) Rare to occasional		Class 3 (N=297) Moderate to severe		
	N	%	N	%	N	%	Two sided P-value
DHOS Exposure							
Income loss due to DHOS	471	24.57	164	29.13	94	31.76	0.01
Participated in DHOS cleanup activities	32	1.66	16	2.83	7	2.36	0.18
Affected recreational hunting/fishing activities	633	33.04	209	37.39	110	37.29	0.09
Physical damage to commercial fishing areas	114	5.96	42	7.46	32	10.81	0.01
Property Loss/Damage due to DHOS or cleanup	45	2.34	21	3.72	4	1.35	0.07
Frequency and Severity of Smelling Oil							< 0.001
None	1222	66.56	298	55.91	143	50.18	
Low	191	10.40	63	11.82	28	9.82	
Medium	169	9.20	60	11.26	30	10.53	
High	254	13.83	112	21.01	84	29.47	
Other contact with oil	395	20.65	134	24.10	79	26.87	0.02
Hit harder than others	95	5.02	43	7.82	26	8.97	0.004
Somewhat/very negative influence on finances	650	34.19	248	44.60	145	49.49	< 0.001
Months Since DHOS (mean, SD)	38.20	4.573	38.57	4.824	38.32	4.964	0.24
Race							< 0.001
White	1148	60.39	273	49.01	141	48.29	
Black	620	32.61	221	39.68	115	39.38	
Other	133	7.00	63	11.31	36	12.33	
Age (mean, SD)	45.92	12.098	45.13	11.676	45.10	11.91	0.27
Education							< 0.001
Less than High School	150	7.80	88	15.60	88	29.73	
High School Graduate	1127	58.61	350	62.06	173	58.45	
College or beyond	646	33.59	126	22.34	35	11.82	
Annual Household Income							< 0.001

Depressive symptoms	Class 1 (N=1928) None		Class 2 (N=565) Rare to occasional		Class 3 (N=297) Moderate to severe		
	N	%	N	%	N	%	Two sided P-value
≤ $20,000	332	18.58	185	35.04	128	46.72	
$20,001–$40,000	347	19.42	132	25.00	63	22.99	
$40,001–$60,000	321	17.96	69	13.07	26	9.49	
≥ $60,001	787	44.04	142	26.89	57	20.80	
Marital Status							< 0.001
Married/Living with Partner	1307	67.90	310	54.96	137	46.13	
Never Married/Separated/Divorced/Widowed	618	32.10	254	45.04	160	53.87	
Currently Employed	1191	64.17	272	52.31	99	37.22	< 0.001
	Mean	SD	Mean	SD	Mean	SD	
Perceived Social Support Score	4.43	1.064	3.84	1.433	3.29	1.602	< 0.001
General Self Efficacy Scale Score	34.93	4.302	33.00	4.788	31.15	5.966	< 0.001
Social Cohesion Score	9.96	2.350	8.94	2.647	8.31	3.045	< 0.001
Informal Social Control Score	17.14	2.924	16.29	3.272	15.67	3.951	< 0.001
Neighborhood Participation Score	1.28	1.557	1.02	1.604	0.93	1.455	< 0.001
CES-D Score	4.88	4.159	20.90	5.423	39.80	7.041	< 0.001

Deepwater Horizon Oil Spill (DHOS); Center for Epidemiologic Studies Depression Scale (CES-D); Standard Deviation (SD); Women and Their Children's Health (WaTCH) Study.

Table 5

Adjusted odds ratios and 99% confidence intervals of belonging to classes with more depressive symptoms (Classes 2 and 3) as compared to no depressive symptoms (Class 1) after multiple imputation in the WaTCH Study, Louisiana, 2012–2014 (N=2790).

	Class 2		Class 3	
	Rare to occasional depressive symptoms		Moderate to severe depressive symptoms	
	aOR	99% CI	aOR	99% CI
DHOS Exposure				
Income loss due to DHOS	0.96	(0.67, 1.37)	1.01	(0.61, 1.67)
Participated in DHOS cleanup activities	1.41	(0.53, 3.72)	0.99	(0.32, 3.04)
Affected recreational hunting/fishing activities	1.27	(0.92, 1.76)	1.07	(0.67, 1.73)
Physical damage to commercial fishing areas	0.83	(0.47, 1.49)	1.31	(0.66, 2.57)
Property Loss/Damage due to DHOS or cleanup	1.11	(0.49, 2.51)	**0.18**	**(0.03, 0.94)**
Frequency and Severity of Smelling Oil				
None	1.00		1.00	
Low	1.32	(0.83, 2.10)	1.31	(0.70, 2.46)
Medium	1.31	(0.81, 2.13)	1.46	(0.75, 2.82)
High	1.43	(0.95, 2.13)	**2.08**	**(1.26, 3.43)**
Other contact with oil	1.10	(0.71, 1.70)	1.30	(0.81, 2.10)
Hit harder than others	1.20	(0.65, 2.22)	1.20	(0.57, 2.52)
Somewhat/very negative influence on finances	1.31	(0.95, 1.83)	1.52	(0.97, 2.37)
Education				
Less than high school	1.32	(0.75, 2.31)	**3.08**	**(1.45, 6.59)**
High school graduate	1.05	(0.73, 1.52)	1.46	(0.85, 2.67)
College or beyond	1.00		1.00	
Annual Household Income (year prior to DHOS)				
≤ $20,000	**1.80**	**(1.08, 3.02)**	1.68	(0.84, 3.33)
$20,001–$40,000	1.56	(1.00, 2.46)	1.34	(0.72, 2.47)
$40,001–$60,000	1.01	(0.63, 1.60)	0.79	(0.38, 1.62)
≥ $60,001	1.00		1.00	
Currently Unemployed	1.38	(1.00, 1.89)	**2.21**	**(1.44, 3.39)**
Perceived Social Support Score	**0.80**	**(0.71, 0.90)**	**0.69**	**(0.60, 0.79)**
Social Cohesion Score	0.93	(0.86, 1.01)	0.92	(0.83, 1.02)
Informal Social Control Score	0.99	(0.94, 1.05)	0.97	(0.90, 1.04)
Neighborhood Participation Score	0.95	(0.85, 1.06)	1.01	(0.88, 1.16)

Adjusted Odds Ratio (aOR); Confidence Interval (CI); Deepwater Horizon Oil Spill (DHOS); Women and Their Children's Health (WaTCH) Study.

Controlling for: months since the DHOS, race, age, marital status, and self-efficacy.

Table 6

Social capital constructs measured in the WaTCH Study, Louisiana, 2012–2014.

	Perceived social support	
1.	Is there anyone you could count on for everyday favors like getting a ride, borrowing a little money, or errands?	*[yes/no]*
2.	Is there anyone you could count on to take care of you if you were confined to bed for several weeks?	
3.	Is there anyone you know who you could count on to lend you several hundred dollars for a medical emergency?	
4.	Is there anyone you could talk to if you were having troubles with family relationships?	
5.	Is there anyone who could help you locate housing if you had to move?	
	Neighborhood Social Cohesion	
1.	I think my neighborhood is a good place for me to live.	*[yes/no]*
2.	People in this neighborhood do not share the same values.	
3.	My neighbors and I want the same things from the neighborhood.	
4.	I can recognize most of the people who live in my neighborhood.	
5.	I feel at home in this neighborhood.	
6.	Very few of my neighbors know me.	
7.	I care about what my neighbors think of my actions.	
8.	I have no influence over what this neighborhood is like.	
9.	If there is a problem in the neighborhood, people who live here can get it solved.	
10.	It is very important to me to live in this particular neighborhood.	
11.	People in this neighborhood generally don't get along with each other.	
12.	I expect to live in this neighborhood a long time.	
	Neighborhood Social Control	
1.	If a group of neighborhood children were skipping school and hanging out on a street corner, how likely is it that your neighbors would do something about it? Would you say…	*[Very Likely; Likely; Unlikely; Very Unlikely]*
2.	If some children were spray-painting graffiti on a local building, how likely is it that your neighbors would do something about it? Would you say…	
3.	If a child was showing disrespect to an adult other than his parent, how likely is it that people in your neighborhood would scold that child? Would you say…	
4.	If there was a fight in front of your house and someone was being beaten or threatened, how likely is it that your neighbors would break it up? Would you say…	
5.	Suppose that because of budget cuts the fire station closest to your home was going to be closed down by the city. How likely is it that neighborhood residents would organize to try to do something to keep the fire station open? Would you say…	
	Neighborhood Organization Participation	
	In the past 12 months, have you yourself participated in the following activities?	*[yes/no]*
1.	Neighborhood or block organization meeting?	
2.	Business or civic group?	
3.	Nationality or ethnic pride club?	
4.	A local or state political organization?	
5.	Volunteered in a local organization?	
6.	Veterans group?	
7.	Labor union?	
8.	Literary, art, study, book club, or discussion groups?	
9.	Fraternity, sorority or alumni group?	

Table 7

Results of multivariate linear regression of CES-D score after multiple imputation in the WaTCH Study, Louisiana, 2012–2014 (N=2790).

DHOS exposure	beta	s.e.	Two-sided FDR corrected P-value
Income loss due to DHOS	−0.17	0.54	0.79
Participated in DHOS cleanup activities	0.65	1.49	0.73
Affected recreational hunting/fishing activities	1.42	0.92	0.20
Physical damage to commercial fishing areas	0.43	0.87	0.05
Property Loss/Damage due to DHOS or cleanup	−1.70	1.39	0.30
Frequency and Severity of Smelling Oil			
None	ref		
Low	0.76	0.70	0.34
Medium	1.60	0.74	0.06
High	**2.94**	**0.62**	< **0.001**
Other contact with oil	0.64	0.53	0.30
Hit harder than others	1.42	0.92	0.20
Somewhat/very negative influence on finances	**1.53**	**0.48**	**0.006**
Education			
Less than high school	**4.48**	**0.83**	< **0.001**
High school graduate	1.13	0.51	0.05
College or beyond	ref		
Annual Household Income (year prior to DHOS)			
≤ $20,000	**3.22**	**0.77**	< **0.001**
$20,001–$40,000	**1.76**	**0.64**	**0.02**
$40,001–$60,000	−0.35	0.63	0.67
≥ $60,001	ref		
Currently Unemployed	**2.54**	**0.47**	< **0.001**
Perceived Social Support Score	**−1.81**	**0.18**	< **0.001**
Social Cohesion Score	**−0.52**	**0.13**	< **0.001**
Informal Social Control Score	−0.10	0.08	0.30
Neighborhood Participation Score	0.02	0.14	0.87

Deepwater Horizon Oil Spill (DHOS); False Discovery Rate (FDR); Standard Error (s. e.); Women and Their Children's Health (WaTCH) Study.

Controlling for: months since the DHOS, race, age, marital status, and self-efficacy.

Table 8

Results of multivariate logistic regression using CES-D Cut-off score of 16 after multiple imputation in the WaTCH Study, Louisiana, 2012–2014 (N=2790).

	Probable clinical depression vs. Non-clinically significant depression (CES-D Score ≥ 16)	
	aOR	**99% CI**
DHOS Exposure		
Income loss due to DHOS	0.90	(0.65, 1.25)
Participated in DHOS cleanup activities	1.03	(0.43, 2.46)
Affected recreational hunting/fishing activities	1.24	(0.92, 1.67)
Physical damage to commercial fishing areas	1.01	(0.61, 1.67)
Property loss/damage due to DHOS or cleanup	0.88	(0.38, 2.06)
Frequency and Severity of Smelling Oil		
None	1.00	
Low	1.15	(0.75, 1.75)
Medium	1.22	(0.78, 1.90)
High	**1.57**	**(1.10, 2.22)**
Other contact with oil	1.14	(0.83, 1.57)
Hit harder than others	1.38	(0.81, 2.36)
Somewhat/very negative influence on finances	**1.48**	**(1.10, 1.98)**
Education		
Less than high school	**1.88**	**(1.15, 3.08)**
High school graduate	1.21	(0.86, 1.70)
College or beyond	1.00	
Annual Household Income (year prior to DHOS)		
≤ $20,000	**1.70**	**(1.08, 2.68)**
$20,001–$40,000	1.43	(0.96, 2.13)
$40,001–$60,000	0.96	(0.63, 1.46)
≥ $60,001	1.00	
Currently Unemployed	**1.52**	**(1.15. 2.02)**
Perceived Social Support Score	**0.76**	**(0.69, 0.85)**
Social Cohesion Score	0.93	(0.86, 1.00)
Informal Social Control Score	0.98	(0.94, 1.03)
Neighborhood Participation Score	0.98	(0.90, 1.08)

Adjusted Odds Ratio (aOR); Confidence Interval (CI); Deepwater Horizon Oil Spill (DHOS); Women and Their Children's Health (WaTCH) Study.

Controlling for: months since the DHOS, race, age, marital status, and self-efficacy.

Table 9

Adjusted odds ratios and 99% confidence intervals of belonging to classes with more depressive symptoms (Classes 2 and 3) as compared to no depressive symptoms (Class 1) after listwise deletion in the WaTCH Study, Louisiana, 2012–2014 (N=1891).

	Class 2		Class 3	
	Rare to occasional depressive symptoms		Moderate to severe depressive symptoms	
	aOR	99% CI	aOR	99% CI
DHOS Exposure				
Income loss due to DHOS	0.97	(0.63, 1.51)	0.95	(0.51, 1.79)
Participated in DHOS cleanup activities	1.83	(0.57, 5.91)	1.11	(0.23, 5.45)
Affected recreational hunting/fishing activities	1.35	(0.90, 2.03)	1.23	(0.67, 2.24)
Physical damage to commercial fishing areas	0.78	(0.37, 1.62)	1.60	(0.69, 3.71)
Property Loss/Damage due to DHOS or cleanup	1.17	(0.40, 3.48)	0.18	(0.01, 3.36)
Frequency and Severity of Smelling Oil				
None	1.00		1.00	
Low	1.36	(0.78, 2.38)	0.79	(0.35, 1.82)
Medium	1.55	(0.86, 2.80)	0.97	(0.41, 2.29)
High	1.53	(0.92, 2.54)	**1.86**	**(1.01, 3.42)**
Other contact with oil	1.00	(0.64, 1.56)	1.12	(0.61, 2.05)
Hit harder than others	1.20	(0.55, 2.62)	1.13	(0.42, 3.00)
Somewhat/very negative influence on finances	1.20	(0.80, 1.81)	1.45	(0.84, 2.52)
Education				
Less than high school	1.12	(0.55, 2.29)	1.60	(0.63, 4.02)
High school graduate	1.00	(0.63, 1.59)	1.16	(0.58, 2.30)
College or beyond	1.00		1.00	
Annual Household Income (year prior to DHOS)				
≤ $20,000	**2.00**	**(1.06, 3.80)**	1.96	(0.84, 4.56)
$20,001–$40,000	1.68	(0.97, 2.93)	1.68	(0.80, 3.53)
$40,001–$60,000	1.01	(0.57, 1.76)	0.99	(0.43, 2.24)
≥ $60,001	1.00		1.00	
Currently Unemployed	1.24	(0.84, 1.84)	**2.54**	**(1.56, 4.13)**
Perceived Social Support Score	**0.80**	**(0.69, 0.93)**	**0.69**	**(0.58, 0.83)**
Social Cohesion Score	**0.89**	**(0.81, 0.97)**	**0.88**	**(0.79, 0.98)**
Informal Social Control Score	1.02	(0.96, 1.10)	1.02	(0.93, 1.12)
Neighborhood Participation Score	0.95	(0.82, 1.09)	1.04	(0.88, 1.24)

Adjusted Odds Ratio (aOR); Confidence Interval (CI); Deepwater Horizon Oil Spill (DHOS); Women and Their Children's Health (WaTCH) Study.

Controlling for: months since the DHOS, race, age, marital status, and self-efficacy.