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Coping with oil spills: oil exposure and trait anxiety among residents of Gulf Coast states after the Deepwater Horizon oil spill

By

Zachary E. Goldman
Degree to be awarded: Master of Public Health

Environmental Health

_____

Dr. Matthew O. Gribble, PhD DABT
Committee Chair

# Coping with oil spills: oil exposure and trait anxiety among residents of Gulf Coast states after the Deepwater Horizon oil spill

By

Zachary E. Goldman

B.S.
Purdue University
2017

Thesis Committee Chair: Dr. Matthew O. Gribble, PhD DABT

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# Abstract

Coping with oil spills: oil exposure and trait anxiety among residents of Gulf Coast states after the Deepwater Horizon oil spill

By Zachary E. Goldman

**Background:** The objective of this cross-sectional study was to describe the association of oil exposure with anxiety after the Deepwater Horizon oil spill and to evaluate potential effect modifiers of that association.

**Methods:** To assess the impacts of the 2010 Deepwater Horizon oil spill, the Centers for Disease Control and Prevention conducted the Gulf States Population Survey, a random-digit-dial telephone survey completed between December 2010 and December 2011 with 38,361 responses in four different Gulf Coast states— Louisiana, Florida, Alabama, and Mississippi. We used Tobit regression to model anxiety as measured by the Generalized Anxiety Disorder (GAD-7) symptom inventory.

**Results:** Among those directly exposed to oil, participation in oil spill cleanup activities was associated with lower anxiety, after controlling for confounders ($\beta$=-3.83, 95% CI: -6.55, -1.12).

**Conclusion:** Oil contact was associated with greater anxiety, but this association appeared to be mitigated by cleanup participation.

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## INTRODUCTION

In April 2010, a fatal explosion on the Deepwater Horizon drilling rig in the Gulf of Mexico resulted in the largest accidental marine oil spill in history.[1] The explosion released over 4 million barrels of oil into the Gulf, and in an effort to remediate the spill, an additional 2.1 million gallons of dispersants were released onto the ocean surface.[2] This spill continued for nearly 3 months and affected more than 600 miles of shoreline spanning from Florida to Texas.[3,4]

Adverse mental health outcomes have been reported among individuals exposed to the Deepwater Horizon oil spill, including those who participated in cleanup activities.[1,2] During the Deepwater Horizon oil spill cleanup operation, many residents and workers came into direct contact with the oil. Qualitative studies of exposed fishermen, families, and oil industry workers on the Gulf Coast described uncertainty about the future and developed generalized anxiety, stress reactions, and posttraumatic stress disorder months after the explosion.[1] Previous research has concluded that individuals ultimately cope well with disasters, yet 56% of exposed respondents developed major depression disorders or generalized anxiety disorders.[5-7]

The objective of this cross-sectional study was to describe the association of oil exposure with anxiety after the Deepwater Horizon oil spill and to evaluate potential effect modifiers of that association. Although prior studies have examined the relationships between oil exposure and anxiety, effect modifiers such as self-mastery (coping ability), emotional support, and cleanup participation have not been closely examined.

## METHODS

The Gulf States Population Survey (GSPS) was a random-digit-dial telephone survey conducted between December 2010 and December 2011 by the Centers for Disease Control and

Prevention in partnership with the Substance Abuse and Mental Health Services Administration and state and local health departments to assess the impacts of the Deepwater Horizon oil spill. The survey was created to provide information on the mental health status of the coastal population in areas affected by the oil spill. The GSPS included 38,361 responses from individuals aged ≥18 years old residing in one of 25 coastal counties or parishes in Louisiana, Florida, Alabama, and Mississippi.[8] The percentage of eligible individuals who were recruited and completed the GSPS interview was 44.2%.[9] The data for the GSPS was weighted to adjust for United States Census population estimates, and the survey design, sampling methods, and weights were based on methods used for the Behavioral Risk Factor Surveillance System.[10]

We used Tobit regression to model anxiety as measured by the Generalized Anxiety Disorder (GAD-7) symptom inventory.[11] Tobit regression is a tool for modeling differences by exposure status in an underlying dependent variable (e.g., anxiety) assumed to be normally-distributed whose true values are censored by the measurement instrument. GAD-7 scores range from 0 to 21 for anxiety symptom severity, thereby censoring underlying trait anxiety.

We adjusted models for age (continuous), gender (male/female), race (white/black/other), Hispanic ethnicity (yes/no), smoking status (never/former/current), binge drinking (yes/no), exercise (yes/no), marital status (married/not currently married), and employment status (employed [employed for wages, self-employed] / not employed [out of work, unable to work] / other [homemaker, student, retired]). We further added interaction terms with how often people felt they had the emotional support they needed (always/usually/sometimes/rarely/never), and perceived self-mastery, a confirmatory factor analysis score derived from 5 items (strength of agreement with “I have little control over the things that happen to me”, “What happens to me in the future mostly depends on me”, “I can do just about anything I really set my mind to do”, “I

am confident in my ability to handle unexpected problems", and "When I need suggestions about how to deal with a personal problem, I know there is someone I can turn to").[12]

In fully adjusted models, we tested for an interaction between direct contact with oil and participation in oil spill cleanup efforts. We also examined the association of cleanup participation with anxiety, controlling for the same confounders among the subpopulation with direct oil exposure, and tested for interactions with emotional support and self-mastery. We used survey estimation methods to account for the survey design, with singleton primary sampling units treated as certainty units. Missing data were handled by multiple imputation by chained equations with 80 imputations.[13] All analyses were conducted using Stata S/E 15.1.

**RESULTS**

Characteristics of the weighted study population are provided in Table 1. Trait anxiety was 2.98 units higher (95% CI: 0.90, 5.06) among individuals directly exposed to oil compared to individuals not exposed to oil, after controlling for confounders (Table 2). There was no heterogeneity in the oil-anxiety association across levels of emotional support (4-degrees-of-freedom F test: p=0.64) (Table 3). There was also no significant effect modification of oil exposure's association with trait anxiety by self-mastery. Anxiety was 2.37 units lower (95% CI: -8.41, 3.66) among individuals with the maximum estimated value of self-mastery and who were exposed to oil compared to those who were not exposed. Anxiety was 8.41 units higher (95% CI: -0.20, 16.61) among individuals with the minimum estimated value of self-mastery and who were exposed to oil compared to those who were not exposed. There was, however, a significant antagonistic interaction between direct oil exposure and participation in cleanup activities for trait anxiety.

Among individuals directly exposed to oil, cleanup participation was associated with 3.83 less units of anxiety, after controlling for confounders (95% CI: -6.55, -1.12) (Table 4). Among individuals exposed to oil, there was no significant interaction between participating in cleanup activities and emotional support for trait anxiety (4-degrees-of-freedom F test: p=0.09) (Table 5). Individuals with the maximum estimated value of self-mastery and who were exposed to oil had 4.65 less units of anxiety when participating in an oil spill cleanup versus not participating (95% CI: -5.98, 15.28). Individuals with the minimum estimated value of self-mastery and who were exposed to oil had 13.50 less units of anxiety when participating in an oil spill cleanup versus not participating (95% CI: -25.92, -1.07). Thus, although the interaction term between cleanup participation with self-mastery among those directly exposed to oil was not statistically significant (p=0.12), there is suggestive evidence that participation may have had a larger benefit among individuals with lower self-mastery. Among individuals exposed to oil, there was no significant interaction between participating in cleanup activities and being paid for cleanup activities for trait anxiety, with a β-coefficient for the fully adjusted model of -0.88 (95% CI: -7.19, 5.42).

## DISCUSSION & CONCLUSIONS

This study found positive associations of oil contact with anxiety that were attenuated among those who participated in oil spill cleanup efforts. Although previous Deepwater Horizon oil spill research has shown cleanup work to be associated with adverse mental health effects,[1,2] with several moderating factors, we found that individuals exposed to oil had lower anxiety when they also participated in cleanup activities.

Increasing civilian participation in disaster-related cleanup activities may increase resilience and recovery of individuals and the surrounding community.[14] Findings have also shown that individuals tend to participate more in cleanup activities if they live in areas closest to and directly impacted by the oil spill.[14] Moreover, this study agrees with previous research on the effect of general volunteering on mental health. In a longitudinal study in the United Kingdom, individuals who engaged in volunteering regularly appeared to have higher levels of mental well-being compared to those who never volunteered.[15] A 2017 cross-sectional study found that combat veterans who volunteered in disaster relief social service organizations reported positive mental health responses as a result of helping those in need.[16]

This study had several limitations. Because this was a cross-sectional survey, there was potential for reverse causality between cleanup activity events and anxiety symptoms both assessed after the oil spill.[17] It is also unknown whether respondents who participated in oil spill cleanup activities were healthier at baseline and had fewer mental health conditions. As the GSPS was a random-digit-dial telephone survey, the associations may introduce bias due to potential effects of recall bias or social desirability bias among the GSPS study participants.[18] Future longitudinal cohort studies would allow researchers to compare exposed and unexposed populations on short-term and long-term health effects[19], validating prior cross-sectional studies.

Anxiety disorders are the most prevalent mental health condition in the United States and can be severely disabling.[20] Generalized anxiety disorders account for 2.8%-8.5% of cases in routine general medical examinations and 1.6%-5.1% in individuals aged 15-45 years in the United States population.[21-23] Generalized anxiety disorders have been found to potentially be risk factors for comorbid conditions, such as depression and medically unexplained symptoms,[24] and more specific anxiety disorders, such as panic disorders, social anxiety disorders, and

specific phobias.[25] Although this cross-sectional study is limited in its ability to draw firm causal inferences, the findings from this paper raise the possibility that safe cleanup participation activities could limit mental health harm from oil spills and that assessing the impact of volunteering in recovery activities, such as oil spill cleanups, may benefit those impacted by disasters. Further research, such as trials evaluating post-oil exposure cleanup participation as an intervention, is needed.

**Table 1. Characteristics of the weighted survey population, stratified by direct oil contact and participation in cleanup activities during the Deepwater Horizon oil spill.**

| Characteristic | Direct oil contact | No direct oil contact | Participated in cleanup activities | Did not participate in cleanup activities |
|---|---|---|---|---|
| **Gender (%)** | | | | |
| Female | 45.63 (0.38, 0.53) | 52.15 (0.50, 0.54) | 43.91 (0.33, 0.54) | 52.09 (0.50, 0.54) |
| Male | 54.37 (0.47, 0.62) | 47.85 (0.46, 0.50) | 56.09 (0.46, 0.67) | 47.91 (0.46, 0.50) |
| **Mean age (years)** | 42.80 (39.56, 46.04) | 48.64 (47.79, 49.49) | 38.68 (34.96, 42.40) | 48.71 (47.89, 49.54) |
| **Mean GAD-7 Score** | 6.30 (4.90, 7.70) | 3.96 (3.68, 4.24) | 3.60 (2.57, 4.59) | 4.15 (3.86, 4.44) |
| **Race (%)** | | | | |
| White | 76.51 (0.68, 0.85) | 69.28 (0.67, 0.72) | 72.01 (0.61, 0.83) | 69.66 (0.67, 0.72) |
| Black | 10.53 (0.07, 0.14) | 20.49 (0.19, 0.22) | 17.58 (0.08, 0.27) | 19.92 (0.18, 0.22) |
| Other | 12.96 (0.04, 0.22) | 10.23 (0.08, 0.12) | 10.41 (0.04, 0.17) | 10.41 (0.09, 0.12) |
| **Hispanic Ethnicity (%)** | | | | |
| Yes | 13.04 (0.04, 0.23) | 11.27 (0.09, 0.13) | 8.04 (0.01, 0.15) | 11.56 (0.10, 0.13) |
| No | 86.96 (0.77, 0.96) | 88.73 (0.87, 0.91) | 91.96 (0.85, 0.99) | 88.44 (0.87, 0.90) |
| **Employment (%)** | | | | |
| Employed | 59.96 (0.52, 0.68) | 52.09 (0.50, 0.54) | 63.93 (0.53, 0.75) | 52.07 (0.50, 0.54) |
| Not Employed | 15.48 (0.10, 0.21) | 15.50 (0.14, 0.17) | 11.82 (0.06, 0.18) | 15.68 (0.14, 0.17) |
| Other | 24.56 (0.18, 0.32) | 32.41 (0.30, 0.35) | 24.25 (0.13, 0.35) | 32.26 (0.30, 0.34) |
| **Marital status (%)** | | | | |
| Married | 51.35 (0.43, 0.59) | 52.01 (0.50, 0.54) | 42.55 (0.32, 0.53) | 52.42 (0.50, 0.55) |
| Not Married | 48.65 (0.41, 0.57) | 47.99 (0.46, 0.50) | 57.45 (0.47, 0.68) | 47.58 (0.45, 0.50) |
| **Exercise (%)** | | | | |
| Yes | 81.66 (0.76, 0.88) | 72.84 (0.71, 0.75) | 89.40 (0.84, 0.95) | 72.65 (0.71, 0.75) |
| No | 18.34 (0.12, 0.24) | 27.16 (0.25, 0.29) | 10.60 (0.05, 0.16) | 27.35 (0.25, 0.29) |
| **Binge drinking (%)** | | | | |
| Yes | 22.49 (0.17, 0.28) | 14.82 (0.13, 0.16) | 71.34 (0.62, 0.81) | 85.31 (0.84, 0.87) |
| No | 77.51 (0.72, 0.83) | 85.18 (0.84, 0.87) | 28.66 (0.19, 0.38) | 14.69 (0.13, 0.16) |
| **Smoking (%)** | | | | |
| Never | 52.13 (0.44, 0.60) | 54.50 (0.52, 0.57) | 49.67 (0.39, 0.60) | 54.57 (0.52, 0.57) |
| Former | 21.22 (0.15, 0.27) | 23.72 (0.22, 0.26) | 22.19 (0.13, 0.32) | 23.61 (0.22, 0.25) |
| Current | 26.65 (0.20, 0.33) | 21.78 (0.20, 0.24) | 28.14 (0.19, 0.37) | 21.82 (0.20, 0.24) |
| **Emotional support (%)** | | | | |
| Always | 40.21 (0.32, 0.48) | 50.00 (0.48, 0.52) | 52.81 (0.42, 0.63) | 49.16 (0.47, 0.51) |
| Usually | 32.82 (0.26, 0.40) | 27.04 (0.25, 0.29) | 32.08 (0.23, 0.41) | 27.20 (0.25, 0.29) |
| Sometimes | 15.86 (0.11, 0.21) | 14.40 (0.13, 0.16) | 6.34 (0.02, 0.10) | 14.89 (0.13, 0.16) |
| Rarely | 6.71 (0.03, 0.10) | 3.96 (0.03, 0.05) | 4.82 (0.01, 0.09) | 4.11 (0.03, 0.05) |
| Never | 4.39 (0.01, 0.08) | 4.61 (0.04, 0.06) | 3.95 (-0.00, 0.08) | 4.63 (0.04, 0.06) |

**Table 2. Associations between direct contact with oil and latent trait anxiety in communities participating in the Gulf States Population Survey.**

| Model | Differences in Anxiety (95% CI) |
|---|---|
| Model 1: Unadjusted association | 3.50 (1.63, 5.37) |
| Model 2: Adjusted for age, race, Hispanic ethnicity, gender | 3.42 (1.64, 5.21) |
| Model 3: Further adjusted for exercise, smoking, and binge drinking | 3.54 (1.67, 5.41) |
| Model 4: Further adjusted for employment and marital status | 3.45 (1.58, 5.31) |
| Model 5: Further adjusted for self-mastery and emotional support | 2.98 (0.90, 5.06) |

Note: CI, confidence intervals.

**Table 3. Associations between direct contact with oil and anxiety, by frequency of emotional support in communities participating in the Gulf States Population Survey.**

| Emotional Support | Differences in Anxiety (95% CI) |
|---|---|
| Always get emotional support | 4.85 (0.76, 8.93) |
| Usually get emotional support | 1.14 (-0.85, 3.13) |
| Sometimes get emotional support | 1.61 (-0.97, 4.20) |
| Rarely get emotional support | 2.86 (-1.05, 6.78) |
| Never get emotional support | 2.31 (-6.33, 10.96) |

Note: CI, confidence intervals.

**Table 4. Differences in latent trait anxiety between individuals participating in oil spill cleanup activities compared to individuals not participating in oil spill cleanup activities, among individuals with direct contact with oil in communities participating in the Gulf States Population Survey.**

| Model | Differences in Anxiety (95% CI) |
|---|---|
| Model 1: Unadjusted association | -3.93 (-7.42, -0.43) |
| Model 2: Adjusted for age, race, Hispanic ethnicity, gender | -3.58 (-6.76, -0.41) |
| Model 3: Further adjusted for exercise, smoking, and binge drinking | -3.61 (-6.71, -0.50) |
| Model 4: Further adjusted for employment and marital status | -3.75 (-6.57, -0.94) |
| Model 5: Further adjusted for self-mastery and emotional support | -3.83 (-6.55, -1.12) |

Note: CI, confidence intervals.

**Table 5. Associations between oil spill cleanup participation and anxiety, by frequency of emotional support in communities participating in the Gulf States Population Survey.**

| Emotional Support | Differences in Anxiety (95% CI) |
|---|---|
| Always get emotional support | -4.04 (-7.62, -0.46) |
| Usually get emotional support | -4.45 (-9.20, 0.29) |
| Sometimes get emotional support | 1.80 (-2.41, 6.01) |
| Rarely get emotional support | -6.74 (-11.83, -1.65) |
| Never get emotional support | -3.43 (-14.89, 8.03) |

Note: CI, confidence intervals.

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