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Why Does Disaster Recovery Work Influence Mental Health?: Pathways through Physical Health and Household Income

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Abstract

Disaster recovery work increases risk for mental health problems, yet the mechanisms underlying this association are unclear. We explored links from recovery work to posttraumatic stress (PTS), major depression (MD) and generalized anxiety disorder (GAD) symptoms through physical health symptoms and household income in the aftermath of the *Deepwater Horizon* oil spill. As part of the NIEHS GuLF STUDY, participants (N = 10,141) reported on cleanup work activities, spill-related physical health symptoms, and household income at baseline, and mental health symptoms an average of 14.69 weeks (SD = 16.79) thereafter. Cleanup work participation was associated with higher physical health symptoms, which in turn were associated with higher PTS, MD, and GAD symptoms. Similar pattern of results were found in models including workers only and investigating the influence of longer work duration and higher work-related oil exposure on mental health symptoms. In addition, longer worker duration and higher work-related oil exposure were associated with higher household income, which in turn was associated with lower MD and GAD symptoms. These findings suggest that physical health symptoms contribute to workers' risk for mental health symptoms, while higher household income, potentially from more extensive work, might mitigate risk.

Keywords

Disaster recovery work; *Deepwater Horizon* oil spill; posttraumatic stress; major depression; generalized anxiety; physical health; income; path analysis

In the aftermath of disasters, recovery workers play an important role in minimizing damages and losses and restoring community functioning as quickly as possible. Unfortunately, involvement in recovery work has been associated with an increased risk for

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mental health problems across a range of postdisaster settings, including terrorist attacks, and oil spills (e.g., Cuckor et al., 2011; Palinkas, Petterson, Russell, & Downs, 1993). Not all recovery workers experience postdisaster mental health problems, however, and an understanding of the mechanisms underlying the mental health of disaster recovery workers could yield important observations that could mitigate the risk in this population.

In the current study, we focus on the mental health consequences of disaster recovery work involving cleanup activities in the aftermath of the *Deepwater Horizon* oil spill. At least two mechanisms could link disaster recovery work to mental health outcomes in this context. First, cleanup work could contribute to adverse mental health outcomes through physical health. That is, participation in cleanup work could be associated with higher physical health symptoms that in turn are associated with higher mental health symptoms. The relationship between cleanup work and physical health symptoms has received mixed support. A general population study showed no differences in physical distress between Gulf Coast residents who were and were not involved in cleanup activities after the *Deepwater Horizon* oil spill (Fan, Prescott, Zhao, Gotway, & Galea, 2014); however, the study's coverage of the most affected communities was limited. Other investigations in the aftermath of prior spills have shown involvement in cleanup work to be associated with increased risk for a range of acute respiratory conditions, including cough, shortness of breath, and decreased forced vital capacity, as well as nausea, dizziness, headaches, and skin and eye irritation (e.g., Aguilera, Mendez, Pasaro, & Laffon, 2010). No published study to our knowledge has assessed whether cleanup workers' physical health symptoms are predictive of their mental health. However, general population studies in the aftermath of the *Deepwater Horizon* oil spill have found significant positive associations between indicators of physical health (e.g., concerns about the physical health effects of the spill, chronic health conditions) and a range of mental health conditions (Fan et al., 2014; Gill, Piccou, & Richie, 2012). Larger bodies of research have also demonstrated consistent links between the physical health conditions associated with cleanup work and mental health both in the aftermath of other disasters (e.g., Polusny et al., 2008) and in the general population (e.g., Scott et al., 2007; Peterlin et al., 2011).

Second, income from cleanup work might mitigate potential mental health consequences. That is, participation in cleanup work could be associated with higher income than other employment opportunities, which in turn could be associated with lower mental health symptoms. News reports in the aftermath of the spill cited hourly wage ranges for cleanup jobs from $12 to $32 that were higher than the 2010 federal minimum wage of $7.25, increased wages for ship captains, and overtime pay (Bureau of Labor Statistics, 2011; Clifford, 2010; Pounds, 2010). Additionally, BP and government agencies launched efforts to create cleanup work opportunities for unemployed workers, including workers whose jobs were displaced as a direct result of the spill (Brown, 2010; Clifford, 2010). It is therefore possible that participation in cleanup work, versus non-participation, was associated with higher income for many eligible workers in the area. Since cleanup workers were drawn from the impacted Gulf community, those who participated in cleanup also may have suffered fewer financial losses than others whose livelihoods were jeopardized by the spill. Several published studies in the aftermath of the *Deepwater Horizon* oil spill have demonstrated significant associations between income loss and more severe psychological

symptoms (e.g., Drescher, Schulenberg, & Smith, 2014; Fan et al., 2014; Grattan et al., 2013). However, none to our knowledge has examined relationships between higher levels of income and mental health in this context. The larger body of research on income and mental health suggests that this relationship is complex, depending on such factors as levels of inequality and subjective social status (Adler, Epel, Castellano, & Ickovics, 2000; Kahn, Wise, Kennedy, & Kawachi, 2000). Nonetheless, with few exceptions (e.g., McMillan, Enns, Asmundson, & Sareen, 2010), epidemiological studies have provided evidence that higher income decreases the likelihood of mood and anxiety disorders (Lorant, Deliège, Eaton, Robert, Philippot, & Ansseau, 2003; Sareen, Afifi, McMillan, & Admundson, 2011).

In summary, although research on this topic is limited, it suggests two mechanisms through which cleanup work after the *Deepwater Horizon* oil spill could be associated with mental health in addition to main effects of work-related exposures. First, it suggests that cleanup work is associated with physical health symptoms that in turn increase risk for mental health conditions. Second, it suggests that income linked to cleanup work might mitigate some of the potential mental health consequences. However, only one study to our knowledge has examined mechanisms from disaster recovery work to mental health. Among recovery workers in the aftermath of the 9/11 terrorist attacks, the extent to which workers perceived other recent life experiences (e.g., death of a close family member, getting married) had had a negative impact mediated the relationship between disaster work exposure and symptoms of posttraumatic stress (PTS), major depression (MD), and generalized anxiety disorder (GAD) (McCaslin et al., 2005). This study did not isolate indirect pathways through events specifically related to income and physical health, however, and is further limited by its cross-sectional design and potential for reverse causality between perceptions of life events and psychological symptoms.

The literature on this topic is limited in at least five ways. First, studies have not looked at whether specific aspects of recovery work (e.g., duration of work, exposure to potentially hazardous materials) are associated with psychological symptoms. Work characteristics could also influence factors within mechanistic pathways, such that, for example, longer tenure of work might be associated with higher income, and greater exposure to potentially hazardous materials with more physical health symptoms (e.g., Aguilera et al., 2010). Second, with a few exceptions (e.g., Cuckor et al., 2011), most studies have relied on cross-sectional data, potentially leading to inflated estimates of mental health impacts. Third, no published study on disaster workers to our knowledge has accounted for predisaster mental or physical health, making the extent to which postdisaster symptoms represent emergent or ongoing difficulties unclear. Fourth, studies have not controlled for comorbid psychological symptoms and have therefore provided limited information on whether the mental health impacts of recovery work are specific to a certain class, or classes, of symptoms. Finally, only one study to our knowledge has investigated the mental health consequences of cleanup work in the aftermath of the *Deepwater Horizon* oil spill (Fan et al., 2014). Using data from a large population-based study, the authors found that participation in cleanup work was not significantly associated with frequent mental distress or current depression. Mechanisms linking cleanup work to mental health in this context were not explored, however.

Current Study

The current study examined mechanisms linking cleanup work in the aftermath of the *Deepwater Horizon* oil spill to mental health (PTS, MD, and GAD symptoms) through physical health symptoms and 2010 household income. We assessed mechanistic pathways from cleanup work participation for the full sample, as well as from two aspects of cleanup work (duration and oil exposure) among workers only. Data were collected at two time points – cleanup work, retrospective reports of physical health symptoms during the spill, and 2010 household income were collected at enrollment between March 2011 and March 2013 (Wave 1; W1), and mental health symptoms at subsequent home visit assessments an average of 14.69 weeks later (Wave 2; W2). Predisaster mental and physical health were also assessed at W1 and controlled for in the analysis, providing greater insight into pre to postdisater changes in these constructs. Models controlled for comorbid symptoms, allowing for greater specificity in the assessment of the direct and indirect mental health impacts of cleanup work.

Methods

Procedures

Data were from the National Institute of Environmental Health Sciences (NIEHS) Gulf Long-Term Follow-Up STUDY (GuLF STUDY), a prospective cohort study of cleanup workers from the *Deepwater Horizon* oil spill. Working from multiple lists of persons involved in the cleanup effort, 58,923 individuals who were presumed eligible (age 21 or over and capable of completing an interview in English, Spanish, or Vietnamese) and had sufficient contact information were identified as potential participants. A total of 32,608 participants (55% of potentially eligible individuals; 90% of those contacted and confirmed to be eligible) completed a telephone interview at W1, between March 2011 and March 2013, an average of 87.30 weeks after the well was capped on July 15, 2010 (SD = 19.63; Range: 36.57–141.14). The survey assessed details of the participant's cleanup work, if any, as well as demographic characteristics, medical histories, and physical health symptoms at the time of the spill. Participants were classified as workers if they participated in at least one full day of cleanup work. W1 interviews averaged 30 minutes.

A subsample of 24,275 English- or Spanish-speaking participants residing in Gulf states was invited to participate in the W2 assessment, which was conducted in the participant's home and consisted of collection of biological samples, clinical assessments, and additional interview data collection, including structured mental health indices. Although 17,833 (73.5%) initially agreed to participate, 11,193 (62.3%), including 8,968 cleanup workers, completed W2 an average of 14.79 weeks (SD = 16.72) after W1. Relative to the full W1 sample, W2 participants reported significantly lower socioeconomic status, more health problems, and were more likely to be racial/ethnic minorities. The Institutional Review Board of NIEHS approved the study procedures, and participants provided verbal consent at W1 and written consent at W2.

Participants

The current study included participants who completed both W1 and W2. Among these participants, the subsample of 8,968 workers included 1,052 (11.7%) workers who received paychecks from government sources, ranging from the federal to the town level (*government workers*). Government workers were systematically different from non-government workers, for example reporting significantly longer duration of cleanup work, significantly lower exposure to oil, significantly greater 2010 household income, and significantly fewer spill-related physical health symptoms. Because these differences could influence the magnitude and direction of pathways in our hypothesized models, government workers were excluded from the analysis. Therefore, the final sample for the current study consisted of 10,141 participants, 7,916 workers and 2,225 non-workers, who completed W2 an average of 14.69 weeks ($SD = 16.79$) after W1. Demographic characteristics for the final sample are listed in Table 1. We note here that 203 of the workers in the final sample (2.6%) were missing data on source of paycheck, and analyses were replicated excluding these participants.

Measures

Duration of cleanup work—At W1, workers provided details of their cleanup work employment, including the number of tasks they performed, and the start and end dates for each task and for their overall oil spill work. This information was used to determine the total number of days workers were involved in cleanup efforts.

Cleanup work-related oil exposure—Cleanup workers provided extensive details at W1 about each cleanup work-related position they had held, including the setting of each position (e.g., rig, barge, boat or ship, land; names of all vessels worked), job title (e.g., driller, electrician, housekeeper), and activities performed (from a list of approximately 100 activities), and dates worked. A team of industrial hygienists with over 100 years combined of exposure assessment experience developed a semi-quantitative job exposure matrix to estimate the levels of oil spill-related chemical exposures for study participants based on the jobs and activities that they reported. From the reported activities and other job characteristics, groups of activities that were expected to have similar distributions of total hydrocarbon (THC) exposure within a given period of time during the cleanup were identified. These exposure groups were then linked to data on exposure measurements taken by BP and its contractors during the oil spill to assess workers' personal inhalant exposures. Specifically, approximately 26,000 personal airborne measurements of THC exposure were collected via passive dosimeters worn by workers during the cleanup. These workers were not necessarily those who participated in the GuLF STUDY, although there may have been some overlap. Arithmetic means of THC exposure were calculated for each exposure group identified in the job exposure matrix. Arithmetic means were then mapped onto an ordinal intensity score that mimicked a log-based scale, ranging from 1 to 7, with higher values indicating greater THC exposure. THC exposure scores were then assigned to each task reported by GuLF STUDY participants. An overall measure of maximum THC exposure level was developed based on the highest exposure job held and the highest exposure level across time periods in a specific exposure group. Additional information on developing the exposure measure, including handling of values below the limit of detection and how measurement censoring was handled can be found elsewhere (Huynh et al., 2014).

Physical health symptoms—At W1, participants completed a 24-item inventory indicating how often they experienced physical health symptoms (e.g., “cough,” “watery or itchy eyes”) at the time of the spill, from *never* (0) to *all of the time* (4). Scale items were derived from standard inventories of respiratory symptoms (e.g., Ferris, 1978) as well research on the physical health effects of oil spills (e.g., Aguilera et al., 2010). For the present analysis, responses were summed to create a spill-related physical health symptom severity score (range: 0–96).

Household income in 2010—Participants reported on their annual household income in 2010 at W1, and their responses were coded on an ordinal scale ranging from 1 (*less than $10,000*) to 13 (*more than $200,000*).

Posttraumatic stress symptoms—At W2, participants completed the four-item Primary Care PTSD Screen (Prins et al., 2003), on which they indicated whether they experienced symptoms from each *DSM-IV* PTSD symptom cluster over the prior month, and the sum of affirmative responses, ranging from 0–4, was included (α = .76). Scores of 3 or 4 are indicative of probable PTSD (Prins et al., 2003).

Generalized anxiety symptoms—Participants completed the seven-item Generalized Anxiety Disorder-7 (*GAD-7*) at W2. Participants were asked how many days during the past two weeks they were bothered by anxiety symptoms (e.g., “feeling nervous, anxious or on edge”). For each item, participants’ responses were classified into four levels (0 = 0–1 days; 1 = 2–6 days; 2 = 7–11 days; 3 = 12–14 days) and a sum of the responses was included (range: 0–21). The GAD-7 has been shown to have excellent internal consistency and test-retest reliability, with scale scores of 10 or greater indicative of probable GAD (Spitzer, Kroenke, Williams & Lowe, 2006) (α = .93).

Major depression symptoms—At W2, the Patient Health Questionnaire-8 (*PHQ-8*) assessed how many days over the past two weeks participants experienced eight symptoms of MD (e.g., “felt down, depressed, or hopeless”). The same categories for items were used as with the GAD-7, and the sum of items was included (range: 0–24). Previous studies have found the PHQ-8 to have excellent internal consistency, test-retest reliability, and construct validity, with scores of 10 or greater indicative of probable MD (Kroenke, Spitzer, & Williams, 2001) (α = .90).

Pre-spill physical health conditions—At W1, participants reported on whether they had ever been diagnosed with 13 physical health conditions (e.g., asthma, emphysema, coronary heart disease, cancer) and, if so, the approximate date or their age at the time of first diagnosis. This information was used to determine whether participants had a pre-spill diagnosis of each condition, and the total sum of pre-spill physical health conditions was included.

Pre-spill mental health diagnosis—Participants reported at W1 whether they had ever been diagnosed with any of the following: acute stress disorder, anxiety, panic disorder, PTSD, and depression. Participants who answered affirmatively indicated either the

approximate date or their age at the time of first diagnosis, which determined whether the participant had a pre-spill probable mental health diagnosis.

Data Analysis

Data analysis consisted of three path analytic models in which cleanup work was both directly associated with W2 PTS, MD, and GAD symptoms, and indirectly associated with them through 2010 household income level and physical health symptoms at the time of the spill. Model 1 included all participants and a dichotomous indicator of whether participants completed one day or more of cleanup work as the exposure. Model 2 included cleanup workers only and the duration of cleanup work as the exposure. To facilitate interpretation of model coefficients for direct and indirect pathways including duration, we divided the number of days of cleanup work by the interquartile range of this variable (*IQR* = 120.00). Model 3 also included cleanup workers only and cleanup work-related oil exposure as the exposure. All models included a pathway from pre-spill physical health conditions to physical symptoms at the time of the spill, a pathway from the dichotomous indicator of whether the participant had a pre-spill probable mental health diagnosis to W2 PTS, MD and GAD symptoms, and covariances between W2 PTS, MD and GAD symptoms. The models included participants with complete data on the three exogenous variables (the exposure, pre-spill physical health conditions, and pre-spill probable mental health diagnosis). Maximum likelihood estimation with robust standard errors, via the MLR estimator, was used to handle missing data on endogenous variables, as well as non-normality. Prior to the analysis, we evaluated for differences between cases with complete and incomplete data on exogenous variables for each model using Bonferroni-corrected independent samples *t*-tests and chi-square analysis. Goodness of fit of tested models was evaluated using the Root Mean Square Error of Approximation (RMSEA) and its 90% confidence interval (CI), and the Comparative Fit Index (CFI). The following criteria were used to determine acceptable model fit: RMSEA and its upper limit close to or below 0.06, and CFI close to or above 0.95 (Hu & Bentler, 1999). In cases of poor model fit, modification indices were inspected and models with additional, non-hypothesized paths were tested. Indirect effects from exposures to each class of W2 symptoms through 2010 household income level and physical health conditions at the time of the spill were computed as the product of the path from the exposure to the mediator and the path from the mediator to the outcome. Path analyses were conducted in Mplus 7.1 (Muthén & Muthén, 1998–2012), and data management, descriptive statistics, and missing data analysis were conducted in SPSS 21.0 (IBM Corp., 2011). As mentioned previously, in supplementary analysis, we replicated the path analytic models excluding the 203 workers (2.6%) who were missing data on whether they received paychecks from government sources.

Results

Descriptive Statistics

Table 1 shows descriptive data for participant demographics and variables included in the analysis. The majority of participants (78.2%) were male, and 53.7% identified as White, 35.5% as Black, and 6.0% as Hispanic. On average, participants were 44.05 years old (*SD* = 13.13; Range: 21–90), and 21.8% had less than a high school education. Among workers,

the average duration of cleanup work was 142.25 days (*SD* = 139.75), and the average maximum level of oil exposure was 4.50 (*SD* = 1.08; Range: 2–7). At W2, 5.5% of participants met the criterion for probable PTSD, 24.9% for probable GAD, and 16.5% for probable MD.

Missing Data Analysis

In Model 1, 2.1% of the participants ($n = 210$) were dropped due to missing data on one or more of the exogenous variables; 1.8% of workers ($n = 142$) were dropped in Model 2, and 2.2% ($n = 175$) were dropped in Model 3. Participants dropped due to missing data in Model 1 had significantly lower 2010 household income ($t[187.34] = -5.33$, $p < .001$, equal variances not assumed), significantly higher physical health symptoms at the time of the spill ($t[9,094] = 7.73$, $p < .001$), higher W2 PTS, MD, and GAD symptoms ($t[208.50] = 3.36$, $p < .001$, $t[197.84] = 6.45$, $p < .001$, and $t[205.36] = 6.84$, $p < .001$, respectively, equal variances not assumed), and were less likely to have completed at least one day of cleanup work ($\chi^2[1] = 13.65$, $p < .001$), compared to those who were included. Participants dropped due to missing data in Model 2 had significantly lower 2010 household income ($t[132.73] = -4.32$, $p < .001$, equal variances not assumed), significantly higher physical health symptoms at the time of the spill ($t[7,121] = 5.15$, $p < .001$), and significantly higher MD and GAD symptoms ($t[134.04] = 5.20$, $p < .001$ and $t[137.93] = 5.23$, $p < .001$, respectively, equal variances not assumed), compared to those who were included. Participants dropped due to missing data in Model 3 had significantly lower 2010 household income ($t[170.37] = -5.01$, $p < .001$, equal variances not assumed), significantly higher physical health symptoms at the time of the spill ($t[7,121] = 5.31$, $p < .001$) and significantly higher MD and GAD symptoms ($t[167.93] = 4.45$, $p < .001$ and $t[173.35] = 4.62$, $p < .001$, respectively, equal variances not assumed), compared to those who were included.

Path Analysis

Model 1—The initial model including cleanup work as the exposure had unacceptable fit with the data, *RMSEA* = .09 (90% CI = .08–.10), *CFI* = .96, and inspection of modification indices suggested the addition of a covariance between 2010 household income level and physical health symptoms at the time of the spill. The model with this addition had acceptable fit, *RMSEA* = .03 (90% CI = .02–.04), *CFI* > .99, and is illustrated in Figure 1a. As shown, having worked on the oil spill was significantly associated with higher W2 PTS, MD and GAD symptoms and higher physical health symptoms at the time of the spill, but was not significantly associated with higher 2010 household income. Higher 2010 household income was significantly associated with lower W2 MD and GAD symptoms, but not significantly associated with PTS symptoms. Higher physical health symptoms at the time of the spill were associated with higher W2 PTS, MD and GAD symptoms. Analysis of indirect effects showed that working on the oil spill had a positive indirect effect through physical health symptoms at the time of the spill on W2 symptoms of PTS (*Est.* = .04, *SE* = .01, $p < .001$), MD (*Est.* = .29, *SE* = .05, $p < .001$), and GAD (*Est.* = .34, *SE* = .05, $p < .001$). In contrast, none of the indirect effects through 2010 household income reached statistical significance (PTS: *Est.* < .001, *SE* < .001, $p = .598$; MD: *Est.* = −.01, *SE* = .01, $p = .235$; GAD: *Est.* = −.01, *SE* = .01, $p = .247$).

Model 2—As with Model 1, the initial model containing cleanup work duration had unacceptable fit with the data (*RMSEA* = .10 [90% CI = .09–.11], *CFI* = .95), but acceptable fit when the covariance between 2010 household income level and physical health symptoms at the time of the spill was included (*RMSEA* = .03 [90% CI = .03–.04], *CFI* > .99). The final Model 2 is illustrated in Figure 1b. As shown, longer duration of cleanup work was significantly associated with lower W2 MD and GAD symptoms, whereas the direct path to W2 PTS symptoms was non-significant. Longer duration of cleanup work was associated with significantly higher 2010 household income and physical health symptoms at the time of the spill. Higher 2010 household income was significantly associated with lower W2 MD and GAD symptoms, whereas the path from 2010 household income to W2 PTS symptoms was non-significant. Higher physical health symptoms at the time of the spill were associated with significantly higher W2 PTS, MD, and GAD symptoms. Indirect effects analysis found that longer duration of cleanup work had a significant positive indirect effect through higher physical health symptoms at the time of the spill on W2 symptoms of PTS (*Est.* = .03, *SE* < .01, *p* < .001), MD (*Est.* = .22, *SE* = .02, *p* < .001) and GAD (*Est.* = .26, *SE* = .03, *p* < .001), and a significant negative indirect effect through higher 2010 household income on W2 symptoms of MD (*Est.* = −.01, *SE* = .01, *p* = .009) and GAD (*Est.* = −.01, *SE* = .01, *p* = .037). The indirect path from duration of cleanup work to PTS through 2010 household income was non-significant (*Est.* < .001, *SE* < .001, *p* = .990).

Model 3—Again, the initial model containing oil exposure had unacceptable fit with the data (*RMSEA* = .10 [90% CI = .09–.10], *CFI* = .95), but acceptable fit when the covariance between 2010 household income level and physical health symptoms at the time of the spill was included (*RMSEA* = .03 [90% CI = .03–.04], *CFI* > .99). In the final version of Model 3 (Figure 1c), oil exposure was significantly associated with higher W2 PTS and GAD symptoms, whereas the direct path from oil exposure to W2 MD symptoms was non-significant. Oil exposure was also significantly associated with higher physical health symptoms at the time of the spill and higher 2010 household income. As in Models 1 and 2, higher 2010 household income was significantly associated with lower W2 MD and GAD symptoms, but not significantly associated with W2 PTS symptoms. Higher physical health symptoms at the time of the spill were significantly associated with higher W2 PTS, MD and GAD symptoms. Indirect effects analysis found that higher oil exposure had a significant positive indirect effect through higher physical health symptoms at the time of the spill on W2 symptoms of PTS (*Est.* = .04, *SE* < .01, *p* < .001), MD (*Est.* = .29, *SE* = .02, *p* < .001), and GAD (*Est.* = .33, *SE* = .03, *p* < .001), and a significant negative indirect effect through higher 2010 household income on W2 symptoms of MD (*Est.* = −.01, *SE* < .001, *p* = .031) and GAD (*Est.* = −.01, *SE* < .001, *p* = .044). The indirect path from oil exposure to PTS through 2010 household income was non-significant (*Est.* = < .01, *SE* < .01, *p* = .637).

Supplementary analyses—After excluding the 203 workers (2.6%) who were missing data on source of paycheck, the magnitude, direction, and statistical significance of all pathways within each model were consistent with the respective model including these participants. The full results of these analyses are available upon request.

Discussion

In this study, we sought to understand why disaster recovery work influences mental health outcomes through analysis of data from a large cohort study of participants who completed cleanup work training after the *Deepwater Horizon* oil spill. We found consistent support for a model wherein cleanup work-related exposures were both directly associated with higher levels of three classes of psychiatric symptoms (PTS, MD and GAD symptoms) and indirectly associated with higher psychiatric symptoms through higher spill-related physical health symptoms. Additionally, we found that, among workers, longer duration of work and work that involved more exposure to oil were indirectly associated with lower psychiatric symptoms through higher levels of 2010 household income. Taken as a whole, the results suggest that investigating only the direct impact of disaster recovery work may, on the one hand, underestimate the negative impacts of such experiences through increased physical health problems, and on the other, could obscure the potential mental health benefits of more extensive involvement in cleanup work, both in terms of longer duration and greater exposure to oil, through higher household income.

Although our results were generally consistent across different aspects of cleanup work and different mental health outcomes, there were some noteworthy exceptions. For example, whereas among the full sample, participation in cleanup work was associated with higher levels of all three symptom classes, among the subsample of workers only, longer duration of work was uniquely associated with lower MD and GAD symptoms and higher oil exposure with higher PTS and GAD symptoms. In addition, across all of the models, higher 2010 household income was significantly associated with lower GAD and MD symptoms, but not with PTS symptoms. It is possible that both longer duration of work and higher household income serve as markers of job stability, which could ease general anxiety and hopelessness about the future, but not protect against mental health symptoms directly connected to trauma exposure. On the other hand, higher oil exposure could increase risk for specific traumatic experiences (e.g., sense of life threat, exposure to fires) that could trigger symptoms common to GAD and PTS, such as feeling restless or “on edge,” but not MD. Future research could incorporate markers of job stability and specific traumatic experiences to test these hypotheses. Additional research could also include other factors that have been shown to promote postdisaster psychological resilience, including social support, place attachment, and community resources (Felix & Affifi, 2015; Norris, Stevens, Pfefferbaum, Wyche, & Pffeferbaum, 2008; Scannell, Cox, Fletcher, & Heykoop, 2016).

The results are generally consistent with studies in the aftermath of prior spills showing significant associations between cleanup work and mental health symptoms (Palinkas et al., 1993). Building on prior work, we show that among workers, specific characteristics of cleanup work are differentially associated with psychological outcomes. The finding that longer work duration was associated with lower MD and GAD symptoms was contrary to expectations. One possible explanation is that longer-term jobs led to greater feelings of job stability and social support from colleagues, both of which could confer mental health benefits (Sinokki et al., 2009; Sverke, Hellgren, & Näswall, 2002). Alternatively, the direction of causality could be reversed, such that workers with lower levels of preexisting depression and anxiety were more likely to secure long-term jobs (e.g., Paul & Moster,

2009). A third explanation could be that participants who worked the longest had the most skills and were generally the most employable, characteristics that could also confer mental health benefits. The direct effects of oil exposure on PTS and GAD symptoms could be further mediated by greater perceptions of life threat during work activities, or worries about the long-term effects of the spill and similar catastrophic events. Oil exposure could also be a proxy for other work-related experiences, such as seeing dead animals or severe harm to wildlife, which might in turn influence PTS and GAD symptoms.

The mechanisms observed in the study are also consistent with prior research, particularly the large body of literature linking physical and mental health outcomes (e.g., Scott et al., 2007). The results also contribute to the growing body of literature linking cleanup work to physical health problems (e.g., Aguilera et al., 2010), and extend this work by showing that specific characteristics of work – longer duration and greater oil exposure – increase physical health risks. The most novel contribution is the finding that longer duration of cleanup and work activities that involved greater oil exposure were associated with higher 2010 household income, which in turn was associated with lower MD and GAD symptoms. The data in the current study were not detailed enough to determine whether higher household income was the result of participants' employment in the cleanup, or because those who worked on the cleanup longer and who completed tasks that involved more oil exposure came to the effort with higher levels of prior resources and job stability prior to the spill. Nonetheless, these significant associations align with observations in the news media about the potential economic benefits of cleanup work (e.g., Pounds, 2010). Whereas prior studies have focused on the psychological consequences of economic losses after the spill (e.g., Fan et al., 2014), we showed that the higher levels of household income, potentially due to cleanup work, were associated with lower MD and GAD symptoms. Higher household income could reduce symptoms by leading to greater hope and less anxiety about one's future financial stability.

This study had at least six limitations. First, there might have been unmeasured preexisting differences between workers and non-workers in the full sample, as well as by work duration and oil exposure among the worker subsample. Participants who did cleanup work might have had better pre-spill physical and mental health than those who did not, for example. However, in this case, pre-spill differences would bias the findings toward the null and moreover the analysis controlled for probable pre-spill physical and mental health conditions. Second, several constructs (e.g., income level, pre-spill conditions, physical health symptoms during the cleanup) were assessed retrospectively at W1, and could have been biased by current functioning. Although this concern is somewhat attenuated given that the mental health outcomes were assessed at W2, retrospective bias could have nonetheless led to inflated estimates. Third, in our assessment of 2010 household income level, we could not discern what proportion of income was from cleanup work. We also did not control for pre-spill income and therefore the models did not provide insight into the influence of changes in income on mental health. Fourth, PTS symptoms were assessed using a four-item screener, and mental and physical health symptoms more generally were self-reported and not confirmed by medical reports or clinical exams. Furthermore, spill-related physical symptoms were weighted equally, and it is possible that some were more strongly associated with mental health than others. Fifth, regarding the assessment of work-related

characteristics, we relied on participants' reports of dates of employment and tasks, which could not be confirmed by official records. Although a panel of experts derived indices of oil exposure for each task based in part on air measurements among some workers during the cleanup operation, most participants' actual levels of exposure were not obtained, and the index was based on the maximum exposure across multiple jobs reported by participants and not a time-weighted average that took into account changes in exposure levels over time and work duration. On the other hand, had we used a time-weighted average, we would have created lower average exposures for those who worked longest, as exposures largely decreased over time. Thus, by using the maximum exposure over time, we did not create this possible reverse causal pathway. Finally, there were systematic differences between participants with and without missing data on exogenous variables, which limits external validity of the study. Models were replicated using list-wise deletion and the pattern of results was consistent (available upon request), somewhat attenuating this concern.

These limitations notwithstanding, the results of the study provide greater insight into why disaster recovery work is generally associated with adverse mental health outcomes. They also suggest that disaster work is not a uniformly negative experience, as higher levels of household income, potentially from longer duration of cleanup work and work that involves greater exposure to oil, can have psychological benefits. Although we are wary of drawing conclusions due to our rough assessment of income and the observational nature of the study, it is possible that efforts to boost financial compensation among workers with lower-paying jobs, combined with ongoing monitoring of workers for psychiatric symptoms, could reduce the overall mental health burden of cleanup work. The findings also suggest that efforts to reduce physical health symptoms during cleanup activities, such as through ongoing training and monitoring in the use of personal protective equipment and practices or reassigning workers with emergent symptoms to tasks that involve lower exposure to oil and other potentially hazardous materials, could protect against PTS, MD and GAD symptoms.

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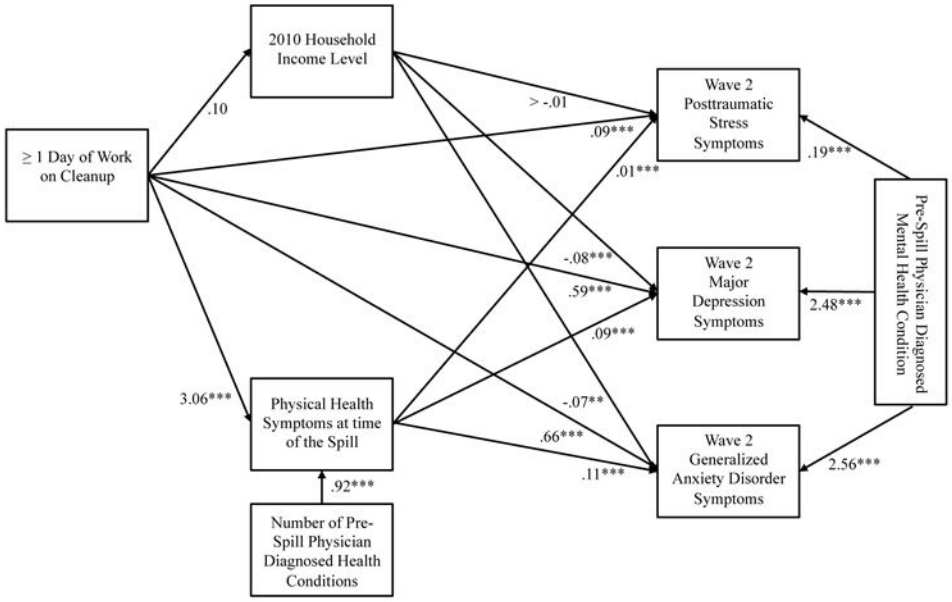
a)



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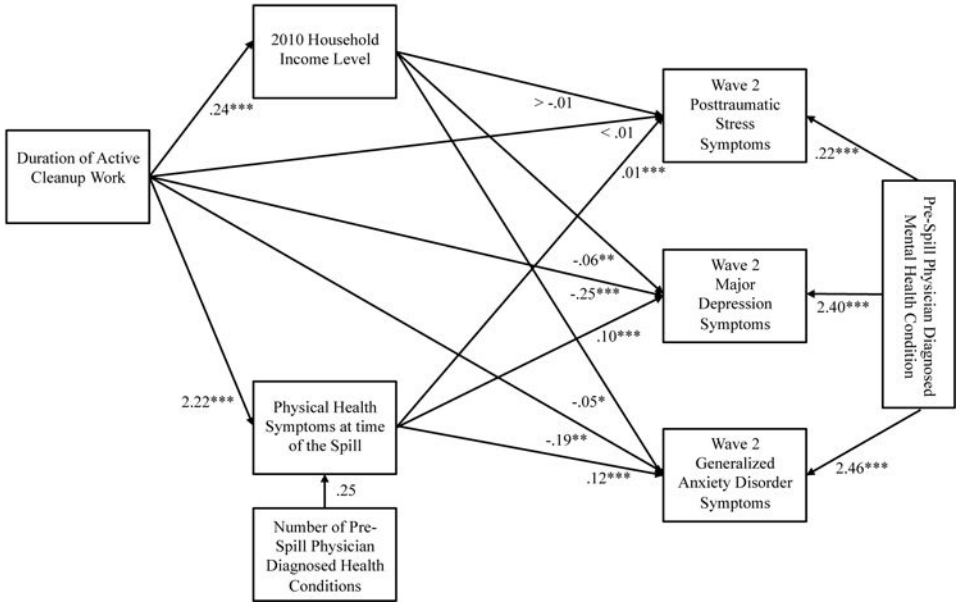

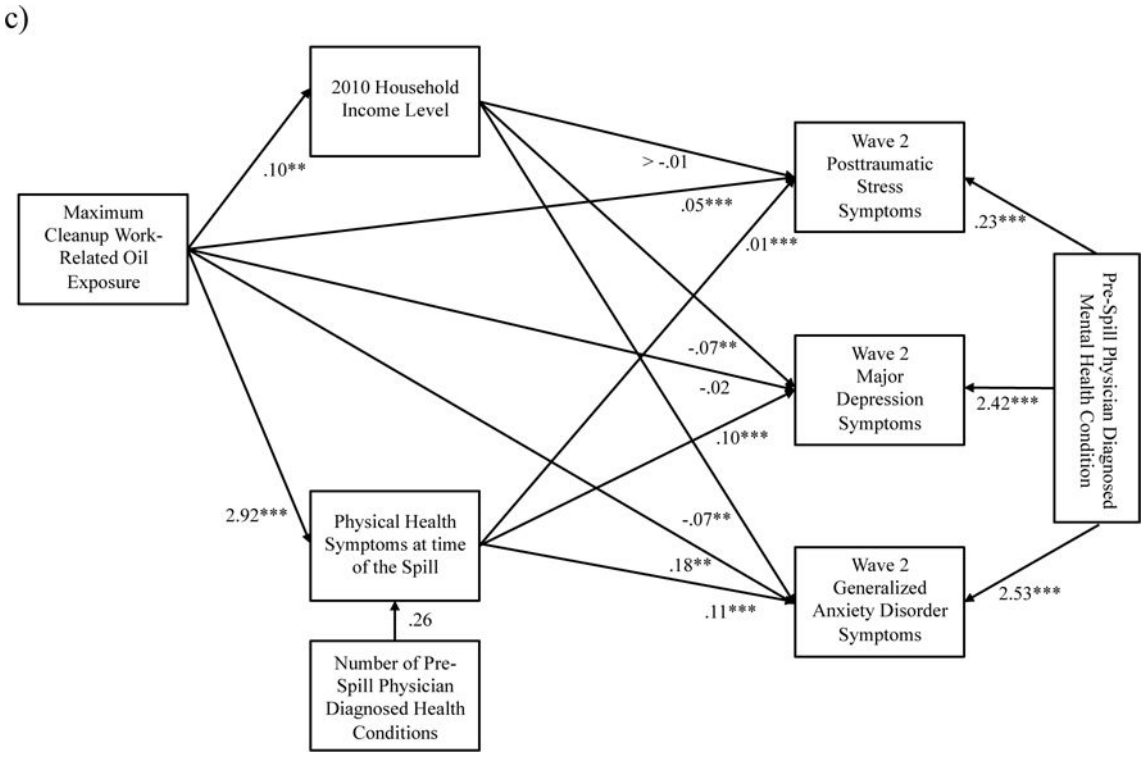

Figure 1.

Path model including (1a) whether participant completed at least one full day of cleanup work, (1b) duration of cleanup work, and (1c) cleanup work-related oil exposure. Unstandardized coefficients are presented. For clarity, covariances between Wave 2 posttraumatic stress, major depression, and generalized anxiety disorder symptoms, and between 2010 household income level and physical health symptoms at the time of the spill all not shown (all $p < .001$). *$p < .05$, **$p < .01$, ***$p < .001$.

Table 1

Participant Demographics and Descriptive Statistics for Variables Included in the Analysis (N = 10,141)

	M (SD) or %	*Range*
Demographic characteristics		
Gender		
Male	78.2%	–
Female	21.8%	–
Race		
White	53.7%	–
Black	35.5%	–
Asian	0.7%	–
Other or multiracial	6.9%	–
Ethnicity		
Hispanic	6.0%	–
Non-Hispanic	94.0%	–
Age	44.05 (13.13)	21–90
Less than a high school education	21.8%	–
Exposures		
At least one day of cleanup work	78.1%	–
Duration of cleanup work (days)	142.25 (139.75)	1–977
Maximum cleanup work-related oil exposure	4.50 (1.08)	2–7
Mediators		
Wave 1 income level	4.08 (3.16)	1–13
Physical health symptoms at time of spill	24.66 (19.46)	0–96
Outcomes (Wave 2)		
Posttraumatic stress symptoms	0.40 (0.91)	0–4
Major depression symptoms	4.12 (6.00)	0–24
Generalized anxiety disorder symptoms	5.39 (6.70)	0–21
Pre-spill Covariates		
Physician diagnosed mental health condition	9.3%	–
Number of physician diagnosed physical health conditions	0.58 (0.98)	0–9