



# Mental health indicators and lung function following a large oil spill

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To the Editor:

Natural and anthropogenic disaster-related experiences can exacerbate background stressors, which may lead to negative mental health outcomes [1]. However, few studies have assessed mental health indicators related to measured lung function in the aftermath of a disaster. In 2010 the *Deepwater Horizon* disaster resulted in the largest maritime oil spill in US history and negatively affected proximal communities, which experienced increased distress and post-traumatic stress disorder (PTSD)-like symptoms attributed to the disaster [2, 3]. We investigated the relationship between mental health indicators and lung function following this disaster.

We used cross-sectional data from the Gulf Long-Term Follow-up Study (GuLF Study), a prospective cohort of adults (n=32 608) who participated in response and cleanup activities following the 2010 *Deepwater Horizon* oil spill, and others who received worker safety training but were not hired [4]. Enrolled participants completed telephone interviews between March 2011 and March 2013. Participants who were English- or Spanish-speaking residents of Alabama, Florida, Louisiana, Mississippi or Texas (n=25 304) were eligible for a home visit exam. 11 193 eligible participants completed a home visit exam (May 2011 to May 2013) and, of these, 10 040 completed spirometry testing. We analysed spirometry data from participants with spirometry tests meeting American Thoracic Society/European Respiratory Society (ATS/ERS) quality standards [5]. All home visit participants provided written informed consent. This study was approved by the National Institute of Environmental Health Sciences institutional review board.

Participants completed psychological assessments on multiple mental health endpoints using validated questionnaires. Recommended standardised cut-off points were used to classify participants. Perceived stress was measured at enrolment using Cohen's perceived stress scale and being positive for stress was defined as having a score  $\geq 9$  (range 0–16) [6]. The remaining tests were measured at the home visit. Depression was measured using the eight-item Patient Health Questionnaire depression scale (PHQ-8) tool and defined as having a score  $\geq 10$  (range 0–27) [7]. Generalised anxiety disorder was measured using the 7-item Generalized Anxiety Disorder scale (GAD-7) and defined as having a score  $\geq 10$  (range 0–21) [8]. Finally, PTSD was measured using the Primary Care PTSD (PC-PTSD) screener and defined as having a score  $\geq 3$  (range 0–4) [9].

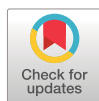
Home visit participants performed spirometry using an ultrasonic spirometer (EasyOne; ndd Technologies, Andover, MA, USA) administered by trained examiners. Lung function outcomes of interest included forced expiratory volume in 1 s (FEV<sub>1</sub>; mL), forced vital capacity (FVC; mL) and their ratio (FEV<sub>1</sub>/FVC; %). Tests for 10 019 participants (workers and non-workers) were overread by a spirometry expert for quality control and 7 487 met the ATS/ERS within- and between-manoeuvre acceptability criteria, defined as at least three acceptable manoeuvres, with variability of either FEV<sub>1</sub> or FVC  $\leq 150$  mL or equivalent quality deemed by a spirometry over-reader expert (defined as having a score of either A, B or C) [5]. After excluding participants with missing information on any mental health outcome (n=833) and excluding participants with missing covariate information (n=858; 49% of which were missing income data) the final analysis sample was composed of 5 796 participants.

Information on demographic, socioeconomic, lifestyle and health measures was collected at enrolment using a structured telephone interview. Anthropometric measures, including height and weight, were

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**Among GuLF Study participants, findings indicate better lung function associated with severe depression and generalised anxiety, and no association between lung function and PTSD symptoms or perceived stress** <https://bit.ly/3xpLNRB>

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obtained by examiners at the home visit. Potential confounders were selected using a directed acyclic graph and included age at home visit (years), sex (male, female), height at home visit (cm), weight (lbs), race (white, black, other), ethnicity (Hispanic, non-Hispanic), smoking status (current heavy, current light, former, never), and secondhand smoke exposure (yes, no), education level (less than high school/equivalent, high school diploma/gED, some college/2 year degree, 4 year college graduate or more), and income level (<USD 20 000, USD 20 000–50 000, >USD 50 000). Height squared ( $\text{cm}^2$ ) was included in models based on its reported quadratic relationship to lung function measures [10]. We also controlled for pre-existing lung disease (doctor's diagnosis of bronchitis, emphysema or asthma; yes, no) and oil spill response and cleanup work hierarchical job class (response work, operations, decontamination, cleanup on water, cleanup on land, non-worker). FEV<sub>1</sub> and FVC were statistically significantly associated with height, height squared, age and comorbid lung disease ( $p < 0.05$ ) in our data, providing further support for inclusion in the adjustment set and support for the validity of our spirometry results. Finally, we adjusted for area deprivation using a published index linked to participant home visit addresses [11].

We evaluated the relationship of each mental health outcome (PTSD, depression, stress and anxiety) to the lung function measures. We modelled mental health outcomes separately, treating each as an independent variable and adjusting for age, sex, race/ethnicity, height (cm), height squared ( $\text{cm}^2$ ), weight, smoking, secondhand smoke, income, education, neighbourhood deprivation, pre-existing lung disease, and oil spill response and cleanup work jobs in each model. All analyses were conducted using SAS v 9.4 (SAS Institute, Cary, NC, USA).

Perceived stress and PTSD symptoms were not associated with any lung function measure (table 1). Compared to those without depression, those with severe depression scores had a higher FEV<sub>1</sub> ( $\beta$  61 mL, 95% CI 21, 101) and FVC ( $\beta$  62 mL, 95% CI 16, 109), but not FEV<sub>1</sub>/FVC ratio. Participants with severe generalised anxiety disorder scores *versus* those without also had higher FEV<sub>1</sub> ( $\beta$  78 mL, 95% CI 44, 113), FVC ( $\beta$  71 mL, 95% CI 31, 112), and FEV<sub>1</sub>/FVC ratio ( $\beta$  0.56%, 95% CI 0.15, 0.97).

We examined the relationship between adverse mental health measures and lung function in a large population of adults living in US Gulf states enrolled in a cohort following the 2010 *Deepwater Horizon* disaster. Despite findings of adverse mental health outcomes associated with response and cleanup work following the *Deepwater Horizon* disaster [2], results here indicate better lung function associated with severe depression and generalised anxiety.

Our results are discordant with the existing literature on depression and anxiety, which has reported links between mental health and/or stress and poor respiratory health. Psychological stress can lead to hyperresponsiveness of the hypothalamic pituitary axis, increasing secretion of inflammatory cytokines and the release of cortisol that may trigger hormones (*e.g.* corticotrophin) [12]. This can potentiate the immune system, or autonomic control, resulting in bronchoconstriction [13]. Higher depression scores have been associated with lower FEV<sub>1</sub> [14] while war-related stressors have been associated with increased risk of asthma [15]. It is unclear why we observed better lung function for those with depression and generalised anxiety. Results may be attributable to limited generalisability, uncontrolled confounding, such as lack of data on clinical management of stress, or limitations of cross-sectional analyses. It is possible that selection bias could have affected study results. However, we assessed the prevalence of adverse mental health outcomes among excluded home visit participants and found that the prevalence of each outcome was very

**TABLE 1** Adverse mental health outcomes and lung function, Gulf Long-Term Follow-up Study (GuLF Study) participants (2011–2013) (n=5796)

Mental health outcomes	Subjects	Mean differences		
		FEV <sub>1</sub> , mL	FVC, mL	FEV <sub>1</sub> /FVC, %
Perceived stress	1524 (26%)	2 (–31, 35)	5 (–34, 44)	–0.05 (–0.44, 0.35)
PTSD symptoms	280 (5%)	14 (–52, 80)	–5 (–82, 72)	0.58 (–0.20, 1.36)
Depression	894 (15%)	61 (21, 101)	62 (16, 109)	0.32 (–0.15, 0.79)
Generalised anxiety	1290 (22%)	78 (44, 113)	71 (31, 112)	0.56 (0.15, 0.97)

Mean differences are presented with 95% confidence intervals. All models adjusted for: age, sex, race, ethnicity, height, height squared, weight, smoking, secondhand smoke, educational level, income, area deprivation, pre-existing lung disease (bronchitis, emphysema, asthma), and oil spill response and cleanup work jobs. Mental health outcomes were modelled separately; models are not mutually adjusted for other outcomes. FEV<sub>1</sub>: forced expiratory volume in 1 s; FVC: forced vital capacity; PTSD: post-traumatic stress disorder.

similar to that in the analytic sample: depression (15% included *versus* 15% excluded); anxiety (22% included *versus* 24% excluded); stress (26% among included *versus* 29% excluded); PTSD (5% included *versus* 6% excluded) so we do not expect large differences in results due to these exclusions. Findings for PTSD symptoms agree with a prior study that found no association between PTSD and lung function measures, although the authors did find an association with asthma [16]. In that study, traumatic stress was associated with modestly lower FEV<sub>1</sub> and FEV<sub>1</sub>/FVC ratio measures. Given the dearth of information on specific mental health disorders and adverse respiratory health and inconsistent results across studies, prospective studies are needed to clarify this relationship.

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