ORIGINAL RESEARCH

Psychological Vulnerability of Residents of Communities Affected by the *Hebei Spirit* Oil Spill

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ABSTRACT

Objective: Psychological health is an important issue after disasters. This study aimed to investigate the prevalence of psychological symptoms among 993 residents of Taean District in South Korea after the *Hebei Spirit* oil spill and to examine determinants of vulnerability in residents' psychological symptoms.

Methods: Symptoms of post-traumatic stress (PTS), depression, suicidal ideation, and anxiety were assessed by questionnaires, and the responses were analyzed by using the survey analysis considering the sampling frame.

Results: Among the study subjects, the symptom prevalences of PTS, depression, suicidal ideation, and anxiety were 19.5%, 22.0%, 2.3%, and 4.2%, respectively, and symptoms were higher in people who were female, were older, were less educated, and had lower family income. People with fishery or related occupations compared to those with unrelated livelihoods and people residing in the vicinity of the oil band in the contaminated coastline showed additively increased symptom risks of PTS. Risk of suicidal ideation was predominantly increased in people with fishery or related occupations compared with those with unrelated livelihoods.

Conclusions: Social supports, including compensation for income loss and community mental health programs, and longer follow-up studies are needed for residents in the communities affected by the *Hebei Spirit* oil spill. (*Disaster Med Public Health Preparedness.* 2016;10:51-58)

Key Words: petroleum pollution, public health, stress, psychological

Oil spills are man-made disasters that can seriously affect both ecosystems and human health and life in a widespread area over a long-term period.[1] The impact of an oil spill on the residents in contaminated areas may be intense, prolonged, and complex in nature. Oil spills can lead to not only physical health, economic, and toxicological effects, but also mental health effects.[2] Oil spills have been known to cause large-scale and personal economic damages, especially in the commercial fishery industry,[3] which subsequently causes psychological stress in local communities[4] and disruptions of community bonds.[5] Research on the psychological and behavioral health effects of oil spill disasters has been recommended as a top priority.[6] Susceptible biological factors such as sex and adaptive capacity such as family support have been reported as important determinants of suicide risk.[7]

The *Hebei Spirit* oil spill occurred on December 7, 2007, in the West Sea off the coast of the Taean peninsula of South Korea. The magnitude of the oil spill was approximately 10,900 tons of crude oil, which was approximately one-third the size of the *Exxon Valdez* oil spill. The *Hebei Spirit* oil spill was the largest oil spill in South Korea, and contaminated 1052 km of the country's western coastline.[8] Subsequent to the spill, 4 residents from the affected communities committed suicide from January 2008 to February 2010. Most of the cleanup workers were local residents in the villages near the coastline who continuously participated in the cleanup effort over several months along the contaminated coastline, mostly as a means of temporary livelihood. In January 2013, a local court assessed $693.2 million for total damages including compensations for economic damage to local residents, expenses for cleanup work, and expenses for marine ecosystem restoration by local government agencies, of which $390.7 million was awarded to the local residents of Taean District.[9] However, those amounts were far below the amounts that the affected community expected and for which it petitioned.

Previous studies have been conducted on mental health in relation to oil spills, including the

Sea Empress,[10] Exxon Valdez,[3] and Prestige[11] oil spills and the most recent large accident, the Deepwater Horizon oil spill.[12,13] A previously published study on the Hebei Spirit oil spill was a brief report on acute stress in a selected small group of victims.[14] In the present study, therefore, we aimed to investigate the prevalence of psychological symptoms in a representative sample of residents and to examine the determinants of psychological vulnerability following the Hebei Spirit oil spill for assessment of needs for public mental health intervention in the affected area.

METHODS
Study Subjects
The study subjects were residents who lived in the Taean District from July 7, 2008, to August 1, 2008. A stratified sampling method was used that was based on the distance to the oil band and contaminated coast. The communities (myeons and eups, administrative districts equivalent to towns and townships, respectively) facing the shoreline were categorized into four regions: I, closest to the spill point (less than 15 km) and directly affected by the thick oil band (Sowon and Wonbuk); II, from 15 km to 25 km from the spill site (Geunheung and Iwon); III, remote from the spill site, more than 25 km from the spill site (Anmyeon, Gonam, and Nam); and IV, inland villages that were less dependent on maritime activities (Taean-eup, downtown Taean) (Figure 1). The sampling unit was ri, the smallest administrative district

equivalent to a village, and the study ri were randomly selected among the lists of ri in each classified region. Sampling rates were 4% (452 of 11,313), 3% (260 of 8672), 2% (346 of 17,341), and 1% of the population (266 of 26,584) of regions I, II, III, and IV, respectively.[15]

Each interviewer was trained on the survey, visiting homes, informing subjects and obtaining consent, conducting the interview, and recording methods for questionnaires, which included questions on sociodemographic factors and scales for psychological symptoms. Five such trained interviewers visited all houses in the sampled villages and interviewed one person per household. The house visits were supported by the Taean District administrative office and corresponding village social workers. Among 1324 interviewees, a total of 993 subjects were included for statistical analysis after excluding 127 incomplete samples and 204 subjects younger than 19 years of age.

This study was approved by the institutional review board at the Dankook University Hospital (Cheonan, Republic of Korea). Written informed consent was obtained from each subject prior to the interview.

Geographical Variables of Oil Spill Exposure
Besides the 4 classified regions described above, we used geographical variables to represent the degree of oil spill

FIGURE 1

Map Showing the Locations of the Study Areas and the Oil Band of the *Hebei Spirit* Oil Spill in Taean, Korea, 2007.
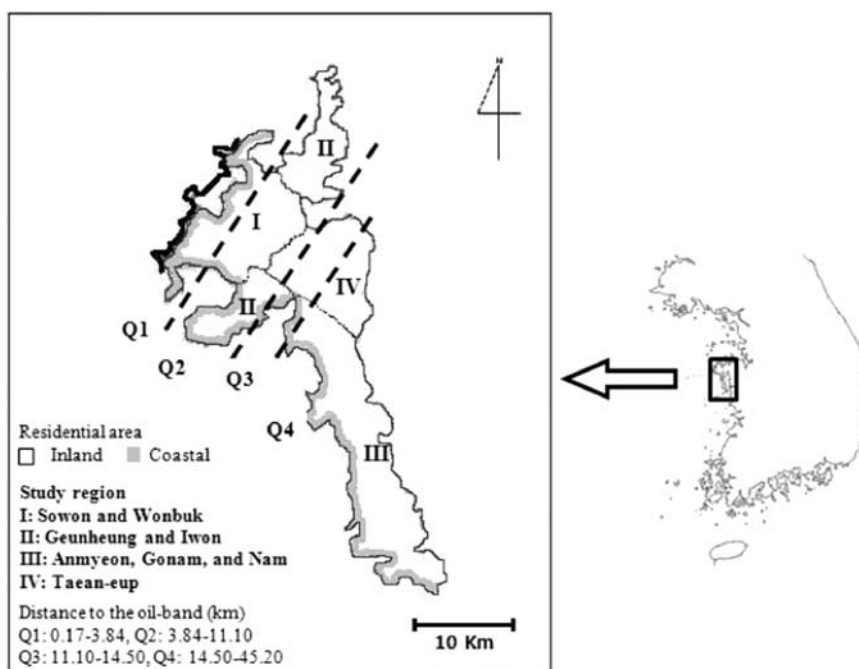
exposure, inland or coastal area, and the distance to the oil band (Figure 1). An area was considered to be either a coastal area, if the villages (ri's) directly bordered water, or an inland area, if the villages did not border the water. The straight-line distance to the oil band from the residential location of each participant was measured by using a global positioning system on an Internet map application.[16] For 114 subjects for whom no address was available for the village (ri), this distance was replaced by the median distance of subjects who resided in the same town or township (myeon or eup).

Psychological Symptoms
Post-Traumatic Stress
Post-traumatic stress (PTS) was assessed by use of the post-traumatic diagnostic scale (PDS), which was originally developed by Foa et al[17] and was subsequently translated into the Korean language and validated.[18] The Korean version of the PDS is composed of 17 items of PTS-related symptoms, with each item scored from 0 to 3 points. The individual scores are then summed with a possible total score from 0 to 51 points. This scale also measures the frequency of a traumatic event. A subject with a total score above 15 points was considered to be experiencing PTS symptoms.[19] The Cronbach's α of the Korean version of the PDS was 0.95 in this study.

Depression
The Korean version of the Center for Epidemiologic Studies Depression Scale (CES-D)[20] was used to assess depressive symptoms experienced during the week leading up to the interview. This scale contains 20 items that measure feelings of depression, with each item having a possible score from 0 (rarely or none [less than 1 day]) to 3 (most or all [5-7 days]). The cutoff point for a clinically depressed patient is 25 and that for a high-risk group in the community is 21.[21] The Cronbach's α of the Korean version of the CES-D was 0.90 in this study.

Suicidal Ideation
Suicidal ideation was measured by using the Korean version of the Scale for Suicidal Ideation (SSI).[22] Each of the 19 items was scored from 0 (none or rarely) to 2 points (every time). A high-risk group was defined by a score greater than 16 out of 38 possible total points. The Cronbach's α was 0.93 in this study.

Anxiety
The Korean version of the Symptom Checklist–90-Revision (SCL-90-R) was used to assess anxious symptoms.[23] Possible scores were from 0 (none) to 4 (very severe) points for each of the 10 items. The cutoff point was a T score of 70 on the standardized distribution of the Korean population for a high-risk group. The Cronbach's α was 0.95 in this study.

Modifiers, Confounders, or Other Covariates
Information on other covariates was obtained during the house visit interview. Occupation was classified into 2 categories (fishery: culturist, fishery, and shell-fishing, and non-fishery: services, agriculture, government officer, part-time worker, business professional, and others). Educational attainment was also classified into 2 categories (<12 years: less than high school graduation, and ≥12 years: high school graduation or more). Participation in the cleanup work (yes or no), demographic factors such as age, sex, household income (≤999 KRW/month, 1000-2999 KRW/month, and ≥3000 KRW/month), and marital status (married, never married, or divorced/separated) were considered in the analyses.

Statistical Analysis
The finite population correction (FPC) and sampling weights using the 2008 population numbers of each region (I to IV) of Taean District[15] were calculated, which were used in the survey analysis methods. The formula was as follows[24]:

$$FPC = \text{square root}[(\text{population size}-\text{sample size})/$$
$$(\text{population size}-1)]$$

The FPC was used for prevalence only because it is used to reduce the variance when a substantial fraction of the total population of interest has been sampled. The FPC was not used for evaluation of psychological symptoms because it may not be appropriate if the target of inference is the process generating the data rather than the statistics of a particular finite population.[25] Sampling weights were determined by using the population number of a given region, divided by the sample size of the same region.

Symptom prevalence and 95% confidence intervals (CIs) were calculated by using the survey analysis methods based on the weighted population of the sampled area.[25] To examine the association between oil spill exposure and psychological symptoms, the odds ratio (OR) and 95% CI were estimated by using the survey logistic regression model adjusted for several covariates, including age, sex, marital status, educational attainment, cleanup work, and occupation. P for trend was calculated by using the ordinary or continuous scales of the variables in the corresponding survey logistic model. To examine the modifying effects of occupation on the association between oil spill exposure and psychological symptoms, we tested the significance of the interaction. To test the statistical significance of the multiplicative interaction, the log likelihood ratio test was conducted between with and without the interaction term in the corresponding survey logistic model.[26] To test the additive interaction, the relative excess risk due to interaction and 95% CI was estimated by using the epi.interaction() function in the R package epiR.[26] All analysis was conducted by using R version 2.13.1[27] with the significance level set at P < 0.05.

RESULTS

Prevalence of Psychological Symptoms of the Study Subjects

The overall prevalences of post-traumatic stress disorder (PTSD), depression, suicidal ideation, and anxiety symptoms were 19.5%, 22.0%, 2.3%, and 4.2%, respectively. The psychological symptoms of PTSD, depression, and suicidal ideation were the most prevalent (49.0%, 39.9%, and 5.1%, respectively) in the closest category (the lowest quartile) of the distance from residential area to the oil band and the second most prevalent in the fishery or related occupational group (45.0%, 37.7%, and 4.7%, respectively). The anxiety symptom was the highest in the fishery or related occupational group, followed by the closest category of the distance to the oil band (11.3% and 9.5%). Prevalence of psychological symptoms except for suicidal ideation was higher in subjects who were aged 40 years or older, married, less educated, of middle or lower household income, residing in regions exposed to oil (from IV to I regions in decreasing order), residing closer to the oil band (from Q1 to Q4 distance in order), and participating in cleanup work. Contrary to this, suicidal ideation prevalence was higher among males, people younger than 39 years, those who were highly educated (12 or more years of education), and those of middle or higher household income (Table 1), but the significances of difference in sex, age, education, and income disappeared in the multivariate model adjusted for occupation (data not shown).

Risk of Psychological Symptoms According to Geographical Distance to Oil Band and Occupation

When analyses were performed separately with distance and occupation in association with psychological symptoms, all types of symptoms showed a significant association with closer distance and fishery or related occupation. After mutual adjustment for distance and occupation, PTS and depression remained significantly associated with both distance and occupation, whereas suicidal ideation and anxiety remained significantly associated only with occupation. Thus, a fishery or related occupation had a stronger impact on suicidal ideation and anxiety than did living closer to an oil band (Table 2).

Synergistic Effect of Geographical Distance to the Oil band and Occupation

The interactive effects of distance and occupation by type of psychological symptoms are illustrated in Figure 2. PTS was significantly associated with distance and occupation, with a significant additive synergism (P value for additive interaction = 0.03). Depression showed a similar pattern but without a significant interaction effect (Table S1). A significantly increased risk of suicidal ideation was shown only in people with a fishery or related occupation. Anxiety showed a higher risk among people with a fishery or related occupation regardless of distance than among people living distant from the oil band and with a non-sea-related occupation (P value for multiplicative interaction = 0.06).

DISCUSSION

We found that symptoms of PTSD, depression, suicidal ideation, and anxiety were prevalent among residents of the coastal communities affected by the Hebei Spirit oil spill. These prevalences increased significantly along with increasing severity of oil exposure and were higher in people with a fishery or related occupation than in those with other livelihoods. People with a fishery or related occupation and people residing in the vicinity of the oil band in the contaminated coastline showed additively increased symptom risks of PTSD. Risk of suicidal ideation was predominantly increased in people with a fishery or related occupation. Risk of anxiety was higher among people with a fishery or related occupation regardless of distance as well as among those residing within a closer distance with a non-sea-related occupation.

We found increased psychological symptoms according to exposure level or proximity to the oil spill, which was described as a direct effect due to the disaster itself, as well as a significant association with occupation, which was described as an indirect effect or economic damage/income loss as a result of the disaster.[6] These findings are consistent with previous reports on the associations between oil spill accidents and the mental health of people affected by the Exxon Valdez,[29] Sea Empress,[10] and Prestige[30] accidents.

Although it may not be appropriate to directly compare the results of the present study with those reported in previous studies because of the different measurement tools used, the PTSD symptom prevalence in the present study is compatible with that for survivors 6 months after the Oklahoma city bombing (36%),[31] for the US population outside of New York City 2 months after the 9/11 terrorist attacks on the Twin Towers in Manhattan (17%),[32] and for residents 1 year after experiencing the Exxon Valdez oil spill (17%).[29]

In terms of depression, the prevalence in the present study is consistent with the 23% prevalence in survivors of the Oklahoma city bombing,[31] the 20.2% prevalence in residents of the communities exposed to the Exxon Valdez oil spill,[29] and the 35% prevalence in residents directly affected by the Gulf of Mexico oil spill,[2] although the measurement tools were all different. However, the prevalence had decreased from 62.7% at 8 weeks after the Hebei Spirit oil spill by use of the same scale, the CES-D.[14]

The prevalence of suicidal ideation was 4.0% in subjects from region I towns (Sowon and Wonbuk) in this study. This prevalence was much decreased from the 18.3% at 8 weeks after the Hebei Spirit oil spill accident.[14]

TABLE 1

Prevalence of Psychological Symptoms of the Study Subjects in Areas Affected by the *Hebei Spirit* Oil Spill, Taean, Korea, 2008[a]

Characteristics	N	Post-Traumatic Stress Case	Prev (95% CI)	Depression Case	Prev (95% CI)	Suicidal Ideation Case	Prev (95% CI)	Anxiety Case	Prev (95% CI)
All	993	258	19.5 (19.3, 20.0)	258	22.0 (22.0, 22.2)	28	2.3 (2.0, 2.4)	54	4.2 (4.0, 4.3)
Sex									
Male	436	104	19.6 (19.3, 19.9)	100	21.1 (20.8, 21.4)	17	3.2 (3.0, 3.3)	19	3.4 (3.2, 3.5)
Female	557	154	19.5 (19.2, 19.7)	158	23.1 (22.8, 23.4)	11	1.7 (1.6, 1.8)	35	5.0 (4.9, 5.2)
Age, years									
19-39	297	39	10.4 (10.1, 10.7)	53	17.6 (17.2, 17.9)	9	3.1 (3.0, 3.3)	6	1.4 (1.2, 1.5)
40-59	332	96	23.3 (22.9, 23.7)	109	28.3 (27.9, 28.8)	14	2.6 (2.4, 2.7)	30	7.7 (7.5, 8.0)
≥60	364	123	25.2 (24.8, 25.6)	96	20.5 (20.1, 20.9)	5	1.4 (1.3, 1.5)	18	3.7 (3.5, 3.8)
Marital status									
Married	601	168	21.5 (21.3, 21.8)	168	24.0 (23.7, 24.3)	17	2.1 (2.0, 2.3)	40	5.4 (5.3, 5.6)
Never been married	213	28	9.0 (8.7, 9.3)	36	15.5 (15.1, 15.9)	5	2.5 (2.3, 2.6)	2	0.8 (0.7, 0.9)
Had been married but single now	163	55	26.3 (25.7, 26.9)	48	24.6 (24.0, 25.2)	6	3.3 (3.1, 3.6)	10	5.0 (4.7, 5.3)
Educational attainment									
<12 years	397	136	27.6 (27.2, 28.0)	124	26.4 (26.0, 26.8)	8	1.7 (1.6, 1.8)	27	6.0 (5.8, 6.3)
≥12 years	477	82	13.6 (13.3, 13.9)	107	20.7 (20.4, 21.0)	19	3.1 (3.0, 3.2)	23	3.4 (3.2, 3.5)
Household income (1000 KRW/month)[b]									
≤999	479	157	24.5 (24.2, 24.9)	132	23.0 (22.6, 23.3)	10	1.6 (1.5, 1.7)	25	4.5 (4.4, 4.7)
1000-2999	283	70	19.7 (19.3, 20.1)	84	24.9 (24.5, 25.4)	13	3.4 (3.2, 3.5)	22	5.7 (5.5, 6.0)
≥3000	162	16	8.7 (8.4, 9.1)	26	16.4 (16.0, 16.9)	4	2.9 (2.7, 3.2)	6	2.5 (2.3, 2.7)
Occupation[c]									
Non-sea-related	722	118	12.3 (12.1, 12.5)	146	17.8 (17.6, 18.0)	13	1.7 (1.7, 1.8)	23	2.3 (2.2, 2.4)
Fishery and related	270	139	45.0 (44.5, 45.6)	111	37.7 (37.1, 38.2)	15	4.7 (4.4, 4.9)	31	11.3 (11.0, 11.7)
Region									
Taean-eup (IV)	224	21	9.4 (9.1, 9.6)	39	17.4 (17.1, 17.7)	3	1.3 (1.2, 1.4)	6	2.7 (2.5, 2.8)
Anmyeon, Gonam, and Nam (III)	229	43	18.8 (18.4, 19.2)	44	19.2 (18.8, 19.6)	8	3.5 (3.3, 3.7)	8	3.5 (3.3, 3.7)
Geunheung and Iwon (II)	167	39	23.4 (22.7, 24.0)	42	25.1 (24.5, 25.8)	2	1.2 (1.0, 1.4)	9	5.4 (5.1, 5.7)
Sowon and Wonbuk (I)	373	155	41.6 (40.9, 42.2)	133	35.7 (35.0, 36.3)	15	4.0 (3.8, 4.3)	31	8.3 (7.9, 8.7)
Residential area									
Inland	513	90	14.4 (14.1, 14.6)	101	18.2 (17.9, 18.4)	10	1.9 (1.8, 2.0)	21	3.4 (3.3, 3.5)
Coastal	366	143	32.3 (31.9, 32.8)	125	29.1 (28.7, 29.6)	13	3.2 (3.0, 3.4)	16	5.4 (5.2, 5.6)
Distance from residential area to the oil-band (km)[d]									
Q1 (0.17-3.84)	253	124	49.0 (48.2, 49.8)	101	39.9 (39.1, 40.7)	13	5.1 (4.8, 5.5)	24	9.5 (9.0, 10.0)
Q2 (3.84-11.10)	257	70	27.6 (27.0, 28.2)	74	29.3 (28.7, 29.9)	4	1.5 (1.4, 1.7)	16	6.3 (6.0, 6.6)
Q3(11.10-14.50)	236	18	8.2 (8.0, 8.5)	34	15.5 (15.2, 15.8)	3	1.4 (1.3, 1.5)	5	2.3 (2.2, 2.4)
Q4 (14.50-45.20)	247	46	18.5 (18.2, 18.9)	49	20.2 (19.8, 20.6)	8	3.1 (2.9, 3.3)	9	3.7 (3.5, 3.9)
Cleanup work									
No	166	18	8.4 (8.1, 8.8)	23	14.3 (13.9, 14.7)	3	2.2 (2.0, 2.3)	1	0.2 (0.2, 0.3)
Yes	815	236	22.2 (22.0, 22.5)	232	24.2 (24.0, 24.5)	25	2.5 (2.4, 2.6)	52	5.2 (5.1, 5.4)

[a]Abbreviations: CI, confidence interval; Prev, prevalence. Prevalence (%) and 95% CIs were estimated by using survey data analysis based on the weighted population of the sampled area.

[b]1000 KRW = 0.96 USD (30 June 2008); GNI (Korea, 2008) = 19,231 USD.

[c]The fishery and related occupations included culturist, fishery and shell-fishing; non-sea-related occupations included services, agriculture, officer, part-time worker, professional, and others.

[d]The straight line of the distance from the subject's residential house to the nearest oil band in the coastline. Numbers are not always the same total because of missing values.

The anxiety symptom prevalence in this study was lower than the 34.0% prevalence in residents 1 year after the *Exxon Valdez* oil spill,[29] the 11.0% prevalence in residents at 14 months after the *Prestige* oil spill accident,[30] and the 48% prevalence in residents directly affected by the Gulf of Mexico oil spill.[2] Increased symptom risk of anxiety in people with a fishery or related occupation regardless of distance may show an indirect exposure as a major determinant. However,

the increased risk among people with a non-sea-related occupation but who resided within the vicinity of the oil band may reflect general anxiety due to being a visual witness to the disaster. The findings of a synergistically increased risk of PTS among people with a fishery or related occupation and living closer to the oil band and the predominantly strong impact of occupation on suicidal ideation imply a target group on whom future planned public intervention

TABLE 2

Risk of Psychological Symptoms in Association With Geographical Distance of Residential Site to Oil Spill Band and Occupation of Study Subjects in Area Affected by the *Hebei Spirit* Oil Spill, Taean, Korea, 2008[a]

	No. of Subjects	Case	OR (95% CI) Model 1 (separate)	OR (95% CI) Model 2 (mutually adjusted)
Post-traumatic stress				
Distance to the oil band (km)[b]			P-trend <0.0001	P-trend <0.0001
Q1 (0.17-3.84)	253	124	4.00 (2.50, 6.39)	3.77 (2.30, 6.16)
Q2 (3.84-11.10)	257	70	1.75 (1.07, 2.87)	1.91 (1.15, 3.20)
Q3 (11.10-14.50)	236	18	0.55 (0.30, 1.02)	0.73 (0.38, 1.38)
Q4 (14.50-45.20)	247	46	1 (ref)	1 (ref)
Occupation[c]				
Non-sea-related	722	118	1 (ref)	1 (ref)
Fishery and related	270	139	5.03 (3.25, 7.78)	4.00 (2.52, 6.34)
Depression				
Distance to the oil band (km)[b]			<0.0001	<0.0001
Q1 (0.17-3.84)	253	101	2.39 (1.53, 3.73)	2.15 (1.36, 3.41)
Q2 (3.84-11.10)	257	74	1.62 (1.02, 2.57)	1.69 (1.06, 2.70)
Q3 (11.10-14.50)	236	34	0.72 (0.43, 1.20)	0.86 (0.51, 1.45)
Q4 (14.50-45.20)	247	49	1 (ref)	1 (ref)
Occupation[c]				
Non-sea-related	722	146	1 (ref)	1 (ref)
Fishery and related	270	111	3.45 (2.26, 5.29)	2.94 (1.88, 4.57)
Suicidal ideation				
Distance to the oil band (km)[b]			0.19	0.45
Q1 (0.17-3.84)	253	13	2.65 (1.05, 6.67)	1.83 (0.72, 4.64)
Q2 (3.84-11.10)	257	4	0.62 (0.17, 2.23)	0.58 (0.16, 2.04)
Q3 (11.10-14.50)	236	3	0.43 (0.1, 1.77)	0.49 (0.11, 2.17)
Q4 (14.50-45.20)	247	8	1 (ref)	1 (ref)
Occupation[c]				
Non-sea-related	722	13	1 (ref)	1 (ref)
Fishery and related	270	15	7.31 (2.5, 21.38)	5.34 (1.73, 16.46)
Anxiety				
Distance to the oil band (km)[b]			0.02	0.08
Q1 (0.17-3.84)	253	24	2.61 (1.06, 6.45)	2.05 (0.78, 5.36)
Q2 (3.84-11.10)	257	16	1.93 (0.73, 5.08)	2.05 (0.79, 5.32)
Q3 (11.10-14.50)	236	5	0.71 (0.2, 2.54)	1.02 (0.26, 3.99)
Q4 (14.50-45.20)	247	9	1 (ref)	1 (ref)
Occupation[c]				
Non-sea-related	722	23	1 (ref)	1 (ref)
Fishery and related	270	31	6.26 (2.56, 15.31)	5.21 (2.07, 13.12)

[a]Abbreviations: CI, confidence interval; OR, odds ratio; ref, reference. Model 1: ORs and 95% CIs were estimated by using the survey logistic regression model adjusted for age, sex, marital status, educational attainment, and cleanup work. Model 2: additionally to model 1, distance to oil band and occupation were mutually adjusted in one model. *P* for trend was calculated by using the continuous scale of the exposure variable in the corresponding model.

[b]The straight line of the distance from the subject's residential house to the nearest oil band in the coastline.

[c]The fishery and related occupations included culturist, fishery, and shell-fishing; non-fishery occupations included services, agriculture, officer, part-time worker, professional, and others.

should be focused. Furthermore, community mental health programs as well as programs of socioeconomic compensation should consider all people who have worked in fisheries or in a related occupation beyond the physical border of oil contamination.

Limitations

The present study had some limitations. First, we did not perform a comparison of the study findings with findings for an unexposed area. Instead, we compared groups at different levels of oil exposure, ie, internal comparisons, which may have reduced the possibility of reporting bias due to exaggerated responses on subjective symptoms among people in the exposed area compared with unexposed areas. Although the extent to which a psychological measurement is biased is unknown,[33] comparisons within exposed areas might be less biased than comparisons between exposed and unexposed areas in terms of reporting. On the other hand, mental health effects due to an oil spill disaster have been shown to reach far beyond the oil band in comparison with physical health effects.[4,34] Therefore, a survey confined to communities

FIGURE 2

ORs and 95% CIs of Psychological Symptoms for Distance to the Oil Band and Occupation of the Study Subjects in the *Hebei Spirit* Oil Spill, Taean, Korea, 2008.
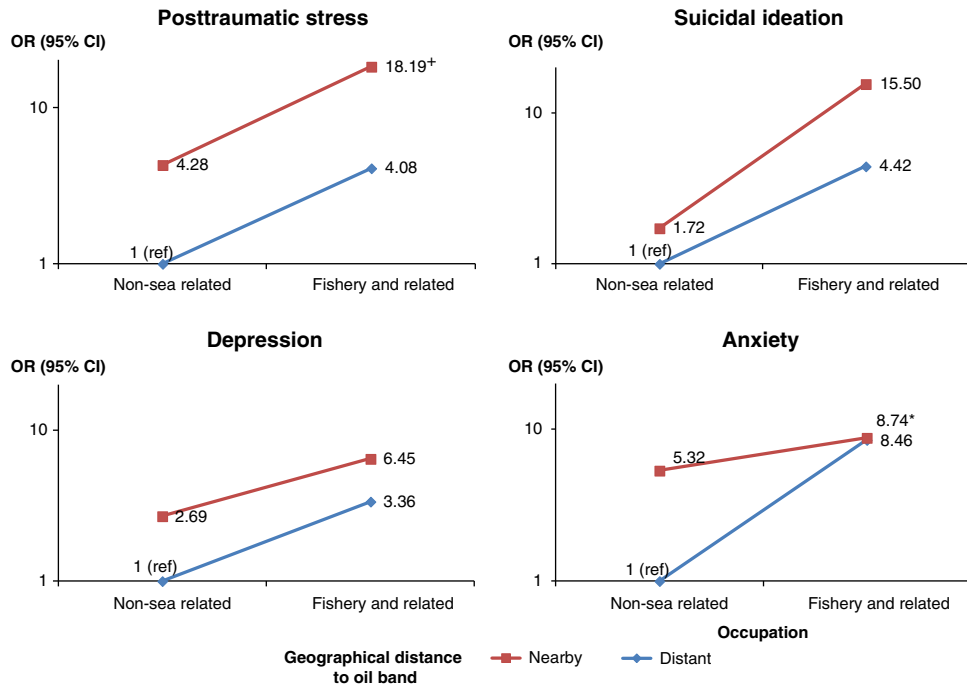
Abbreviations: CI, confidence interval; OR, odds ratio. ORs and CIs were estimated by using the survey logistic regression model adjusted for age, sex, marital status, educational attainment, and cleanup work. Geographical distance: the straight line of distance from the subject's residential house to the nearest oil band in the coastline (km). Q3-Q4, 11.10-45.20 km; Q1, 0.17-3.84 km. The fishery and related occupations included culturist, fishery, and shell-fishing; non-fishery-related occupations included services, agriculture, officer, part-time worker, professional, and others.
*P value for multiplicative interaction <0.1: calculated from the P value for interaction term in the survey logistic model.
+ P value for additive interaction <0.05: calculated from the P value for relative excess risk due to interaction.[28]

severely affected by the oil spill as in the present study may not grasp the whole magnitude of the mental health effects. Second, differences might exist between responders and nonresponders to the questionnaire interview. However, the nonresponse rate of this survey was 9.6%, and the potential selection bias due to nonresponse should be negligible. Third, psychological symptoms in this study were not clinically diagnosed but were assessed by using existing questionnaire scales. Therefore, a potential misclassification bias in the psychological outcomes may have existed, but it should not be differential regarding the exposure status. Last, the cross-sectional design limits establishing a causal relationship between the oil spill and mental distress in the affected community members.

CONCLUSIONS
Although both direct and indirect exposure to an oil spill increased the risk of PTS, depression, suicidal ideation, and anxiety symptoms, indirect exposure, ie, economic impacts, was a stronger determinant for suicidal ideation. Longer

follow-up study and social supports including a compensation program for income loss and community mental health programs are needed for residents in the area affected by the *Hebei Spirit* oil spill.

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Conflict of interest

The authors declared no conflicts of interest.

Supplementary material

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