Prolonged Respiratory Symptoms in Clean-up Workers of the *Prestige* Oil Spill

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***Rationale*: The wreckage of the oil tanker *Prestige* in November 2002 produced heavy contamination off the coast of Galicia, Spain.**

***Objectives*: To evaluate the prevalence of respiratory symptoms in local fishermen more than 1 year after having participated in clean-up work.**

***Methods*: Questionnaires including qualitative and quantitative information about clean-up activities and respiratory symptoms were distributed among associates of 38 fishermen's cooperatives. Both postal and telephone follow-up was performed. The association between participation in clean-up work and respiratory symptoms was evaluated using multiple logistic regression analyses, adjusted for sex, age, and smoking status.**

***Measurements and Main Results*: Between January 2004 and February 2005, data were obtained from 6,780 fishermen (response rate, 76%). Sixty-three percent had participated in clean-up operations. Lower respiratory tract symptoms (LRTS) were more prevalent in clean-up workers: odds ratio (OR), 1.73; 95% confidence interval (CI), 1.54–1.94. This association was consistent for men and women, for different fishermen's cooperatives, and for different types of respiratory symptoms, and remained after excluding those who reported anxiety or believed that the oil spill had affected their health (OR, 1.57; 95% CI, 1.37–1.80). The risk of LRTS increased with the number of exposed days, exposed hours per day, and number of activities (linear trend, $P < 0.0001$). The excess risk of LRTS decreased when more time had elapsed since last exposure: OR, 2.33, 1.69, and 1.24 for less than 14 months, 14–20 months, and more than 20 months, respectively.**

***Conclusions*: Participation in clean-up work of oil spills may result in prolonged respiratory symptoms that last 1 to 2 years after exposure.**

Keywords: oil spill; *Prestige*; disaster; respiratory; epidemiology

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

Short-term respiratory effects in clean-up workers of oil spills have been reported, but possible longer-term effects have not been studied.

What This Study Adds to the Field

We found increased prevalence rates of respiratory symptoms in fishermen 1 to 2 years after having participated in clean-up activities of the *Prestige* oil spill. This is suggestive of a persistent respiratory effect.

On November 19, 2002, the oil tanker *Prestige* foundered and sank about 200 km off the coast of Galicia, northwestern Spain. The vessel carried 77,000 tons of "Bunker C Oil," a residual fuel oil characterized by a high viscosity and low solubility in water, and a high (50%) content of aromatic hydrocarbons including several polycyclic compounds. During the following months, in total about 67,000 tons of oil were spilled into the Atlantic Ocean. As a result, the oil heavily contaminated more than 1,000 km of coastal zone, in particular in Galicia.

More than 100,000 persons were involved in clean-up activities including volunteers, army personnel, and specialized companies. During the first weeks of the disaster, clean-up work was done mainly by local fishermen and their families. These first initiatives were characterized by an improvisational approach of gathering, transport, and storage of the oil, and of cleaning of containers and clothes and boots used during clean-up work. There was a lack of adequate personal protective equipment during this period. It can be expected that the proportion of volatile compounds in the oil and hence airborne exposure levels were highest in these first weeks; however, comparable repeated exposure measurements over time were not available to confirm this.

In a study performed in Galicia in April–May 2003, various acute health problems were reported by volunteers and paid workers shortly after doing clean-up activities (1). Apart from musculoskeletal problems, the most commonly reported symptoms included headaches, dizziness, eye and throat irritation, and respiratory problems. In addition, a study done in June 2003 evaluated retrospectively acute health effects in 800 clean-up workers from two less affected regions on the Cantabrian coast of Spain (2, 3). When compared with paid cleaners, volunteers, and bird cleaners, the study showed that fishermen predominantly gathered oil from the sea, received health and hygiene

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information less often, and used a mask during clean-up work less frequently. Fishermen also reported headaches, throat irritation, and respiratory symptoms more often. These acute effects are consistent with findings from epidemiologic surveys done in clean-up workers of other oil spills, including the wreckages of the *Erika* (4) in France (1999) and the *Nakhodka* (5) in Japan (1997).

To our knowledge, no previous study has explored long-term respiratory effects in clean-up workers of oil spills. Our main aim was to evaluate prolonged respiratory symptoms in coastal fishermen from Galicia after at least 1 year of having participated in clean-up operations of the *Prestige* oil spill. We compared prevalence rates of respiratory symptoms between fishermen who did and did not perform clean-up work. Some of the results of this study have been previously reported in the form of abstracts (6, 7).

METHODS

Study Population

Fishermen in Galicia are organized in 63 geographically defined cooperatives. For the present study, we selected 44 cooperatives that are predominantly involved in coastal fishing and shellfish farming. Cooperatives were invited to participate in the summer and fall of 2003, and census data of their associates were obtained and updated. Six fishermen's cooperatives (about 2,450 associates) were excluded because they could not provide complete census data, leaving 38 cooperatives with, in total, 10,523 associates. We excluded open sea fishermen because they were not comparable to coastal fishermen regarding their availability to do clean-up work and to participate in the study, resulting in a final target population of 9,050 fishermen. On the basis of the amounts of oil gathered from the coast provided by the local authorities, the 38 cooperatives were grouped into three areas that differed according to the degree of contamination (Figure 1).

Questionnaire and Field Work

A questionnaire was developed, suitable for both self-administration and (telephone) interview. Questions on respiratory symptoms and medication usage were taken from the Spanish protocol of the European Community Respiratory Health Survey (8). Answers had to be recorded as "yes" or "no." Validity and reliability of the symptom questions have been reported elsewhere (9). Symptoms and the use of inhaled and oral "medicines to help your breathing" referred to the previous 12 months. Questions about clean-up activities were based on previous studies on health effects of oil spill (5) or created *ad hoc*. We asked about clean-up work in three periods: (*1*) from the start of the spill to December 31, 2002; (*2*) from January 1 to February 28, 2003; and (*3*) from March 1, 2003, onward. The last items of the questionnaire included health problems and anxiety related to the spill, and beliefs about the effects of the oil spill on the participant's own health (10). These questions were asked to all, regardless of status concerning participation in clean-up work. The questionnaire was prepared in both the Spanish and Galician languages, and was pilot-tested in one fishermen's cooperative.

Informative meetings were organized in all cooperatives, and questionnaires were made available for all associates to be completed on site, or for those not present to be completed and returned later. Fishermen who did not return a questionnaire received one sent to their home address. Finally, telephone follow-up was performed for associates who had not provided questionnaire responses, and for those who had provided questionnaires with missing information on selected relevant issues. It has previously been demonstrated that the reliability of both methods of administration was comparable (9). The data were obtained between January 2004 and February 2005, that is, 14 to 27 months after the start of the disaster (*see* the online supplement).

Data Analysis

Associations between participation in clean-up activities and chronic respiratory symptoms were evaluated using logistic regression analyses, adjusting for sex, age (equally sized categories for 17–34, 35–45, 46–54, and 55–80 yr), and smoking status (never-smokers, current smokers, and ex-smokers). Potential heterogeneity between cooperatives in the association between participation in clean-up work and respiratory symptoms was examined by standardized methods for random-effects meta-analysis (11). Statistical significance of linear trend was evaluated by the χ^2 statistic for unadjusted association, as well as by P value for the continuous exposure variable from the adjusted logistic regression model. Statistical analyses were done with Stata version 8 (StataCorp, College Station, TX).

RESULTS

Questionnaire information was obtained from 6,869 fishermen (overall response rate, 76%; range, 45 to 93% across cooperatives).

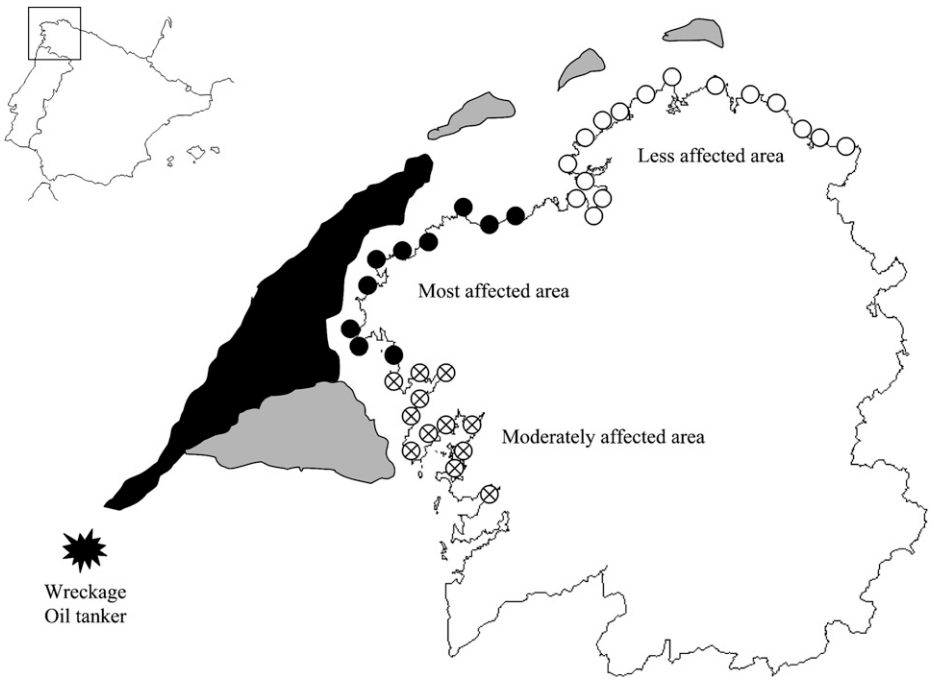

Figure 1. Map showing the geographic location of the 38 fishermen's cooperatives, classified according to the degree of coastal contamination. The combination of strong western winds and northern sea currents transported the oil as indicated by the *black* and *gray* areas. *Open circles*, less affected area (in total about 6,000 tons of oil gathered); *crossed circles*, moderately affected area (in total about 11,580 tons of oil gathered); *solid circles*, most affected area (in total about 44,156 tons of oil gathered). Source: Autonomous government of Galicia (http://www.xunta.es/).

There was no significant correlation (Spearman's r, 0.24; $P = 0.14$) between the response rate and the proportion of fishermen who had participated in clean-up work in each cooperative. Only a small part (26%) of the total nonresponse consisted of fishermen who were contacted but refused to participate. The remainder could not be contacted, despite repeated attempts to do so. Data were obtained through completed questionnaires during the informative meetings at the cooperatives (26%), postal questionnaires (20%), or telephone interviews (54%). After excluding 89 individuals (1%) with missing data for participation in clean-up activities, sex, age, or smoking habit, the final population for analysis comprised 6,780 individuals.

One-third of the population were women, who were on average 7 years older than the men (Table 1). Two-thirds of the men and more than half of the women had participated at least 1 day in clean-up work, the vast majority of them in the first 7 weeks after the oil spill. Those who participated in clean-up work were more likely to be smokers (39 vs. 35%), and were on average 3 years younger (43 vs. 46 yr).

Prevalence rates of lower and upper respiratory tract symptoms were significantly higher in fishermen who had participated in clean-up activities (Table 2). These associations were consistent for both sexes. The use of oral medication to treat respiratory symptoms was more common in clean-up workers, but no association was found with the use of inhalers. Regarding chronic airway diseases, no associations were found between participation in clean-up work and chronic bronchitis or rhinitis, whereas the prevalence of asthma tended to be lower among clean-up workers. Excluding participants who reported having asthma or chronic bronchitis did not alter the observed results. Finally, the association between clean-up work and the prevalence of any lower respiratory tract symptom was significant for never-smokers (odds ratio [OR], 1.54; 95% confidence interval [95% CI], 1.29–1.84), ex-smokers (1.54; 95% CI, 1.17–2.03), and current smokers (2.03; 95% CI, 1.70–2.42; $P < 0.01$ for difference in risk from never-smokers).

TABLE 1. CHARACTERISTICS OF STUDY POPULATION BY SEX

	Men	Women
Participants, n (%)	4,594 (100)	2,186 (100)
Age, yr: mean (range)	41.7 (17 to 80)	48.9 (17 to 78)
Current smokers, n (%)	2,230 (48.5)	330 (15.1)
Ex-smokers, n (%)	1,104 (24.0)	173 (7.9)
Coastal fishermen, n (%)	3,435 (74.8)	158 (7.2)
Shellfish farmers, n (%)	677 (14.7)	1,811 (82.8)
Other,* n (%)	482 (10.5)	217 (9.9)
Less affected area (16 cooperatives), n (%)	769 (16.7)	406 (18.6)
Moderately affected area (12 cooperatives), n (%)	2,701 (58.8)	1,496 (68.4)
Most affected area (10 cooperatives), n (%)	1,124 (24.5)	284 (13.0)
Participation in clean-up activities, n (%)	3,103 (67.5)	1,178 (53.9)
From November 16, 2002, to December 31, 2002,† n (%)	2,591 (83.5)	895 (76.0)
From January 1, 2003 to February 28, 2003,† n (%)	1,204 (38.8)	515 (43.7)
From March 1, 2003 onward,† n (%)	680 (21.9)	312 (26.5)
Total number of days involved, mean (range)	38.2 (1 to 576)	30.3 (1 to 349)
Number of hours per day involved, mean (range)	6.2 (0.5 to 24)	5.1 (1 to 19)

Data obtained from n = 6,780 individuals from 38 fishermen's cooperatives.

* Mainly retired, unemployed, and housewives.

† Percentages relative to clean-up workers only. The three categories are not mutually exclusive; numbers add up to more than 100%.

All following analyses were done with men and women combined, adjusting for sex, age, and smoking status. The overall OR of any lower respiratory tract symptom was 1.73 (95% CI, 1.54–1.94). Similar ORs were obtained after fixed- or random-effects adjustment for area or for cooperative (data not shown). Stratification for area yielded an OR for any lower respiratory tract symptom of 1.26 (95% CI, 0.97–1.64), 1.83 (95% CI, 1.58–2.12), and 1.76 (95% CI, 1.32–2.35) for the less, moderately, and most affected areas, respectively ($P < 0.05$ for interaction between less and moderately affected areas). We also evaluated this association separately for each cooperative. Meta-analysis using data from the 26 cooperatives with at least five exposed and five nonexposed symptomatic participants showed a consistent association between participation in clean-up work and lower respiratory tract symptoms across cooperatives (Figure 2); the P value for heterogeneity was 0.10. There was no association between the cooperative-specific response rate and OR (Spearman's r, −0.12). Stratification for mode of reply showed similar associations for the first responders during the informative meetings (OR for any lower respiratory tract symptom, 1.48; 95% CI, 1.15–1.90), for intermediate responders using postal questionnaires (OR, 1.40; 95% CI, 1.08–1.80), and for late responders using telephone interviews (OR, 1.55; 95% CI, 1.33–1.81).

The risk of having symptoms increased with the degree of exposure, that is, quantitatively increasing participation in clean-up activities (Table 3). A significant dose-related trend was seen when evaluating number of days, average number of hours per day, and number of different activities. These three categorical exposure variables were mutually correlated; χ^2 ranged from 220 to 761 ($P < 0.0001$). Visual inspection of the associations between the degree of exposure continuously and the risk of reporting symptoms, using generalized additive models, did not confirm a linear shape across the entire ranges of the three exposure variables. More than half of the clean-up workers never or only sometimes used a face mask during clean-up activities. The risk of lower respiratory tract symptoms for this group was higher than for those who used a face mask often or always (Table 3). The use of a face mask was less common among those who participated more days or more hours per day in clean-up activities, but was not associated with the number of tasks.

The majority of clean-up workers participated in at least three different activities (Table 3). Almost all activities were associated with respiratory symptoms when analyzed without taking into account other tasks (Table 4). Backward multiple regression modeling was applied to identify activities that were independently associated with symptoms. Tasks that were significantly related to symptoms included cleaning the sea and beaches; transport of the oil; and cleaning boats, clothes, and boots that had been used for gathering oil.

The time elapsed from the last clean-up exposure until completing the questionnaire could be assessed for those who had done all clean-up work before March 2003 and ranged from 322 to 771 days. The association between clean-up work and respiratory symptoms was less apparent in those with more time elapsed since last exposure (Table 5), although it was still significant when more than 20 months had elapsed. Excluding clean-up workers with less than 12 months elapsed (322 to 365 d) resulted in similar findings. Finally, the total number of days of participation in clean-up work was smaller for those with more time elapsed, but the number of hours per day and the number of activities were not associated with the elapsed time. Dose-dependent associations with number of days, number of hours per day, or number of tasks were apparent in each of the categories of elapsed time.

TABLE 2. ASSOCIATIONS BETWEEN PARTICIPATION IN CLEAN-UP ACTIVITIES OF THE *PRESTIGE* OIL SPILL AND RESPIRATORY OUTCOME BY SEX

	Men (*n = 4,594*)		Women (*n = 2,186*)	
	Prevalence (%)	OR (*95% CI*)*	Prevalence (%)	OR (*95% CI*)*
Wheeze with breathlessness	9.6	1.47 (1.17–1.85)	11.0	1.51 (1.14–2.01)
Wheeze apart from colds	10.5	1.61 (1.29–2.02)	9.1	1.30 (0.96–1.76)
Nocturnal attacks of shortness of breath	10.3	1.35 (1.09–1.68)	14.7	1.33 (1.05–1.70)
Chronic cough	16.1	1.99 (1.64–2.42)	17.1	1.71 (1.34–2.16)
Chronic phlegm	17.6	2.02 (1.67–2.43)	13.0	1.57 (1.21–2.05)
Any lower respiratory tract symptom†	33.4	1.84 (1.59–2.13)	33.7	1.55 (1.29–1.87)
Nasal symptoms‡	30.0	1.87 (1.62–2.16)	30.1	1.61 (1.33–1.94)
Inhalation medication usage	9.7	1.15 (0.93–1.43)	11.6	1.08 (0.83–1.40)
Oral medication usage	11.7	1.99 (1.60–2.48)	16.7	1.49 (1.18–1.88)
Asthma§	4.7	0.75 (0.56–1.00)	6.1	0.79 (0.55–1.12)
Chronic bronchitis§	4.6	1.08 (0.80–1.45)	3.8	1.19 (0.76–1.86)
Nasal allergy or rhinitis§	7.9	0.93 (0.74–1.18)	11.4	0.95 (0.73–1.24)

Definition of abbreviations: CI = confidence interval; OR = odds ratio.

Data obtained from n = 6,780 individuals.

* ORs (95% CIs) relative to those who did not participate in clean-up activities (n = 1,491 and 1,008 for men and women, respectively), adjusted for age and smoking status.

† Wheeze with breathlessness, wheeze apart from colds, nocturnal attacks of shortness of breath, chronic cough and/or chronic phlegm.

‡ A problem with sneezing, or a runny or blocked nose when not having a cold or the flu in the last 12 months.

§ According to questions "Do you have, or has a doctor told you that you have ...."

Anxiety and the belief that the oil spill had affected their health were reported by 20 and 8%, respectively, of all fishermen. After excluding 1,616 participants with an affirmative response to the anxiety and/or the health belief effect variables, ORs were lower but still significantly above unity (OR for any lower respiratory tract symptom, 1.57; 95% CI, 1.37–1.80). The same was true when evaluating associations between participation in clean-up work and respiratory symptoms, adjusting for both anxiety and the health belief effect variables (OR, 1.57; 95% CI, 1.40–1.77).

DISCUSSION

In this large cross-sectional study, we found that fishermen who had participated in the clean-up work of the *Prestige* oil spill had an increased prevalence of respiratory symptoms more than 1 year after the beginning of the spill. This association was linked to various types of clean-up activities and was consistent for several subgroups, and the risk increased with the duration of clean-up work and with the number of performed tasks, and seemed to be weaker when more time had elapsed since the last clean-up activity. Our findings suggest that participation in clean-up work of oil spills may result in prolonged adverse respiratory health effects 1 to 2 years after exposure.

Since the late 1980s, several other major oil spills have resulted in heavy coastal contaminations around the world. Scientific and public attention to the ecologic and human health impact was attracted by disasters related to wreckages of the *Exxon Valdez* (Alaska, 1989) (12), the *Braer* (Shetland Islands, UK, 1993) (13), the *Sea Empress* (Wales, UK, 1996) (10), the *Nakhodka* (Japan, 1997) (5), and the *Erika* (Brittany, France, 1999) (4). Potential effects on human health were evaluated in epidemiologic studies focusing on either residents (10, 13) or clean-up workers (4, 5). These surveys were typically performed promptly after the incident and were based on relatively small study populations. A common finding was an increased prevalence of acute respiratory symptoms during or shortly after presumed exposure to the oil. A major drawback of such an approach is the likelihood of response bias. This type of bias is less likely to play an important role in our analyses because

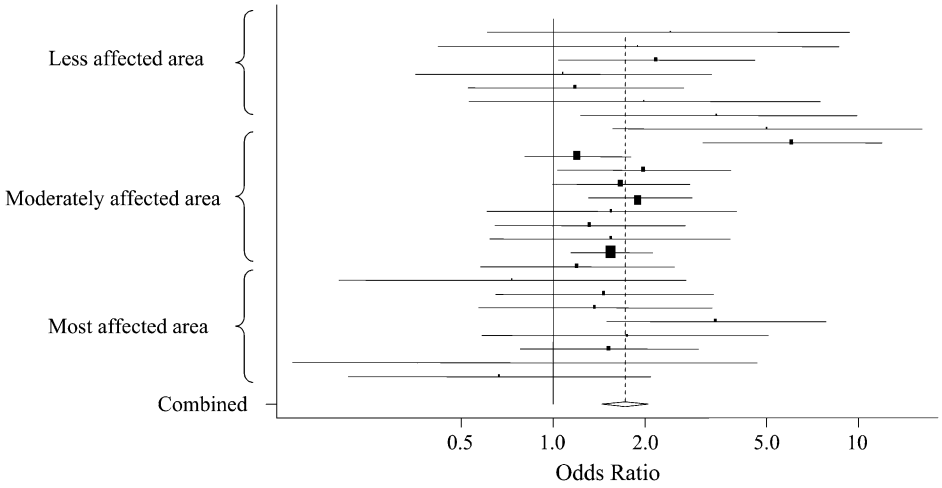

Figure 2. Association between participation in clean-up activities and lower respiratory tract symptoms by fishermen's cooperative. Odds ratio (OR) and 95% confidence interval (95% CI), adjusted within cooperative for sex, age, and smoking status, are shown. The size of each *solid square* is proportional to the reciprocal of the variance of the estimate for the cooperative. The *open diamond* indicates the 95% CI of the combined ORs from the model, with cooperative as the random effect. Twenty-six cooperatives with at least five participants, with and without symptoms for both exposed and unexposed, were included; $P = 0.10$, test for heterogeneity.

TABLE 3. DOSE–RESPONSE RELATIONSHIPS BETWEEN PARTICIPATION IN CLEAN-UP ACTIVITIES AND LOWER RESPIRATORY TRACT SYMPTOMS*

	Number†	OR (*95% CI*)‡
No participation in clean-up activities	2,499	1.00 (reference)
1 to 3 d of participation	982	1.26 (1.07–1.49)
4 to 9 d of participation	964	1.87 (1.59–2.20)
10 to 34 d of participation	1,089	1.87 (1.59–2.19)
35 or more days of participation	1,075	1.89 (1.61–2.22)
P for linear trend		<0.0001
⩽4 h/d Participation	1,275	1.35 (1.16–1.58)
>4 to <6 h/d Participation	832	1.74 (1.46–2.07)
⩾6 to <8 h/d Participation	964	1.88 (1.59–2.22)
⩾8 h/d Participation	1,093	2.12 (1.81–2.48)
P for linear trend		<0.0001
One type of clean-up activity	897	1.37 (1.15–1.63)
Two types of clean-up activity	868	1.58 (1.33–1.87)
Three types of clean-up activity	890	1.65 (1.39–1.96)
Four types of clean-up activity	647	1.92 (1.58–2.32)
Five or more types of clean-up activity	953	2.35 (1.99–2.77)
P for linear trend		<0.0001
Use of face mask often or always	1,937	1.39 (1.21–1.59)
Use of face mask never or only sometimes	2,279	2.05 (1.81–2.33)§

Definition of abbreviations: CI = confidence interval; OR = odds ratio.

* Wheeze with breathlessness, wheeze apart from colds, nocturnal attacks of shortness of breath, chronic cough and/or chronic phlegm.

† Data on number of days, hours per day, types of clean-up activities, and use of face mask were not available for 171, 117, 26, and 65 participants, respectively.

‡ ORs (95% CIs) relative to those who did not participate in clean-up activities (n = 2,499), adjusted for sex, age, and smoking status.

§ $P < 0.001$ for difference between ORs for the two face-mask categories.

separate questions were used to assess (*1*) exposure to clean-up work and (*2*) chronic respiratory symptoms that occurred in the previous year—in other words, well after the start of the disaster.

As far as we know this is the first study that has evaluated prolonged health effects in clean-up workers of a major oil spill. Longer-term health effects of the *Braer* oil spill were evaluated in residents of the affected coastal area of the Shetlands as compared with an unaffected control area 5 months after the spill. Taking into account the initial (13) and follow-up (14) surveys, a decrease in prevalence rates of throat, skin, and eye irritation was found in the exposed population during the 5-month follow-up. Interestingly, it was also noted that after these 5 months more throat irritation and breathlessness on exertion, as well as new onset of wheeze, was reported among the residents exposed to the *Braer* oil spill as compared with the nonexposed control population.

Increased prevalence rates of lower and upper respiratory tract symptoms more than 1 year after the last clean-up activities in our study are suggestive of prolonged and possibly persistent respiratory effects. It is noted that no associations with diagnosed respiratory conditions were observed, and that there were even fewer individuals with asthma among the clean-up workers. The latter can probably be explained by the recommendations of the health authorities that those with asthma and those with other allergic diseases should not participate in clean-up activities. This excludes the possibility that the observed positive associations with respiratory symptoms could be explained by confounding by chronic respiratory disease status and even suggests that a "healthy (clean-up) worker effect" may have led to an underestimation of the risk estimates.

The excess risk of respiratory symptoms was less apparent in fishermen who took part in the survey more than 20 months after their last clean-up activities. This finding may point toward reversibility of the adverse effects after a certain time period. However, this finding cannot be substantiated from this cross-sectional design with retrospective exposure assessment. The recall of exposure may have been influenced by the time elapsed since the clean-up activities. We have identified an appropriate cohort to be followed up to properly evaluate further changes in symptom prevalence over time.

The spilled oil from the *Prestige* contained a variety of volatile hydrocarbons: principally alkanes and various aromatic compounds, including benzene, toluene, and styrene. Many of these volatiles are known to have irritant properties to the mucosal membranes (15), and were therefore likely involved in the appearance of acute irritative symptoms of the eyes, nose, throat, and lower airways. Personal exposure measurements in volunteers who gathered oil from the beaches revealed a mean concentration of total volatile hydrocarbons of 500 $\mu g/m^3$ (16). In addition, various secondary cleaning tasks (mainly of boats and protective clothing) were independently associated with respiratory symptoms in our study. Although measured exposure data are not available and we did not systematically collect

TABLE 4. ASSOCIATION BETWEEN PARTICIPATION IN DIFFERENT TYPES OF CLEAN-UP ACTIVITIES AND LOWER RESPIRATORY TRACT SYMPTOMS*

Type of Clean-up Activity	Number	OR (*95% CI*)†	OR (*95% CI*)‡
Gathering oil from the sea	2,591	1.94 (1.70–2.21)	1.31 (1.13–1.53)
Gathering oil from coastal rocks	1,853	1.80 (1.57–2.05)	—
Gathering oil from confined coastal caves	823	1.94 (1.63–2.31)	—
Gathering oil from beaches	2,245	1.76 (1.55–2.00)	1.19 (1.05–1.35)
Transport of gathered oil	2,040	1.94 (1.70–2.22)	1.15 (1.01–1.32)
Cleaning boats used for gathering oil	1,476	2.19 (1.88–2.54)	1.25 (1.06–1.47)
Cleaning containers used for gathering oil	677	2.13 (1.77–2.56)	—
Gathering affected birds	387	2.17 (1.73–2.73)	—
Cleaning affected birds	43	1.11 (0.56–2.20)	—
Cleaning working clothes or boots that were used during the gathering of oil	1,114	2.23 (1.91–2.60)	1.28 (1.10–1.49)
Other activities§	327	1.89 (1.48–2.42)	1.32 (1.04–1.68)

Definition of abbreviations: CI = confidence interval; OR = odds ratio.

* Wheeze with breathlessness, wheeze apart from colds, nocturnal attacks of shortness of breath, chronic cough and/or chronic phlegm.

† ORs (95% CIs) relative to those who did not participate in clean-up activities (n = 2,499), adjusted for sex, age, and smoking status.

‡ ORs (95% CIs) relative to those who did not perform this type of clean-up activity, adjusted for sex, age, smoking status, and the other activities included in the multivariable model (n = 3,859 + 2,499 = 6,358).

§ Including a variety of tasks such as preparatory work, cleaning other used equipment, distribution of material, and miscellaneous tasks.

TABLE 5. ASSOCIATION BETWEEN PARTICIPATION IN CLEAN-UP ACTIVITIES AND RESPIRATORY SYMPTOMS ACCORDING TO TIME ELAPSED SINCE LAST CLEAN-UP ACTIVITIES

Time Elapsed	Number	Any Lower Respiratory Tract Symptom*	Nasal Symptoms†
322 to 436 d	1,042	2.33 (1.98–2.74)	2.66 (2.27–3.11)
437 to 610 d	1,048	1.69 (1.44–1.99)	1.90 (1.62–2.24)
611 to 771 d	1,056	1.24 (1.05–1.46)	0.91 (0.76–1.09)
Unknown‡	1,135	1.89 (1.62–2.22)	1.98 (1.70–2.32)

Data represent odds ratios (95% confidence intervals) relative to those who did not participate in clean-up activities (n = 2,499), adjusted for sex, age, and smoking status.

* Wheeze with breathlessness; wheeze apart from colds; nocturnal attacks of shortness of breath; chronic cough and/or chronic phlegm.

† A problem with sneezing, or a runny or a blocked nose when not having a cold or the flu in the last 12 months.

‡ Either did clean-up work from March 1 onward (n = 992) or had incomplete information (n = 143).

specific information regarding the cleaning methods, anecdotally it is known that this often involved organic solvents and thus providing an additional source of inhalatory exposure to volatile hydrocarbons. The available evidence for longer term effects of exposures to moderate levels of irritants during days to weeks, however, is scarce. In occupational asthma research there is increasing acceptance of the possibility that recurrent exposures to respiratory tract irritants can result in more persistent asthma-like symptoms and increased bronchial responsiveness, accompanied by an airway inflammatory response (17). This hypothesis may provide an explanation for our findings, further supported by higher prevalence rates of lower respiratory tract symptoms among those who were presumably exposed more intensively and/or for a longer period. However, to our knowledge no study has specifically addressed prolonged respiratory effects of exposures to irritant volatiles in similar situations and therefore strong conclusions regarding the causal agents and the biological plausibility cannot be drawn.

Respiratory complaints typically form part of "medically unexplained physical symptoms" (MUPS), which are frequently reported in the aftermath of (environmental) disasters (18). These symptoms may occur immediately or up to several years after the disaster (19, 20). MUPS may therefore provide an alternative explanation of overall increased prevalence rates of respiratory symptoms in our study population, and possibly also of the observed differences between those who did and did not participate in clean-up work. Regarding the latter, we used a comparison group of coastal fishermen who lived and worked in the same area as the clean-up workers. In spite of not taking part in clean-up work, it is likely that they experienced similar levels of distress, anger, and anxiety related to the impact of the oil spill in this community, which largely depends economically on the sea and the coast. Thus, although MUPS probably played a part in the reported respiratory symptoms, it is unlikely to explain the major part of the observed effect of clean-up work.

This study has a number of potential limitations that need to be considered. First, the information on both exposure and health outcome was self-reported and therefore potentially biased. We judge it unlikely that there was much exposure misclassification when using the reported participation in clean-up work. However, it is possible that those who participated in clean-up work were more likely to report respiratory symptoms, particularly if they were preoccupied about potential effects on their health (10). This could have been the case, for instance, if they recalled acute respiratory symptoms that occurred during clean-up work. In a sensitivity analysis we excluded those who reported anxiety and those with a belief that the oil spill had affected their health, and found that, although somewhat weaker, there was still a significant association between participation in clean-up work and respiratory symptoms. This indicates that perceptual bias (21) cannot be regarded as a major explanation of our findings.

Although the overall response rate was fair (76%) and only a small part of all nonresponse actually represented a refusal to participate, there were some differences in response rate between the fishermen's cooperatives. In this perspective, it is important to note that the cooperative-specific response rate was associated neither with the main exposure variable (i.e., having done clean-up work) nor with the odds ratio for respiratory symptoms. This suggests that the level of affectedness and social involvement in the local society did not influence participation in the study. Importantly, it also indicates that risk estimates were probably not biased by more participation of fishermen who had (more) respiratory symptoms (22, 23).

In conclusion, participation in clean-up activities of oil spills may result in prolonged respiratory symptoms lasting 1 to 2 years after exposure. Increasing the awareness of potential chronic respiratory effects among clean-up workers of future oil spills, in combination with appropriate hygiene regulations, is strongly recommended. In addition, all involved individuals with recurrent exposure to oil should be subjected to medical surveillance to detect potential clinical disorders in the longer term.

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