

Health Effects of Exposure to Oil Spills

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The sinking of the oil tanker *Prestige* off the coast of Galicia was not only the worst ecological disaster ever to affect Spain, it also led to thousands of people who participated in the cleanup of the contaminated areas being exposed to potentially dangerous toxic substances.

As the airway is one of the principal routes of entry into the body of these toxic compounds, the possible effects of exposure to such spills is of particular interest and concern to respiratory specialists. The paucity of clinical information available on the subject was the motive for this paper, which reviews the scientific studies undertaken in the aftermath of other accidents involving oil tankers and concludes with a summary of the clinical and epidemiological data published to date on the *Prestige* oil spill.

Key words: *Oil spills. Exposure. Health.*

La exposición a las mareas negras y sus efectos en la salud

El naufragio del petrolero *Prestige* frente a las costas gallegas no sólo supuso el mayor desastre ecológico en la historia de nuestro país, sino que también propició la exposición de miles de personas que participaron en la limpieza de las zonas contaminadas a compuestos potencialmente tóxicos para la salud. Teniendo en cuenta que la vía respiratoria es una de las principales puertas de entrada de estos compuestos en el organismo, los posibles efectos de estos vertidos preocupan especialmente a los profesionales que nos dedicamos a las enfermedades respiratorias. Sin embargo, la información clínica que tenemos es manifiestamente insuficiente. Por tal motivo se ha elaborado esta revisión. En ella se analizan los estudios científicos realizados a propósito de otros naufragios de petroleros. Finalmente se exponen los datos clínicos y epidemiológicos de las investigaciones publicadas hasta la fecha con ocasión del hundimiento del buque *Prestige*.

Palabras clave: *Vertidos de fuel. Exposición. Salud.*

Introduction

On November 13, 2002 the 30-year-old single-hull oil tanker *Prestige* sent out a Mayday signal from a position close to Cape Finisterre on the coast of Spain. The tanker was transporting fuel oil from Saint Petersburg in Russia and Ventspils in Latvia to Singapore under a Bahamas flag of convenience. The first signs of the spillage were observed on the Galician coast on November 16. After sinking 130 miles to the southwest of Cape Finisterre on November 19, the tanker discharged part of its 77 000 ton cargo of fuel oil.¹ The resulting oil slick affected the whole coastline of Galicia and also contaminated parts of the coastline of Asturias, Cantabria, and the Basque Country. In the worst ecological disaster ever to affect Spain, the oil polluted

beaches, rocky shorelines, and the sea bed. In Galicia, the spillage affected a considerable stretch of coastline in an irregular way determined by the particular geography of the seaboard, the weather conditions, and the marine currents (Figure 1).

Cleaning up the spillage was a laborious task and much of the work was carried out by teams of volunteers (made up of local residents from the affected area but also people who traveled from other parts of Galicia, other regions in Spain, and even from other countries) in one of the most impressive displays of community support in our recent history. The impact on local communities was very significant because most of the crews of the fleet that usually fishes in Galician territorial waters (approximately 28 000 people) could not fish and had to spend every day for months—in some cases over a year—working on cleanup activities.

Oil is an organic compound that is extracted from the earth's crust and transported to different parts of the world in pipelines and tanker ships. The unrefined product is called crude oil. In the refinery, crude oil is separated into light fractions (refinery gas and gasoline), intermediate fractions (kerosene and diesel), and heavy fractions (light

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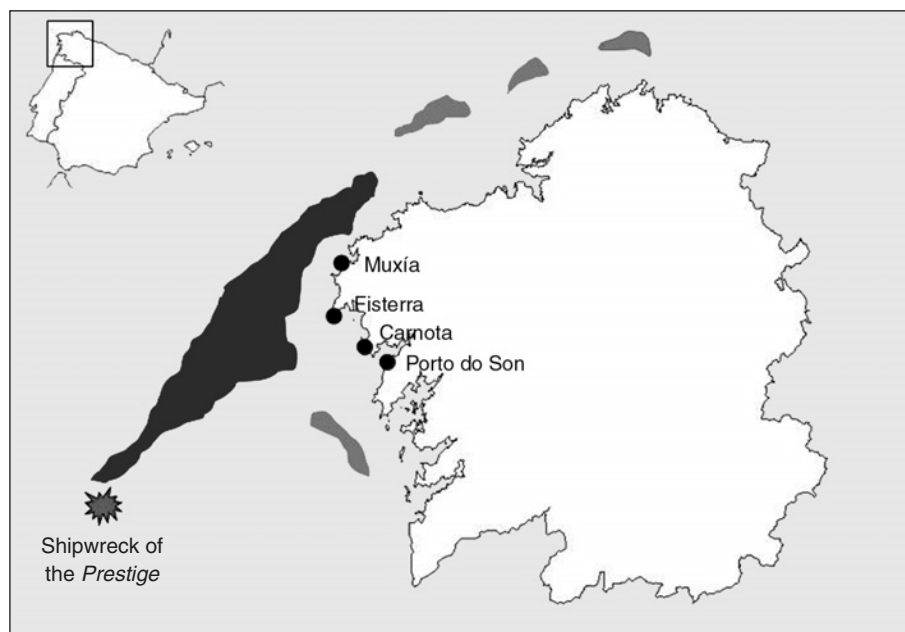


Figure. Map showing the extent of the pollution caused by the *Prestige* oil slick and the areas included in the study by Gestal Otero et al.²

fuel oil, heavy fuel oil, and asphalt). The *Prestige* was transporting a heavy fuel oil classified—because of its high sulfur content (4%)—as M100 in the Russian system, number 6 in English terminology, and number 2 on the French scale. This type of fuel is characterized by its high density (992.1 kg/m³ at 15°C) and strong viscosity (615 centistokes at 50°C and 30 000 at 15°C). It has a low evaporation rate and natural dispersion and forms a stable emulsion when mixed with water. The biodegradation rate of the spill is unknown and was probably under 10% in the first few months. The fuel oil spilled was composed of a complex mix of hydrocarbons, resins, asphaltenes, and heteromolecules (Table 1).^{3,4}

The people involved in the task of cleaning up the oil were exposed to these potentially toxic substances, which mainly enter the human organism either by inhalation or via the skin and mucous membranes. The digestive tract is another, less important, route that should be taken into account. The subsequent kinetics of these substances are

poorly understood. Animal studies show that hydrocarbons accumulate primarily in the lungs and in organs with a high fat content. Since the detoxification process generates metabolites and conjugates that are eliminated in urine and feces, they do not, in general, remain in the organism. The metabolization process may also generate reactive molecules that bind to DNA to form adducts.

Acute exposure to volatile organic compounds (VOCs) may cause neurological symptoms, such as headache, nausea, dizziness, and sleepiness. It can also cause breathing difficulties, nausea, vomiting, and abdominal pain.^{5,6} The classification published by the International Agency for Research on Cancer (IARC) categorizes some of the VOCs present in the fuel being transported by the *Prestige* (such as, for example, benzene) as Group 1 agents, that is, substances that have been evaluated as being proven human carcinogens.⁷ Substances in this group are closely associated with hematologic cancer. Others, such as toluene, ethylbenzene, and styrene, belong to Group 2B, the

TABLE 1
Composition of the *Prestige* Fuel Oil and Toxicity of its Components

	Composition	Toxicity
Aromatic hydrocarbons (50%)	Volatile organic compounds: benzene, toluene, xylene Polycyclic aromatic hydrocarbons: naphthalene, phenanthrene, dibenzothiophene, fluoranthene, chrysene, and alkyl derivatives High molecular weight: benzofluoranthenes, perilene, benz[a]anthracene, benzo[a]pyrene, etc	Acute symptoms (respiratory and neurovegetative). Carcinogens Possible carcinogens. Endocrine alterations. Skin and mucosal irritants Probable carcinogens. Mucosal irritants
Saturated hydrocarbons (22%) Resins and asphaltenes (28%) Heteromolecules with atoms of sulfur, oxygen, nitrogen, heavy metals (cadmium, lead, nickel)		Endocrine alterations. Carcinogens

TABLE 2
Summary of the Literature on Oil Spills*

Spill	Design	No.	Subjects	Time Elapsed	Exposure Measured	Chief Findings
<i>Exxon Valdez</i> ⁹	Cross-sectional	599	Residents	1 y	No	Anxiety, posttraumatic stress
<i>Braer</i> ¹⁰	Cross-sectional	512	Residents	8 d	Yes	Headache, throat irritation, itchy eyes
<i>Sea Empress</i> ¹¹	RCS	1089	Residents	7 wk	No	Headache, throat irritation, itchy eyes
<i>Nakhodka</i> ¹²	Cross-sectional	282	Cleanup participants	20 d	Yes	Headache, throat irritation, itchy eyes
<i>Erika</i> ¹³	Cross-sectional	1465	Cleanup participants	1 mo	No	Headache, dermatitis, irritated eyes, respiratory symptoms, nausea

*RCS indicates retrospective cohort study.

classification applied to agents that have been evaluated as being possibly carcinogenic to humans on the basis of evidence of carcinogenicity in animals. Polycyclic aromatic hydrocarbons can damage skin and mucous membranes, and are toxic to the endocrine system.⁸ These compounds have been implicated in the pathogenesis of tumors, and especially in the formation of skin tumors. The following polycyclic aromatic hydrocarbons present in the fuel oil carried by the *Prestige* are classified by the IARC as Group 2A agents and are, therefore, considered probably carcinogenic to humans: benz[a]-anthracene, benzo[a]pyrene, and dibenz[a,h]anthracene. Others, such as naphthalene, benzo[b]fluoranthene, benzo[j]fluoranthene, and benzo[k]fluoranthene, are classified as Group 2B substances, possibly carcinogenic to humans. Heavy metals also have carcinogenic properties and may affect the endocrine system. No research has been carried out to date on the long-term effects of exposure to this combination of toxic substances, the possibility of interactions between these agents, or the greater or lesser degree of individual susceptibility depending on the genetic profile.

Several scientific societies and environmental organizations have evaluated the impact on public health and safety and the ecological and economic repercussions of this catastrophe.

Information Obtained in Previous Oil Spills

Over the last few decades, numerous accidents involving large oil tankers have occurred close to the coasts of several countries, and several epidemiological studies have investigated the impact of exposure to oil spillage on the health of the affected population. Table 2 summarizes the methods and principal findings of these studies.⁹⁻¹³

The Exxon Valdez (Alaska, March 24, 1989)

The *Exxon Valdez* incident is the earliest oil spill about which a certain amount of scientific information is available. This tanker released over 40 000 tons of crude oil and more than 11 000 people were involved in the cleanup operation. A report published by the National Institute for Occupational Safety and Health provided data on the 1811 compensation claims filed by people involved in the operation: 800 (44%) were related to injuries (cuts, sprains, and contusions), 264 (15%) to respiratory problems, and 44 (2%) to dermatitis.¹⁴ Research into the repercussions

of this spill focused mainly on the impact of the event on mental health. In one such cross-sectional epidemiological study, Palinkas et al,⁹ who used questionnaires to survey a sample of 599 people (women and men) 1 year after the spill, found that individuals who had been exposed were 3.6 times more likely to have generalized anxiety disorder, 2.9 times more likely to have posttraumatic stress disorder, and 2.1 times more likely to obtain a high score on the depression scale.

The Braer (Scotland, January 5, 1993)

The *Braer* oil tanker with its 85 000 ton cargo ran aground off the southwest coast of Shetland, and high winds in the area for several days following the accident led to extensive coastal pollution. Peak expiratory flow rate was measured 3 days later in children aged 5 to 12 years who lived within a 5 km radius of the spill.¹⁵ Nine to 12 days after the accident this measurement was repeated and spirometry was performed. In total, 44 (79%) children were assessed on the first occasion and 56 (92%) on the second. The results obtained at 3 days fell within the normal range even among children with asthma, and no later deterioration in lung function was observed. In a cross-sectional study, Campbell et al¹⁰ evaluated 420 exposed individuals living within a 5 km radius of the accident 1 to 2 weeks after the shipwreck and compared this group with 92 controls (people living in Hillswick, 95 km north of the affected area). Using a questionnaire, they assessed symptoms before (2 weeks) and after the accident. Peak expiratory flow rate was measured, hemoglobin concentrations and complete blood count were determined, and renal and liver function tests were performed. Urine was analyzed for sugar, protein, red blood cells, and markers of exposure to polycyclic aromatic hydrocarbons. The response rate was 66%, and nonrespondents were followed up by way of a telephone survey. In exposed participants, there was a higher prevalence of headache, throat irritation, dermatitis, and itchy eyes after the accident than during the 2-week period before the spill. The differences for other symptoms, including diarrhea, nausea, wheezing, cough, and chest pain, were much less marked. A higher prevalence of headache, throat irritation, and itchy eyes was found in the exposed group than among controls. Most of the participants reported onset of symptoms on the day after the spill, and in 97% symptoms resolved within a week. No differences were found in peak expiratory flow

rate or in the results of blood and urine analysis. Higher urinary hippuric acid was, however, detected in the exposed group, a result that may indicate exposure to toluene. Six months later, the same authors reevaluated these 2 cohorts (344 of the 420 exposed participants and 77 of the 92 controls) by way of a comprehensive questionnaire, measurement of peak expiratory flow, and analysis of markers in blood and urine.¹⁶ In that study, more members of the exposed group reported throat irritation and breathlessness than the controls, and perceived their health to be poorer. No differences were found in the results of lung function testing or blood and urine analysis.

In the case of the *Braer* oil spill, the exposed population was studied very soon after the catastrophe and the response rate was good. However, the results of these studies may have been affected by recall and reporting biases. Furthermore, the functional testing and biological analysis were probably not sensitive enough to detect effects.

The objective of another study carried out in the aftermath of the *Braer* accident was to detect evidence of any primary genetic damage that might have occurred as a result of exposure by quantifying DNA adducts and monitoring the frequency of genetic events induced by this primary damage (cytogenic damage or genetic mutations).¹⁷ The authors analyzed samples from 20 exposed individuals extracted first during the acute phase of the incident and then 10 weeks and 10 months after maximum exposure. The results were compared to those of 7 controls. The numbers of DNA adducts and genetic events observed were similar at all time points and no differences were found between the exposed group and the controls.

The Sea Empress (Wales, February 15, 1996)

When the *Sea Empress* discharged 72 000 tons of its 130 000 ton cargo of crude oil, the resulting oil slick polluted 200 km of coastline. In a retrospective cohort study, Lyons et al¹¹ investigated the acute impact of the spill on the physical and mental health of the affected population. Information was collected by way of a questionnaire distributed by mail 7 weeks after the accident. This survey included a health diary for the 4 weeks following the accident to be completed retrospectively and a symptom checklist used in the *Braer* study. The questionnaire was mailed to 539 subjects resident in the affected area (the exposed group) and 550 residents of an unaffected part of the coast (the control group). The response rate was high (69%) and similar in both the affected (68%) and unaffected (70%) areas. After adjusting for age, sex, smoking status, anxiety, and reported concern about the effects of oil exposure, an association was observed between exposure to the spill and headache (odds ratio [OR], 2.35; 95% confidence interval [CI], 1.56-3.55), sore eyes (OR, 1.96; 95% CI, 1.06-3.62), and sore throat (OR, 1.70; 95% CI, 1.12-2.60). These authors did not follow up the participants later or measure biological markers.

The Nakhodka (Japan, January 2, 1997)

The *Nakhodka*, a Russian oil tanker carrying 19 000 tons of number 6 fuel oil, broke up just northwest of the

Japanese Oki Islands and released over 6000 tons of its cargo, causing an oil slick that polluted the west coast of Japan. The spill affected an inaccessible area and the cleanup was done manually with shovels and buckets. In an epidemiological study, Morita et al¹² investigated the acute effects of oil exposure in the group of men and women who took part in the cleanup activities. They report that environmental levels of hydrocarbons and their components (peak level on January 15, 1.51 parts per million [ppm]), suspended particles (peak level on January 18, 0.088 mg/m³), and sulfur (<0.001 ppm) remained below accepted limits for occupational exposure at all times. Four subjects wore portable devices to measure activated carbon during a 2-hour period while working on cleanup activities on January 31. The concentrations of benzene, toluene, and xylene recorded were considerably below toxic levels. Public health nurses interviewed 282 residents of the affected area 20 days after the spill. The interview was guided by a questionnaire and data was collected on each subject's daily participation in the cleanup activities, direct exposure to fuel oil, as well as their state of health and symptoms following exposure. In addition, urine samples from 95 participants obtained at the end of a day's work were tested to measure the presence of metabolites secondary to hydrocarbon exposure (hippuric acid for toluene; methylhippuric acid for xylene, and *trans,trans*-muconic acid for benzene). Most of the participants were over 40 years of age. On average, the men had worked on cleanup activities for 4.7 days and the women for 4.4 days. Over 40% of the subjects only participated for 1 or 2 days, and only 17% worked on the cleanup for more than 10 days. The participants came into direct contact with the fuel oil, especially on the face and arms. All of the cleanup workers wore gloves but under 30% wore glasses. Mask use was much higher among women (87%) and lower among men (35%). The most common symptoms reported were back and leg pain (34% in men and 38% in women), headache (9% in men and 28% in women), itchy eyes (21% in men and 36% in women), and irritated throat (13% in men and 21% in women). A positive correlation was found between the number and duration of the symptoms reported and the number of days worked. The chief risk factors for developing symptoms were female sex, number of days worked, and direct contact with fuel oil. With respect to the measurement of hydrocarbon metabolites in urine, only 3 participants had slightly elevated concentrations of hippuric acid, and those levels had returned to normal when a follow-up analysis was performed 4 months later.

Like earlier researchers, those authors investigated acute-phase symptoms and, while comprehensive measurements of exposure were made, the study was, nonetheless, limited by the lack of a control group.

The Erika (France, December 12, 1999)

The *Erika* sank 55 km off the French coast at Penmarch' point on the south coast of Brittany. The tanker was carrying 28 000 tons of heavy number 6 fuel oil, and the spillage reached the coastline on December 24, 1999. Schvoerer et al¹³ carried out a cross-sectional epidemiological survey

on the basis of a self-administered questionnaire that was mailed to 3669 people—both volunteers and paid workers—who took part in the cleanup activities before January 17, 2000. The selection of the study population was based on incomplete lists of the people who took part in the operation provided by the local authorities of some of the affected areas. The response rate was low (43%), and information was collected from 1465 people. Of these, 7.5% reported injuries and 53% some kind of health problem. The most commonly reported symptoms were back pain (30%), headache (22%), and dermatitis (16%). To a lesser degree, participants also reported eye irritation (9%), respiratory problems (7%), and nausea (6%). The length of time spent working on cleanup activities was identified as a risk factor for all of the health problems reported.

One limitation of the study design was the lack of a control group. Moreover, the use of incomplete lists made it impossible to properly define the study population, and this defect, in conjunction with the low response rate, makes it difficult to draw general conclusions from the results. The possible influence of recall and reporting biases should also be taken into account.

An evaluation of the long-term teratogenic and carcinogenic consequences of exposure to this spill concluded that such risks were negligible except in the case of the bird cleaners, who had a slightly increased risk of developing skin cancer.¹⁸

In summary, the studies undertaken to evaluate the repercussions on human health of exposure to oil spills have tended to focus on acute and short-term effects, have been based on symptom assessment, and suffer from a number of methodological limitations. Exposure has been quantified in very few studies. Only 1 study evaluated lung function and other biological markers and even then in a very rudimentary way. Across the board, all the studies report an association between acute exposure to spillage and the presence of neurovegetative symptoms and irritation of the skin, eyes, and throat.

The Case of the Prestige: Initial Scientific Data

The initial data on the effects of exposure to the fuel oil released from the *Prestige* can be obtained from the record of visits to doctors working for the local health service (Plan Sanitario Combinado del Servicio Galego de Saúde).¹⁹ These records show that there were 955 consultations between November 29, 2002 and January 27, 2003. The majority were men (66%), and most of the patients were between 16 and 45 years of age (85%). The health problems most commonly reported were irritated eyes (14%), headache (13.5%), throat irritation (13%), injuries (8%), nausea and vomiting (9%), breathing difficulty (10%), dermatitis (7%), back pain (7%), deterioration in consciousness level (4%), abdominal pain (4%), and cuts (4%).

Gestal Otero et al² undertook a longitudinal epidemiological survey of both paid workers and volunteers with a 5-day follow-up. The fieldwork was done between March 25 and May 31, 2003 (4-6 months after the spill). The sample studied (858 participants) in highly polluted

areas—Porto do Son, Carnota, Fisterra, and Muxía (Figure 1)—comprised 244 volunteers who worked for 1 day, 322 volunteers who worked for 1 week, 186 paid beach cleaners (4 months, 6.5 h/d), and 106 high-pressure hose operators (3 months, 6.5 h/d). The following is a brief description of the study.

Characterization of Exposure

Perceived exposure. In response to a questionnaire used to assess perceived exposure, most of the participants reported using personal protective equipment (gloves, boots, protective clothing, waterproof suit, and mask), but also said that they ate, drank, and smoked in contaminated areas.

Environmental exposure. Personal dosimeters were used to measure VOC levels. The measurements obtained revealed that, in the worst cases (volunteers working at the end of April), VOC levels were equivalent to those of highly polluted cities, such as Athens or Mexico City, with a predominance of light hydrocarbons (benzene, *n*-heptane, toluene, and *n*-octane). Benzene levels were high (volunteers, 388 $\mu\text{g}/\text{m}^3$; workers, 115 $\mu\text{g}/\text{m}^3$) in view of the fact that the yearly average value recommended by the European Union is 5 $\mu\text{g}/\text{m}^3$ (directive 2000/69/EC).

Internal exposure. Internal exposure was quantified by measuring hydrocarbon metabolites in urine (1-hydroxypyrene and ϵ -hydroxyphenantrenes) and heavy metal concentrations in blood. Among the volunteers, the group of people with no prior history of exposure, urine concentrations of 1-hydroxypyrene increased by 40% and of ϵ -hydroxyphenantrenes by 55% between the first and the fifth day of work. Owing to previous accumulated exposure, the paid workers had higher baseline concentrations and no significant changes were observed between the 2 time points in this group. In a different publication related to the same study, Pérez-Cadahía et al²⁰ reported that paid workers also had significantly higher levels of aluminum and nickel as compared to the control data (volunteers before starting work).

Assessment of Acute Symptoms

The results of the questionnaire used by Gestal Otero et al² to assess perception of health problems revealed that the most common symptoms among volunteers (excluding injuries) were headache (19%), back pain (15%), and dizziness (11%); and to a lesser degree dermatitis (4%) and respiratory problems (4%). The paid workers reported back problems (30%), headache (12%), irritated eyes (10%) and throat (9%), and respiratory problems (4%). According to the retrospective reporting in this group, the frequency of these symptoms was the same as during the months prior to the study. Direct contact with fuel oil on the first day of work was associated with a higher number of accidents and problems affecting the respiratory system, muscles, skin, and mucous membranes.

Genetic Toxicity

In the same study, genetic toxicity was investigated in 60 volunteers working on beach cleanup activities after 5 days of work, 60 paid beach cleaners, and 60 pressure hose operators; the results were compared to those of 60 controls. Comet assays were carried out to detect single strand DNA breaks. This assay is based on the following 3 parameters: the percentage of DNA in the comet tail (% tail DNA), which is proportional to the frequency of the damage; tail length, which is directly related to DNA fragment size and proportional to the number of breaks and alkali-labile sites; and comet tail moment, which is calculated as the product of the first 2 parameters. An increase in DNA damage was observed in all 3 variables (% tail DNA, tail length, and tail moment) in the 3 exposed groups, although it was more marked in the volunteers working on beaches and the increase correlated with the level of exposure to VOCs. According to the authors, the type of damage detected is easily repaired.

Genetic toxicity was also investigated by way of micronucleus and sister-chromatid exchange testing in a subgroup of 25 volunteers assessed after 5 days of work on beach cleanup (4h/d), 20 paid beach workers (4 months, 6.5 h/d), 23 pressure hose operators (3 months, 6.5 h/d), and 42 controls.²¹ Any interpretation of these results must take into account that the percentage of smokers was significantly lower among the controls (24%) than in the exposed group (42%), and that the groups were not comparable in terms of age and sex. No differences were observed in micronuclei frequencies and, while the frequency of sister-chromatid exchange was increased in the high pressure hose operators, this difference disappeared when the smokers were excluded from the analysis. No clear reduction of effect was observed among the subjects who wore masks while working.

At this point it is interesting to cite the study by Laffon et al,²² who evaluated possible acute genotoxic damage in the volunteers from the University of A Coruña who cleaned and performed autopsies on birds contaminated by the fuel oil. Those authors used the comet assay and micronucleus test to assess 34 of these volunteers and compared the results to those of 35 controls. They quantified exposure levels by measuring VOC levels in the air of the room where the work was being carried out and by counting the total number of hours worked (35% of the participants worked for under 150 hours, 29% worked for between 150 and 500 hours, and 35% for over 500 hours). VOC concentrations remained below 200 µg/m³, levels equivalent to those found in cities considered relatively unpolluted, and the benzene level was 1.6 mg/m³. Tail length was greater in the exposed group, and this parameter correlated with length of exposure. No differences were found in micronucleus test results. The authors also analyzed each participant's genotype and observed that individuals with polymorphisms in DNA repair genes XRCC1 399G1 and APE 1 148Glu were more likely to present damage as a result of exposure to the fuel.

Endocrine and Immunologic Toxicity

In the endocrine and immunologic toxicity studies carried out by Gestal Otero et al,² blood samples obtained from a group of volunteers before they started work on cleanup activities were used as controls. Circulating levels of interleukin (IL) 2, 4, 6, and 10, tumor necrosis factor- α , and interferon- γ were measured. The paid workers had reduced CD4 cells, IL-2, IL-4, IL-10, and interferon- γ . With respect to the same study, Pérez Cadahía et al²⁰ reported that alterations were detected in the endocrine system unevenly across the groups studied among paid female workers (an increase in prolactin concentrations) and pressure hose operators (a reduction in plasma cortisol levels).

Acute Health Problems

To conclude this review of the literature on the health effects of the *Prestige* cleanup, we will move on to a cross-sectional study by Suárez et al,²³ who investigated the occurrence of acute health problems caused by the spill. They used an incomplete record of participants in the cleanup operations in Cantabria and Asturias supplied by the public health authorities. This record included volunteers, seamen, paid workers, and bird cleaners (4117 in Asturias and 3621 in Cantabria). The authors selected a random sample stratified by type of worker and the number of days worked. The final sample comprised 799 individuals (135 bird cleaners, 266 volunteers, 265 paid workers, and 133 seamen). On the basis of a questionnaire administered during a telephone interview 7 months after the shipwreck, they evaluated the characteristics of the subject's exposure, acute health problems, and use of protective measures. The paid workers and the seamen were the groups that worked on the cleanup for the longest periods. Almost half of the participants reported having been exposed to unpleasant odors and this experience was reported by a greater proportion of the seamen. The overall prevalence of symptoms was not very high: injuries (7%), back pain (5%), headache (8%), eye problems (8%), neurovegetative symptoms (11%), and throat irritation and respiratory problems (8%). In contrast to other studies,¹¹ skin problems were uncommon. A high percentage of seamen (49%) ate in situations where they were in contact with the fuel oil. This group also presented a higher prevalence of symptoms, especially throat irritation and respiratory problems (30% of the seamen interviewed) and headaches (28%). The most common symptom among the paid workers was headache (16%), among the bird cleaners injuries such as cuts or blisters (19%), and among the volunteers neurovegetative symptoms such as nausea and vomiting (11%). Among the bird cleaners, the number of injuries was directly related to the number of days worked (OR, 27.69 for periods over 20 days) and torn gloves (OR, 11.10). The risk factors for toxic effects (headaches, sore eyes, neurovegetative symptoms, throat irritation, and respiratory problems) were as follows: working for more than 20 days in highly polluted areas, involvement in 3 or more different cleaning activities, skin contact with fuel oil, and perception of unpleasant smells.

TABLE 3
Principal Results of the Published Studies on the Health Effects of the Prestige Oil Spill*

Study	Design	No.	Time Elapsed, mo	Acute Symptoms	Other Findings
Gestal Otero et al ²	Longitudinal	858 (CP)	4-6	Headache, irritated eyes and throat, respiratory symptoms	↑ DNA damage, ↓ CD4, ↑ CD8, ↓ IL-2, IL-4, IL-10, IFN-γ
Suárez et al ²³	Cross-sectional	799 (CP)	7	Headache, irritated eyes and throat, respiratory symptoms	

*CP indicates cleanup participants; IL, interleukin; IFN, interferon.

In a subsequent article, these authors provided more data from the same study relating to the health information received by participants before they started work on the cleanup, the use of protective clothing, and acute health problems.²⁴ The most well informed group were the paid workers (94% of whom received information) and the least well informed were the seamen (68%). Receiving health information was associated with the use of protective measures. The people who did not receive such information had a higher risk for all symptoms, especially itchy eyes (OR, 2.67; 95% CI, 1.13-6.28), neurovegetative symptoms (OR, 2.09; 95% CI, 1.07-4.08), and problems affecting the throat and respiratory system (OR, 2.08; 95% CI, 1.02-4.24). The workers who had the highest level of exposure to the fuel oil were the seamen, who were also the least well informed group and the one with the highest frequency of acute health problems.

Conclusions

The research assessing the health effects of exposure to the fuel oil discharged by the *Prestige*, similar to that carried out in the aftermath of other oil spills, focused on the acute phase and identified mainly neurovegetative symptoms, irritation of the skin and mucous membranes, and respiratory problems. With respect to assessment of symptoms, the 2 studies discussed above dealt with a selected exposed population but did not include a control group, an omission that limits the usefulness of the results. Although Suárez et al^{23,24} observed a relationship between degree of exposure and symptoms, this association was not observed by Gestal Otero et al,² who measured both external and internal exposure levels individually. It is important to note that the seamen may have been particularly affected. As the results of the biological tests were not uniform across the different groups studied, they should be interpreted with caution. The most noteworthy result was the increase in DNA damage. The significance of this finding is not yet clear, and greater understanding can only be achieved by monitoring exposed individuals over time to determine whether the damage has been repaired or whether it leads to the continuous generation of new chromosomal anomalies (chromosomal instability), a situation associated with an increased risk of cancer. The same applies to the immunologic alterations, which may be an indication of a systemic inflammatory reaction that should also be evaluated over time.

The board of the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) set up a multicenter,

multidisciplinary research team in December 2002 to investigate the impact of the *Prestige* oil spill. The SEPAR-*Prestige* study being carried out by this team is an epidemiological survey of the clinical, biological, and functional effects of the *Prestige* oil spill on the respiratory health of seamen on the Galician coast. This is the first study to analyze the long-term impact of exposure to oil spillage on respiratory health. The study population comprises 10 000 inshore fishermen and shellfish harvesters. This is a cross-sectional study comprising 2 consecutive phases. During the initial phase, the target population was defined using a questionnaire. In the second phase, 2 groups were studied (a group of exposed subjects and a group of unexposed controls). Participants completed a symptom questionnaire and underwent lung function testing (spirometry and a methacholine challenge test of bronchial hyperreactivity). Sensitivity was assessed using oxidative stress markers and cytokines in exhaled breath condensate and immunoglobulin E, and chromosomal instability was also studied (using both conventional cytogenetic techniques and molecular analysis). The results will provide detailed data on the long-term respiratory and genetic effects of exposure to oil spills.

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