Symptomatology attributable to psychological exposure to a chemical incident: a natural experiment

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Background: Exposure to a complex emergency has a substantial psychological component, which is rarely assessed. This study compares the health impact of physically and psychologically mediated exposure to a complex emergency.

Setting: The Sea Empress oil tanker spill.

Design: A cross-sectional analysis of self-report questionnaire responses collected from inhabitants of 6 different coastal towns—4 of them physically exposed to the oil spill, 2 unexposed—was undertaken. The towns were known to be psychologically homogeneous before the incident. Perceived risk was used as a measure of psychological exposure. Anxiety, depression and symptom reporting were used as measures of health impact.

Participants: 1089 (69%) men and women aged 18–65 years responded.

Main results: Perceived risk was associated with raised anxiety and non-toxicologically related symptom reporting, whereas physical exposure to oil was only associated with toxicologically related symptom reporting. The impact of raised perceived risk on the population was greater than that of physical oil exposure, involving more persons over a wider area.

Conclusions: Psychological exposure was shown to be quantifiable, and to be a substantially more sensitive measure of health impact than physical exposure in relation to psychological outcomes. This type of analysis has important implications for emergency response planning, and for the interpretation of a complex emergency by the general public.

Psychological exposure to complex emergencies is becoming more frequent and more pervasive due to widespread media coverage.¹ Psychological exposure may be defined as the belief of individuals that they have been exposed to an incident or its consequences, and is in contrast to physical exposure.² Although individuals may be affected by either or both exposures, the mechanisms involved are distinct.

The health, social, psychological and economic impact of psychological exposure to complex emergencies may be as severe as that from physical exposure.³ To respond effectively and appropriately to complex emergencies, the impact of both physical and psychological exposure needs to be estimated. Quantifying the impact of psychological exposure is problematic as, relative to a physical exposure, pre-incident levels of psychological functioning are likely to be unknown. Also, the effect of psychological exposure is likely to be more complicated, varying widely in severity over time and geographical area. Nevertheless, strategies are required to estimate the impact of psychological exposure.

In this paper, we take the opportunity to compare the impact of physical and psychological exposure to a chemical incident (the Sea Empress oil spillage)⁴ occurring in areas known to be psychologically homogeneous before the incident.⁵ Physical exposure was defined as living in an oil-exposed community, whereas psychological exposure was defined as experiencing raised perceived risk. Symptomatology was used as the primary outcome, and anxiety and depression were used as secondary outcomes. Impact on health was explored in terms of possible mechanisms and attributable risk.

METHODS

Background

On 15 February 1996, the Sea Empress, loaded with more than 130 000 tonnes of light crude oil, ran aground off the west coast

of Wales, UK. Over the subsequent week, an estimated 72 000 tonnes of crude oil and 360 tonnes of heavy fuel oil were released into the sea. Approximately 200 km of coastline was contaminated, producing strong smells for the local residents.⁴

Study population

A random sample of 1585 adults aged 18–65 years was selected from general practitioners' (GP) registers in six towns in west Wales. Four towns were located in areas directly affected by coastal oil pollution (exposed population = 794). Two towns were in areas free of oil pollution (unexposed population = 791). A survey conducted 4 years previously in five of the six towns, including one of the unexposed towns, found no difference in Short Form-36 mental health scores between oil-exposed and oil-unexposed towns.⁵

Data collection

A questionnaire was mailed to participants 7 weeks after the incident. The questionnaire included the Hospital Anxiety and Depression Scale, a validated and widely used measure of anxiety and depression.⁶ The questionnaire also included items on occupation, smoking, age, sex, symptoms and perceived risk. Oil exposure was assessed in terms of living in oil-exposed or oil-unexposed communities. Perceived toxic exposure, assessed in terms of perceived risk, was assessed by a single question on each of three issues. These were health, finance and the environment. The questions were as follows and were answered using a five-point scale:

As a result of the Sea Empress oil spillage, do you think your health in the future will be: much better, 1; better, 2; unchanged 3; worse, 4; or much worse, 5.

As a result of the Sea Empress oil spillage, do you expect your financial circumstances to be: much better, 1; better, 2; unchanged 3; worse, 4; or much worse, 5.

As a result of the oil spillage, do you think that your future enjoyment of the local surroundings will be: much better, 1; better, 2; unchanged 3; worse, 4; or much worse, 5.

Health impact was assessed using a symptoms checklist that had been previously validated for detecting the toxicological and non-toxicological effects of oil exposure.⁷ The symptoms assessed were headache, nausea, vomiting, diarrhoea, sore eyes, runny nose, sore throat, cough, itching skin, skin rash, blisters, shortening of breath, tiredness or weakness and other. Confounding variables assessed were age, gender, occupation, anxiety,⁶ depression⁶ and social deprivation.⁸ Social deprivation was assessed by postcode.

Statistical analysis

To isolate the acute effects of oil exposure, the effects of prior illness were removed by omitting individuals who were ill on the day of the oil spillage or who reported symptoms on the first day of the incident—that is, before any oil exposure. For the purpose of logistic regression, the number of symptoms was modelled as a two-level factor variable indicating the presence or absence of reported symptoms. Due to the skewed distributions of the perceived risk questions, perceived risk was defined as a two-level factor. The lower three categories were collapsed into a no perceived risk category, and the higher two categories into a some perceived risk category. Depression and anxiety were split at the median and treated as two-level factors. Age was grouped (18–34, 35–49 and 50–65 years) and deprivation score was entered as a continuous variable. Smoking was treated as a three-level factor (current smoker, ex-smoker, never smoked) and occupation was modelled as a 10-level factor identifying different areas of occupation (farming, fishing, tourism, work at home, commerce, local government/health/education, oil industry, unemployed, retired, other).

The attributable fractions in the exposed population (AF_e) and attributable number (AN) were calculated as shown below⁹

$$AF_e = \frac{I_e - I_u}{I_e}$$

$$AN = N_e I_e AF_e$$

where I_e is incidence in the exposed population, I_u is incidence in the unexposed population, and N_e is the size of the exposed population.

As this is a cross-sectional study in which causality is implied, prevalence rates were substituted for incidence rates. In order to compare the relative impact of oil exposure and perceived oil exposure, the frequency of reporting anxiety, depression or toxicologically related symptoms (headache, sore eyes, sore throat) in oil-exposed areas was compared with the frequency of reporting anxiety, depression or non-toxicologically related symptoms (nausea, vomiting, diarrhoea, runny nose, cough, itching skin, skin rash, blisters, shortening of breath, tiredness or weakness) in persons with raised perceived risk. For simplicity, the population impact of perceived oil exposure was estimated for all perceived risks. For these analyses, therefore, raised perceived risk was defined as a raised risk on any of the three perceived risk scales (health, financial or environmental risk). Population estimates for calculating health impact were taken from the 2001 national census. All analyses were conducted using STATA V.9.

RESULTS

Out of 1585 persons contacted, 1089 (69%) returned usable questionnaires; 53% of the respondents were female and 45% lived in communities exposed to oil. The average age was

40.7 years (standard deviation (SD) = 11.9). There were no significant differences between oil-exposed and oil-unexposed areas with regard to response rates (exposed = 67.8%, unexposed = 69.5%) or gender (exposed = 45.9%, unexposed = 45.4%). Oil-exposed areas were slightly more deprived than unexposed areas (Townsend score mean difference = 0.4, $t = 6.1$, $p < 0.001$) and had a slightly lower proportion of non-smokers ($\chi^2 = 6.8$, $df = 2$, $p = 0.034$). For this reason, the associations for smoking and deprivation are presented in the tables, but are not commented on. The prevalence of current smoking found here (26%) is closely similar to that found in a survey conducted 4 years previously (24%).⁵ One hundred and sixty-five respondents reported symptoms before the incident or on the day of the incident (ie, before the possibility of oil exposure) and were omitted from the analysis.

Oil exposure, perceived oil exposure and emotional status

All perceived risks were higher in oil-exposed areas; however, perceived environmental risk showed the largest difference (fig 1). For oil-exposed and oil-unexposed areas combined, 25% of the sample perceived that their health would be at greater risk due to the incident, whereas 23% perceived that their finances would be at greater risk. With regard to the environment, 63% reported higher perceived risk. Associations between perceived risk variables were modest. The Spearman correlation coefficient between perceived health and perceived environmental risk was 0.41, that between health and financial risk was 0.22, and that between environmental and financial risk was 0.25. If all perceived risks are combined, 255 (30%) participants were both oil-exposed and had raised perceived risk, 125 (15%) were oil-exposed but did not report raised perceived risk, 154 (18%) were not oil-exposed but reported raised perceived risk, and 312 (37%) were not exposed to oil and did not report raised perceived risk.

Logistic regression showed oil exposure to be unrelated to either anxiety or depression before (models 1 and 3) or after (models 2 and 4) adjustment for perceived risk (table 1). However, perceived risk variables were related to emotional status. Anxiety was found to be associated with all perceived risks ($OR_{\text{health}} = 2.33$, 95% CI = 1.43 to 3.81, $p = 0.001$; $OR_{\text{finance}} = 3.18$, 95% CI = 1.86 to 5.43, $p < 0.001$; $OR_{\text{environment}} = 1.64$, 95% CI = 1.15 to 2.35, $p = 0.006$). Depression was found to be associated with perceived health and perceived financial risk ($OR_{\text{health}} = 2.69$, 95% CI = 1.69 to 4.27, $p < 0.001$; $OR_{\text{finance}} = 2.01$, 95% CI = 1.25 to 3.26, $p = 0.004$) but not with perceived environmental risk ($OR = 1.12$, 95% CI = 0.79 to 1.60, $p = 0.52$).

Symptom reporting

In order to compare mechanisms, the reporting of toxic and non-toxic symptoms were each regressed on oil exposure and perceived risk (table 2). Toxic symptom reporting was associated with oil exposure ($OR = 2.33$, 95% CI = 1.56 to 3.48, $p < 0.001$) and with raised perceived risk ($OR = 1.76$, 95% CI = 1.19 to 2.61, $p = 0.005$; model 1). Adjustment for anxiety, depression and non-toxic symptom reporting slightly strengthened the association of toxic symptoms and oil exposure, and nullified the association of toxic symptoms with perceived risk (model 2). Whether or not non-toxic symptom reporting was associated with oil exposure was unclear ($OR = 1.44$, 95% CI = 0.99 to 2.10, $p = 0.056$), although non-toxic symptom reporting was strongly associated with perceived risk ($OR = 2.28$, 95% CI = 1.57 to 3.31, $p < 0.001$; model 3). Adjustment for anxiety, depression and toxic symptoms nullified any association with oil exposure and reduced the

Figure 1 Distribution of risk perception scores according to oil unexposed and oil exposed areas.

association with perceived risk (OR = 1.69, 95% CI = 1.05 to 2.73, $p = 0.031$; model 4). These analyses were repeated omitting the (oil-unexposed) town that had not been included in the pre-incident survey of mental well-being. This slightly reduced the regression coefficients for perceived risk, but made no difference to the overall pattern of results.

From these analyses, it appears that although toxic and non-toxic symptom reporting are closely related, they are also

distinct. Toxic symptom reporting is related to oil exposure, whereas non-toxic symptom reporting is related to perceived risk. Adjusting for anxiety does not affect the association of toxic symptom reporting with oil exposure, but severely attenuates the association of non-toxic symptom reporting with perceived risk. The distinction is clarified by comparing oil exposure and perceived risk as dependent variables (table 3). Living in an oil-exposed community is associated with toxic symptom reporting but not with non-toxic symptom reporting (model 1). These associations are not affected by perceived risk (model 2), anxiety or depression (model 3). Furthermore, anxiety and depression are not related to oil exposure. Raised perceived risk, however, is associated with non-toxic symptom reporting (model 4), but not with toxic symptoms (model 5), and this association is attenuated by anxiety levels (model 6). Anxiety is strongly related to perceived risk (OR = 2.7, 95% CI = 1.82 to 4.00, $p < 0.001$).

Population impact

From the 2001 census, the number of adults aged 18–65 years living in Pembrokeshire was 31 714, of whom 21 104 lived in communities exposed to oil and 10 610 lived in communities not exposed to oil. Owing to the omission from the analyses of persons who had symptoms before the incident, the number of asymptomatic persons in each area before the incident was estimated to be 16 079 and 9826, respectively.

The crude, unadjusted, estimated number of people with toxic symptoms that were attributable to oil exposure was 2805 (table 4). By way of contrast, only 422 persons may be attributed to have had raised anxiety due to oil exposure, and no persons had increased depression. On this basis, the psychological impact of the incident was relatively small.

If, however, we look at perceived risk, a more informative picture emerges. An estimated 13 561 persons who were asymptomatic before the incident were, subsequent to the incident, aware of raised perceived risk, of whom 4888 lived in communities not physically exposed to oil. Of the 13 561 persons, an estimated 3121 had raised anxiety, 1745 had raised

Table 1 Logistic regression of anxiety and depression on oil exposure and perceived risk (adjusted for age, gender, smoking deprivation and occupation)

Emotional status	Model	Predictors	Odds ratio	95% CI
Anxiety	1	Living in an oil-exposed community	1.07	0.78 to 1.45 (p=0.68)
		Ex-smokers	1.84	1.21 to 2.83 (p=0.005)
		Current smokers	1.48	1.04 to 2.11 (p=0.028)
		Deprivation	1.06	0.99 to 1.13 (p=0.052)
	2	Living in an oil-exposed community	0.81	0.57 to 1.14 (p=0.23)
		Ex-smokers	1.63	1.07 to 2.63 (p=0.026)
		Current smokers	1.43	0.99 to 2.08 (p=0.056)
		Deprivation	1.05	0.99 to 1.13 (p=0.13)
		Perceived health risk	2.33	1.43 to 3.81 (p=0.001)
		Perceived financial risk	3.18	1.86 to 5.43 (p<0.005)
3	Perceived environmental risk	1.64	1.15 to 2.35 (p=0.006)	
	4	Living in an oil-exposed community	0.96	0.71 to 1.30 (p=0.80)
		Ex-smokers	1.49	0.98 to 2.27 (p=0.06)
		Current smokers	1.26	0.89 to 1.79 (p=0.19)
Deprivation		1.09	1.02 to 1.16 (p=0.010)	
Depression	4	Living in an oil-exposed community	0.82	0.59 to 1.15 (p=0.26)
		Ex-smokers	1.42	0.92 to 2.21 (p=0.12)
		Current smokers	1.22	0.85 to 1.76 (p=0.28)
		Deprivation	1.06	0.99 to 1.14 (p=0.07)
		Perceived health risk	2.69	1.69 to 4.27 (p<0.001)
		Perceived financial risk	2.01	1.25 to 3.26 (p=0.004)
		Perceived environmental risk	1.12	0.79 to 1.60 (p=0.52)

Table 2 Logistic regression of toxic and non-toxic symptoms on oil exposure, perceived risk and emotional status (adjusted for age, gender, smoking deprivation, occupation)

Dependent variable	Model	Predictors	Odds ratio	95% CI
Toxic symptom reporting	1	Oil exposure	2.33	1.56 to 3.48 (p<0.001)
		Ex-smokers	1.10	0.65 to 1.87 (p=0.72)
		Current smokers	1.21	0.78 to 1.86 (p=0.40)
		Deprivation	1.01	0.94 to 1.09 (p=0.74)
		Perceived risk	1.76	1.19 to 2.61 (p=0.005)
	2	Oil exposure	2.83	1.68 to 4.76 (p<0.001)
		Ex-smokers	0.69	0.34 to 1.39 (p=0.30)
		Current smokers	0.94	0.51 to 1.64 (p=0.83)
		Deprivation	1.02	0.92 to 1.12 (p=0.72)
		Perceived risk	1.03	0.62 to 1.73 (p=0.91)
Non-toxic symptom reporting	3	Anxiety	1.38	0.76 to 2.51 (p=0.30)
		Depression	1.18	0.67 to 2.05 (p=0.57)
		Non-toxic symptoms	26.21	15.8 to 43.4 (p<0.001)
	4	Oil exposure	1.44	0.99 to 2.10 (p=0.056)
		Ex-smokers	1.66	0.96 to 2.86 (p=0.07)
		Current smokers	1.32	0.82 to 2.12 (p=0.25)
		Deprivation	0.99	0.91 to 1.07 (p=0.71)
		Perceived risk	2.28	1.57 to 3.31 (p<0.001)
		Oil exposure	0.98	0.60 to 1.62 (p=0.94)
		Ex-smokers	1.76	0.84 to 3.68 (p=0.13)
		Current smokers	1.49	0.80 to 2.77 (p=0.21)
		Deprivation	0.93	0.84 to 1.03 (p=0.17)
		Perceived risk	1.69	1.05 to 2.73 (p=0.031)
		Anxiety	2.66	1.52 to 4.66 (p=0.001)
		Depression	1.40	0.83 to 2.37 (p=0.20)
		Toxic symptoms	25.53	15.5 to 42.1 (p<0.001)

depression scores and 2363 had non-toxic symptoms that were attributable to raised perceived risk.

DISCUSSION

In a cross-sectional survey, physical exposure to oil (living in an oil-exposed community) was found to be a relatively insensitive predictor of psychological outcome. Physical exposure was not associated with anxiety, depression or non-toxic symptom reporting. In contrast, perceived exposure (raised perceived risk) was associated with greater levels of anxiety and non-toxic symptom reporting. This study has also shown that the health impact of psychological exposure, which occurs far beyond the geographical boundary of physical exposure, can be quantitatively estimated.

Strengths and limitations

Although collected 10 years ago, these data remain of interest due to the continued occurrence of chemical releases (such as at Buncefield, Hertfordshire, UK), other incidents (London Tube bombings, Hurricane Katrina) and perceived incidents,¹⁰ as well as the increasingly widespread impact of media reports. These data provide a rare insight into the perceptions of communities in the aftermath of a large-scale environmental incident, and compare the effects of both physical and psychological exposure on similar but aetiologically distinct outcomes (toxic and non-toxic symptom reporting). They are of particular value due to the availability of mental health data showing oil-exposed and unexposed areas to be psychologically comparable prior to the incident. Few natural experiments, however, are perfect, and there may have been residual differences in mental health between oil-exposed and oil-unexposed communities. However, the exclusion from the analysis of persons reporting illness before the incident would have reduced the influence of differences in prior mental health between areas.

The associations may be driven by perceived exposure being measured at an individual level, whereas physical exposure was measured at an ecological level. Although oil exposure occurs at several levels, the oil-bearing aerosol would be ubiquitous in oil-exposed communities, and it was found that physical oil exposure was strongly related to toxic symptom reporting. It must also be acknowledged that the measures of psychological exposure were themselves crude rather than comprehensive. The perceived risk scales used here produced skewed distributions that required collapsing to two categories before the analysis. The symptoms checklist, however, had been previously validated in the context of an oil spill.⁷ Therefore, individual measures of physical exposure would have provided more precise estimates than fundamentally different relationships. Further work in this area would benefit from the identification and development of measures of psychological exposure and outcome that are contextualised for specific types of emergencies and are normatively distributed in populations exposed to complex emergencies.

These findings may be due to selection and reporting bias. The extent to which the psychological measurement was biased is unknown.¹¹ Although a 69% response rate was achieved, it cannot be assumed that selection bias was not operating. Symptom data were collected retrospectively on one occasion rather than concurrently for each day using a diary format, although the 7-week period between the incident and data collection was within the duration of continuous oil exposure. The extent to which differences in reporting between exposed and unexposed (both physically and psychologically) populations is due to recall bias or the effect of exposure is unknown.

The possibility that residents of oil-unexposed towns were actually exposed to a very low concentration of aerosol must be considered. As one of the two unexposed towns was 70 miles from the incident, the likelihood of this is remote. This eventuality would not, however, materially change the interpretation of the findings. The study would then compare the

Table 3 Logistic regression of oil exposure on toxic symptoms and of perceived risk on non-toxic symptoms (with adjustment for age, gender, smoking deprivation, occupation)

Dependent variable	Model	Predictors	Odds ratio	95% CI
Living in an oil-exposed community	1	Toxic symptoms	2.65	1.63 to 4.33 (p<0.005)
		Non-toxic symptoms	1.01	0.64 to 1.61 (p=0.97)
		Ex-smokers	1.47	0.94, 2.31 (p=0.09)
		Current smokers	1.09	0.75 to 1.58 (p=0.66)
		Deprivation	1.17	1.10 to 1.25 (p<0.001)
	2	Toxic symptoms	2.65	1.60 to 4.41 (p<0.001)
		Non-toxic symptoms	0.80	0.49 to 1.30 (p=0.37)
		Ex-smokers	1.29	0.81 to 2.06 (p=0.28)
		Current smokers	1.05	0.71 to 1.54 (p=0.81)
		Deprivation	1.17	1.09 to 1.26 (p<0.001)
	3	Toxic symptoms	2.73	1.64 to 4.55 (p<0.001)
		Non-toxic symptoms	0.89	0.54 to 1.47 (p=0.65)
		Ex-smokers	1.35	0.85 to 2.16 (p=0.21)
		Current smokers	1.08	0.73 to 1.59 (p=0.70)
		Deprivation	1.18	1.09 to 1.26 (p<0.001)
Raised perceived risk	4	Raised perceived risk	3.50	2.49 to 4.93 (p<0.001)
		Anxiety	0.74	0.49 to 1.11 (p=0.14)
		Depression	0.85	0.58 to 1.26 (p=0.42)
	5	Toxic symptoms	1.37	0.86 to 2.20 (p=0.19)
		Non-toxic symptoms	2.09	1.33 to 3.26 (p=0.001)
		Ex-smokers	1.65	1.06 to 2.55 (p=0.025)
		Current smokers	1.24	0.87 to 1.77 (p=0.24)
		Deprivation	1.04	0.98 to 1.11 (p=0.24)
	6	Toxic symptoms	1.05	0.65 to 1.73 (p=0.83)
		Non-toxic symptoms	2.22	1.40 to 3.54 (p=0.001)
		Ex smokers	1.56	0.99 to 2.45 (p=0.06)
		Current smokers	1.23	0.85 to 1.76 (p=0.28)
		Deprivation	1.00	0.93 to 1.07 (p=0.94)
	7	Living in an oil-exposed community	3.27	2.35 to 4.56 (p<0.001)
		Toxic symptoms	0.98	0.59 to 1.62 (p=0.93)
		Non-toxic symptoms	1.75	1.08 to 2.84 (p=0.023)
		Ex-smokers	1.41	0.89 to 2.25 (p=0.15)
		Current smokers	1.15	0.78 to 1.67 (p=0.48)
	8	Deprivation	0.98	0.92 to 1.05 (p=0.65)
		Living in an oil-exposed community	3.55	2.52 to 4.99 (p<0.001)
		Anxiety	2.70	1.82 to 4.00 (p<0.001)
	9	Depression	0.96	0.65 to 1.41 (p=0.84)

impact of psychological exposure with that of high- and extremely low-level oil exposure. The point made here, that psychological exposure is important and its effects can be quantified, would remain the same.

Table 4 Comparative impact of environmental exposure (oil) and psychological exposure (perceived risk) on the population

Comparison	Size of exposed population	Prevalence of exposed population	AF _e (95% CI)	Attributable number
Toxic symptoms attributable to oil exposure	16 079	0.3062	0.570 (0.43 to 0.68)	2805
Raised anxiety attributable to oil exposure	16 079	0.5230	0.050 (-0.09 to 0.16)	422
Non-toxic symptoms attributable to perceived risk	13 561	0.3265	0.534 (0.39 to 0.64)	2363
Raised anxiety attributable to perceived risk	13 561	0.6301	0.365 (0.27 to 0.45)	3121

AF_e, attributable fraction in the exposed population

The population impact estimates reported here are unadjusted, and are not independent of each other. The confidence with which attributable risk estimates may be interpreted would be increased if there were readily available methods for deriving adjusted estimates. Although these may be calculated,¹² few, if any, software packages appear to produce them as a standard output. However, as this criticism applies to both physical and psychological exposure, it does not change the basic message that psychological exposure has an impact that is distinct from, and comparable in size to, physical exposure. The estimated population impact was almost certainly conservative. Effects on children and the elderly were excluded. Also, one of the communities not exposed was 10 miles beyond the

What is already known on this topic

- Physical exposure to a complex emergency can have psychological effects. These include raised anxiety and symptom reporting.
- These effects can vary in severity and over time, but are limited to the area defined by physical exposure to the hazard or its physical consequences.

What this paper adds

- Psychological exposure—the belief of individuals that they have been exposed to a hazard—has an effect on anxiety and symptom reporting over and above that of physical exposure in a complex emergency. The effects of psychological exposure are not limited to the area defined by physical exposure, and hence can cover a wider area and have a greater population impact than those of physical exposure.

Policy implications

- Healthcare provision should be made for the occurrence of low-level psychological distress in psychologically exposed populations.
- The incidence of low-level psychological distress in psychologically exposed populations may be minimised by the provision of relevant information.
 - Information should be accurate and include levels of confidence/uncertainty.
 - Information should include the future health, economic and environmental implications of the emergency, as well as immediate safety advice and service access issues.
- The information should be made available to populations that are adjacent to those that are physically exposed.
- Research should be commissioned to establish background population levels of psychological functioning, to allow data on the effects due to psychological exposure to complex emergencies to be interpreted with confidence.
- Research should be commissioned to establish for different types of complex emergency:
 - The variety of likely psychological exposures and their effects.
 - The geographical dispersion of effects due to psychological exposures in relation to the location of the complex emergency.

administrative boundary used for the attributable number of calculations. However, to have generalised more widely would have required making assumptions about the strength of effect in communities increasingly remote from the incident and from the coast, and these may have been unwarranted. For these reasons, the population impact figures reported here are indicative rather than precise. Nevertheless, these findings show that, at a population level, the psychological impact of a complex emergency can be estimated with a reasonable degree of precision.

Interpretation

The impact of accidental oil release on the environment has been studied extensively, although epidemiological investigations are scarce,¹³ with attention being given to acute health effects^{4 7 14 15} or chronic psychiatric effects.¹⁶ Acute psychological effects have not been studied closely, although psychological

effects have been studied in other disaster contexts.¹⁷ The use of the attributable risk to estimate the impact of psychological exposure to disaster has not been studied previously, although attributable risk has been used in relation to psychological outcome from a physical exposure.¹⁸

It is unlikely that these associations are unrelated to the oil spillage. Questions remain, however, over the mechanisms involved. The associations suggest that raised perceived risk is associated with raised anxiety and raised non-toxic symptom reporting. The association of perceived risk with anxiety is consistent with many other studies.^{19–21} Nevertheless, inferring causality in observational associations involving psychological variables is perilous. The extent to which perceived risk affects anxiety²² or anxiety increases perceived risk²¹ can be left to experimental psychology. It is sufficient here to note that anxiety is likely to be the primary emotion through which symptom reporting is mediated. Symptom reporting has been shown to be associated with exposure to environmental incidents.^{7 23 24} Experimental studies have shown perceived risk to affect symptom reporting.^{25 26} In our data, perceived risk was associated with oil exposure and with symptom reporting. Similar associations have been reported elsewhere.^{27–31}

These analyses show that the incident had important public health consequences beyond the geographical boundary of exposure to oil. In this case, it was found that the psychological impact varied according to the outcome of interest, and was not necessarily of substantial proportions. Although an estimated 13 500 persons had raised perceived risk, the effect of the incident on anxiety and symptom reporting was modest, being limited to around 3000 persons. This information is important from two perspectives. First, it allows the relevant agencies to plan a proportionate response. Second, it provides relatively accurate data, which will be more informative to the media and public alike than speculation.

In summary, we have shown that psychological exposure to a complex emergency can have a greater health impact than physical exposure. We have shown that the relative impacts of different exposures can be estimated. The effects reported were found under conditions involving minimal personal suffering and latent threat. It is highly likely that the same methodology would be appropriate for a wide range of scenarios, including those involving imminent threat and more acute human suffering. The psychosocial impact of acute emergencies, as illustrated by events in New York, Madrid and London, is now recognised globally as a major factor in public health responses, but the psychosocial mechanisms underlying this impact have so far received much less attention than medical management.³² It may be that this is due, in part, to the absence of reliable estimates of impact. The World Health Organisation recommends that mental health, and by extension psychosocial considerations, must be integrated in preparedness planning.³² This study shows how such planning might acquire an evidence base.

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