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Acute Health Problems among the People Engaged in the Cleanup of the Nakhodka Oil Spill[1]

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To determine if the Nakhodka oil spill and subsequent cleanup efforts had any health effects on the residents along the oil-contaminated coast, we investigated the health status of Anto residents who resided nearest to the coast where the bow ran aground. Two hundred eighty-two men and women involved in the cleanup activities between January 7 and January 20 were interviewed and examined by public health nurses to determine whether they suffered physical symptoms after exposure to the oil spill. Urine examinations for hydrocarbon toxicological markers were performed on 97 residents. The average number of days worked on cleanup activities was 4.7 days for men and 4.3 for women. Seventeen percent of the subjects had worked on cleanup activities for more than 10 days. Protective equipment was used against direct exposure to oil during the cleanup jobs and consisted of gloves used by almost 100% of the subjects and masks used by 87.1% of women and by only 35.4% of men. Glasses were worn by less than 30% of the subjects. Many symptoms emerged after the beginning of cleanup activities. The principal symptoms included low back pain and leg pain, headache, and symptoms of eyes and throat. Among the subjects undergoing urine tests, only three people showed a higher level of hippuric acid, although they returned to normal in the second examination. Accordingly, the exposure to the oil and the subsequent cleanup efforts were suggested to inflict acute health problems on local residents.

Key Words: **Nakhodka oil spill; health effect; oil cleanup; resident population; hippuric acid.**

INTRODUCTION

On January 2, 1997, the Russian tanker Nakhodka, carrying 19000 tons of C oil from China to Russia, broke up northeast of the Oki islands in the Sea of Japan and spilled more than 6000 tons of oil into the sea. The majority of the oil spill hit the western coastline of Japan's main island of Honshu. The bow section of the tanker ran aground near the shore of the Anto district in Mikuni town, Fukui prefecture (Fig. 1). Many residents in Anto, alongside many volunteers from other parts of Japan, had worked long hours daily to remove the destructive oil. Because machines could not access the area, workers had to use ladles and buckets to clean up the spill (Fig. 2). This cleanup job was very difficult because of continuing stormy weather. In other regions along the contaminated coast, many residents and volunteers worked to remove the oil; however, the Anto area was damaged the most severely and a great number of volunteers helped to clean up this area. During and after the cleanup, some of the participants visited first medical aid stations, which were built on the contaminated coast by the Sakai-gun Medical Associations and the local government, where they complained of many symptoms. In Kyoto and Ishikawa prefecture, four workers died from heart attack or stroke during the cleanup and were compensated by the Japanese government as occupational accidents.

Several epidemiological investigations of major oil spills (Linden, 1990; Jones, 1991; Campbel, 1993; Wolfe

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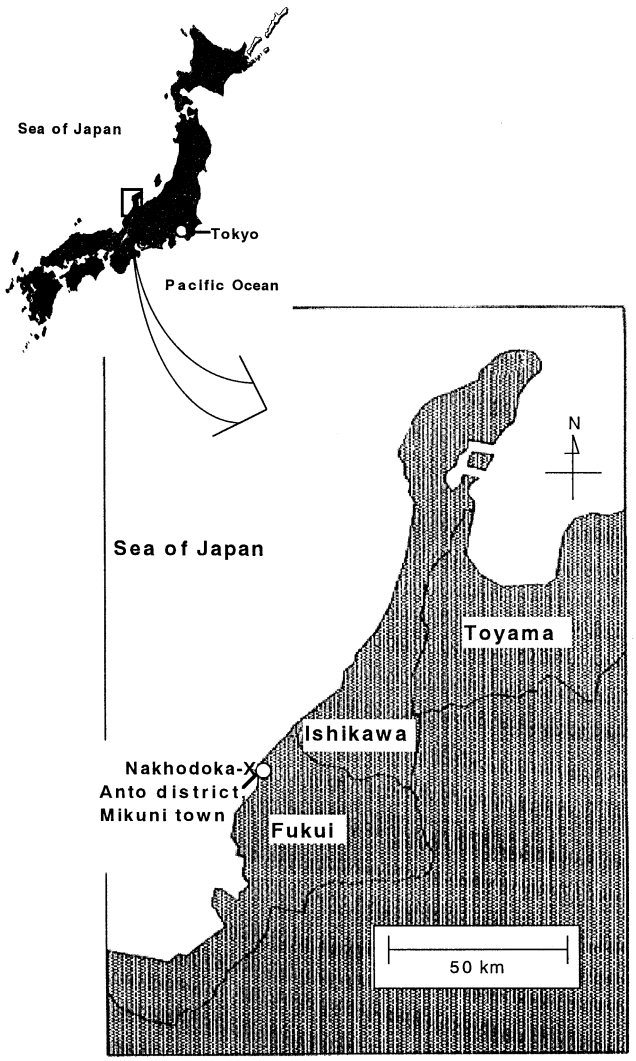

FIG. 1. The location of the place (X) where the tanker Nakhodka grounded and the Anto district (O) where this study was conducted.

et al., 1994; Cooke, 1996) have been undertaken infrequently. It was reported that the prevalence of physical health symptoms and psychiatric disorders (Palinkas *et al.*, 1992, 1993) was significantly increased after technological disasters like oil spills. However, there have been only a few reports that documented the health effects of such disasters on exposed residents and those engaged in cleanup operations. Further, those investigations were performed at later stages in the accidents.

In this study, we investigated the acute influence of exposure to the oil spill and subsequent cleanup efforts on the health status of the local residents. The information contained in this report can be utilized by community public health officials to improve the health status deteriorated by this disaster in this region and assess the future health risks of the people exposed to the oil spill.

METHODS

Monitoring of Environmental Conditions

The Environmental Policy Planning Division, Fukui prefectural government, started detailed environmental sampling using an air quality monitoring car at Anto on January 10, estimating concentrations of hydrocarbons, hydrogen sulfide, suspended particles, and oil mist in the air around the site where the Nakhodka bow ran aground. Data on weather conditions were obtained from the daily record of the nearest fire station to Anto.

Monitoring of Individual Exposure to Hydrocarbons

We asked four residents in Anto to carry a personal air sampler (MP-15CF, Shibata, Tokyo, Japan) with active carbon tubes (8015-053, 8015-0532, Shibata, Tokyo, Japan) for 2 h of cleanup activity on January 31 to collect the air from Anto. Concentrations of benzene, toluene, and xylene in the air collected by these samplers were measured by gas chromatography/mass spectrometric detection at the National Institute of Public Health (Hayakawa *et al.*, 1997).

Health Status and Exposure to the Oil

Out of 1041 Anto residents, 282 men and women, who were almost all adult residents in the area nearest to the contaminated shore, were interviewed. Public health nurses visited them at their homes and carried out interviews between January 20 and January 31. A uniform questionnaire was used to find out demographic details, daily participation in cleanup activities, direct exposure to oil, medical history, and present involvement of illness. At the same time, the prevalence of each symptom that emerged after the oil reached the shore and the date of its onset and end up to the day of interview were obtained (see appendix).

Urine Examination

The urine of 97 residents selected by volunteering in Anto, 95 persons of whom were the same subjects as those above, was collected in the evening after work on the cleanup jobs. Three toxicological markers of hydrocarbons, hippuric acid for toluene, methylhippuric acid for xylene, and *trans-trans*-muconic acid for

FIG. 2. The cleanup operation at the coast of Anto district. The photograph was presented by courtesy of the Yomiuri Shimbun.

benzene, were determined by high-performance liquid chromatography/fluorescence detection.

Statistical Analysis

Data handling and analyses were performed using the SPSS (SPSS Inc., Chicago, USA) programs. χ^2 values (derived with the Mantel-Haenzel formula) were calculated for categorical data, and t tests were performed for continuous data. A multivariate logistic regression model was applied to clarify the risk factors for having any of the listed symptoms on several variables which were selected from the above information of interviewed residents by using the prior univariate analysis.

RESULTS

Environmental Pollutions

Atmospheric conditions from January 10 to January 31 are represented in Table 1. In winter, it is very cold and windy with heavy snowfall along the coast of the Sea of Japan. During this study period, it had been stormy with only 3 good days. Cleanup operations were often suspended because of bad weather. As shown in Table 1, the highest concentration of hydrocarbons (excluding methane) was 1.51 ppmC on January 15. Excepting this date, the highest concentrations of hydrocarbons in a day were less than 1.0 ppmC and averages over a day were less than 0.5 ppmC during this period. Components of hydrocarbons (isobutane, *n*-butane, *n*-pentane, benzene, *n*-octane, ethylbenzene, and xylene) in the air in Anto were analyzed on January 8, 9, and 21. Each hydrocarbon concentration was very low and far below the occupational acceptable limit (total butane, 500 ppm; *n*-pentane, 300 ppm; benzene, 10 ppm; *n*-octane, 300 ppm; ethylbenzene, 100 ppm; xylene, 100 ppm). The highest concentration of suspended particles on any given day was 0.088 mg/m^3 on January 18 and it was below the occupational acceptable limit (2 mg/m^3). The concentration of hydrogen sulfide was measured in three different areas of the Anto district on January 11 and they were all less than the detectable limit (0.001 ppm). The concentrations of oil mist

TABLE 1

Atmospheric Conditions during the Cleanup Operations in Anto District

Date	June 10	June 11	June 12	June 13	June 14	June 15	June 16	June 17	June 18	June 19	June 20
Weather	Cloudy	Partly cloudy	Clear	Clear	Cloudy/ rain	Cloudy	Cloudy	Cloudy	Cloudy/ rain	Cloudy	Rain
Average wind speed (m/sec)	0.8	2.6	1.9	1.6	6	5.5	1.7	2.2	8.5	2.3	2.4
Cleanup operation (performed, ○; suspended because of bad weather, ×)	○	○	○	○	×	×	○	○	×	×	○
Concentrations of atmospheric pollutants											
Hydrocarbon (excluding methane) (ppmC)											
Average	0.16	0.21	0.21	0.2	0.14	0.56	0.18	0.19	0.11	0.12	0.05
Highest	0.3	0.42	0.73	0.47	0.8	1.51	0.58	0.3	0.36	0.22	0.13
Lowest	0.02	0.08	0.04	0.05	0.05	0.16	0.05	0.07	0.05	0.04	0.01
Floating particles (mg/m^3)											
Average	0.014	0.018	0.011	0.014	0.018	0.033	0.011	0.016	0.041	0.02	0.016
Highest	0.032	0.036	0.034	0.044	0.059	0.041	0.023	0.03	0.088	0.051	0.036
Lowest	0.006	0.007	0.002	0	0	0.025	0	0	0.009	0.001	0.001

Date	June 21	June 22	June 23	June 24	June 25	June 26	June 27	June 28	June 29	June 30	June 31
Weather	Cloudy/ rain	Cloudy/ rain	Cloudy	Rain	Cloudy/ snow	Rain	Cloudy	Cloudy/ rain	Snow	Cloudy	Clear
Average wind speed (m/sec)	8.4	8.3	1.8	1.9	4.1	4.6	1	1.7	2.2	10.4	2.3
Cleanup operation (performed, ○; suspended because of bad weather, ×)	×	×	×	×	×	×	○	○	×	×	○
Concentrations of atmospheric pollutants											
Hydrocarbon (excluding methane) (ppmC)											
Average	0.14	0.08	0.09	0.12	0.08	0.06	0.1	0.07	0.04	0.06	0.11
Highest	0.51	0.33	0.21	0.2	0.29	0.12	0.36	0.14	0.11	0.14	0.22
Lowest	0.02	0.02	0.04	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.05
Floating particles (mg/m^3)											
Average	0.021	0.026	0.018	0.02	0.012	0.014	0.02	0.029	0.017	0.017	0.014
Highest	0.056	0.061	0.038	0.046	0.032	0.041	0.056	0.07	0.043	0.041	0.037
Lowest	0.005	0.002	0	0	0	0	0.002	0.006	0.002	0	0

TABLE 2

Concentrations of Benzene, Toluene and Xylene in the Air Collected by Personal Samples

Sample No.	Benzene	Toluene	Xylene (ppb)
No. 1	1.850	8.34	1.430
No. 2	0.703	2.04	0.426
No. 3	0.613	2.19	0.556
No. 4	1.125	3.95	0.672

were measured in two or three places in Anto every day from January 10 and they were lower than 0.005 mg/m^3 which was below the occupational acceptable limit (3 mg/m^3).

Individual Exposure to Hydrocarbons

The concentrations of benzene, toluene, and xylene in the air collected by four air samplers are shown in Table 2. These concentrations were much lower than their toxic levels (the occupational acceptable limit is 10 ppm for benzene, 100 ppm for toluene, and 100 ppm for xylene).

Health Status and Its Relation to Exposure to the Oil

Characteristics of subjects. The characteristics of the subjects involved in this study are presented by gender in Table 3. The average age of men was slightly higher than that of women. The percentage of people engaged in commercial fisheries was significantly higher in women (31.5%) than in men (17.4%). The people working in commercial fisheries were older than those working in other jobs (Fig. 3).

Working on cleanup activities. The average number of days worked on cleanup activities between January 7 and January 20 were 4.7 for men and 4.4 for women (Table 3). More than 40% of the subjects participated in cleanup activities only 1 or 2 days. On the other hand, 17% of the subjects worked on cleanup activities more than 10 days. The older people participated in cleanup activities more frequently than the younger people (Fig. 4).

Half of the subjects participated in both scooping up the oil from water by ladles and transporting it to waiting trucks by buckets. While the activities of the other half were confined to one or the other.

Direct exposure to and protection from oil. Direct exposure to oil was mainly from oil sticking to the face and secondarily from sticking to the hands (Table 3). The subjects washed off oil sticking to their skin with water and soap or chemical agents for

TABLE 3
Characteristics of Resident Subjects in Anto by Gender

	Male ($n = 127$)	Female ($n = 155$)
	Mean ± SD	
Age (years)	55.6 ± 12.8	54.7 ± 14.8
Days of working on cleanup jobs	4.7± 3.6	4.4 ± 3.6
	Number (%)	
Occupation*		
Fishery	21 (17.4%)	47 (31.5%)
Other jobs	70 (57.9%)	67 (45.0%)
Without occupation	30 (24.8%)	35 (23.5%)
Kinds of cleanup jobs*		
Scooping up oil by the coast	13 (10.2%)	6 (4.1%)
Carrying out oil by buckets	30 (23.6%)	54 (36.7%)
Both scooping up and carrying out	76 (59.8%)	77 (52.4%)
Other jobs	8 (6.3%)	10 (6.8%)
Direct exposure to oil		
Sticking on your face**	56 (44.1%)	44 (28.4%)
Sticking on your hands	27 (21.3%)	30 (19.4%)
In your eyes	4 (3.1%)	11 (7.1%)
Rates of using protections		
Gloves	124 (100%)	154 (99.4%)
Mask**	45 (35.4%)	135 (87.1%)
Glasses	27 (22.8%)	22 (14.2%)
Illness before the oil spill		
Hypertention	19 (15.0%)	24 (15.5%)
Low back pain	10 (7.9%)	16 (10.3%)
Symptoms during cleanup activities		
Having any of the listed symptoms**	72 (56.7%)	122 (78.7%)
Principal symptoms		
Symptoms of eyes**	27 (21.3%)	56 (36.1%)
Symptoms of throat	17 (13.4%)	33 (21.3%)
Symptoms of skin**	8 (6.3%)	26 (16.8%)
Dull headache, headache**	11 (8.7%)	44 (28.4%)
Low back pain and leg pain	44 (34.6%)	59 (38.1%)

*,** Significantly different between male and female (*$P < 005$, **$P < 0.01$).

removing oil. Whereas most of them used kerosine or petroleum to wash off oil sticking to clothing.

The level of usage of the protective equipment was lower than expected. Although 87.1% of the women answered that they had used masks, only 35.4% of the men had used masks (Table 3). As far as using glasses, less than 30% of the subjects, both men and women, answered that they had used glasses. However, those who wore glasses did not use the special safety glasses provided by the local government but their own. Gloves were used by almost 100% of the subjects.

Symptoms. The principal complaints of symptoms occurring between January 6 and January 20 were low back pain and leg pain, headache, and symptoms of eyes (sore eyes, jiggling of vision, teary eyes, etc.) and throat (sore throat, scratchy throat, etc.). The percentage of the subjects experiencing at least one symptom was 56.7% for men, which was a significantly lower rate than that of 78.7% for women (Table 3). Many symptoms started after the beginning of cleanup activities and the occurrence of low back pain and leg pain and symptoms of eyes decreased when cleanup operations were suspended (Fig. 5). The longer the working days, the more subjects complained of symptoms, the more kinds of symptoms, and the longer duration of the symptoms (Figs. 6 and 7). These symptoms occurred in association with the number of working days on cleanup activities.

Hypertension and low back pain appeared as the principal illnesses of the subjects before the oil spill in this study (Table 3). The average number of symptoms of the subjects with hypertension was 2.9,

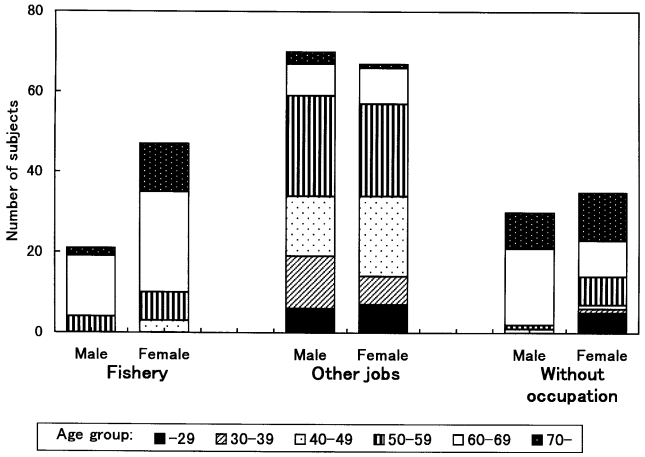

FIG. 3. Relation between occupation classified into three categories (fishery, other jobs, without occupation) and 10-year age groups among resident subjects in Anto by gender.

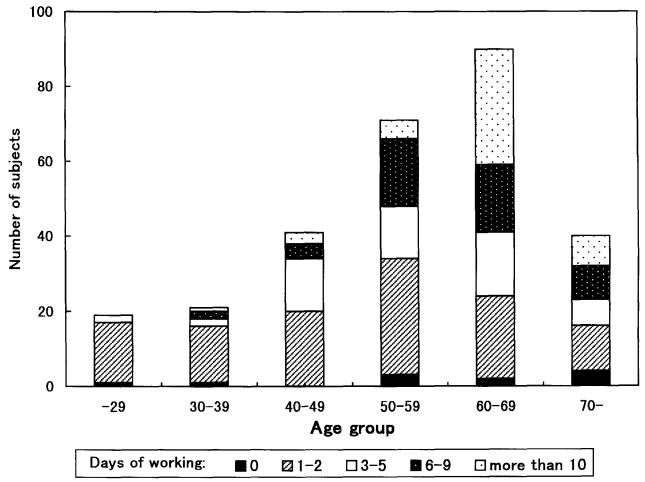

FIG. 4. Relation between the number of days of working on cleanup jobs and 10-year age groups.

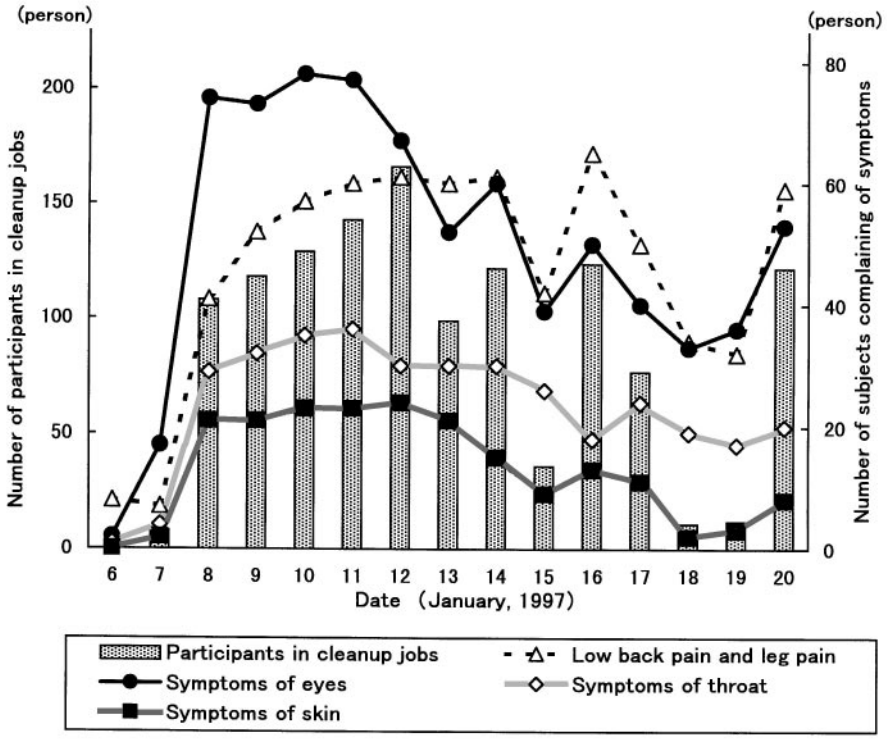

FIG. 5. Changes in the number of subjects participating in cleanup jobs and complaining of different kinds of symptoms between January 6 and January 20.

which was significantly higher than the average of the subjects without hypertension (1.8). Similarly, the subjects with low back pain had more symptoms than the subjects without it.

Multiple logistic regression. A stepwise multiple logistic regression model was applied to clarify the risk factors for having at least one symptom with several relevant variables shown in Table 4. As a result of

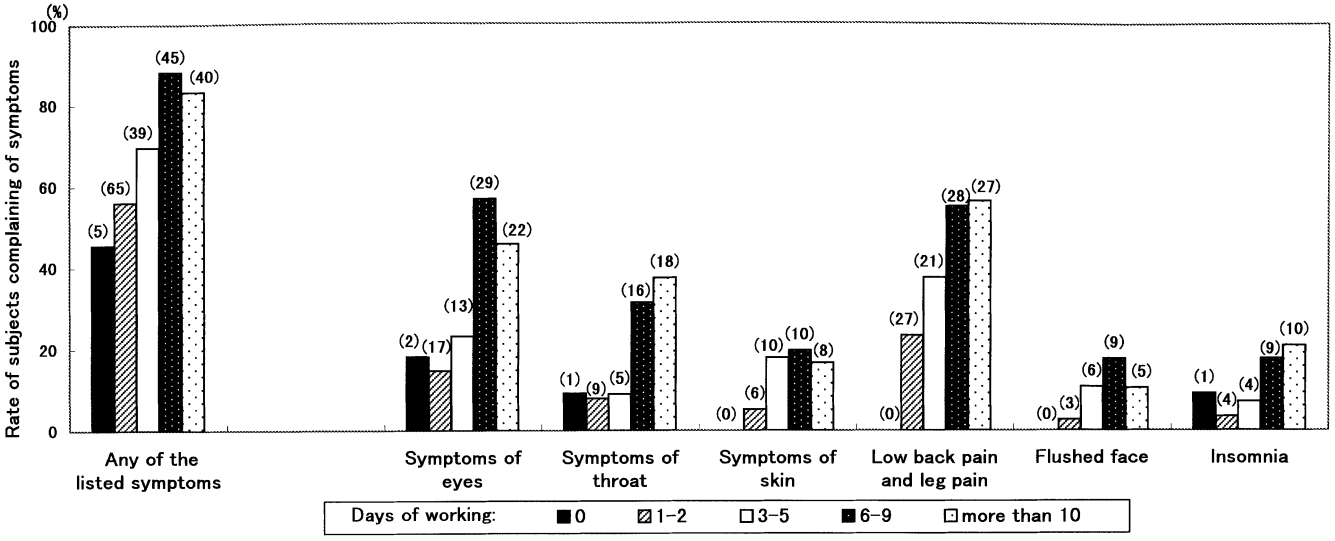

FIG. 6. Relation between the number of days of working on cleanup jobs and the frequency of symptoms. Values in parentheses are numbers of subjects having symptoms.

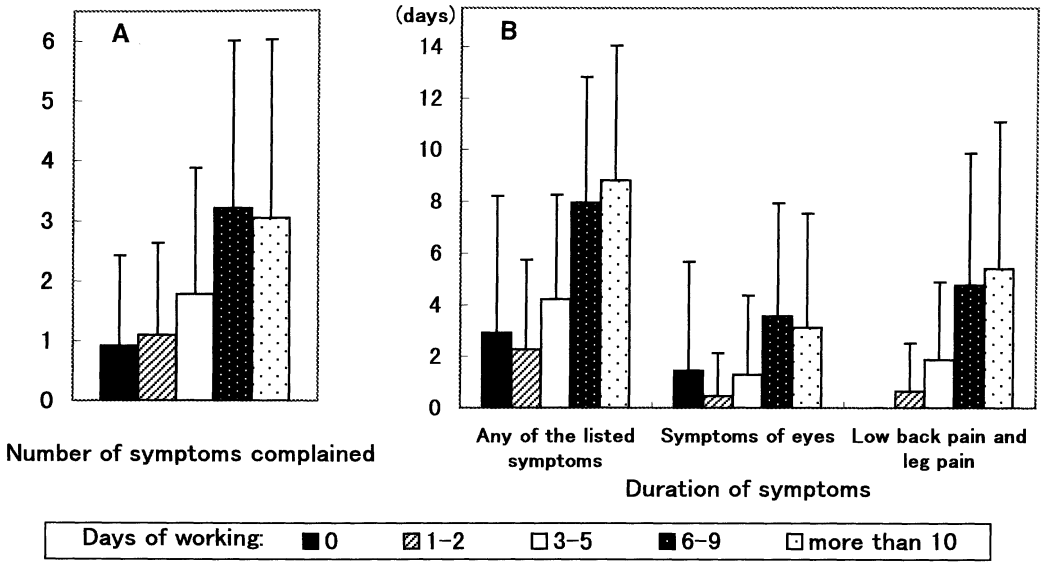

FIG. 7. Relation between the number of days of working on cleanup jobs and the number of symptoms (A), and between the number of days of working and the duration of symptoms (B). Values are mean ± SD.

this analysis, being of female gender, the number of working days on cleanup activities, direct exposure to oil, and history of hypertension and low back pain were shown to be significant risk factors for the development of symptoms ($P < 0.05$).

Urine examination. Only three individuals out of the 97 subjects showed slightly higher levels of hippuric acid (>1.0 g/L). However, they showed normal levels of hippuric acid in the second examination performed in May 1997.

DISCUSSION

In this study, exposure to the oil and cleanup efforts are suggested to cause acute health problems in local residents. The previously reported studies into the health effects of major oil spills by the Amoco Cadiz in 1978 (Menez *et al.*, 1978) and the Exxon Valdez in 1989 (Barinaga, 1989; Rall, 1989) focused on the subjects occupationally exposed. In contrast, the studies of the oil spill by the Braer in 1993 (Christie, 1993; Campbel *et al.*, 1993) focused on exposed residents whether working on cleanup jobs or not. In the case of the Nakhodka oil spill, local residents had to participate in the cleanup activities from the beginning because of the decision by the local fishermen's cooperative union and the local community. Therefore, they experienced both direct oil exposure and cleanup efforts under stormy conditions simultaneously.

TABLE 4
Risk Factors for Having Any of the Listed Symptoms

Factors	Odds	95% CI
Female gender (vs male)	4.06	2.22–7.45
Days of working on cleanup jobs (every category in 0, 1–2, 3–5, 6–9, and 10 days and more)	1.66	1.25–2.22
Direct exposure to oil (vs no exposure)	2.69	1.47–4.93
Hypertension before the oil spill (vs no history)	3.80	1.36–10.59
Low back pain before the oil spill (vs no history)	14.26	1.73–117.6

Toxic compounds in fuel C oil are now being analyzed, and evidently, only a few volatile components were present in the oil (Hayakawa *et al.*, 1997). According to the observations of atmospheric conditions since January 7, concentrations of volatile toxic compounds in the air from Anto were low (Mushrush *et al.*, 1994). Therefore, it was inconceivable that those compounds from the oil caused the physical symptoms directly by toxicological mechanisms. However, the concentration of benzo(α)pyrene and the level of mutagenicity in the extracts from the oil (Kira *et al.*, 1994; Attias *et al.*, 1995) which reached the coast of Mikuni were reported to be higher than the average in soil samples abtained in Tokyo (Goto *et al.*, 1997). Consequently, the risk assessment for carcinogenicity and the bioremediation of hydrocarbons should be studied.

To determine the extent of damage for physical health caused by C oil, three metabolites, hippuric

acid, methylhippuric acid, and *trans-trans*-muconic acid, were analyzed. They are usually used as an index of exposure to xylene, toluene, and benzene, respectively (Saxton *et al.*, 1993). Three individuals showed slightly higher levels of hippuric acid in the first examination. However, toluene is not the only source of urinary hippuric acid, which is a normal constituent of urine and may originate from food containing benzoic acid or benzoates. Considering that the subjects showed normal levels of hippuric acid in the second examination, there seemed to be no continuous exposure to toxic levels of toluene that could affect human health.

Human reactions to acute exposure to petroleum components are mainly transient and short lived (Lillienberg *et al.*, 1992; Smith, 1993). Accidental contact with petroleum or exposure to its vapor causes skin irritation and/or stinging or redness of the eyes. Prolonged or repeated exposure to low concentrations of volatile components of oil can produce nausea, dizziness, headache, or drowsiness (Goldstein *et al.*, 1970; Kaplan *et al.*, 1993). In the Braer oil spill, headaches, sore throats, and itchy eyes were reported to be the initial effects of the oil spill on the health of exposed residents (Crum, 1993; Campbel *et al.*, 1993).

In this study, most of the subjects' symptoms started after the beginning of the cleanup activities. As seen from the questionnaire records, they complained of symptoms after working on the cleanup jobs and some symptoms decreased immediately after stopping the cleanup jobs. Many of the symptoms that disappeared easily, such as flushed face and stimulation to mucosa and skin, were considered to be acute responses to exposure to the oil. Some of those that disappeared easily were muscloskeletal symptoms, such as low back pain, the results of tiredness from cleanup jobs and bad weather. On the other hand, general symptoms, for example, fatigue, nausea, and headache, did not improve immediately. These general symptoms may be signs of the aggravation of chronic disease. In addition, we should consider the association between general symptoms and mental health. Some investigators have reported the importance of mental health care after disasters (Palinkas *et al.*, 1992, 1993).

In the case of oil spills, the disaster affected not only the environment (Pearce, 1993; Kirby, 1993; Becker *et al.*, 1997) and human physical status but also the community systems and economical status. This Nakhodka oil spill damaged commercial fisheries and affected visitor turnout at beaches. Therefore, this research should be continued in order to clarify and improve mental and physical health conditions of damaged area with respect to community health.

APPENDIX

Questionnaire on Health Status of Residents along the Contaminated Coast

Date: / /

1. Name: Address: Age: Sex: Male Female
   Occupation:
   Have you ever worked on a tanker or disposal of oil by profession? yes no
2. Participation in cleanup activities: yes no
   Beginning date of cleanup jobs: Date: / /
   Kinds of cleanup jobs:
   ① Scooping up oil by the coast
   ② Carrying out oil by buckets
   ③ Scooping up and carrying out
   ④ Other jobs
3. Direct exposure to oil:
   ① None
   ② Sticking on your hands
   ③ Sticking on your face
   ④ In your eyes
   ⑤ Inhalation of oil mist
   ⑥ Sticking on your contact lens

4. Method for washing off oil sticking
   On the body:
   ①With water
   ②With soap
   ③Using thinner
   ④Using chemical agents cleaning oil
   ⑤Through medical care
   ⑥Using alcohol
   On clothes: Using an organic solvent yes no

5. Protection from oil sticking during cleanup jobs
   Gloves: ①None ②Cloth ③Rubber ④Vinyl ⑤Other materials
   Mask: ①None ②Gauze ③Protective mask with carbon filter
   Glasses ①None ②Common glasses ③Sunglasses ④Goggles ⑤Other glasses

6. Please list your medical history.
   Do you have any illnesses at present not connected with exposure to oil?
   The name of illnesses:
   Treatment state:

7. When did you participate in cleanup jobs?

	January, 1997																										
Date	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Cleanup jobs																										
Using gloves																										
Using a mask																										
Using glasses																										

(Participation and using protections: O)

Have you contracted any symptoms during cleanup jobs?
(Residents choose the symptoms they contracted from the following list and answer the date of its onset and duration)

List of Symptoms

1. Sore eyes
2. Jiggling of vision
3. Itchy eyes
4. Eyestrain
5. Injection of conjunctiva
6. Puffy eyes
7. Teary eyes
8. Eye mucus
9. Poor vision
10. Runny nose
11. Itchy nose
12. Dry throat
13. Scratchy throat
14. Sore throat
15. Phlegm
16. Cough
17. Dizziness
18. Skin swelling
19. Itchy skin
20. Eruption or blister
21. Flushed face
22. Skin irritation
23. Palpitation
24. Dull headache, headache
25. Nausea, vomiting
26. Loss of appetite
27. Stomachache
28. Abdominal pain
29. Diarrhea
30. Constipation
31. General fatigue
32. Fever
33. Coldness of extremities
34. Numbness of extremities
35. Tingling in extremities
36. Tremor of extremities
37. Weakness of extremities
38. Insomnia
39. Anxiety
40. Loss of concentration
41. Irritability
42. Leg pain or low back pain
43. Injury

8. Have you contracted any illnesses since exposure to oil? If so, please list them and any treatments you have received.

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