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Self-reported Occupational Exposures Relevant for Cancer among 28,000 Offshore Oil Industry Workers Employed between 1965 and 1999

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Abstract

The objective of this study was to examine self-reported frequency of occupational exposure reported by 28,000 Norwegian offshore oil workers in a 1998 survey. Predictors of self-reported exposure frequency were identified to aid future refinements of an expert-based job-exposure-time matrix (JEM). We focus here on reported frequencies for skin contact with oil and diesel, exposure to oil vapor from shaker, to exhaust fumes, vapor from mixing chemicals used for drilling, natural gas, chemicals used for water injection and processing, and to solvent vapor. Exposure frequency was reported by participants as the exposed proportion of the work shift, defined by six categories, in their current or last position offshore (between 1965 and 1999). Binary Poisson regression models with robust variance were used to examine the probabilities of reporting frequent exposure ($\geq 1/4$ vs. $<1/4$ of work shift) according to main activity, time period, supervisory position, type of company, type of installation, work schedule, and education. Holding a non-supervisory position, working shifts, being employed in the early period of the offshore industry, and having only compulsory education increased the probability of reporting frequent exposure. The identified predictors and group-level patterns may aid future refinement of the JEM previously developed for the present cohort.

Keywords

petroleum industry; inhalation; skin contact; carcinogens; health hazards

Introduction

From the late 1960s, exploration and drilling for oil and gas in the North Sea resulted in a large number of wells that are operated from movable and stationary installations. The workers have experienced disastrous accidents and possibly long-term exposure to various

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substances. Questions have been raised about potential long-term ill-health such as cancer, skin disorders, neurological disease, hearing impairment, and consequences of psychological stress.(1) A Norwegian initiative to evaluate incidence of chronic diseases among offshore workers was hampered by incomplete employee lists and lack of recorded work histories. Thus, a large survey was conducted in 1998 to more fully identify Norwegian offshore workers and their employment patterns.(2) From the survey, a cohort of 28,000 Norwegian offshore workers was established with self-reported information on work history, occupational exposure, and lifestyle factors.(2)

Offshore job categories from the survey were previously used as a framework by industrial hygienists to develop a job-time-exposure matrix (JEM) for prospective analyses of cancer risk in the cohort.(3-4) Exposure estimates for each job category by time period were assessed by a team of experts because monitoring reports from the Norwegian offshore work environment that could assist the exposure assessment efforts were scarce, especially from the period before 1990.(3) Other occupational data, including the participants' self-reported frequency of exposure to several broad categories of offshore exposures, from the survey were not available to these experts at the time of the JEM development.

In the present study, we evaluated the survey data on self-reported occupational exposures relating to the participants' last or current position offshore, which ranged in time from the late 1960s through 1998 to identify predictors of reporting exposure to each exposure type. We evaluated potential differences in exposure frequency between main platform activities, time period, and other job characteristics such as supervisory or non-supervisory jobs, type of company, type of installation, work schedule, and educational level. Whereas the previously developed JEM was assessed solely at a job- and time period-level, the predictors of exposure frequency and the resulting group-level patterns identified here can be used in future refinements of the JEM to capture differences in exposure frequency within sub-groups of participants holding the same job.

Methods

Study Population

The 1998 offshore worker survey was based on a roster of 61,339 men and women who possibly had been working in the Norwegian offshore oil industry, according to employment lists of onshore and offshore petroleum workers, member lists from unions, and data from schools, and other sources. Questionnaires were mailed to the home addresses of 57,328 men and women who were alive and resident in Norway by September 1998 (Table I). Reminder questionnaires were distributed later the same year to improve the response rate. A total of 35,303 persons responded, whereof 7316 were excluded from the cohort because they never worked offshore, and 70 were excluded because they worked on ships only, or were missing a personal identification number (Table S1, supplemental material). In total, 27,917 men and women who confirmed work for more than 20 days on an offshore installation (hereafter, offshore workers) between 1965 and 1999 were included in the cohort. The survey response rate has been estimated to 69% among true offshore workers verified by linkage to the Norwegian State Register of Employers and Employees.(5)

Participation in the survey was voluntary and based on informed consent. Necessary legal and ethical approvals were obtained from the Norwegian Data Inspectorate, the Regional Committee for Medical Research Ethics, and the Norwegian Directorate of Health.

Questionnaire

The questionnaire collected information on demographics, current or last position offshore, additional employments offshore (if applicable), occupational exposures in current or last position (see supplemental material), activities during off-duty periods, non-offshore occupational history, and data on lifestyle and diet. Since exposure information was reported only for the current or last position offshore, our focus hereafter is on characteristics associated with this employment. From the survey we identified 31 job categories, which were grouped according to main platform activity: (1) production (production and process, 4 job categories); (2) drilling (drilling and well maintenance, 7 job categories); (3) maintenance (maintenance, inspection, deck and construction, 16 job categories); (4) catering (catering and office/administration, 4 job categories). Job categories that did not match the previous four activities (*e.g.* pilots, divers, radio operators, helicopter guards, maritime deck workers) were grouped as (5) miscellaneous.

From a list of 17 exposures (question 29, supplemental material), the workers were asked to identify which occupational exposures they experienced in their current or last offshore position. The respondents categorized the proportion of the daily work shift that they were exposed into one of six categories: (1) almost the entire work shift, (2) $\frac{3}{4}$ of the work shift, (3) $\frac{1}{2}$ of the work shift, (4) $\frac{1}{4}$ of the work shift, (5) rarely during the work shift, and (6) never during the work shift. The following seven exposures were selected for detailed characterization based on the exposures' relevance for cancer and on their potential to aid refinement of the agents addressed in the expert assessed JEM: (1) skin contact with oil and diesel, (2) oil vapor from shaker and other mud cleaning (denoted as oil vapor), (3) exhaust fumes (predominantly diesel), (4) vapor from mixing chemicals used for drilling (denoted as chemical vapor), (5) natural gas, (6) chemicals used for water injection and processing, and (7) solvent vapor (from painting, cleaning, degreasing).

Demographic variables included gender (male/female), age in 1998, and educational level (compulsory/folk high school/vocational training/upper secondary/university or college degree). In subsequent analyses, the category "folk high school (one-year boarding school)", which was reported by only 1% of the workers, was merged with "compulsory". Other collected variables related to last or current position offshore included supervisor or manager position (yes/no), type of company (operating/contractor), type of installation (stationary platforms anchored directly onto the seabed/movable installations such as jack-ups and semi-submersibles), work schedule (daytime/nighttime/shiftwork), year started position (continuous), and duration in position (continuous years and months). The year left position (summed start and duration) was grouped into three time periods: 1967–1979, 1980–1989, and 1990–1999.

We did not have detailed information on the work tours and work shifts directly from the respondents, but the Norwegian oil industry practiced regular offshore tour patterns. During the 1970s, the offshore tour pattern was 2 weeks offshore followed by 2 weeks of shore

leave. During the 1980s and 1990s the shore leave was extended to 3 or 4 weeks. Tours usually did not exceed 2 weeks, and one offshore tour usually consists of 168 hours (12 hours a day for 14 consecutive days). The variable work schedule captured the longest held schedule-type, with the categories “daytime” and “nighttime” mainly representing 168 hours of daytime or nighttime work for each tour, respectively, and with “shiftwork” referring to rotating or changing work schedules. The most common “shiftwork” patterns in the Norwegian offshore industry were: (1) “full-shift” where the respondent worked *either* daytime only *or* nighttime only for each tour of 168 hours, changing to the opposite schedule every other tour; (2) “rollover-shift day/night” with 84 hours daytime shifts followed by 84 hours nighttime shifts; (3) “rollover-shift night/day” with 84 hours nighttime shifts followed by 84 hours daytime shifts.(6)

Statistics

Descriptive statistics were displayed for all exposures by main activity. Binary Poisson regression with robust variance was used to examine the probability of reporting exposure $\frac{1}{4}$ of the work shift (coded as 1, hereafter “frequently exposed”) compared to rarely or never during the work shift (coded as 0, hereafter “infrequently exposed”). Poisson regression was preferred to logistic regression to avoid extreme estimates (odds ratios) for frequent outcomes.(7) The relative risk (RR) and corresponding 95% confidence intervals (CIs) of reporting frequent exposure were estimated according to main platform activity, calendar year left position, supervisor/manager, type of company, type of installation, work schedule, and educational level. Relative risks greater than 1 indicate a higher probability of reporting frequent exposure than the reference group, whereas values less than 1 indicate a lower probability. Tests for trend were examined for year left position (treated as a continuous variable). Pearson's chi-squared and Cramer's V tests were used to examine associations between categorical variables, and interaction-terms were included in the regression model to test for possible interaction.

All statistical analyses were performed using Stata, version 13.1 (StataCorp, College Station, TX, USA).

Results

In 1998, when the survey was conducted, 85% of the respondents were between 25 and 54 years old, nearly half (46%) of the survey respondents reported maintenance as their main platform activity, and over 85% of the respondents started working in their last or current position in the 1980s or 1990s (Table I). Only 2% of the respondents reported leaving their last position in the 1960s and 1970s. Almost 39% had a supervisor or managerial position, nearly 34% worked for an operating company, over 70% worked at a stationary installation, 41% were working shifts, and over 39% had vocational training as highest achieved education. Women constituted 9% of the study population. Some differences between the female and the male survey respondents were observed: women were somewhat younger, had a higher educational level, and only 13% held a managerial position. Moreover, most of the women were employed in catering activities (67%) (Table I).

The most frequently reported exposure was skin contact with oil and diesel (Table II). More than 8,000 offshore workers (29%) reported such dermal exposure for ¼ or more of the work shift. The second most frequently reported exposure was solvent vapor, where 22% of all workers reported such exposure for ¼ or more of the work shift. Differences were observed by main activity. The most frequently reported exposures among production workers were natural gas, chemicals used for water injection, and skin contact with oil and diesel, about 30% of these workers reported such exposure for ¼ or more of the work shift. Over half of the workers engaged in drilling activities reported skin contact with oil and diesel or exposure to oil vapor from shaker and other mud cleaning for ¼ or more of the work shift, and about 30% of the maintenance workers reported skin contact with oil and diesel and exposure to solvent vapor for ¼ or more of the work shift. The latter exposure was also the most frequently reported exposure by catering workers, with 16% reporting exposure for ¼ or more of the work shift.

Factors associated in regression models with the probability that an offshore worker reported that he or she was frequently exposed (¼ or more of work shift) are shown in Tables III (for the first four exposures) and IV (for the latter three exposures). Production workers had the highest probabilities of reporting frequent exposure to natural gas and to chemicals used for water injection and processing, while drilling workers had the highest probabilities of reporting frequent skin contact with oil and diesel, exposure to oil vapor, exhaust fumes, and chemical vapor. Maintenance workers had the highest probabilities of reporting frequent exposure to solvent vapor. The probabilities of reporting frequent exposure were higher among those who left their position in the 1980s, compared to those who left in the 1990s for all exposures. Linear tests for trend by year left position (continuous variable) showed statistically significant decreasing trends for reporting frequent exposure to all exposures except skin contact with oil and diesel and exposure to exhaust fumes. For most exposures, being in a managerial position reduced the probability of reporting frequent exposure. Contractor employees had higher or equal probabilities of reporting frequent exposure to all exposures except natural gas and chemicals used for water injection and processing, as opposed to those employed in operator companies. Compared to work on stationary installations, working on a movable installation increased the probabilities of reporting frequent exposure to all types except exposure to natural gas and to chemicals used for water injection and processing, where (for the latter two exposures) probabilities were reduced. Compared to daytime workers, shiftworkers had higher probabilities of reporting frequent exposure to all the examined types. Pearson's chi-squared and Cramer's V tests between work schedule and main activity showed a significant (chi-squared: $P < 0.001$), but low to moderate association (Cramer's V = 0.2960), respectively. Subsequent tests of interaction between these variables in the regression models did not change the results materially. Similarly, nighttime workers had increased probabilities of reporting frequent exposure to oil vapor, to exhaust fumes, to chemical vapor, and to solvent vapor. Workers with only compulsory education as their highest attained educational level had higher probabilities of reporting frequent exposure to all kinds than workers with a university or college degree.

Discussion

This study used survey data to describe the relationship between employment and subject-specific characteristics and perceived exposures relevant for cancer among Norwegian offshore workers employed 1965 – 1999. Depending on exposure type, between 7% and 29% of all offshore workers considered themselves exposed for ¼ or more of the work shift. Further, the probability of reporting frequent exposure was generally higher among those who reported on offshore work before the 1990s, those who were employed by a contractor company, those who served on a movable installation, those who worked shift, and those who had only compulsory education.

The probabilities of reporting frequent exposure according to main activity showed two clear patterns. First, drilling workers had the highest probabilities of reporting frequent exposure to skin contact with oil and diesel, oil vapor, to exhaust fumes, and to vapor from mixing chemicals used for drilling. Second, production workers had the highest probabilities of reporting frequent exposure to natural gas and chemicals used for water injection and processing. Frequent exposure to solvent vapor was, however, an exception, where maintenance workers had the highest probability of reporting such exposure.

The declining trends of reporting frequent exposure with time, estimated in the regression models, coincide with the implementation of improved technology such as closed fluid flow lines and mud pits and more efficient ventilation systems.(8) Additionally, the authorities' attention has been more directed towards health and safety standards in the 1990s than in earlier decades.(9) The observed downward changes in the probability of reporting frequent exposure to vapors from oil and chemicals used for drilling are consistent with the findings by Steinsvåg *et al.*(8), who observed a decline in concentrations of oil mist and vapor in the mud-handling areas offshore between 1979 and 2004. Some of this decrease was probably due to a gradual shift in the 1980s from diesel-based drilling mud to low- and non-aromatic oils with higher boiling point that produce less vapor.(8)

For most exposures, the probabilities of reporting frequent exposure were lower or equal among supervisors compared with non-supervisors. One explanation may be that supervisors spend more time on administrative office work than colleagues without a managerial responsibility. Still, in certain job categories a supervisor might be highly exposed while performing complex work tasks that require experience and acquired skills.

Contractors had elevated probabilities of reporting typical drilling exposures such as vapors from oil and mixing chemicals, compared to operators. As being engaged in drilling-activities was largely accounted for in the model, we speculate that the observed difference between contractors and operators might be due to the fact that contractors are very specialized and rotate between platforms to conduct certain jobs often within short timeframes, which might intensify exposure compared to operators who are located on one platform with fixed work-tasks. However, we cannot rule out residual confounding linked to activity-specific differences that were not adequately controlled for in the regression models.

Differences in reported exposure according to stationary or moveable installations coincides with Steinsvåg *et al.*(8) who found that drilling workers on movable drilling rigs experienced

twice the concentrations of oil mist and vapor as their peers on stationary rigs, which they suggested may be because drilling workers on movable rigs likely used older technologies with less developed ventilation systems and more time spent in exposed areas.

Shiftwork was associated with a higher probability of reporting frequent exposure to all types compared to daytime work. Although correlation tests between main activity and work schedule showed a significant association of low to moderate strength, tests of interaction between these variables did not change the results materially, and other factors such as difference in the distribution of exposed work tasks according to work schedule and reduced alertness and performance and thus more inadvertent exposure contact may also contribute. (10)

Our finding that level of education was inversely related with the probability of reporting frequent exposure, after controlling for main platform activity, may reflect differences in job tasks and use of personal protective equipment, or that differential recall or reporting by educational level occurred. This finding is consistent with Quinn *et al.*(11) who found that low wage was associated with high chemical exposure after controlling for industry and job, and thus they concluded that sociodemographic characteristics should be considered when exposure is assessed by means of questionnaires.

Overall, our findings suggest that, beyond main activity, several employer, workplace, and subject-specific factors influence exposure frequency and these differences were not captured in the previously developed JEM.(3-4) These additional predictors of exposure could be used as exposure modifiers in future work to refine the JEM. For example, to refine expert assessed dermal mineral oil exposure estimates, we would use our findings based on reported frequency of skin contact with oils and diesel to modify the original JEM rating by a factor of 1.2 for participants who worked on movable rigs compared to stationary rigs and by a factor of 1.6 for workers on shiftwork compared to day shift.

The use of the survey's self-reported exposure information has several limitations. Self-reported exposure is subject to recall bias that may occur differentially by time period, and the time trends observed here need to be interpreted cautiously and within the context of known changes in work practices. However, many of our findings based on self-reports were consistent with known technological improvements and measured differences in exposure. Additionally, we would not expect differential recall bias by case status because the exposure information was collected independently of disease status as data on incident disease outcomes were collected prospectively from independent registers rather than from the participants.(12) The use of broad exposure groups in this survey to improve subject recall, leaves uncertainty as to the respondents' exposure to specific hazardous components, such as benzene and polycyclic aromatic hydrocarbons. Moreover, self-reporting is vulnerable to each worker's subjective understanding of intensity and tolerance. For instance, some of the recorded skin contact may possibly involve only minor contamination of surfaces and clothes, whereas others may have reported on immersion and other direct contact with the chemicals, and thus a dose may be difficult to determine. The impact of differing perceptions, however, would be minimized by using group-level patterns. Another important limitation is that the chosen way of reporting exposure frequency provides no

direct measure of intensity of exposure. Some workers might have had short-term peak exposures with high intensity, which may contribute substantially to the total burden of exposure. Frequency was reported for a typical 12-h work shift, and thus assumes that the work activities are constant across the duration of the job.

A strength of the present study was the large population. The survey's estimated response rate of 69% was fairly high compared to other occupational surveys,(13-14) and thus we expect that results from the survey can be generalizable to the majority of offshore workers. Moreover, the large number of respondents and our goal to develop job category and time period-specific patterns, rather than subject-specific estimates, should produce robust findings that are less prone to misclassification. Using group-level estimates, rather than subject-specific estimates, to aid exposure assessment efforts will reduce the influence of outliers. Additionally, exposure misclassification using a group-based approach would be expected to follow a Berkson error structure and thus be unbiased but imprecise.(15) Another strength was the survey information on other work-related factors beyond job category that captures some within-job heterogeneity, enabling us to examine the effects of these factors on the probability of reporting frequent exposure that would not be captured using analyses solely based on job category. Thus we propose to use the identified predictors in conjunction with the previously developed JEM as modifiers to the JEM's exposure frequency estimates.

Conclusions

In summary, a large survey of offshore oil workers provided important insights into the prevalence and frequency of seven broad categories of exposure for different activity groups and for different time periods. An increase in the probability of reporting frequent exposure seemed to be predicted by work-related factors such as holding a non-supervisory position, being a contractor employee, working on movable installations, shiftwork, and low educational level, when adjusted for the effects from main platform activity and from time period of exposure. These predictors may be used to refine the expert-based JEM previously developed for the present cohort to capture broad differences in exposure frequency by employer-, job-, and participant-level factors. Moreover, this information is relevant for future preventive efforts in the offshore industry.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Gardner R. Overview and characteristics of some occupational exposures and health risks on offshore oil and gas installations. *Ann Occup Hyg.* 2003; 47(3):201–210. [PubMed: 12639833]
2. Strand, LÅ.; Andersen, A. Kartlegging av kreftrisiko og årsaksspesifikk dødelighet blant ansatte i norsk offshorevirksomhet – innsamling av bakgrunnsdata og etablering av kohort. Oslo, Norway: Cancer Registry of Norway; Sep. 2001 [Identification of cancer risk and cause-specific mortality among employees in the Norwegian offshore oil industry: data retrieval and cohort establishment] Report in Norwegian
3. Steinsvåg K, Bråtveit M, Moen BE. Exposure to carcinogens for defined job categories in Norway's offshore petroleum industry, 1970 to 2005. *Occup Environ Med.* 2007; 64:250–258. [PubMed: 17043075]
4. Steinsvåg K, Bråtveit M, Moen B, Austgulen LV, Hollund BE, Haaland IM, et al. Expert assessment of exposure to carcinogens in Norway's petroleum oil industry. *J Expo Sci Environ Epidemiol.* 2008; 18(2):175–182. [PubMed: 17457323]
5. Stenehjem JS, Kjærheim K, Rabanal KS, Grimsrud TK. Cancer incidence among 41 000 offshore oil industry workers. *Occup Med (Lond).* In press.
6. Petroleum Safety Authority Norway. Risikonivå på norsk sokkel – hovedrapport fase 6. Stavanger, Norway: Petroleum Safety Authority Norway; Apr. 2006 [Risk level on the Norwegian continental shelf – report phase 6]. Report in Norwegian
7. Zou G. A modified Poisson regression approach to prospective studies with binary data. *Am J Epidemiol.* 2004; 159(7):702–706. [PubMed: 15033648]
8. Steinsvåg K, Bråtveit M, Moen BE. Exposure to oil mist and oil vapor during offshore drilling in Norway, 1979–2004. *Ann Occup Hyg.* 2006; 50(2):109–122. [PubMed: 16141252]
9. Alteren, B.; Gaupset, S.; Lie, T.; Lindøe, P.; Olsen, E.; Ryggvik, H., et al. HMS-arbeid under endring. Trondheim, Norway: SINTEF; Dec. 2002 [HSE efforts changing] Report in Norwegian Available from: URL: http://www.sintef.no/upload/Teknologi_og_samfunn/Sikkerhet%20og%20p%C3%A5litelighet/Rapporter/STF38%20A03406.pdf [18 Nov 2012]
10. Parkes, KR.; Clark, MJ.; Payne-Cook, E., editors. U.K. Health and Safety Executive. Psychosocial aspects of work and health in the North Sea oil and gas industry Part III Sleep, mood, and cognitive performance: A comparison of offshore shift patterns. U.K Health and Safety Executive; 1997. Report #OTH 96 530
11. Quinn MM, Sembajwe G, Stoddard AM, Krieger D, Sorensen G, Hartman C, et al. Social disparities in the burden of occupational exposures: results of a cross-sectional study. *Am J Ind Med.* 2007; 50:861–875. [PubMed: 17979135]
12. Teschke K, Olshan AF, Daniels JL, De Roos AJ, Parks CG, Schultz M, et al. Occupational exposure assessment in case-control studies: opportunities for improvement. *Occup Environ Med.* 2002; 59:575–594. [PubMed: 12205230]
13. Kjærheim K, Mykletun R, Aasland OG, Haldorsen T, Andersen A. Heavy drinking in the restaurant business: the role of social modelling and structural factors of the work place. *Addiction.* 1995; 90(11):1487–1495. [PubMed: 8528034]
14. Goldberg M, Chastang JF, Leclerc A, Zins M, Bonenfant S, Bugel I, et al. Socioeconomic, demographic, occupational, and health factors associated with participation in a long-term epidemiologic survey: a prospective study of the French GAZEL cohort and its target population. *Am J Epidemiol.* 2001; 154(4):373–384. [PubMed: 11495861]
15. Heid IM, Küchenhoff H, Miles J, Kreienbrock L, Wichmann HE. Two dimensions of measurement error: Classical and Berkson error in residential radon exposure assessment. *J Expo Sci Environ Epidemiol.* 2004; 14(5):365–377.

Table 1

Baseline Characteristics

Characteristics	Women		Men		Total	
	N	%	N	%	N	%
Age in 1998						
15–24	23	0.9	135	0.5	158	0.6
25–34	777	30.2	4520	17.8	5297	19.0
35–44	1035	40.3	9292	36.7	10,327	37.0
45–54	522	20.3	7559	29.8	8081	29.0
55–64	184	7.2	3190	12.6	3374	12.1
65–74	26	1.0	615	2.4	641	2.3
75–84	3	0.1	36	0.1	39	0.1
Main activity ^A						
Production	151	5.9	1813	7.2	1964	7.0
Drilling	146	5.7	3634	14.3	3780	13.5
Maintenance	273	10.6	12,643	49.9	12,916	46.3
Catering/office/adm.	1726	67.2	2912	11.5	4638	16.6
Miscellaneous	237	9.2	4092	16.1	4329	15.5
Missing	37	1.4	253	1.0	290	1.0
Year left position ^A						
1967–1979	7	0.3	489	1.9	496	1.7
1980–1989	334	13.0	2888	11.4	3222	11.5
1990–1999	1864	72.5	18,714	73.8	20,578	73.7
Missing	365	14.2	3256	12.9	3621	13.0
Supervisor/manager ^A						
Yes	337	13.1	10,518	41.5	10,855	38.9
No	2180	84.8	14,434	57.0	16,614	59.5
Missing	53	2.1	395	1.6	448	1.6
Type of company ^A						
Operating	1196	46.5	8170	32.2	9366	33.6

Characteristics	Women		Men		Total	
	N	%	N	%	N	%
Contractor	1207	47.0	16,400	64.7	17,607	63.1
Missing	167	6.5	777	3.1	944	3.4
Type of installation ^A						
Stationary	1641	63.9	18,059	71.3	19,700	70.6
Movable	810	31.5	6044	23.9	6854	24.6
Missing	119	4.6	1244	4.9	1363	4.9
Work schedule ^A						
Daytime	1459	56.8	12,698	50.1	14,157	50.7
Night time	70	2.7	1001	4.0	1071	3.8
Shiftwork	902	35.1	10,398	41.0	11,300	40.5
Missing	139	5.4	1250	4.9	1389	5.0
Educational level						
Compulsory	382	14.9	3010	11.9	3392	12.2
Vocational training	562	21.9	10,412	41.1	10,974	39.3
Upper secondary	853	33.2	6003	23.7	6856	24.6
University/college	745	29.0	5736	22.6	6481	23.2
Missing	28	1.1	186	0.7	214	0.8

Note:

^A In current or last position offshore.

Table II

Self-reported Exposure by Main Activity

Self-reported Exposure Main Activity	Never during Work Shift		Rarely during Work Shift		¼ of Work Shift		½ of Work Shift		¾ of Work Shift		Almost the entire Work Shift		Missing	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Skin contact with oil and diesel														
Production	140	7.1	1147	58.4	452	23.0	120	6.1	60	3.1	20	1.0	25	1.3
Drilling	178	4.7	1511	40.0	918	24.3	511	13.5	328	8.7	278	7.4	56	1.5
Maintenance	1668	12.9	6913	53.5	2190	17.0	922	7.1	457	3.5	388	3.0	378	2.9
Catering	2516	54.2	1539	33.2	197	4.2	51	1.1	22	0.5	23	0.5	290	6.3
Miscellaneous	943	21.8	2092	48.3	672	15.5	254	5.9	118	2.7	123	2.8	127	2.9
Missing	67	23.1	89	30.7	24	8.3	16	5.5	8	2.8	11	3.8	75	25.9
Total	5512	19.7	13,291	47.6	4453	16.0	1874	6.7	993	3.6	843	3.0	951	3.4
Oil vapor from shaker and other mud cleaning														
Production	642	32.7	969	49.3	211	10.7	71	3.6	30	1.5	7	0.4	34	1.7
Drilling	390	10.3	1460	38.6	837	22.1	529	14	278	7.4	233	6.2	53	1.4
Maintenance	4027	31.2	6527	50.5	1173	9.1	399	3.1	177	1.4	152	1.2	461	3.6
Catering	3163	68.2	1043	22.5	107	2.3	26	0.6	10	0.2	13	0.3	276	6.0
Miscellaneous	1863	43.0	1794	41.4	296	6.8	115	2.7	60	1.4	58	1.3	143	3.3
Missing	89	30.7	86	29.7	23	7.9	8	2.8	5	1.7	5	1.7	74	25.5
Total	10,174	36.4	11,879	42.6	2647	9.5	1148	4.1	560	2.0	468	1.7	1041	3.7
Exhaust fumes														
Production	393	20.0	1362	69.3	131	6.7	32	1.6	6	0.3	7	0.4	33	1.7
Drilling	601	15.9	2377	62.9	441	11.7	170	4.5	69	1.8	45	1.2	77	2.0
Maintenance	2550	19.7	8257	63.9	1101	8.5	308	2.4	133	1.0	123	1.0	444	3.4
Catering	2518	54.3	1699	36.6	103	2.2	25	0.5	15	0.3	13	0.3	265	5.7
Miscellaneous	1174	27.1	2524	58.3	317	7.3	106	2.4	37	0.9	33	0.8	138	3.2
Missing	83	28.6	101	34.8	20	6.9	4	1.4	1	0.3	7	2.4	74	25.5
Total	7319	26.2	16,320	58.5	2113	7.6	645	2.3	261	0.9	228	0.8	1031	3.7
Vapor from mixing chemicals used for drilling														

Self-reported Exposure Main Activity	Never during Work Shift		Rarely during Work Shift		1/4 of Work Shift		1/2 of Work Shift		3/4 of Work Shift		Almost the entire Work Shift		Missing	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Production	1461	74.4	427	21.7	27	1.4	8	0.4	3	0.2	2	0.1	36	1.8
Drilling	869	23.0	1538	40.7	625	16.5	356	9.4	180	4.8	153	4.0	59	1.6
Maintenance	7664	59.3	4069	31.5	450	3.5	118	0.9	72	0.6	47	0.4	496	3.8
Catering	3605	77.7	690	14.9	39	0.8	9	0.2	5	0.1	6	0.1	284	6.1
Miscellaneous	2836	65.5	1143	26.4	113	2.6	46	1.1	34	0.8	20	0.5	137	3.2
Missing	132	45.5	58	20.0	11	3.8	4	1.4	5	1.7	2	0.7	78	26.9
Total	16,567	59.3	7925	28.4	1265	4.5	541	1.9	299	1.1	230	0.8	1090	3.9
Natural gas														
Production	268	13.6	1 051	53.5	461	23.5	92	4.7	48	2.4	19	1.0	25	1.3
Drilling	1572	41.6	1768	46.8	210	5.6	73	1.9	37	1.0	22	0.6	98	2.6
Maintenance	5859	45.4	5776	44.7	499	3.9	163	1.3	51	0.4	49	0.4	519	4.0
Catering	3137	67.6	1108	23.9	64	1.4	15	0.3	9	0.2	14	0.3	291	6.3
Miscellaneous	2259	52.2	1621	37.4	185	4.3	68	1.6	20	0.5	24	0.6	152	3.5
Missing	115	39.7	83	28.6	8	2.8	1	0.3	1	0.3	4	1.4	78	26.9
Total	13,210	47.3	11,407	40.9	1427	5.1	412	1.5	166	0.6	132	0.5	1163	4.2
Chemicals used for water injection and processing														
Production	385	19.6	936	47.7	443	22.6	108	5.5	40	2.0	18	0.9	34	1.7
Drilling	2113	55.9	1270	33.6	179	4.7	76	2.0	30	0.8	23	0.6	89	2.4
Maintenance	7141	55.3	4580	35.5	448	3.5	102	0.8	50	0.4	28	0.2	567	4.4
Catering	3547	76.5	719	15.5	62	1.3	9	0.2	5	0.1	5	0.1	291	6.3
Miscellaneous	2751	63.5	1211	28.0	144	3.3	40	0.9	17	0.4	21	0.5	145	3.3
Missing	136	46.9	59	20.3	10	3.4	6	2.1	2	0.7	1	0.3	76	26.2
Total	16,073	57.6	8775	31.4	1286	4.6	341	1.2	144	0.5	96	0.3	1202	4.3
Solvent vapor														
Production	451	23.0	1249	63.6	194	9.9	24	1.2	8	0.4	6	0.3	32	1.6
Drilling	843	22.3	2087	55.2	561	14.8	134	3.5	51	1.3	32	0.8	72	1.9
Maintenance	1567	12.1	7127	55.2	2118	16.4	745	5.8	442	3.4	528	4.1	389	3.0
Catering	1594	34.4	2062	44.5	415	8.9	150	3.2	99	2.1	73	1.6	245	5.3
Miscellaneous	1224	28.3	2368	54.7	415	9.6	113	2.6	40	0.9	39	0.9	130	3.0

Self-reported Exposure Main Activity	Never during Work Shift		Rarely during Work Shift		$\frac{1}{4}$ of Work Shift		$\frac{1}{2}$ of Work Shift		$\frac{3}{4}$ of Work Shift		Almost the entire Work Shift		Missing	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Missing	54	18.6	105	36.2	32	11.0	15	5.2	8	2.8	7	2.4	69	23.8
Total	5733	20.5	14,998	53.7	3735	13.4	1181	4.2	648	2.3	685	2.5	937	3.4

Table III
Probability of Reporting Exposure According to Work-related Factors

Work-related Factors	Skin Contact with Oil and Diesel				Oil Vapor from Shaker and Other Mud Cleaning				Exhaust Fumes				Vapor from Mixing Chemicals Used for Drilling			
	No. of Persons	No. of Exposed	RR ^A	95% CI <i>P</i> -value	No. of Persons	No. of Exposed	RR ^A	95% CI <i>P</i> -value	No. of Persons	No. of Exposed	RR ^A	95% CI <i>P</i> -value	No. of Persons	No. of Exposed	RR ^A	95% CI <i>P</i> -value
Main activity																
Catering	4348	293	1.00	Ref.	4362	156	1.00	Ref.	4373	156	1.00	Ref.	4354	59	1.00	Ref.
Production	1939	652	4.14	3.57-4.80	1930	319	3.51	2.84-4.35	1931	176	2.04	1.60-2.60	1928	40	1.43	0.91-2.25
Drilling	3724	2035	6.69	5.86-7.64	3727	1877	10.10	8.42-12	3703	725	3.95	3.25-4.81	3721	1314	16.42	12-22
Maintenance	12,538	3957	4.52	3.97-5.15	12,455	1901	4.08	3.40-4.89	12,472	1665	3.64	3.03-4.38	12,420	687	4.04	2.97-5.51
Miscellaneous	4202	1167	4.27	3.72-4.90	4168	529	3.31	2.71-4.05	4191	493	3.08	2.51-3.79	4192	213	3.47	2.47-4.87
Year left position																
1967–1979	471	160	0.90	0.79-1.02	470	117	0.93	0.80-1.09	468	75	1.09	0.87-1.37	469	98	1.50	1.26-1.79
1980–1989	3062	954	1.02	0.97-1.08	3050	653	1.14	1.06-1.23	3043	416	1.11	1.00-1.23	3053	413	1.56	1.42-1.72
1990–1999	20,089	6176	1.00	Ref.	20,032	3515	1.00	Ref.	20,043	2368	1.00	Ref.	19,984	1542	1.00	Ref.
<i>Continuous^B</i>			<i>1.002</i>	<i>0.292</i>			<i>0.994</i>	<i>0.007</i>			<i>0.994</i>	<i>0.096</i>			<i>0.971</i>	<i><0.001</i>
Supervisor/manager																
No	16,040	5020	1.00	Ref.	15,984	3000	1.00	Ref.	15,989	1866	1.00	Ref.	15,962	1367	1.00	Ref.
Yes	10,583	3045	0.97	0.93-1.01	10,551	1765	0.91	0.86-0.97	10,561	1340	1.20	1.12-1.30	10,528	941	1.06	0.97-1.15
Type of company																
Operating	9147	2417	1.00	Ref.	9111	1241	1.00	Ref.	9118	874	1.00	Ref.	9106	400	1.00	Ref.
Contractor	17,033	5516	1.01	0.96-1.06	16,992	3446	1.10	1.03-1.18	16,989	2266	1.08	0.99-1.18	16,947	1869	1.44	1.28-1.62
Type of installation																
Stationary	19,159	5281	1.00	Ref.	19,109	2935	1.00	Ref.	19,116	1958	1.00	Ref.	19,068	1168	1.00	Ref.
Movable	6604	2438	1.20	1.15-1.26	6580	1636	1.20	1.13-1.27	6581	1091	1.33	1.23-1.45	6574	1034	1.47	1.35-1.60
Work schedule																
Daytime	13,775	2873	1.00	Ref.	13,746	1192	1.00	Ref.	13,753	1014	1.00	Ref.	13,722	332	1.00	Ref.
Night time	1030	278	1.06	0.95-1.20	1029	181	1.36	1.17-1.59	1027	119	1.43	1.17-1.75	1031	90	1.86	1.46-2.37
Shiftwork	10,970	4587	1.57	1.50-1.65	10,926	3150	2.11	1.96-2.28	10,926	1885	2.03	1.85-2.22	10,911	1770	3.05	2.65-3.50
Educational level																
Compulsory	3181	1048	1.00	Ref.	704	3163	1.00	Ref.	3160	486	1.00	Ref.	3138	401	1.00	Ref.

Table IV

Probability of Reporting Exposure According to Work-related Factors

Work-related factors	Natural gas				Chemicals used for water injection and processing				Solvent vapor			
	No. of persons	No. of exposed	RR ^A	95% CI <i>P</i> -value	No. of persons	No. of exposed	RR ^A	95% CI <i>P</i> -value	No. of persons	No. of exposed	RR ^A	95% CI <i>P</i> -value
Main activity												
Catering	4347	102	1.00	Ref.	4347	81	1.00	Ref.	4393	737	1.00	Ref.
Production	1939	620	8.61	6.77-11	1930	609	9.41	7.17-12	1932	232	0.84	0.72-0.99
Drilling	3682	342	3.58	2.79-4.58	3691	308	4.30	3.25-5.70	3708	778	1.01	0.91-1.12
Maintenance	12,397	762	2.34	1.87-2.94	12,349	628	2.53	1.95-3.28	12,527	3833	1.60	1.48-1.73
Miscellaneous	4177	297	2.94	2.29-3.77	4184	222	2.90	2.16-3.88	4199	607	0.87	0.78-0.98
Year left position												
1967–1979	463	28	0.85	0.58-1.25	460	41	1.36	1.00-1.86	469	144	1.23	1.05-1.45
1980–1989	3015	244	1.24	1.08-1.43	3019	199	1.20	1.02-1.40	3068	839	1.18	1.10-1.26
1990–1999	19,971	1667	1.00	Ref.	19,940	1453	1.00	Ref.	20,098	4474	1.00	Ref.
<i>Continuous^B</i>			<i>0.987</i>	<i>0.004</i>			<i>0.990</i>	<i>0.036</i>			<i>0.984</i>	<i><0.001</i>
Supervisor/manager												
No	15,899	1350	1.00	Ref.	15,886	1232	1.00	Ref.	16,045	4128	1.00	Ref.
Yes	10,522	765	0.95	0.86-1.05	10,491	607	0.87	0.78-0.97	10,593	2031	0.89	0.84-0.94
Type of company												
Operating	9098	1111	1.00	Ref.	9093	1030	1.00	Ref.	9136	1267	1.00	Ref.
Contractor	16,893	970	0.67	0.60-0.74	16,853	783	0.56	0.49-0.63	17,057	4783	1.70	1.59-1.82
Type of installation												
Stationary	19,048	1648	1.00	Ref.	18,995	1403	1.00	Ref.	19,160	4231	1.00	Ref.
Movable	6532	385	0.72	0.63-0.81	6536	366	0.84	0.74-0.96	6621	1716	1.10	1.04-1.17
Work schedule												
Daytime	13,724	714	1.00	Ref.	13,690	523	1.00	Ref.	13,795	2694	1.00	Ref.
Night time	1026	56	0.97	0.71-1.32	1027	42	1.09	0.79-1.52	1035	249	1.22	1.08-1.38
Shiftwork	10,848	1240	1.45	1.29-1.62	10,851	1194	1.67	1.47-1.89	10,954	2919	1.34	1.27-1.41
Educational level												
Compulsory	3119	217	1.00	Ref.	3110	209	1.00	Ref.	3193	1180	1.00	Ref.

Work-related factors	Natural gas				Chemicals used for water injection and processing				Solvent vapor			
	No. of persons	No. of exposed	RR ^A	95% CI <i>P-value</i>	No. of persons	No. of exposed	RR ^A	95% CI <i>P-value</i>	No. of persons	No. of exposed	RR ^A	95% CI <i>P-value</i>
Vocational training	10,510	1055	1.01	0.86-1.19	10,490	974	1.02	0.86-1.21	10,600	2469	0.70	0.66-0.75
Upper secondary	6635	434	0.89	0.75-1.06	6614	408	0.93	0.78-1.12	6669	1802	0.78	0.73-0.83
University/college	6327	418	0.74	0.61-0.89	6335	268	0.50	0.40-0.61	6349	732	0.44	0.40-0.48

Notes: RR = relative risk; CI = confidence interval; Ref. = reference category.

^AFor each exposure, all factors were included in the regression model simultaneously.

^BYear left position included as continuous variable.