

# Injuries to International Petroleum Drilling Workers, 1988 to 1990

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*Nonfatal work-related injury (NFI) rates are 49% higher among oil and gas field workers than among workers in all US industries combined, and these injuries are more severe (the rate of lost workdays in the oil and gas field services industry is 2.8 times that of all US industries combined). We analyzed the 1988 to 1990 incident reports submitted by drilling companies to the International Association of Drilling Contractors, an industry-wide international trade association representing 95% of the world's oil and gas drilling companies. We determined geographic and occupation-specific incidence rates by full-time equivalents, calculated per job category and year. Of the 5,251 reports, 5,218 (99.4%) were of NFI and 33 (0.6%) of fatal work-related injuries (FI). The overall NFI rate was 1.2/100 full-time equivalents and the overall FI rate was 7.5/100,000 full-time equivalents. Reported NFI in US territory was 4 times more common than in non-US territory. Reported FI in US and non-US waters were 4 and 5 times more common than on land, respectively. Three job categories—floormen, roustabouts, and derrickmen—accounted for 74% of the NFI and 64% of FI, with a rate ratio, compared with rates for all other occupations, of 10.5, 8.5, and 7.0 for NFI and 5.0, 9.4, and 4.0 for FI. Among all occupations, the body part most frequently injured was the upper extremity (1,631/5,218 [31%]). The four key NFI types and circumstances identified included the upper extremities "caught in" (857/5,218 [16%]), the back "strained" (592/5,218 [11%]), the lower extremities "struck by" (538/5,218 [10%]), and the lower extremities injured while "slipping" (402/5,218 [8%]). Results of these analyses revealed several high-risk occupations in this industry and identified high-risk activities that can be targeted for further study.*

Petroleum drilling workers experience excess mortality compared with other workers.<sup>1</sup> In addition, nationally published rates of nonfatal work-related injuries (NFI)<sup>2,3</sup> are 49% higher for the oil and gas field services industry (standard industrial classification code [SIC] 138, which includes oil and gas drilling, exploration, and services) than for all US industries combined. Moreover, these NFI tend to be more severe, with a 2.8-fold higher rate of lost workdays than all US industries combined.<sup>2</sup> Very little occupation-specific NFI rate or circumstance data are available about petroleum drilling workers.

In 1983, the Bureau of Labor Statistics (BLS) reported high frequencies of NFI in a small group of workers in oil and gas drilling and services.<sup>4</sup> This report did not, however, include the population-at-risk data necessary for rate calculations. Therefore, the value of these data is limited.

Personal factors such as age, rate of job change, rate of rig transfer (reassignment),<sup>5</sup> and type A behavior<sup>6</sup> have been shown to affect NFI rates among petroleum drilling workers. Previous studies, however, have not addressed the geographic location and occupation-specific factors directly associated with the injury, eg, the type of equipment used, specific location on the rig, and other detailed circumstances surrounding the injury event (which lend themselves more to applied prevention).

NFI to one body area—the lower back—have been extensively studied among petroleum drilling workers.<sup>7,8</sup> Although well designed, these studies were limited to one company's offshore work force and focused primarily on only one body site.

To understand more fully the international scope and epidemiology of

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all injuries (NFI and fatal work-related injuries [FI]) to this high-risk group, both on and offshore, we analyzed incident data collected for a 3-year period (1988 to 1990) by the International Association of Drilling Contractors (IADC), an industry-wide trade association representing approximately 95% of the world's oil and gas drilling companies. Not included as members of the IADC were companies in the former Soviet Union, China, and a few other smaller companies.

### Materials and Methods

The IADC defined an NFI/FI as any work-related injury that prevented an employee from returning to work on his or her regular job by the next regularly scheduled workday. Injuries and fatalities that occurred during off-duty hours or were caused by natural disasters (eg, hurricanes, tornadoes, and floods) were excluded regardless of the worker's duty status. If the injury happened on the last day of a work week but the employee recovered in time to return to the job for the next regularly scheduled work period (which generally was 7 days later), the injury was not included. If the employee was placed on other duty because of the injury, the NFI was included.

Safety managers of IADC-member petroleum drilling companies gathered the data and submitted it monthly to the IADC. The IADC performed quality control of the data, verifying any inconsistencies directly with the company. The IADC maintained a computerized spreadsheet of the data and tabulated overall company rates of NFI and FI for an industry-wide safety awards program designed to recognize outstanding safety records of individual companies. Participation by private companies in this industry-wide safety program was voluntary.

The data gathered included company code, whether the injury was fatal, the date of the event, the geographic location (US or non-US and on land or water), occupation of the victim, body part injured, circumstance of injury (eg, "slip or fall,"

"struck by," or "caught in"), equipment used at the time, operation the worker was performing at the time, and the location of the occurrence on the rig.

To estimate the person-hours of work for each occupation, we multiplied the standard number of workers in each occupation on each different rig type (IADC, personal communication, 1991) by the number and type of rigs in operation. The Offshore Data Services (Houston, Texas) provided the US and non-US offshore rig counts, and the *Oil and Gas Journal* provided the Baker-Hughes land rig counts for this period. Water-based crews worked 12-hour shifts for 7 days, then were off for 7 days. Land-based crews worked standard 8-hour shifts. Assuming 2,000 person-hours equal one full-time equivalent (FTE), we expressed NFI rates in terms of 200,000 person-hours or 100 FTEs and FI rates in terms of 100,000 FTEs. This estimate allowed comparisons with rate calculations by the BLS and the National Safety Council (NSC).

A typical offshore drill crew included 2 drillers (supervisors of the crew); 8 floormen, who handled the lower end of the pipe with equipment called tongs and slips; 8 roustabouts, who provided routine maintenance (eg, paint chipping, cleaning up, and handling equipment on the deck of the rig); 2 derrickmen, who handled the top end of the pipe; and 2 motormen, who maintained the engines. Other miscellaneous work offshore was performed by electricians, mechanics, welders, crane operators, barge engineers, toolpushers, and superintendents.

We performed data analysis by using EpiInfo, Lotus 1-2-3, dBase IV,

and BMDP software. We calculated rates of FI and NFI in each occupation and geographic category as numbers of events divided by FTEs. One FTE equaled 2,000 person-hours. We computed 95% confidence intervals (CIs) by the procedure of Ederer and Mantel (9) for the rate ratios (RRs).

### Results

During the period 1988 to 1990, 347 (87%) of the 398 IADC-member companies submitted incident reports. Of the 5251 reports, 5218 (99.4%) were of NFI and 33 (0.6%) were of FI (Table 1). We observed an overall reported NFI rate of 1.2/100 FTEs. NFI rates differed among geographic locations: US or non-US and on land or water rigs. The combined US land and water NFI rate was 2/100 FTEs, and NFI were 4 times more likely to be reported in US than in non-US territory. NFI rates on US and non-US water were also higher than those on US and non-US land. The water-to-land RR for NFI was 1.3 (95% CI = 1.2, 1.4) for US and 5.1 (95% CI = 4.6, 5.8) for non-US rigs.

The overall FI rate was 7.5/100,000 FTEs. The combined (land and water) US and non-US FI rates were 6.5/100,000 FTEs and 8.3/100,000 FTEs, respectively. FI rates on water (regardless of location) were far higher than on land, with US and non-US FI rates of 19.2 and 20.2, respectively, and an overall water-to-land FI RR of 4.6 (95% CI = 1.3, 14.8) for US and 5.1 (95% CI = 2.2, 16.8) for non-US rigs.

Three occupations—floormen, roustabouts, and derrickmen—had substantially higher risks of NFI and FI. For both NFI and FI, these occupations had rates 4 to 10 times higher

TABLE 1  
Petroleum Drilling Worker Injuries by Geographic Location, 1988–1990

Injury Type	US Land		Non-US Land		US Water		Non-US Water		Total	
	N	Rate	N	Rate	N	Rate	N	Rate	N	Rate
Nonfatal*	3273	1.9	388	0.2	785	2.5	772	1.2	5218	1.2
Fatal†	7	4.0	7	3.9	6	19.2	13	20.3	33	7.5
Total	3280	1.9	395	0.2	791	2.5	785	1.2	5251	1.2

\* Nonfatal injury rates per 100 full-time equivalents (FTEs).

† Fatal injury rates per 100,000 FTEs.

**TABLE 2**  
Petroleum Drilling Worker Injuries, by Occupation, 1988-1990

Occupation	Nonfatal Injuries				Fatal Injuries			
	N	Rate*	Rate Ratio	95% CI†	N	Rate‡	Rate Ratio	95% CI†
Floormen	2538	4.2	10.5	9.9, 11.3	11	18.1	5.0	2.1, 11.9
Roustabouts	600	3.4	8.5	7.7, 9.4	6	33.9	9.5	2.5, 23.3
Derrickmen	745	2.8	7.0	6.4, 7.6	4	14.9	4.2	0.5, 10.7
Other	1335	0.4	Ref§		12	3.6	Ref§	
Total	5218	1.2			33	7.5		

\* Nonfatal injury rates per 100 FTEs.  
† CI, confidence interval.  
‡ Fatal injury rates per 100,000 FTEs.  
§ Ref, Reference.

than all other occupations combined (Table 2).

The body part injured most frequently differed between NFI and FI (Table 3). Upper extremities (including the fingers, hands, or arms) accounted for 1631/5218 (31%) NFI; the largest proportion of NFI to any body part. Head or neck injuries accounted for the greatest proportion of FI (11/33 [33%]).

The circumstances of NFI and FI varied with the body part affected. Overall, 46% of NFI could be accounted for by four combinations of circumstance and body part: upper extremities injured while "caught in" equipment, back "strained," lower extremities "struck by" equipment, and lower extremities injured while "slipping" (Table 4). Similarly, 30% of FI were accounted for by two combinations of circumstance and body part: head or neck "struck by" or trunk "struck by" equipment.

Two pieces of equipment—pipes and tongs—accounted for 48% (409/857) of upper extremities "caught in" equipment and 45% (240/538) of lower extremities "struck by" NFI. The two operations of "tripping in or out," which is the drilling activity of moving the drill bit into or out of the hole, which is required to change the drill bit itself, and "materials handling" accounted for 24% (141/592) and 14% (85/592), respectively, of back "strained" NFI. Forty-four percent of NFI to the lower extremities as a result of a slip or fall occurred on the rig floor (76 [19%]), rig pad (59 [15%]), or stairs or ladders (40 [10%]).

**TABLE 3**  
Petroleum Drilling Workers Injuries, by Body Part, 1988-1990

Body Part	Nonfatal Injuries		Fatal Injuries	
	N	%	N	%
Upper extremities	1631	31	0	0
Lower extremities	1340	26	2	6
Back	1068	20	0	0
Head/neck	366	7	11	33
Other	813	16	20	61
Total	5218	100	33	100

**Discussion**

These data show that the large majority of reported injuries were on US land or water rigs. Most of the reported injuries were on land-based rigs; however, the rate of nonfatal and fatal injuries was higher on water-based rigs. We found three high-risk occupations in the petroleum drilling industry—roustabouts, floormen, and derrickmen. In addition, four key types and circumstances contributed to a substantial proportion of the injuries.

The four key injury types and circumstances identified in our study included the upper extremities "caught in," the back "strained," the lower extremities "struck by," and the lower extremities injured while "slipping." Although these four key injury types and circumstances account for 45% of NFI, multiple environmental and work practice factors could be important contributors to nonfatal and fatal injuries, such as weather conditions, prior training, age of the worker, number of rig transfers, and time on the

**TABLE 4**  
Petroleum Drilling Worker Injuries, by Body Part and Circumstance, 1988-1990

Body Part and Circumstance	Nonfatal Injuries	
	N	%
Upper extremities "caught in"		
Pipes	210	25
Tongs	199	23
Elevators	86	10
Ropes or cables	48	6
Other	314	36
Total	857	100
Back "Strained" by		
Tripping in or out	141	24
Material handling	85	14
Routine drilling operations	64	11
Making connection	59	10
Rig repairs	59	10
Other	184	31
Total	592	100
Lower Extremities "Struck by"		
Pipes	193	36
Tongs	47	9
Ropes or cables	36	7
Hand tools	25	5
Other	237	43
Total	538	100
Lower Extremities "Struck by"		
Laying down/picking up	103	19
Tripping in or out	93	17
Rigging up or down	55	10
Making connection	44	8
Other	243	46
Total	538	100
Lower Extremities "Slip-Fall" on		
Rig floor	76	19
Rig pad	59	15
Stairs, ladders	40	10
Mixing room	28	7
Other	199	49
Total	402	100
Other	2829	54
Total	5218	100

job. Because data concerning these factors were not available, we could not evaluate their impact.

The costs, circumstances, and economic factors of low back injuries in petroleum drilling workers have been reported elsewhere.<sup>7,8</sup> In these studies the issue of malingering by US workers was raised. Although our data cannot specifically address this point, we did observe that the US nonfatal to fatal injury RR (0.3) was markedly higher than the comparable ratio on non-US rigs (0.06). The interpretation of this finding is difficult. One hypoth-

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esis is reporting bias. Underreporting of NFI among non-US land and offshore companies would explain this finding. Another possible explanation is that the more liberal workers' compensation program in the United States may provide incentive to report NFIs.

The case definition used to gather these data is moderately strict. Lost workday requirements, as defined by the IADC for this data set, preclude minor injuries, regardless of whether they require medical attention. The case definition used by the BLS and the NSC (the Occupational Safety and Health Administration case definition) for total recordable injury rates in SIC 138 (oil and gas field services) includes loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment. Lost workday is not a requirement to be included in the total recordable case rates. However, both the BLS and NSC also calculate rates of lost workday cases, which are a subset of the total recordable cases (which results in smaller rates and more severe injuries). Therefore, rate comparisons between these, the BLS, and NSC data must be done by using comparable case definitions. Clearly, the rates of lost workday cases of the BLS and NSC more closely approximate the rates generated here.

The 1991 BLS nationally published rate of lost workday cases for SIC 138 is 5.5/100 FTEs,<sup>2</sup> compared with a rate of 3.7/100 FTEs in all industries combined. The most comparable rate generated by our study is the rate for combined US land and offshore NFI, 2/100 FTEs. A comparable injury rate published by the NSC is 0.99/100 FTEs. The differences between these three sources can be attributed to subtle differences in the case definition of

a nonfatal injury, calculation of person-hour denominator data, and, in the case of the NSC, certain biases associated with volunteer reporting, such as the lack of representativeness associated with few reporters.

Mueller et al<sup>5</sup> published a rate of lost workdays due to NFI among petroleum drilling workers of 2.5/100 FTEs, a figure very close to our data (2/100 FTEs). This report also lists occupation-specific rates of lost time due to injury similar to the results reported here, with floormen, derrickmen, and roustabouts having elevated rates of 4.2, 4, and 2.6, respectively.

Offshore petroleum drilling workers work under extraordinarily hazardous conditions. Their stress and levels of anxiety are high.<sup>5</sup> Manually managing very large pieces of equipment, often moving rapidly, requires agility, dexterity, and alert attention to detail. The long working hours or shift and the stressful working schedule of 7 days on and 7 days off, combined with a wet and slippery work environment, mitigate against safety. In addition, individual circumstances of frequent rig changes and youth contribute to increased injury rates.<sup>4</sup>

These studies have identified several high-risk occupations and work-related activities amenable to further study and prevention strategies. The potential exists to redesign equipment and/or implement changes in the physical motions required to do a job, which might make the job safer. Safety education of workers remains important. Efforts like these, in terms of injury data collection and the promotion of injury control programs, are valuable spheres of influence for trade associations like the IADC.

Our recommendations include that further study of all potential risk factors associated with nonfatal and fatal

injuries is necessary; consider redesigning tongs and other equipment involved in the "tripping in and out" operation to make them less likely to get arms caught or legs struck; consider equipment to decrease the need for lifting to prevent back injuries; and consider using nonskid surfaces on the rig floor, pad, and stairs. In addition, we recommend that 4-digit SIC code data be gathered by government sources to elucidate intraindustry risks; 3-digit code data can be misleading in that it may represent too broad a characterization.

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