

A case crossover study of triggers for hand injuries in commercial fishing

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ABSTRACT

Objectives: Previous studies estimate hand and wrist injuries are common in commercial fishing. Risk factors including working with catch, handling gear and slips or falls, have been identified from activity and injury contact reports, but no studies have examined the influence of transient risk factors, or triggers. This case crossover study design was conducted to investigate triggers for acute hand trauma in commercial fishing.

Methods: A case crossover study was nested within a previously established prospective cohort of 217 southeastern United States commercial fishermen followed from April 1999 through October 2001. Hand injury cases and controls were matched using three control selection strategies. Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated to determine if transient risk factors such as glove use, engaging in more than one type of fishing, maintenance activities and other covariates of interest increased the risk of occupational traumatic hand/wrist/digit injuries.

Results: 21% (46/217) of fishermen reported one or more hand/wrist/digit injuries, yielding 65 eligible cases. Performing maintenance work (any vs none) (OR 3.1, 95% CI 1.8 to 5.5) and using multiple types of fishing equipment in comparison to using only one type (OR 1.9, 95% CI 0.9 to 3.8) were associated with increased risk of hand/wrist/digit injury. There was no evidence glove use was protective (any vs none) for hand/wrist/digit injury (OR 0.9, 95% CI 0.5 to 1.7).

Conclusions: The case crossover design is a useful method to determine triggers of commercial fishing-related hand/wrist/digit injuries. Maintenance work was strongly associated with hand/wrist/digit injury for these fishermen.

Work-related hand injuries are responsible for over 1 million yearly emergency room visits¹ and an average of five lost work days per worker per year in the USA.² A 2001 review of 12 international studies from a selection of industries reported the rate of hand injuries ranged from 0.33 in food product manufacturing to 11.0 in steel manufacturing per 100 worker-years.³ Risk factors for work-related hand injuries include age, experience on the job, hazardous work conditions and gender.³ However, factors that vary within an individual over time can be challenging to identify with traditional study designs. Case crossover study designs,⁴ in which cases are self-matched to their own control periods, are well suited for studying the effects of these transient risk factors. Previous case crossover studies found performing unusual work tasks, being distracted or rushed, equipment or tool malfunction, new work methods, or not wearing gloves were associated with an increased risk of work-related hand injury.^{5–8}

The commercial fishing industry has high traumatic injury rates. Previous studies with commercial fishermen indicated that roughly one quarter to half of all fishing-related injuries were hand injuries,^{9–17} and the rate of hand injuries in commercial fishing has been estimated at 2.4 per 100 worker-years.³ Common causes of fishing-related hand injuries include working with catch, handling pots, nets and lines, as well as slips or falls.^{9–11 14 16 17} Studies have described the circumstances surrounding hand injury events but to date have not examined time-varying risk factors, or triggers, associated with commercial fishing hand injuries. The purpose of this study was to identify transient risk factors (referred to here as triggers) associated with work-related acute hand, wrist or digit injuries in commercial fishing. We used a case crossover design.

METHODS

This case crossover study of traumatic hand/wrist/digit injuries was nested within a prospective cohort of 217 southeastern US commercial fishermen originally assembled during the period April 1999 to May 2000 for the purpose of studying exposure to a toxic marine micro-organism and possible neurological symptoms.¹⁸ The population recruited for this parent study included individuals 18–65 years of age who fished on coastal rivers and sounds or on the ocean for at least 20 h per week for at least 6 months of the year. The Institutional Review Board of the School of Public Health at the University of North Carolina, Chapel Hill approved all study procedures. Details of recruitment and study protocols for the cohort have been previously reported.^{18–20}

From August 1999 to October 2001 fishermen were interviewed by telephone about their fishing work, exposures on and off the water, and whether they were injured. Work-related traumatic injury events were defined as “accidents or events that damaged your body, and required: first aid at the time of injury, or, medical care at some later time, or, time away from work”. Multiple injuries could be reported per event and details of the type of injury and the body part affected were requested for up to three injuries per interview period. The period between calls varied but they were made approximately weekly for April through October and biweekly for November through March.

The study base for the case crossover analysis consisted of commercial fishermen at risk for a hand, wrist or digit injury while engaged in commercial fishing work on or off the water. The hazard period was defined as the 7–10-day interval covered by a phone interview during

which fishermen were engaged in fishing work on or off the water. Eligible cases were identified as having sustained a reported hand, wrist or digit injury during the interview period. Injury types included penetrating wounds, contusions, sprains, strains, fractures, dislocations, burns, bites and stings. Triggers were assessed over the interview week and included maintenance activity, glove use, joint pain, working on the water, hours of fishing work off the water, working on the Atlantic ocean, fishing with more than one gear type and season (April to October versus November to March).

The unit of analysis in this investigation was the interview period. A fisherman could have more than one injury event during follow-up, so each case period had a matching set of one or more control periods. For each injury event, controls were sampled from the risk set which included interview periods before or after the event. Control periods also included interview periods where an event occurred. Since controls should represent the source population the cases came from, previous (and subsequent) case periods had the potential to be selected as control periods.^{21 22}

Case and control periods were self-matched within workers using control selection strategies from Mittleman *et al.*²³ In pair (1:1) matching, the case period was matched to the previous interview period. Ninety per cent of control interviews were within 9 days of the case interview. For the remaining 10%, the lag ranged from 16 to 31 days and included one outlier of 85 days, while in one case the subsequent interview had to be used as there was no previous interview. In multiple interval (1:5) matching, cases were matched with five randomly selected control periods. In addition, we matched cases to all available control periods (1:all matching). This approximates a full cohort analysis and has been referred to as a full-stratum bi-directional case crossover design.²⁴

Analysis

Descriptive frequencies and univariate statistics were calculated by fisherman, injury event (case) and injury. Distribution of transient risk factors was examined from January to December to identify seasonal variation in exposure. Conditional logistic regression models used the proportional hazards regression procedure to estimate odds ratios (OR) and 95% confidence intervals (95% CI) for the odds of a hand/wrist/digit injury event. Potential triggers in univariate analyses with an OR of either ≥ 1.2 or ≤ 0.8 were included in multivariate models. Confidence limit ratios (CLR, calculated as the upper confidence limit divided by the lower confidence limit) were produced to quantify precision for all estimates.²⁵ We stratified estimates by season to determine the presence of heterogeneity.

RESULTS

A total of 217 fishermen accumulated 9211 interviews during follow-up. Fishermen were predominantly white (99%), non-Hispanic males (87%) with a mean age of 43 years (SD 12) (table 1). Fishing for crabs with pots was the most common activity performed (66%) followed by taking fish with gillnets (61%) and trawling for shrimp (36%). Forty-six fishermen (21%) reported one or more hand, wrist or digit injury events during follow-up for a total of 65 eligible case injury events. Of the fishermen, 67% had one injury event, 24% had two injury events and 9% had three injury events over follow-up. Injured and uninjured fishermen were generally similar with respect to fixed factors, but injured fishermen were more likely to use multiple gear types.

The majority of injured fishermen (95%) were interviewed within a week of the hand injury event; 55% were interviewed within 4 days. Prior to the injury event, fishermen were most often working with fishing gear or performing maintenance work (table 2). The most common contact causes of the hand injury events included sharp objects, catch or other sea animals, and gear. Injury events were not severe: 60% required no time off and no care from anyone other than the fisherman (table 2).

Sixty-five injury events resulted in 72 separate injuries to the finger (53%), hand (32%), thumb (7%) and wrist (7%) and 1% involved multiple structures. Most of the injuries were penetrating wounds such as lacerations (46%), punctures (17%) and abrasions (15%). Closed injuries included contusions (7%), bites or stings (7%), sprains and strains (3%), burns (3%) and other (3%). When injury type and location were considered together, the top four most common injuries were finger laceration (25%), hand laceration (15%), hand abrasion (8%) and finger puncture (8%).

Table 1 Demographic characteristics of a cohort of southeastern United States commercial fishermen, 1999 to 2001

	Hand injured (n = 46), n (%)	Not hand injured (n = 171), n (%)	Total (n = 217), n (%)
Age			
18–19	1 (2.1)	6 (3.5)	7 (3.2)
20–29	5 (10.9)	20 (11.7)	25 (11.5)
30–39	7 (15.2)	44 (25.7)	49 (22.6)
40–49	15 (32.6)	51 (29.8)	67 (30.9)
50–59	11 (23.9)	38 (22.2)	50 (23.0)
60+	7 (15.2)	12 (7.0)	19 (8.8)
Gender			
Male	40 (87.0)	149 (87.1)	189 (87.1)
Female	6 (13.0)	22 (12.9)	28 (12.9)
Race			
White	46 (100)	170 (99.4)	216 (99.5)
Black	0 (0)	1 (0.6)	1 (0.5)
Education			
<12 years	10 (21.7)	60 (35.1)	70 (32.3)
High school	24 (52.2)	61 (35.7)	85 (39.2)
>12 years	12 (26.1)	50 (29.2)	62 (28.6)
Type of fishing gear*			
Finfish			
Gill net	31 (67.4)	102 (59.7)	133 (61.3)
Pound net	5 (10.1)	14 (8.2)	19 (8.8)
Long haul	1 (2.2)	4 (2.3)	5 (2.3)
Hook and line	10 (21.7)	33 (19.3)	43 (19.8)
Other	16 (34.8)	33 (19.3)	49 (22.6)
Crab			
Pots	29 (63.0)	114 (66.7)	143 (65.9)
Other	9 (19.6)	22 (12.9)	31 (14.3)
Shrimp	16 (34.8)	62 (36.3)	78 (35.9)
Oyster	9 (19.6)	32 (18.7)	41 (18.9)
Clam	16 (34.8)	29 (17.0)	45 (20.7)
Other	10 (21.7)	41 (24.0)	51 (23.5)
Number of fishing gear types			
1	7 (15.2)	44 (25.7)	51 (23.5)
2	13 (28.3)	55 (32.2)	68 (31.3)
3+	26 (56.5)	72 (42.1)	98 (45.2)
Number of interviews per person			
Mean (SD)	47 (16.1)	41 (18.8)	42 (18.4)
Range	9–78	3–73	3–78

*Percentages sum to more than 100% because many participants engaged in more than one type of fishing.
SD, standard deviation.

Table 2 Traumatic hand injury event details (cases = 65) in southeastern United States commercial fishermen (n = 46), 1999–2001

	Cases (%)
Prior activity	
Working with nets, pots or lines	19 (29.7)
Maintenance	17 (26.6)
Working with catch	13 (20.3)
Load, unload, trailer boat, dock, cast off, etc	8 (12.5)
Non-specific activities while commercial fishing	8 (10.9)
Missing	1
Contact cause	
Knife, hook or other sharp object	18 (28.1)
Finfish, shellfish or other sea animals	13 (20.3)
Fishing gear	11 (17.2)
Tools or equipment	10 (15.6)
Other	9 (14.1)
Falling on a hard surface	4 (6.3)
Severity	
No time off, self care	38 (60.3)
No time off, external care*	14 (22.2)
Time off, self care	6 (9.5)
Time off, external care*	5 (7.9)
Missing	2
Time lost from accident	
Not slowed down at work and no lost time	36 (55.4)
Slowed down at work but no lost time	18 (27.7)
Lost time less than 1 week	10 (15.4)
Lost time 1 week or more	1 (1.5)

*External care includes care from anyone other than the individual and includes medical personnel, co-workers or family members.

Maintenance work was performed most frequently between November and April (fig 1A). Off the water work mirrored this distribution. On the water work was performed at the highest frequency from May to October. Fishing with more than one gear type during the week was more common from May through August. Glove use increased in frequency from May to November, while joint pain and working on the ocean were more constant during this period (fig 1A,B; also see supplementary figure 1b).

Regardless of the method used to sample controls, performing maintenance work and fishing with more than one gear type during the interview week were associated with an increased odds of a hand/wrist/digit injury. There was no evidence that use of gloves was associated with a decreased odds of a hand/wrist/digit injury because the confidence intervals were wide relative to the estimated strength of association (table 3). Season was strongly associated when the previous interview period was used as the control. However, when cases were

matched to five or more control periods, the association for season attenuated. No clear association of injury with joint pain or work on the Atlantic ocean versus other waters was observed.

Matching case periods with five control periods or all available control periods yielded greater precision than pair matching, as indicated by smaller CLRs, but the marginal gain in precision from using all control periods rather than five was modest (table 3). Point estimates of the OR were in the same direction and generally similar in magnitude to all the matching methods.

Results for work on the water and working more than 4 h off the water during the week were different depending on the sampling strategy (table 3). Using the previous interview period as the control, working on the water increased the odds of a hand/wrist/digit injury. When other control periods were included, working on the water decreased the odds of a hand/wrist/digit injury while hours of off water work was associated with increased odds.

When all transient risk factors were included in multivariate models, we observed similar associations for most triggers except for fishing in the Atlantic ocean (table 4). On and off water variables were not included in the final model to avoid over controlling when maintenance and ocean were included.

DISCUSSION

In this group of commercial fishermen, maintenance work and using more than one gear type were strong transient risk factors for a hand/wrist/digit injury event. The data do not provide evidence of a protective effect from using gloves, and its magnitude was imprecisely estimated. We observed inconsistent results for joint pain and fishing in the Atlantic ocean. The results were similar for the three methods of sampling controls, with precision increasing with the matching ratio, as expected.

Our results for maintenance work and using more than one gear type support the descriptive results from previous research in commercial fishing. Hospital discharge and insurance claim data from New Zealand commercial fishermen¹⁴ found operating winches (35/78) and using knives (13/78) were common causes of hand/wrist/digit injuries. Cuts and jamming hands were common causes of hand injuries reported to insurance companies among Swedish commercial fishermen.^{16, 17} In this study, working with gear and performing maintenance work were responsible for 29% and 26% of hand/wrist/digit injury events, respectively. Knives, hooks and other sharp objects caused 28% of injury events.

In this group of small-scale, independent commercial fishermen, the majority of hand/wrist/digit injuries were not severe

Figure 1 (A, B) Monthly distribution of triggers for hand injury in southeastern United States commercial fishermen (n = 46), 1999–2001.

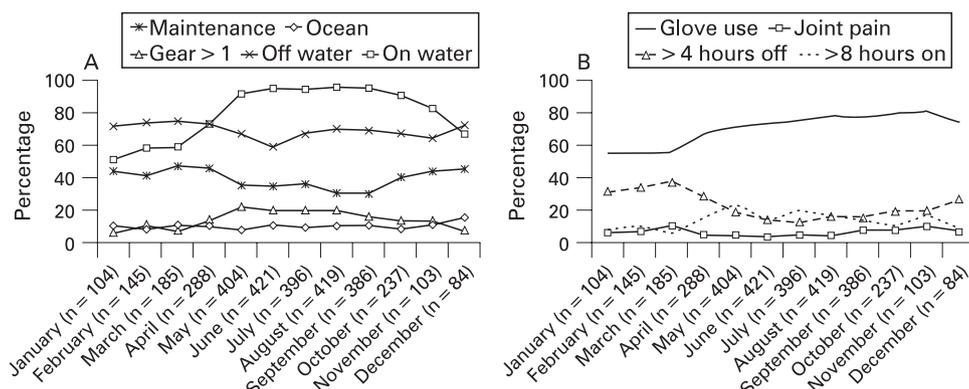


Table 3 Unadjusted ORs* and 95% CIs for triggers of hand injury using three control sampling strategies in southeastern United States commercial fishermen (n = 46, cases = 65), 1999–2001

	Cases n = 65	Controls								
		Uni-directional, 1:1 previous interview period			Bi-directional, 1:5 randomly selected periods			Bi-directional, 1:all interview periods		
		n = 65	OR (95% CI)	CLR	n = 325	OR (95% CI)	CLR	n = 3107	OR (95% CI)	CLR
Maintenance work	39	30	2.3 (1.0 to 5.5)	5.8	115	3.8 (2.0 to 7.2)	3.6	1147	3.2 (1.8 to 5.6)	3.1
No (ref)	26	35			210			1960		
Glove use	44	46	0.8 (0.4 to 1.9)	5.2	243	0.6 (0.3 to 1.2)	4.0	2234	0.8 (0.4 to 1.6)	3.6
No (ref)	21	19			82			873		
Joint pain	4	5	0.7 (0.1 to 3.6)	25.8	24	0.8 (0.2 to 2.7)	12.2	172	1.0 (0.3 to 3.2)	10.3
No (ref)	61	60			301			2935		
Number fishing gear										
>1	15	10	2.2 (0.7 to 7.0)	9.9	40	2.9 (1.3 to 6.8)	5.3	508	1.9 (1.0 to 3.8)	4.0
≤1	50	55			285			2599		
Atlantic ocean	7	8	0.7 (0.1 to 3.7)	26.9	35	1.0 (0.3 to 3.1)	9.5	305	0.9 (0.3 to 2.7)	8.5
Other location	58	57			290			2802		
Season										
Apr–Oct	46	42	2.4 (0.6 to 8.8)	14.2	245	0.8 (0.4 to 1.4)	3.4	2326	0.8 (0.5 to 1.5)	3.0
Nov–Mar	19	23			80			781		
On or off water										
Hours off water										
≥4	15	18	0.7 (0.3 to 1.8)	6.9	54	1.6 (0.8 to 3.1)	3.9	611	1.4 (0.8 to 2.6)	3.5
<4	50	47			271			2496		
Work on water	53	50	1.5 (0.5 to 4.2)	7.8	282	0.6 (0.3 to 1.4)	4.6	2674	0.7 (0.4 to 1.5)	4.0
No (ref)	12	15			43			433		
Work off water	42	45	0.7 (0.3 to 1.8)	7.3	203	1.1 (0.6 to 2.3)	3.9	2132	0.9 (0.5 to 1.7)	3.6
No (ref)	23	20			122			975		

*Modelled with conditional logistic regression using proportional hazards regression.

CI, confidence interval; CLR, confidence limit ratio calculated as the upper confidence limit divided by the lower confidence limit²⁵; OR, odds ratio.

and were self-reported. Previous studies of commercial fishing captured more severe injuries reported to hospitals or to insurance companies. It is important to recognise, however, that most of the fishermen in this population were self-employed and do not have health insurance. As a result, they may be reluctant to go to a doctor unless absolutely necessary.

Although an injury itself may not be a source of lost work-time, a subsequent infection of the injured area could be. A baseline survey of these fishermen revealed 87% of hand/wrist/digit injuries sustained in the past 12 months were penetrating wounds and 32% of those became infected.²⁰

In contrast to previous case crossover studies of occupational hand injury, this study included strains and sprains. Previous studies have excluded these injury types because the onset can be difficult to determine.^{5–7, 8} The strains and sprains reported in this study were individually reviewed and determined to be acute in their onset. The unit of analysis in this study was the event and 33% of fishermen had more than one event. We assumed events were independent in this analysis.

Previous case crossover studies using health clinic and insurance data found glove use was consistently protective for hand/wrist/digit injury,^{6–8} particularly for lacerations and puncture wounds.⁶ Results for glove use in this study were not as strong as observed in other studies. This could be attributed to differences in glove use by work task or variation in glove use over the hazard period (7–10-day interview period).²⁶ We also learned from ethnographic interviews with North Carolina fishermen that the majority wear thin rubber work gloves when fishing with their gear, but the gloves are not thick enough to protect fishermen from the spines of fish, pincers of crabs and sharp objects on the boat.²⁷ The loose fitting gloves worn for fishing activities interfere with the dexterity required for maintenance work, and we did not have information on the type of glove worn.

We suspect that differences in the observed associations by sampling strategy could be attributed to seasonal differences in exposure to transient risk factors.^{21–24, 28–29} When the case was matched to the previous control period, season was associated

Table 4 Adjusted ORs* and 95% CIs for triggers of hand injury using three control sampling strategies in southeastern United States commercial fishermen (n = 46), 1999–2001

	Uni-directional 1:1 previous interview period OR (95% CI)	CLR	Bi-directional 1:5 randomly selected interview periods OR (95% CI)	CLR	Bi-directional 1:all interview periods OR (95% CI)	CLR
Maintenance work vs none	2.2 (0.9 to 5.3)	5.9	3.7 (1.9 to 7.1)	3.7	3.1 (1.8 to 5.5)	3.1
Glove use vs none	0.8 (0.3 to 2.0)	6.1	0.6 (0.3 to 1.3)	4.4	0.9 (0.5 to 1.7)	3.7
Joint pain vs none	0.7 (0.1 to 3.7)	28.4	0.6 (0.2 to 2.3)	14.7	1.0 (0.3 to 3.3)	10.6
Fishing gear >1 vs ≤1	2.0 (0.6 to 6.5)	10.3	2.9 (1.3 to 6.9)	5.5	1.9 (0.9 to 3.8)	4.0
Atlantic ocean vs other location	0.8 (0.1 to 4.5)	32.9	1.5 (0.5 to 4.7)	10.1	1.0 (0.4 to 3.0)	8.2

*Modelled with conditional logistic regression using proportional hazards regression.

CI, confidence interval; CLR, confidence limit ratio calculated as the upper confidence limit divided by the lower confidence limit²⁵; OR, odds ratio.

with an increased odds of a hand injury event. In this strategy the control period was most likely to be in the same season as the case period (91% of pairs were in the same season). Increasing the number of control periods selected per case, as in 1:5 and 1:all, increased the likelihood that the interview was in a different season and thereby potentially attenuating the effects of season. We did not observe confounding by season in our analyses. However, uncontrolled confounding of exposure could still occur as a result of seasonal differences in fishing activities not accounted for by our season variable. We observed monthly differences in the distribution of triggers (fig 1A,B) which provided some evidence for hypothesised differences in risk over the year. Furthermore, detailed interviews with North Carolina commercial fishermen revealed seasonal differences in the work activities due to several factors including regulation, weather, what and how many types of fishing were performed, task distribution among crew, and working on other non-commercial fishing-related jobs.²⁷

Differences between the three control selection strategies could be attributed to changes in exposure after sustaining a hand injury. In this scenario, results from bi-directional control sampling may be biased. However, results in table 3 indicate that the odds ratios from bi-directional control sampling are similar to those using the previous control period with the exception of those variables which vary by season and were discussed above.

Other risk factors we did not measure, but which could predict hand/wrist/digit injury events, include the amount of time spent fishing, the volume of catch, weather, equipment malfunction, rushing, distraction and drug or alcohol intake. Previous case crossover studies have suggested rushing, performing new tasks, working with faulty equipment and inadequate training as risk factors for occupational hand injury.^{7,8} Unusual work activities have also been identified as risk factors for occupational injuries.³⁰

The case crossover design controls for fixed individual-level differences through self-matching, thus eliminating the need to control for these factors in the analysis. In this study, the hand/wrist/digit injury events and exposures of interest were prospectively assessed weekly or once every 2 weeks: 55% of fisherman sustaining an injury were interviewed within 4 days and all but three were interviewed within 1 week of the event. With such short lag times from interview to event, it is unlikely that fishermen in this study under-reported their injuries.³¹ Similarly, we do not expect recall of exposure to be an important source of bias in this study. A previous study observed transient workplace exposures can be reliably recalled by subjects interviewed by telephone within 4 days of an injury event.³² In this study, exposure information was gathered prospectively, that is an injured fisherman was not asked to recall their exposure from a period when they were not injured, thereby minimising recall bias. However, the 7–10-day hazard period assumed uniform exposure throughout the interview week. Consequently, we were unable to capture exposure variability within the interview period if present.

Performing maintenance work and using more than one type of fishing gear during the week were associated with higher risk of sustaining a hand/wrist/digit injury. Over half of the injury events in this group occurred while working with nets, pots and lines or during maintenance work. Gathering additional information on specific tasks, equipment and any special circumstances surrounding the event would inform potential interventions that could reduce the risk of hand injuries. Glove use is important in preventing hand/wrist/digit injuries in other

Main messages

- ▶ Hand/wrist/digit injuries were common in this cohort of small-scale commercial fishermen, but most such injuries were not severe.
- ▶ Performing maintenance work and using more than one type of fishing gear during the week were associated with a higher risk of sustaining a hand/wrist/digit injury.
- ▶ There was no evidence that glove use was protective for hand/wrist/digit injuries in this group.
- ▶ Case crossover studies nested within an occupational prospective cohort can be useful for studying exposures that vary over time.

Policy implication

Research on the effectiveness of gloves for preventing hand injuries among fishermen, particularly during maintenance operations, is recommended.

industries. Future studies in commercial fishing might assess whether gloves of different design or thicker material would reduce the risk of injury. The increased risk observed for maintenance work combined with the assumption that fishermen are less likely to wear gloves during these tasks further emphasises the need to explore the effects of different types of gloves.

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