

ORIGINAL ARTICLE

Work related injuries in small scale commercial fishing

S W Marshall, K Kucera, D Loomis, M A McDonald, H J Lipscomb

Injury Prevention 2004;10:217–221. doi: 10.1136/ip.2003.005058

See end of article for authors' affiliations

Correspondence to:
Dr Stephen W Marshall,
CB#7435, Department of
Epidemiology, McGarvan-
Greenberg Hall, School of
Public Health, University of
North Carolina at Chapel
Hill, Chapel Hill, NC
27599-7435, USA;
Smarshall@unc.edu

Objective: To describe the epidemiology of work related injury in a group of small scale, independent commercial fishers.

Design: Cross sectional survey (baseline instrument of a prospective cohort study).

Setting and subjects: Commercial fishers in eastern North Carolina.

Results: A cohort of 219 commercial fishers was established and 215 subjects completed an injury questionnaire. The main types of fishing conducted by the cohort were finfishing (159/215) and crabbing (154/215). Of the 215 fishers, 83 reported that they had suffered an injury event in the previous 12 months, a retrospective recall incidence proportion of 38.6 per 100 workers (95% confidence interval 32.1 to 45.1). The 83 injury events resulted in 94 injuries; 47% were penetrating wounds and 24% were strains/sprains. Half of injuries were to the hand/wrist/digits and 13% were to the back. Of the penetrating wounds, 87% were to the hand/wrist/digits, 32% became infected, and 80% were caused by contact with finfish, shellfish, or other marine animal. Of the strains/sprains, 48% were to the back and 26% were to the shoulder. Seventy percent of strains/sprains were caused by moving heavy objects, mainly either while hauling in nets, pots, or lines or loading/unloading the boat.

Conclusion: In this group of small scale, independent fishers, the most common reported injuries were penetrating wounds to the hand/wrist/digits from marine animals and strains/sprains to the back while moving heavy objects.

The fishing industry includes a wide variety of commercial operators, ranging from small, independent fishing operators using a mix of traditional and modern techniques, through to large ocean going vessels that are highly mechanized. Although fishing has been noted as an occupation with a high risk of traumatic occupational injury since 1713,¹ the literature on fishing related injury relates mainly to deep sea fishing and/or large scale industrialized operations.^{2–7} Relatively little is known about injuries in small scale independent fishers who are less industrialized and fish in coastal areas and inland waterways.

Commercial fishers in eastern North Carolina are small scale independent commercial fishers who work the coastal areas and inland sounds and rivers along North Carolina's coast.⁸ They mainly conduct finfishing and crabbing, followed by shrimping, clamming, and oystering. These fishers operate small and medium size vessels with typical crew sizes of one to three people.^{9–10} There are over 7000 such independent operators in North Carolina. In 2002, the fishing industry was North Carolina's highest earning agricultural industry, with over \$94 million dollars in revenue.

We established a prospective cohort study of fishing related injury in this fishing community. This initial report uses baseline data from that cohort to describe the nature and circumstances of the work related injuries sustained by this group of small scale, independent commercial fishers, based on a 12 month retrospective recall of injury.

METHODS

For logistical efficiency, this study utilized a cohort of volunteer participants established as part of a previous study of exposure to a toxic marine micro-organism and possible impairments in neurological function (the "parent study"). At baseline assessment, the subjects completed a self administered questionnaire during a clinic visit. The questionnaire asked details of their worst traumatic injury in the 12 months before baseline. We obtained detailed information on the type of fishing they were engaged in, whether the

injury was on-water or off-water, their activity immediately before the injury, the contact that caused the injury, the type and site of injury, level of care received, and impact on work.

The target population for the parent study was individuals 18–65 years of age who worked on the inland sounds and rivers, or on the ocean, for at least 20 hours per week for at least six months of the year. Subjects were recruited through a wide variety of mechanisms during the period April 1999 to May 2000.⁸

During August 2000 to May 2002, two ethnographers from our research team conducted extensive fieldwork in order to characterize the nature of fishing work in eastern North Carolina. They conducted interviews, took photographs and video footage, and studied patterns of communication in the community.¹¹ Selected quotes from the field interviews are included here in order to provide an anthropologic context for the epidemiologic results.

Results from the ethnographic research demonstrate that fishers have a low level of utilization of medical services, and are traditionally reluctant to take time off work to get care for, and recover from, injuries. We therefore used a very inclusive definition of injury in order to fully characterize the injury experience of these workers. We asked about the circumstances and natures of the "worst" injury event in the previous 12 months 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". "Work related" injury events were defined as any injury event in the course of fishing work, where fishing work was defined to include off-water activity such as fishing related maintenance (for example, boat repair) or fishing related transportation (for example, driving to the dock), as well as the actual work of harvesting catch on the water.

We also collected data on multiple injuries resulting from a single event. For example, a fall from a ladder might result in both a fracture and a concussion. In analyses dealing with circumstances of the event, we used the injury event as the unit of analysis. In analyses dealing with the nature of the

injuries—that is, the physical damage—we used the injury as the unit of analysis.

The parent study enrolled 238 subjects. Of these, 230 consented to participate in the injury component of the study. We excluded 11 individuals who were not actively engaged in commercial fishing, and a further four individuals who either did not complete the injury questionnaire as part of their baseline testing session or did not attend a baseline testing session that included the injury questionnaire. The final study size was 215.

RESULTS

Table 1 presents selected quotes from the ethnographic interviews. Themes of reluctance to seek medical care, injury from contact with marine animals, and issues around lifting emerged from some interviews, although it should be noted that the predominant themes of the interviews were related to the economic realities of making a day-to-day living from fishing and concerns about state regulations pertaining to the fisheries. Note that the respondents to the field interviews were not members of the cohort, but were other commercial fishers in eastern North Carolina.

The cohort itself was predominantly white (only one African-American) and male, with an age range of 18–65 years. The two main types of fishing conducted during the previous 12 months were finfishing and crabbing (table 2), followed by shrimping, oystering, and clamming. Seventy seven percent had engaged in more than one type of fishing during the previous 12 months.

Eighty three of respondents reported at least one injury in the previous year. The 12 month retrospective recall incidence proportion was therefore 83/215 or 38.6 per 100 workers (95% confidence interval (CI) 32.1 to 45.1). The fishers who reported an injury event were generally similar, in terms of

Table 2 Frequency of personal characteristics, by self reported injury status for previous 12 months; values are number (%) except where otherwise stated

	Injured (n=83)	Uninjured (n=132)	Total (n=215)
Mean age (years)	42	44	43
Gender			
Male	72 (87)	118 (89)	190 (88)
Female	11 (13)	14 (11)	25 (12)
Education			
<12 years	32 (39)	36 (27)	68 (31)
High school	33 (40)	52 (39)	85 (40)
>12 years	18 (21)	44 (34)	62 (29)
Length of boat in meters (feet)			
<6 (<20)	26 (31)	31 (23)	57 (27)
6–9 (20–30)	42 (51)	72 (55)	114 (53)
>9 (>30)	10 (12)	17 (13)	27 (13)
Missing*	5 (6)	12 (9)	17 (8)
Type of fishing†			
Finfish	65 (78)	94 (71)	159 (74)
Gillnet	59	81	140
Hook and line	18	20	38
Other	17	28	45
Crab	61 (73)	93 (70)	154 (72)
Pots	55	86	141
Shedding‡	13	15	28
Other	14	20	34
Shrimp	30 (36)	52 (40)	82 (38)
Oyster	26 (31)	35 (27)	61 (28)
Clam	18 (22)	32 (24)	50 (23)
Other	12 (14)	23 (17)	35 (16)

*These data were not collected for respondents who did not own a boat.

†Any self reported fishing of this type within previous 12 months; percentages sum to more than 100% because many participants engage in more than one type of fishing.

‡Cultivating and harvesting soft shell crabs.

Table 1 Quotes from ethnographic field interviews

Theme	Quote	Source*
Reluctance to use medical services	The wife of one long time fisher, when asked about fishers going to the doctor for cuts and sprains replied: "But they've got to wait for them to get real bad before they'll go to any doctor with it"	Shelton, September 2000, crabber
Reluctance to use medical services; contact with marine animals	This fisher tells of an episode of fish poisoning: "All it was, was the tip of a fin off a rock [fish], it went under that fingernail. And that whole arm turned purple and swelled up. It took it about three or four days. But I didn't pay any attention to it. It didn't hurt that bad. [Then] it kept getting worse and worse"	Patterson, November 2000, crabber and gillnetter
Reluctance to use medical services; contact with marine animals	One fisher's story illustrated how they continue to work despite injuries: "[A] half-inch [fish spine] broke off under the skin. That was at 6 o'clock in the morning. I continued to haul a couple of boat loads of fish that day, fish were cheap back then, you know I was getting a nickel for herring but you, you handle a truckload, you could still make a day's work. At 3 o'clock that afternoon I finally got time to go to the emergency room and he [physician] got it cut out, [got it] pulled out and I went back to the boat, and went and pulled 125 eel pots and my wife raised hell all the time"	Mason, February 2001, gillnetter
Contact with marine animals	"The mackerel is so fast, you'd think he's bit you ONE time and he's actually done like that maybe a hundred times. And you'll bleed like a stuck hog"	Tyrrell, March 2001, gillnetter and shrimper
Contact with marine animals	"Crabs are just as bad, they're just as bad or worse than fish. Everything on a crab will hurt you, stick in you, or bite you"	Wilson, March 2001, gillnetter and crabber
Mechanical assistance with lifting	A fisher over the age of 70 years explains his mechanical lifting system: "I have rigged a little trolley out there on my dock so that I can hoist them [100 pound fish boxes] up and slide them right into my truck so I don't have to pick them up"	Hargrove, September 2000, crabber

*Study alias (not the interviewee's real name), interview date, and main type of fishing.

demographics and the type of fishing, to the uninjured (table 2).

Fourteen percent of the injury events (12/83) resulted in time lost from work, and 25% (21/83) interfered with work but did not result in time lost. Nineteen percent of injury events (16/83) required care from a medical professional. The 12 month retrospective recall incidence proportion for lost time and medical care injuries was therefore 5.6 per 100 workers (exact 95% CI 2.9 to 9.6) and 7.4 per 100 workers (exact 95% CI 4.3 to 11.8), respectively.

The majority of the injury events (54/82 or 65%) took place between 7:00 am and 1:59 pm, when fishers are generally on the water harvesting catch. A further 16% (13/82) occurred between 2:00 pm and 6:59 pm, typical times for selling catch and equipment maintenance. Time of day was missing for one injury event.

The majority of the injury events occurred on the water (table 3). The most common activity before injury for on-water injury events was hauling up nets, pots, or lines. More than half of the on-water injury events involved contact with marine animals (see table 1 for more on the hazards posed by marine animals). The most common type of fishing conducted on the day of injury event, for both on-water and off-water injuries, was crabbing followed by finfishing.

Off-water injury events accounted for 18% of all injury events (table 3). The majority of these occurred on the dock and many involved lifting or moving a heavy object. The most common activity for off-the-water injury events was maintaining equipment or boat, trailering the boat, or working with equipment.

The 83 injury events resulted in 94 injuries. In 74 events there was one injury, seven events resulted in two injuries, and two events resulted in three injuries. Injuries to the hand, wrist, and digits accounted for half the total (47/94), followed by back injury (12/93 or 13%) and injuries to the upper extremities (9/94 or 10%) and shoulders (8/94 or 9%).

The most common type of injury was penetrating wound (44/94 or 47%) followed by sprains and strains (23/94 or

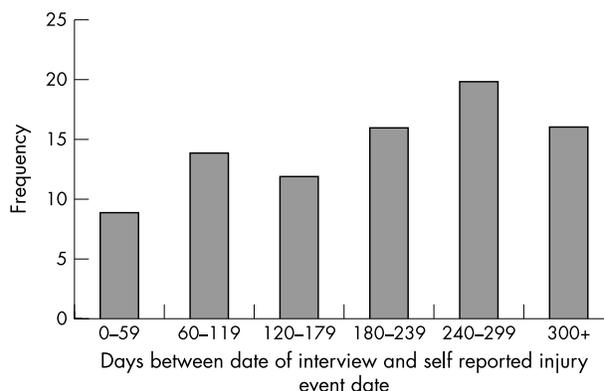


Figure 1 Recall bias plot: elapsed time since reported injury (n=83).

25%). Of the penetrating wounds, 87% (39/44) were to the hand/wrist/digits, 32% (14/44) became infected, and 80% (35/44) were associated with contact with finfish, shellfish, or other marine animal. Of the 94 injuries, a total of 19% (18/94) became infected. All penetrating wounds that became infected were reportedly due to contact with finfish, shellfish, or other marine animal.

Of the strains/sprains, 48% (11/23) were to the back and 26% (6/23) were to the shoulder. Seventy percent (16/23) of strains/sprains were associated with moving heavy objects. Finally, there were two cases of sunburn and one of concussion.

We also asked about general safety behaviors and attitudes in an effort to elicit preliminary information about beliefs and attitudes that might be useful for designing prevention programs. There was no difference in reported swimming ability, seatbelt use, belief in the preventability of injuries between injured and uninjured (table 4).

Because this was a retrospective recall study, we examined the data for evidence of recall effects, such as memory decay

Table 3 Injury circumstances for all injury events (n=83); values are number (%)

On water (n=68)	No (%)	Off water (n=15)	No (%)
Location			
Pamlico River	14 (21)	On the dock	9 (60)
Pamlico Sound	13 (19)	At home, doing fishing work	4 (27)
Neuse River	10 (15)	Other	2 (13)
Albamarle Sound	9 (13)	-	-
Ocean	6 (9)	-	-
Other	16 (23)	-	-
Type of fishing on day of injury event			
None	7 (10)	None	4 (27)
Crab	32 (47)	Crab	6 (40)
Finfish	18 (26)	Finfish	4 (27)
Shrimp	6 (9)	Shrimp	1 (6)
Clam	3 (4)	-	-
Oyster	1 (1.5)	-	-
Other	1 (1.5)	-	-
Activity before event			
Hauling up nets, pots, and lines	28 (42)	Loading the boat	2 (13)
Working with catch on boat	13 (19)	Preparing nets, pots, and lines	2 (13)
Non-specific activities while commercial fishing	9 (13)	Working with catch (off the boat)	2 (13)
Preparing nets, pots, and lines	7 (10)	Getting on and off the boat	2 (13)
Other	11 (16)	Other	7 (48)
Injury contact			
Contact with finfish, shellfish, other marine animal	36 (54)	Lifting/moving a heavy object	5 (33)
Lifting/moving a heavy object	10 (15)	Fell, landing on a hard surface	4 (27)
Contact with fishing gear	6 (9)	Contact with hook or knife	3 (20)
Fell, landing on a hard surface	5 (7)	Other	3 (20)
Other	11 (16)	-	-

Table 4 General safety behavior and attitude, by self reported injury status; values are number (%)

	Injured (n = 83)	Uninjured (n = 132)	Total (n = 215)
Swimming ability			
Not at all	3 (4)	4 (3)	7 (3)
A little to adequately	25 (30)	42 (32)	67 (31)
Good swimmer	41 (49)	54 (41)	95 (44)
Excellent swimmer	14 (17)	32 (24)	46 (21)
Fisher's exact test $p = 0.51$			
Seatbelt use			
Never	6 (7)	7 (5)	13 (6)
Occasionally, half the time, to often	35 (42)	55 (42)	90 (42)
Always	42 (51)	70 (53)	112 (52)
Fisher's exact test $p = 0.81$			
What percent of fishing injuries are preventable?*			
None	5 (6)	5 (4)	10 (5)
Less than half	16 (19)	32 (25)	48 (23)
Half	32 (39)	36 (28)	68 (32)
More than half	26 (32)	52 (41)	78 (37)
All	3 (4)	3 (2)	6 (3)
Fisher's exact test $p = 0.35$			

*Five respondents did not answer this question.

(tendency to forget minor injuries that are distant in time). Figure 1 is a histogram of the recall period (the number of days between the date of administration of the injury questionnaire and the self reported date of the injury event) and indicates no memory decay (memory decay would create clustering of data towards the left hand side of the chart). If anything, the frequency distribution was shifted towards the right hand side of the chart, suggesting the possibility of memory telescoping (tendency to falsely remember major injuries as occurring recently in time).

DISCUSSION

This group of 215 commercial fishers self reported 83 injury events over the previous 12 months. The most common types of injuries were penetrating wounds to the hand/wrist/digits resulting from contact with marine animals and sprains/strains while moving heavy objects. The fishers who reported an injury event were generally similar, in terms of demographics and the type of fishing, to the uninjured, indicating that these injuries arise as part of the typical workday experience for these workers.

This volunteer cohort cannot be considered a random sample of the community of fishers in eastern North Carolina. However, the parent study was related to a non-injury topic, so it is possible that their injury experience did not differ in some systematic fashion from the fishers who choose not to participate. Workers who experienced very disabling injuries before the initiation of this study, and were forced to leave the fishing workforce before our study started, would not be included here. Disabling injuries during the course of the study would have been captured.

These fishers are largely self employed or working for small operations, and are therefore unlikely to have health insurance coverage through their employment or to be covered by workers' compensation plans. Therefore, our incidence proportion estimates for lost time and medical care injuries (5.6 and 7.4 per 100 workers, respectively) may considerably understate the true injury morbidity of this population. Seeking medical care and taking time off work may involve out-of-pocket expenses that these workers are unable to recoup, resulting in a high proportion of injuries receiving self care. Because the proportion of self employed, uninsured workers in this workforce is high, we advise caution when comparing the incidence estimates for lost time and medical care injuries with other industries.

Nearly half of the injury events occurred during crabbing. However, it does not necessarily follow that crabbing is particularly dangerous activity. Crabbing is one of the main types of fishing currently conducted in eastern North Carolina, and it reasonable to assume that the cohort spent more time crabbing than any other type of fishing during the recall period. Data on both injury incidence and time spent fishing is required in order to make inferences about the relative risk of the different types of fishing.

The recall period used in this study—12 months—was selected because we considered *a priori* that these workers would be able to reliably recall their work related injuries over this period. Some methodologic studies have identified strong recall decay effects for injuries over a 12 month period,^{12, 13} however, we did not observe any evidence of recall decay in this study. Given the highly physical nature of fishing work, and dependence of this workforce on a routine daily catch to generate a steady income, it is plausible that they have good recall of their work related injuries. In addition, we asked only about "worst" injury event over the previous 12 months, and this may have minimized recall decay, although this type of question presumably introduces the potential for increased memory telescoping. We also attempted to elicit information about off-water injury events, however, it must be noted that fishers may regard off-water work (for example, boat maintenance) as less directly related to their economic livelihood than on-water activity.

Like traditional farmers, these fishers live and work in communities that are geographically dispersed but socially close knit.^{9, 10} In such communities, diffusion of innovation can be rapid when new techniques or technologies have a clear commercial advantage. This suggests successful injury interventions should not only be effective in preventing injury, they should also be affordable and able to be readily implemented within the framework of existing fishing work activities.

Given the large of proportion of injuries that were penetrating wounds to the hand resulting from contact with marine wildlife, there would seem to be considerable opportunity for increased hand protection. The hand protection typically used by these workers consists only of cloth or rubber gloves, which offer limited protection but do not interfere with dexterous manual tasks such as removing fish from nets, shaking a crab pot, removing crabs from pots, and rebaiting pots. The meat processing industry, which also requires hand protection that minimally restricts manual

Key points

- The epidemiology of work related injuries in fishers has previously been described only for large scale, industrialized fishing operations.
- The contribution of this study is that it describes work related injuries in small scale, independent, community based fishers
- The 12 month retrospective recall incidence proportion was 38.6 per 100 workers (95% CI 32.1 to 45.1).
- The majority of injury events (82%) occurred while fishers were on the water and 42% of these injury events occurred while hauling up nets, lines, or crab pots.
- Thirty seven percent of all injuries were penetrating wounds to the hand/wrist/digits resulting from contact with marine animals.

dexterity, has developed chain mesh gloves with plastic wrist protectors that extend upwards over wrist area. These appear to have been effective in reducing hand injury in that industry.¹⁴

Fishing work imposes stressful loads on the musculoskeletal system.¹⁵ Heavy containers filled with bait or catch must be loaded and unloaded from the boat at the beginning and end of each workday, and moved around within the confined quarters of the boat during the workday. Maintenance of equipment, such as trailers and boats, also involves lifting of heavy, bulky loads under challenging environmental conditions. Increased use of overhead lift cranes on the dock and ramp, and possibly the boat, could do much to reduce the ergonomic stresses of this work. However, innovative engineering solutions are needed to ensure that such equipment can be seamlessly integrated into current work practices. Our ethnographic team learned of only two fishers who routinely employed mechanical aids for lifting or moving catch. Both were over the age of 70 years, and were unable to perform this lifting without assistance.

This cross sectional survey identified penetrating wounds to the hand/wrist/digits from marine animals and strains/sprains to the back while moving heavy objects as the most common injuries in this type of small scale, independent commercial fishing. Interventions for these injuries may include increased use of hand protection and lifting equipment, however, in order to be effective, these interventions probably need to be economically feasible and well integrated into existing work activities.

ACKNOWLEDGEMENTS

This work was supported by a grant from the National Institute for Occupational Safety and Health (NIOSH) (RO1 OH10309). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

The parent study was supported through cooperative agreements between the Centers for Disease Control and Prevention and the

North Carolina Department of Health and Human Services, under the direction of C L Moe, PhD, now with the Department of International Health, Rollins School of Public Health, Emory University, Atlanta, GA, and David A Savitz, PhD of the Department of Epidemiology, University of North Carolina at Chapel Hill. We acknowledge the help of Paula Bell, Steve Hutton, Raymond Vickers, Belinda Lee, and Judy Rafson, who participated in data collection.

The authors acknowledge the significant contributions made by Josh Levinson in collection of the ethnographic material relating to fishers in eastern North Carolina. We thank the commercial fishers who participated in the cohort study and those who took the time to share their fishing experiences with field staff.

Authors' affiliations

S W Marshall, Department of Epidemiology, School of Public Health, Department of Orthopedics, School of Medicine, and the Injury Prevention Research Center, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA

K Kucera, Department of Epidemiology, School of Public Health, and the Injury Prevention Research Center, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA

D Loomis, Departments of Epidemiology and Environmental Science and Engineering, School of Public Health, and the Injury Prevention Research Center, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA

M A McDonald, **H J Lipscomb**, Division of Occupational and Environmental Medicine, Community and Family Medicine, Duke University Medical Center, Durham, North Carolina, USA

REFERENCES

- 1 **Ramazzini B**. *Diseases of workers ("de morbis artium")*. Thunder Bay, Canada: Occupational Health and Safety Press, 1993.
- 2 **Norrish AE**, Cryer PC. Work related injury in New Zealand commercial fishermen. *British Journal of Industrial Medicine* 1990;**47**:726–32.
- 3 **Schnitzer PG**, Landan DD, Russell JC. Occupational injury deaths in Alaska's fishing industry, 1980 through 1988. *Am J Public Health* 1993;**83**:685–8.
- 4 **Jensen OC**. Work related injuries in Danish fishermen. *Occup Med* 1996;**46**:414–20.
- 5 **Torner M**, Larlsson R, Saethre H, et al. Analysis of serious occupational accidents in Swedish fishery. *Safety Science* 1995;**21**:93–111.
- 6 **Torner M**, Nordling PO. Occupational injury in Swedish fishery: 1. Analysis of injury statistics. *Occupational Ergonomics* 2000;**2**:81–9.
- 7 **Thomas TK**, Lincoln JM, Husberg BJ, et al. Is it safe on deck? Fatal and non-fatal workplace injuries among Alaskan commercial fishermen. *Am J Ind Med* 2001;**40**:693–702.
- 8 **Moe CL**, Turf E, Oldach D, et al. Cohort studies of health effects among people exposed to estuarine waters: North Carolina, Virginia, and Maryland. *Environ Health Perspect* 2001;**109**(suppl 5):781–86.
- 9 **Griffith D**. *The estuary's gift: an Atlantic coast cultural biography*. University Park PA: Pennsylvania State University Press, 1999.
- 10 **Levinson JP**. *Dropnet tribes: making a day's work in North Carolina's winter fishery*. Chapel Hill, NC: University of North Carolina at Chapel Hill, 2002.
- 11 **McDonald MA**, Loomis DP, Kucera KL, et al. Use of qualitative methods to map job tasks and exposure to occupational hazards for commercial fishermen. *Am J Ind Med* 2004;**46**:23–31.
- 12 **Harel Y**, Overpeck M, Jones D, et al. The effects of recall on estimating annual nonfatal injury rates for children and adolescents. *Am J Public Health* 1994;**84**:599–605.
- 13 **Mock C**, Acheampong F, Adjei S, et al. The effect of recall on estimation of incidence rates for injury in Ghana. *Int J Epidemiol* 1999;**28**:750–5.
- 14 **Laing RM**, Burrigge JD, Marshall SW, et al. Hand and lower arm injuries among New Zealand meat workers and use of protective clothing. *N Z Med J* 1997;**110**:358–61.
- 15 **Torner M**, Almstrom C, Karlsson R, et al. Working on a moving surface—a biomechanical analysis of musculoskeletal load due to ship motions in combination with work. *Ergonomics* 1994;**37**:345–62.