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Original Article

Musculoskeletal Disorders in Northeast Lobstermen

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ABSTRACT

Background: The objective of this study was to report on the prevalence of musculoskeletal pain in lobstermen in the northeast USA.
Methods: Crews were randomly selected from those licensed to fish in Maine and Massachusetts and followed prospectively. The survey used a Nordic Musculoskeletal Questionnaire format to characterize musculoskeletal disorders.
Results: A total of 395 individuals participated. One half of the respondents reported low back pain. Back pain was attributed to or exacerbated by lobstering. Low back pain was prevalent among both captains and sternmen, while sternmen reported more hand/wrist pain than captains. Multiple locations for pain were common in individual participants.
Conclusion: Equipment or technology to assist material handling should be a priority, as the body segments with high prevalence of pain (back, hand/wrists, shoulders, knees) are all affected by the repetitive and forceful handling of the lobster traps.

1. Introduction

This study examines musculoskeletal pain among lobstermen in the USA. Lobstering is an important commercial fishery based on the size of the effort and the importance of the product to the region's economy [1]. To our knowledge, no investigations to date have examined occupationally-related health outcomes specifically within the lobster industry. Our objective was to calculate prevalence densities for musculoskeletal pains within a sample population of lobstermen. The data presented in this report were collected in the first 2 years of a 4-year exposure period completed at the end of 2015. The prospective investigation was initiated to collect original data for the purpose of estimating total occupational exposure (full-time equivalents) as a denominator for determining rates of morbidity and mortality in lobstering.

A commercial fishery is defined and determined by some authority as an entity engaged in raising or harvesting food from a marine environment. Lobster harvesting, or *lobstering*, is a commercial and recreational fishery of the American Lobster species found in saltwater shoreline areas from maritime Canada to the state of North Carolina (NC). They are most prevalent in the shoreline areas of the Gulf of Maine. In the USA, both federal and state governmental level offices have authority to determine the commercial parameters of the fishery because the American Lobster species is found in federal and state territorial waters. Individual state governments regulate within a 12-mile (19.3-km) boundary from their coastline, and the federal government regulates from there to the full extent of the country's 200-mile (322-km) economic exclusivity zone. Most other fisheries in the region are only federally-regulated.

Lobstering can be qualitatively understood as a set of routine tasks reiterated on a boat equipped for the operation of removing the lobster from baited traps (pots) set on, and hauled up from, the bottom of the ocean in areas relatively near the coastline. In northeast USA, the governing authorities allow access to the fishery throughout the year. Hauling pots is prohibited during nonsunlit hours, so boats typically leave their moorings very early, ensuring time enough to haul hundreds of pots, avoid potentially rougher weather at the end of the day, and still have time to sell the day's catch to a dealer. Lobstering equipment is low technology, including wire pots, rope lines, hydraulic haulers, block and tackle, and containers. There is little regulation of this equipment; there are limits on the number of pots and, in some areas, how they are linked by a line to the surface. Pots range from 0.9 m to 1.5 m long,

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usually up to 0.6 m wide, and about 0.3 m tall. Total weight is about 9 kg after they are weighted with bricks so they do not move on the ocean floor. One of the main exposures for lobstermen is then the repetitive hauling of these weighted pots. There are also hand intensive tasks, most notably the banding of the lobsters' claws, using a pliers-like tool to stretch the thick rubber bands.

Despite increasing attention to commercial fishing as an industry with high risk, critical gaps in the occupational health research literature in commercial fishing across the USA remain [2]. Matheson et al [3] analyzed these gaps for fisheries in general and found two predominant methodological difficulties for making comparable analyses: an uncertain population denominator, and inconsistent or insensitive numerator data collection systems. In addition to the methodological difficulties for determining the comparable magnitude of observable health effects in the industry, the specificity and diversity of the fisheries has been recognized as essential knowledge for the implementation of safety and health measures [4–7]. This report is focused on the data corresponding to the second classic design gap pointed out by Matheson et al [3] with respect to outcomes of nonacute, nonspecific pain attributable to lobstering, and with the additional objective of characterizing the profile of musculoskeletal disorders to inform measures for prevention.

At the time of the investigation, in the USA, the only reportable data mandated for occupationally-related health outcomes were registered with the US Coast Guard. Their data are limited to vessel-related casualties and events that required medical attention, so musculoskeletal disorders are not usually recorded.

There have been only a limited number of studies that have looked at musculoskeletal disorders in the fishing industry. Lipscomb et al [8] found that symptoms causing work interference in the past 12 months were reported by 38.5% of their cohort of NC fishermen. They also found that low back symptoms were the most common cause of work impairment (17.7%) followed by pain in the hands/wrists (7%) or shoulders (7%). Kaerlev et al [9] found high relative risk of rotator cuff, shoulder lesions, carpal tunnel syndrome, and hip arthrosis associated with fishing in Denmark. Lawrie et al [10] found musculoskeletal disorders to be a leading complaint in a survey of Scottish fisherman.

Some studies have reported profiles of nonacute injury outcomes as rates. Bull et al [11] looked at the exposure–outcome relationship in commercial fishing in Norway using utilization data, and the highest rates of injuries were to the fingers/hands/wrists. Studies of Scandinavian fishermen [12–14] were notable for investigating nonfatal injuries as well as exposure to risk for musculoskeletal disorders, potential interventions to reduce the exposures, and analysis of the factors determining the implementation of known preventive safety techniques. Norrish and Cryer [15] examined work-related injuries in New Zealand commercial fishermen using three different data sources. Strains and sprains accounted for 45% of the workers' compensation claims, of which two-thirds were back injuries due to manual material handling. Compensation costs for these injuries were higher than for other injuries. Strains of the knees, shoulders, and forearms were also common. Kucera et al [16] used original data from observations and interviews of southeastern US fishermen to calculate injury rates per 1000 fishing days, incidence rate ratios under various conditions, and proportions of injuries in the sample. Sprains and strains accounted for 18% of the injuries, with almost half of these occurring to the low back.

2. Materials and methods

The objective of this study was to calculate the prevalence of musculoskeletal pain in lobstermen. The term *musculoskeletal disorders* (MSDs) can be used to mean various presentations of musculoskeletal health outcomes. In this study, we sought subjective reports of pain. Such reports could describe acute pain, nonacute or chronic pain, pain with indefinite onset, cumulative trauma, and nonspecific or unidentified pain. We used the terms *pain* or *disorder* to describe any of these presentations. Unlike the National Institute for Occupational Safety and Health definition of MSDs, we allowed subjective reports of acute pain even if they were associated with fractures, contusions, or lacerations.

This paper was based on data from a broader study on the total work exposure of lobstermen [17] in which two survey instruments were employed. The first was designed to collect data on work exposure and acute injuries, and was administered quarterly via phone interview with the captain. This paper reports on results from the second instrument which was designed to collect data on any musculoskeletal pains including cumulative trauma or aches and pains with temporally nonspecific origins.

2.1. Definitions

The individual identified on each state's permit list was referred to as the *permit holder*. The person who was in command of the vessel while it was engaged in actual lobstering (typically, but not necessarily the permit holder) was referred to as the *captain*. Any individual who worked on the vessel while it was actively engaged in lobstering during the previous 3-month quarter who was not the captain was referred to as a *sternman*. Collectively, the captain and any sternmen were referred to as the *crew*.

2.2. Study population

The study population was defined as the crews of all vessels that held a state-based permit to harvest lobsters commercially within the 3-mile (4.8-km) coastal waters (inshore) of Maine (ME) and Massachusetts (MA). These two states represented over 90% of the estimated state-licensed individuals in the northeast lobster industry at the time of the study design (2010–2011). Other northeast states, therefore, were excluded to balance a rigorous study design with the feasibility of covering such a large geographical area.

2.3. Sampling frame and exclusion criteria

The contact information for the lobster permit holders was available electronically for a small fee from the state offices for licensing commercial fishing. A random sample of permit holders was selected from each state's list. Lobstermen who were only licensed to fish beyond the 12-mile state territorial limit (offshore) were excluded because these *offshore* lobstermen typically remain for several days at sea without returning to harbor. Thus, the metric *length of trip* in the calculation of total exposure would not be a logically consistent measure when multiplied by number of days fished per week, as was the case with the *inshore* lobstermen included in the cohort. Further exclusions included seasonal, student, age $<$ 18 years, apprentice, and recreational licenses, or any plan to not engage fully in the fishery, such as retirement.

2.4. Sample size calculations

Using estimates of average crew size and the number of trips per week from the Gulf of Maine Research Institute's [1] study of the ME lobster industry, a sample size of 120 boats in each state (ME and MA) was chosen so that the margin of error for a 95% confidence interval for any binary outcome was $<$ 10%. In order to allow for 15% participant attrition, 138 permit holders from each state were targeted for enrollment. According to the state licensing

bodies, there were approximately 9,600 permit holders in the two states (1,300 in MA, and 8,300 in ME) when the study was designed in 2010. The number of permit holders did not account for non-licensed crew members who typically work as sternmen for captains who may or may not have been the official permit holder of the license. The state regulators had no mandate to account for this segment of the industry. Therefore, the sample size calculation was based on permit holders; sternmen were included by convenience of their association with a recruited permit holder.

2.5. Recruitment and survey protocol

The randomly selected permit holders were initially mailed an invitation containing a study overview, an offer of compensation for participating, and a prepaid postcard that was to be returned indicating the invitee's choice to participate or decline. Any permit holder who did not return the post card within 1 month received a second mailing that contained a copy of the two survey forms and the consent form, and was contacted by telephone within 3 weeks of this second mailing. When additional attempts were necessary in order to make the initial phone contact, callers made attempts at various times of the day. Specifically, an attempt was made to contact each selected permit holder using a minimum of two daytime, two afternoon, two nighttime, and one weekend phone call. This protocol was modified as necessary if a person other than the participant was reached and such person indicated a specific time of day as the best time to call (Fig. 1). This combination of mail, phone, and face-to-face contact during the recruitment phase of the study was used in an effort to maximize the response rate [18,19].

Permit holders who agreed to participate in the study were asked if they were the boat's captain. If the permit holder was not the boat's captain, they were asked to provide the captains contact information and the above telephone contact protocol was repeated

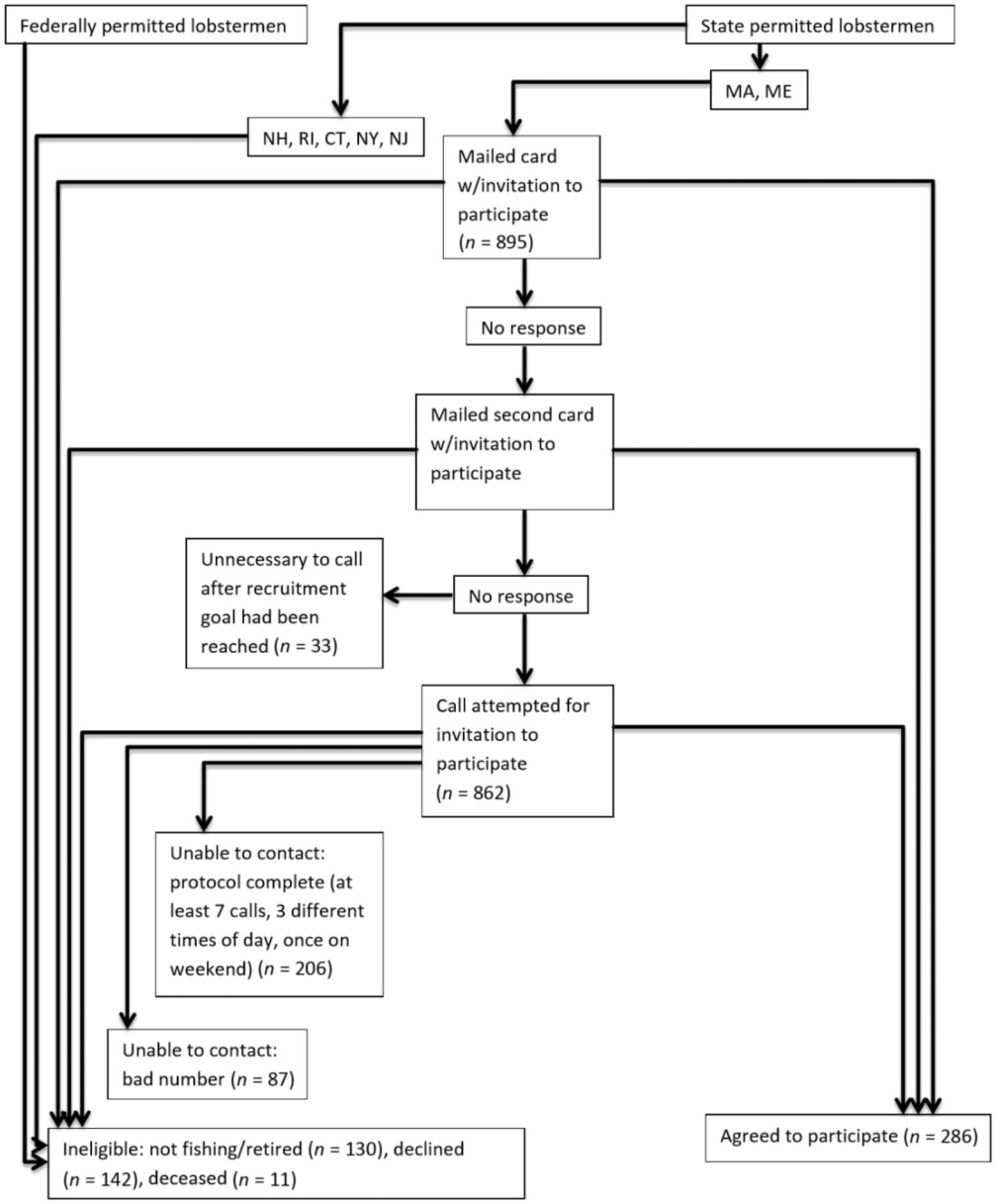

Fig. 1. Flow chart of strategy for recruiting Captains. Sternmen for these Captains were interviewed at convenience, if available.

in an attempt to reach him/her. After obtaining verbal informed consent, identifying information about the boat and its location was collected to enable an ensuing visit to the boat for the administration of the questionnaire. Each crewman, including the captain, received a $10 incentive after completing an interview. Data were collected via face-to-face interview with both the captain and any available sternmen. The original goal was to collect these data on an annual basis, but feasibility issues such as, timing, travel distance for the investigator, and availability and responsiveness of the participant, affected the ability to attain this goal. This report was based on data from the first 2 years of data collection.

The questionnaire utilized in this paper was adapted from the Nordic Musculoskeletal Questionnaire (NMQ) on pains, disabilities, and related medical care [20]. The NMQ instrument has been validated to assess 12-month prevalence of musculoskeletal symptoms. The questionnaire was developed in accordance with a questionnaire development strategy outlined in the literature on the NMQ [21]. We used the same definitions of *cases*, namely aches, pains, or discomforts, the same area/body segment definitions, and we used a body map to help participants visualize the accurate body region if there is a question. Our instrument asked five questions, all found on the original NMQ. These questions were on 3-month prevalence of aches, pains, and discomforts; whether or not the pain was caused by work; whether the pain affected normal work routine; did the participant receive treatment for the pain; and did the pain also occur in the past 7 days. We used a 3-month rather than a 12-month exposure period to reduce recall bias or misclassification. We did not ask whether the pain affected nonwork activity; whether the pain resulted in a change of jobs; the length of duration of the pain; or whether there was history of pain resulting from an accident. Some health-related demographic questions were also included, such as age, height, weight, and sex.

2.6. Data management and analysis

Face-to-face interview data were collected on scannable forms. The data were scanned into a Microsoft Access database using a Canon scanner (DR-2080C) and Cardiff Teleform Desktop software (version 10.4.1; Digital Vision, Highland Park, IL, USA). Samples of scanned data were examined to address possible errors introduced by the transfer from paper to electronic data, and those errors were corrected.

The proportion of participants with musculoskeletal disorders was calculated for each body location. Differences in these proportions between captains and sternmen, and also between states, were analyzed using Chi-square tests. Univariate binomial regression analyses were used to calculate prevalence ratios (PR) for the relationship between MSDs and age, years of experience, crew size, and season. Age was examined as both a continuous variable and grouped in categories ($<$ 35 years, 35–50 years, $>$ 50 years). Season was modeled using three indicator variables with the fourth quarter (fall) as the reference. Significance was assessed by 95% confidence intervals (CI) and $p < 0.05$. All analyses were performed using IBM SPSS Statistics (version 23; SPSS Inc., Chicago, IL, USA).

3. Results

By the end of recruitment in May, 2012, a cohort of 146 participants in ME and 140 participants in MA had agreed to participate. The initial participation rate was estimated at 46.9% in ME and 43.3% in MA. During the 2 years reported here, nine participants from MA and two from ME elected to drop out. Three lobstermen from MA and one from ME were substituted for the drop outs. Of the 279 boats in the cohort, we were able to find and interview 271 captains and 124 sternmen at least once, for a total sample of 395 lobstermen. Twenty-seven boat captains were interviewed during their off-season, so no crew were available and 71 boat captains were operating without crew at the time of the interview. The remaining 173 boat captains were operating with crew, although not all sternmen were available at the time of the interview. If a lobsterman was interviewed more than once, only the most recent data were included. We chose the most recent survey as it was a reflection of the most current experience of the lobstermen. For 36 participants, demographic information was missing, so these participants were not included in models of pain prevalence as a function of age or experience. All interviews contain complete information on reports of pain, so all the participants were included in the calculation of pain prevalence, as well as other models. Demographic information is presented in Table 1. As shown, lobstermen are predominantly male.

Captains were, on average, 16 years older and had 18 more years of experience than sternmen. The distribution of the ages of the cohort was bimodal, reflecting the differences in mean ages between captains ($\bar{x} = 55.0$ years) and sternmen ($\bar{x} = 38.8$ years). The age distribution of the captains was roughly normal, while the age distribution of the sternmen showed some degree of skew toward the older ages (Fig. 2). Experience had a relatively flat distribution across a wide range of ages (1–60 years).

Interviews were not conducted evenly across the four quarters. Most were conducted in the summer (204), followed by the spring (89), fall (69), and winter (32). The prevalence of pain in any body region in the past 3 months did vary by season ($\chi^2_{df=3} = 10.7$, $p < 0.013$), with fall (69.6%) the lowest, followed by winter (71.9%), spring (84.3%), and summer (85.3%). A binomial regression showed that both spring ($p < 0.035$) and summer ($p < 0.04$) had a significantly higher prevalence than fall.

The overall count of individuals reporting pain at any time during the previous 3 months, whether it was caused by work, whether or not it was treated professionally, whether the pain

Table 1
Demographics of lobstermen interviewed in person (mean ± SD)*

	ME		MA		Total		
	Captain	Sternman	Captain	Sternman	Captains	Sternmen	Total
n	137	75	134	49	271	124	395
Sex (% male)	98.5	89.3	99.3	89.8	98.8	88.9	95.9
Age (y)	54 ± 13	38 ± 15	56 ± 12	40 ± 14	55 ± 13	39 ± 15	50 ± 15
Experience (y)	33 ± 13	14 ± 14	28 ± 13	9 ± 8	31 ± 13	12 ± 2	25 ± 16
Height (cm)	180 ± 8	178 ± 8	178 ± 8	178 ± 10	180 ± 8	178 ± 8	178 ± 8
Weight (kg)	94 ± 17	84 ± 17	89 ± 15	84 ± 16	92 ± 16	84 ± 17	89 ± 16

* Not all lobstermen reported all demographic information, although sex was known for obvious reasons. Fifteen ME captains, five ME sternmen, nine MA captains, and seven MA sternmen had missing demographics.

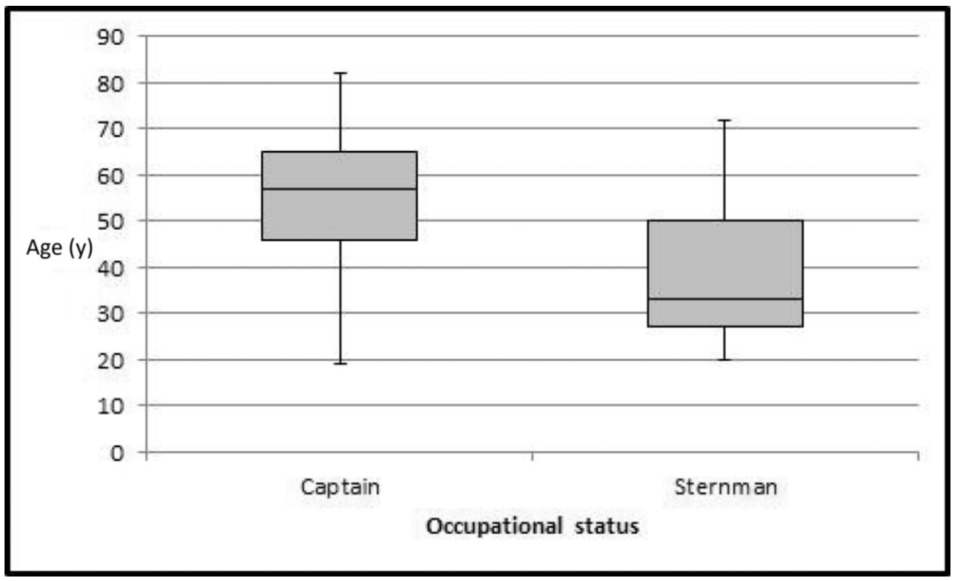

Fig. 2. Age distributions of captains and sternmen in the study.

altered normal work routines, and whether or not the pain was also felt in the past 7 days is displayed in Table 2.

Seventy participants (18%) interviewed reported having no aches or pains at any time during the 3 months prior to the interview. There was an average of 2.6 reports of pain in any body region per person reporting pain during the previous 3 months. The low back was the most prevalent site for pain in the past 3 months and was reported by half of those interviewed. After the low back, the most prevalent locations for pain in the past 3 months were one or both shoulders, cumulatively (38%), one or both hands and/or wrists (30%), and one or both knees (27%). Prevalence during the past 7 days was also highest for the low back (31%), followed by the shoulders (24%), knees (17%), and hand/wrist (16%).

Overall, captains had a higher 3-month prevalence of pain in any body region than sternmen (84.5% vs. 74.2%, $\chi^2 = 5.9$, $p < 0.015$). At most body sites, the 3-month prevalence levels of pain for the captains and sternmen were equal, with three exceptions. In all three of these cases, a higher percentage of sternmen reported pain. These exceptions were for both hands/wrists (sternmen 22.6% vs. captains 12.9%, $\chi^2 = 5.9$, $p < 0.015$), upper back (16.1% vs. 7.0%, $\chi^2 = 7.95$, $p < 0.005$), and low back (56.5% vs. 46.5%, $\chi^2 = 4.3$, $p < 0.039$). Sternmen also reported higher 7-day prevalence for these three sites: both hands/wrists (sternmen 15.3% vs. captains 6.6%, $\chi^2 = 7.6$, $p < 0.006$), upper back (12.1% vs. 3.0%, $\chi^2 = 13.0$, $p < 0.001$), and low back (40.3% vs. 26.6%, $\chi^2 = 7.5$, $p < 0.006$). By contrast, captains had a higher 7-day prevalence of neck pain than sternmen (9.2% vs. 3.2%, $\chi^2 = 4.5$, $p < 0.034$).

A total of 143 individuals reported that the pain they experienced in the low back during the past 3 months was caused by lobstering. The body segment for which the largest proportion of

Table 2
Reports of pain experienced by lobstermen in study

Body segment		Participants ($n = 395$) reporting pain in the cohort per body region									
		Past 3 mo		Caused by work		Received treatment		Altered or prevented normal work		Also in past 7 d	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Head/face		5	1.3	1	0.3	1	0.3	0	0.0	2	0.5
Neck		53	13.4	31	7.8	11	2.8	6	1.5	29	7.3
Shoulder	Right	74	18.7	54	13.7	9	2.3	9	2.3	47	11.9
	Left	24	6.1	16	4.1	4	1.0	2	0.5	13	3.3
	Both	53	13.7	43	10.9	8	2.0	7	1.8	36	9.1
Elbow	Right	24	6.1	18	4.6	5	1.3	3	0.8	13	3.3
	Left	18	4.6	14	3.5	3	0.8	2	0.5	12	3.0
	Both	25	6.3	15	3.8	2	0.5	2	0.5	15	3.8
Hand/wrist	Right	34	8.6	26	6.6	7	1.8	4	1.0	20	5.1
	Left	18	4.6	15	3.8	2	0.5	1	0.3	7	1.8
	Both	63	15.9	45	11.4	9	2.3	4	1.0	37	9.4
Back	Upper	39	9.9	31	7.8	7	1.8	2	0.5	23	5.8
	Lower	199	49.9	143	35.9	56	14.2	23	5.8	122	30.9
Legs	Hips/thighs	43	10.9	36	9.1	10	2.5	6	1.5	31	7.8
	Knee/shin/calf	105	26.6	67	17.0	24	6.1	11	2.8	66	16.7
	Ankles/feet	59	14.9	35	8.9	11	2.8	6	1.5	37	9.4
No. of pain reports in all regions		836		590		169		88		510	
Individuals reporting pain		325	82.3	248	62.8	103	26.1	50	12.7	236	59.7

people reported that they received treatment for pain was also the low back. It was noteworthy that prevalence for care-seeking for these reports of pain was low.

Sixty-two percent ($n = 248$) of the participants in the study reported pain that they attributed to work during the 3 months prior to the interview, and 42 (17%) of those 248 reporting specific work-related pain also reported that the pain affected their normal ability to work (88 cases, 11% of all cases). Fifty of the participants (12%) experienced pain so severe that normal work was impossible. About half of those reporting such pain experienced it in the low back. Of the 23 participants who experienced work-limiting pain in the low back, 19 indicated that it was due to exposure to lobstering.

Univariate binomial regression showed that the probability of any pain in the past 3 months increased moderately with years of experience lobstering (PR = 1.00, 95% CI 1.00–1.01, $p < 0.001$) and with age (PR = 1.00, 95% CI 1.00–1.01, $p < 0.014$). (Note that neither age nor experience was normally distributed.) We were unable to run a binomial regression using age grouped in categories (< 35 years, 35–50 years, > 50 years), so we ran a logistic regression instead. The model fit indicated that age categories were significantly different with respect to the proportion of reports of pain ($\chi^2_{df=2} = 6.00$, $p < 0.050$). The oldest group was more likely to report pain that the youngest group (odds ratio = 2.17, CI 1.88–4.00, $p < 0.013$), while the middle group was not significantly different from the youngest (odds ratio = 1.56, CI 0.74–3.26, $p > 0.05$). State (ME 83.5% vs. MA 78.7%, $\chi^2 = 1.5$, $p > 0.05$), and crew size (PR = 1.05, 95% CI 0.74–1.49, $p > 0.05$) did not show statistically significant effects.

4. Discussion

The data collected during this study have presented a descriptive profile of MSDs to lobstermen in northeast USA. In the literature on occupational safety and health in commercial fishing, this type of research has not been increasing proportionately as much as research translating prior causal investigations into intervention [2]. The specificity of the various fisheries, in general, and the scale of the lobstering fishery, warrant that a descriptive study, such as the current one, informs the field of occupational health and safety about the characteristics of nonfatal, musculoskeletal pains in the industry, as previously, no profile has been established.

Given this background, and the knowledge that multiple risk factors are probably involved, an investigation of pain can be an opening into the understanding of causality [22]. We used an NMQ modified to address the work-relatedness of pain in lobstermen. Our method of direct, face-to-face interviews with a sample cohort of captains recruited to participate in a 4-year, longitudinal study on total occupational exposure and their crew was methodologically unique. The data are meaningful, likely to be representative of lobstering in general, informative toward intervention, and comparable to at least two prior studies on fishermen, as discussed below.

As is true in the general population, MSDs are common in lobstering. Eighty-two percent of the cohort reported pain in at least one body segment. Reports of multiple body locations of pain were common. The type of pain that occupational health intervention would have the highest impact on would be those that are caused by lobstering and, more immediately, those that affected the lobsterman's ability to work in a normal fashion. Anecdotally, participants indicated that lobstering made chronic pains caused by something other than lobstering (e.g., arthritis, old sports injuries) worse.

At least two previous studies used self-reported pain to profile and differentiate the proportion of a commercial fishing population experiencing pain at the various body segments. With respect to our question regarding pain in the previous 3 months, both Törner et al [12] and Lipscomb et al [8] allowed for pain in the previous year, so it is possible that their findings are systematically higher. Nevertheless, in Swedish fishermen, Törner et al [12] found roughly the same proportions as we found in lobstermen in the current study, except a greater percentage of lobstermen reported upper extremity pains than Swedish fishermen (shoulder 38% vs. 30%; forearm/elbow 17% vs. 13%, hand/wrist 30% vs. 21%). In NC fishermen, Lipscomb et al [8] also found a lower percentage reporting pain in the shoulder (38% of lobstermen, 25% of crabbers) than lobstermen, but had higher percentages of pain in the forearm/elbow (27% vs. 17%) and hand/wrist (40% vs. 30%) areas than lobstermen. The Swedish and NC fishermen and the lobstermen in this study were found to have comparable proportions reporting pain in the upper and lower back, and lower extremities.

Lipscomb's investigation also inquired about whether the pain affected normal work routines. In response to this question, notable differences between the proportions of lobstermen and crabbers can be seen in several body locations. The percentage of NC fishermen reporting that pain affected their normal work activity was higher than lobstermen corresponding to all the upper extremity locations, and most notably the lower back, where 18% of NC fishermen's work routine was altered due to pain compared to 6% of lobstermen despite the fact that 52% and 50% reported pain during the previous 3 months, respectively. This contrast may have been affected by differences in the respective method of data collection, where the interviews with NC fishermen were conducted by nurses at a clinic during a physical and medical history assessment, rather than by researchers in the field, often at the end of the work day. These differences may also be related to the difference in time periods for the two studies. Considering the high prevalence of pain, the corresponding prevalence of lobstermen receiving treatment is low. Work at sea can be considered an obstacle that could affect the ability of lobstermen to receive treatment. The traps in the water cannot be left for longer than a few days, so any treatment requiring several days away from lobstering would not be considered with favor.

Other studies on occupational groups that used the NMQ and found low back pain > 50% in the previous 3+ months include communication workers [23], bank office workers [24], specialized healthcare workers [25], and quarry workers [26]. The variety of tasks in these industries point to the multifactorial nature of MSDs, but, while low back pain is prevalent in the general population, the variability of exposure across occupations does not negate the work-relatedness, nor the potential understanding of a dose-response relationship.

If possible, the profiles of pain or injuries should be considered in the context of exposure [27]. While literature has accumulated on the relationship between injury and exposure [28], in general, these are based on Scandinavian fisheries where coding on injury reports were advanced. Data with utilization records have been used to study commercial fishing [9,11,15,29] injury rates, but, again, they are linked to acute events. It was outside the scope of this study to examine or quantify any specific exposure in this lobstering cohort other than the total occupational exposure estimated as full time equivalency and reported elsewhere, yet prior exposure assessment [30] indicated the possibility that the differentiation of captain and sternman work tasks might affect outcomes. Data from this study provided evidence that captains and sternmen on lobster boats have specific work-related outcomes. The prevalence of pain was reported as a proportion rather than a rate because the equivalence of denominator exposure within the cohort has not been established for each specific period of interview per participant. The prevalence proportions reported in this investigation included nonacute pains, so onset may not

necessarily be attributable to a specific task in the mind of the study participants, much less an objective observer. Similar differentiation observed in Swedish fishermen found that the leading subjective assessment of causes of severe low back pain was attributed to shoveling and lifting by deck hands, and to static working postures by captains [12]. However, the study population in Sweden was not working with, or handling, lobster traps [13]. Crabbers in study population of NC fishermen handled traps that were lighter and smaller than lobster traps [8,30]. Kucera et al [31] quantified task exposure using two methods of ergonomic assessment and calculated relative risk to low back pain in NC fishermen. Running the pot puller, a crabber task is comparable to lobstering in posture and frequency, was among the highest relative risks found of any defined task. In lobstering, typically the captain is responsible for running the pot hauler.

Recent programs in the USA, designed to introduce the principles of ergonomics into commercial fishing, indicated that fishermen are interested, experienced, creative problem solvers who seek out ways to reduce risk in their independent operations [7]. One advantage of face-to-face interviews of lobstermen at their boats in this study was to collect unprompted information from lobstermen regarding their insight into ways to reduce the exposure to the risks that lead to MSDs. Their suggestions include both changes in work methods, such as material handling techniques, and equipment redesign, for example, redesigned banding tools to reduce ergonomic exposures to the forearm/wrist/hand area. Scientific investigations of lobster boats have begun to evaluate the effectiveness of various equipment and techniques in Canada [32], but the translatability of the Canadian findings to American lobster boats is unknown. However, the qualitative data from this study would be useful to inform the likely impact of equipment design intervention.

4.1. Limitations

The selected study populations were active fishermen in both investigations, so fishermen debilitated by injury would not be included. It should be recognized that there are over 650 km of coastline to travel from the farthest boundaries of ME and MA. However, more relevant to the challenge of locating boats for this study were the 8,000 km of shoreline that include peninsulas and islands where boats were found either before they left for the day or upon return from the sea. Despite this, only eight of 279 captains were not included because of the infeasibility of accessing them, although a much larger portion of sternmen were not interviewed. At the same time, these challenges led to the point where some participants were interviewed more than once, yet only the most recent interview was included in this analysis. It is possible that some bias was introduced by this, but, because there was approximately 1 year between the first and second surveys, bias due to the previous interview is not expected to be a large factor.

Most of the interviews were conducted during the summer because of convenience. This may have led to some bias as this quarter had the highest prevalence of MSDs.

5. Conclusions

This is the first descriptive study of musculoskeletal pains in lobstermen. We found lower back pain to be prevalent among captains and sternmen, with half of respondents reporting back pain. Sternmen experience more hand/wrist pain than captains. Back pain is attributed to and exacerbated by lobstering work. Prior studies suggest that lobstermen are exposed to repetition, force, and both awkward and static postures that contribute to the observed prevalence of musculoskeletal disorders. Ergonomic interventions to reduce these exposures could reduce the prevalence of the disorders and improve the efficiency of the work. Equipment or technology to assist the material handling ought to be a priority, where body segments with high prevalence of pain (back, hand/wrists, shoulders, knees) may be affected by the repetitive and forceful handling of the lobster traps. Some lobstermen have anecdotally indicated measures that have succeeded in reducing incidence of pain.

Conflicts of interest

None of the authors has any conflict of interest associated with this manuscript.

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