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Chronic Health Risks in Commercial Fishermen: A Cross-Sectional Analysis from a Small Rural Fishing Village in Alaska

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ABSTRACT

Objectives: The purpose of this study is to evaluate chronic health risks before and during the fishing season in a sample of commercial fishermen, addressing the NIOSH priority of Total Worker Health™.

Methods: Gillnet license holders in Cordova, Alaska (n = 607) were contacted to participate in a preseason survey (March 2015) assessing health behaviors. A mid-season survey (July 2015) was also conducted. Physical exams and additional assessments were performed on a subset of these fishermen.

Results: Sixty-six fishermen participated in the preseason survey and 38 participated in the mid-season survey. The study population was overwhelmingly white males with an average age of 49. The average BMI was 27 with 70% of the participants overweight or obese. Nearly 80% of the sample considered their health good or better. Participants reported longer working hours, less sleep, and less aerobic exercise during the fishing season ($P < .05$). FitBit™ monitoring (n = 8) confirmed less sleep and fewer steps during fishing season. In one exam (n = 20), 80% of participants showed measured hearing loss at 4 kz (conversation range), and 70% had one or more upper extremity disorders, including 40% with rotator cuff tendonitis.

Conclusions: The prevalence of hearing loss, upper extremity disorders, and sleep apnea risk factors were higher than in the general population both before and during the fishing season. Occupational factors including exposure to noise, the upper extremity demands of gillnetting, and long working hours while fishing exacerbate these chronic health conditions. Health promotion programs targeted toward these conditions may present opportunities for improving total worker health.

KEYWORDS
Fishing; hearing loss; health promotion

Introduction

The commercial fishing industry involves hazardous work; the industry's injury rate is well above the national average: 189/10,000 FTE versus 104/10,000 FTE.[1] Researchers have described injuries and fatalities among this sector, and occupational health and safety groups like National Institute for Occupational Safety & Health (NIOSH) have implemented successful interventions to reduce hazards associated with commercial fishing. From 1990 to 2009, the NIOSH Alaska Pacific Office has worked to reduce the commercial fishing death rate by 42% by developing practical safety interventions.[2] In addition to the acute hazards associated with commercial fishing, fishermen are also subject to chronic health hazards. Few studies, however, have evaluated the chronic disease risks of commercial fishermen.[3,4]

Fishermen are exposed to many chronic health risks including noise, ultraviolet (UV) radiation, long and irregular work hours, and physical strain.[3] Previous work among fishermen gives evidence for a higher prevalence of hearing loss, certain types of cancer such as actinic keratosis and leukemia, fatigue, and musculoskeletal injuries than in other occupational groups as well as the general population.[5,6] Poor dental care, lack of immunizations, and mental health problems may increase the risk of personal illness at sea, which can necessitate urgent medical evacuation of fishermen.[7] Some countries like Italy and Poland require fitness for duty exams for fishermen to address some of these potential risk factors.[8] As

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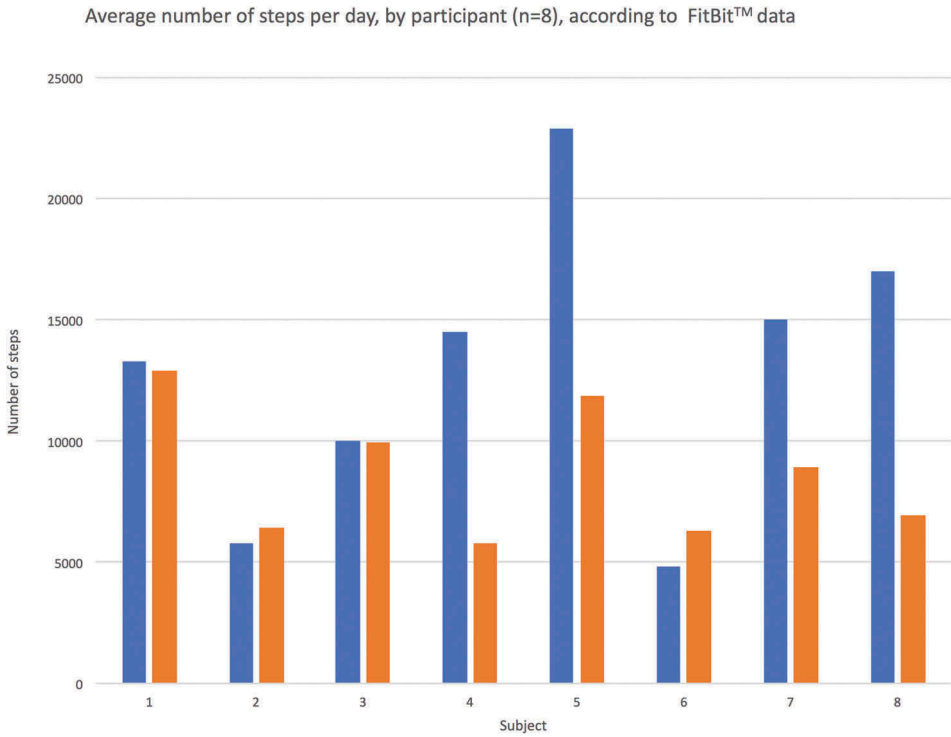

Figure 1. Average number of steps per day preseason and mid-season by participant (n = 8) according to FitBit™ data.

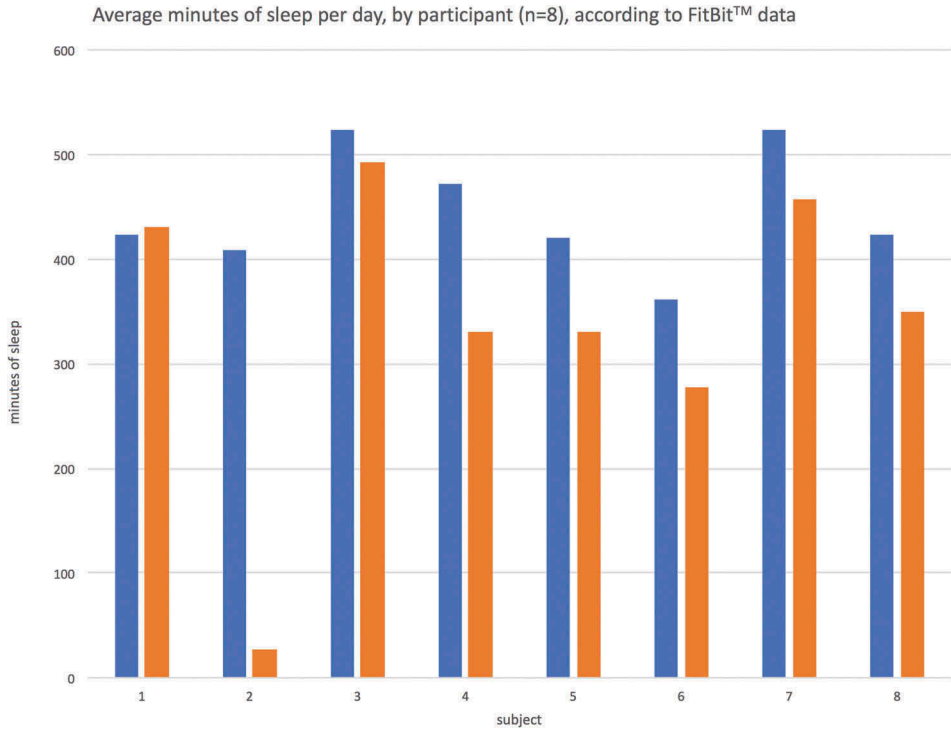

Figure 2. Average minutes of sleep logged per day preseason and mid-season by participant (n = 8) according to FitBit™ data.

the commercial fishing fleet ages, these chronic health risks and others common to the general population such as obesity, cardiovascular disease (CVD), and obstructive sleep apnea (OSA) may become increasingly important to the health of this workforce.[9]

The fishing industry has been targeted as an occupational sector in need of research as part of

the NIOSH National Occupational Research Agenda (NORA) and the National Agriculture, Forestry, & Fishing Agenda. [10] NORA has recognized a need to improve the health of commercial fishermen by reducing occupational causes or contributing factors to illness and disease while prioritizing the reduction of work-related musculoskeletal disorders.[10] In response to concerns identified in NORA, NIOSH developed the Total Worker Health™ (TWH) program in 2011 which focuses on integrating health and injury prevention into the workplace.[11]

To further the NORA agenda and to employ the TWH™ program, we developed a novel health risk appraisal (HRA) and exam protocol to assess chronic health status and health behaviors. The purpose of this study is to evaluate chronic health risks before and during fishing season in a sample of commercial fishermen.

Methods

Selection and description of participants

Eligible participants for this study were 607 gillnet permit holders in the Alaska Copper River salmon fishery (Alaska Department of Fish and Game, Salmon District Area S03E) in 2014. From November 2014 to February 2015, permit holders were contacted via mail with information about the research and study contact information. They were directed to the study website which contained the same information. Cordova District Fishermen United, a local fishing association, sent emails promoting the study to its membership, and the Cordova Alaska Sea Grant university extension office promoted the study. Fishermen who chose to participate underwent informed consent and were assigned a study identification code. The University of Washington IRB reviewed and approved the study protocol before any related activities were conducted.

Development of health risk appraisal and delivery of surveys

The study team developed an HRA that included questions from existing validated instruments.[12–15] These questions targeted demographics, medical history, work history, sleep habits, fatigue, dental care, mental health, physical fitness, use of alcohol and tobacco, noise exposure, and work practices. The HRA addressed most risk factors for OSA included on the STOP BANG questionnaire, which considers the following eight criteria: (1) sex (male), (2) age (increased risk over age 50), (3) BMI (increased risk over 35), (4) neck size (increased risk over 40 cm circumference), (5) history of loud snoring, (6) daytime sleepiness, (7) history of observed apneic episodes during sleep, and (8) treatment for hypertension.[16] The HRA also included open-ended questions for additional concerns.

The HRA underwent several revisions and incorporated input from local and industry stakeholders. The Sea Grant office administered the survey to four Cordova-based fishermen, soliciting feedback, and suggesting revisions to the study team, which were incorporated before distribution of the survey.

Study procedures included a preseason and mid-season survey that were available on the study website. The study team contacted those fishermen who completed the first survey to complete the second. The study team was present in Cordova, Alaska for one week during July 2015 and collected surveys from additional fishermen. Fishermen who completed the first survey but did not complete the second were contacted via telephone and encouraged to complete the second survey.

Study participants received $10 cash for completing each survey. The preseason survey was available from March to April 2015 and focused on health habits before the fishing season. The mid-season survey was available in July 2015.

Physical exam, fitness assessment, audiometry, and actigraphy

During the fishing season, a subset of 20 fishermen who completed both components of the HRA underwent a complete physical exam, including medical history, audiometry, and fitness assessment. A 3-minute step test was used to evaluate participant aerobic fitness. This test used a 12-inch step and standard reference ranges to categorize participant fitness.[17] A Windows™ audiometry application with noise canceling headphones was used for audiograms;

audiometry was evaluated in each ear at 500 hertz (Hz), 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. Standard Snellen eye charts were used for vision assessment at near and far distances. Study participants with corrective lenses wore them for the exam. Participants received $49 cash for participation in this portion of the study.

We attempted to capture activity and sleep duration among participants before the fishing season. FitBit™ One actigraphy monitors were distributed at the Cordova Community Health Fair in April to 10 participants. Participants were instructed to synchronize individual data devices to the FitBit™ website and to wear the FitBit™ for 72 hours before and then during the fishing season, and to log sleep times. Study investigators were able to download participant data via the FitBit™ website.

At the conclusion of the study, all participants received a letter with their individual survey, exam, and Fitbit™ results, recommendations for follow-up, if needed, and a summary of aggregate study findings. The principal investigator returned to Cordova, Alaska after the fishing season to present the study findings at two community meetings and provided an interview for the local newspaper.

Statistical analysis

Descriptive statistics were used to evaluate the distribution of characteristics and to compare the fishermen responses preseason versus midseason, when applicable. BMI was calculated from height and weight reported by participants. Age, years fishing, and BMI were analyzed as continuous variables. Other variables were analyzed categorically, i.e., level of self-described fitness (excellent, very good, good, fair, poor). Self-reported musculoskeletal injuries, pain, and limitations were summed according to degree of self-reported disturbance (very limited, somewhat limited, not limited at all). The results of the 3-minute step test were categorized according to the reference ranges provided.[17] Audiography results were considered abnormal if a "notch" was evident at 4000 Hz on standard audiograms. This notch represents a hearing level threshold above 20 dB.[18] and is diagnostic of noise-induced hearing loss (NIHL). Actigraphy data on number of steps was captured and calculated by the FitBit™ program. Sleep data relied on participants logging their sleep time manually. Differences between fishermen responses preseason and midseason were analyzed with the Wilcoxon signed-rank test, a non-parametric statistical test used when comparing two related samples.[19] All statistical analyses were conducted in Stata version 13 (College Station, TX).

Results

Participant demographics

Sixty-six of 607 (11%) potential participants completed the preseason component of the survey. Table 1 provides descriptive statistics for demographic variables. Most participants were white, male, married, and most had graduated from high school. On average, participants were 49 years old with 27 years of commercial fishing

Table 1. Demographics of preseason survey.

Characteristic		Preseason survey $N = 66$
Mean age and range		49 years, 19–73
Mean experience and range		27 years, 1–58
Sex	Male	92%
	Female	8%
Ethnicity	White	97%
	AIAN	3%
BMI	Normal	29%
	Overweight	49%
	Obese	21%
Other occupation	Yes	58%
	No	42%
Marital status	Married	77%
	Single	15%
	Divorced	5%
	Other	3%
Education level	Less than HS	8%
	Completed HS	18%
	Some college	23%
	College	41%
	Grad school	10%
Health insurance	Yes	89%
	No	11%
Overall health assessment	Excellent	21%
	Very good	50%
	Good	27%
	Fair/poor	2%
Physician visit	Within 1 year	59%
	1–2 years	17%
	3 or more	24%
Dental visit	Within 1 year	62%
	1–2 years	26%
	3 years or more	12%
Current smoker	Yes	3%
	No	97%

AIAN: American Indian and Alaska native, HS: high school.

experience. Most participants reported another occupation in addition to commercial fishing.

Overall health and fitness

As shown in Table 1, health behaviors and health maintenance were evaluated in the preseason survey with some of the same behaviors evaluated during the mid-season survey. Nearly 90% of respondents reported health insurance and most reported a physician visit (59%) and a dental visit (62%) within the last 12 months. The mean BMI of our sample, based on reported height and weight, was 27.1 with nearly 70% of participants categorized as overweight or obese (BMI>25, n = 46, 70%). Ninety-seven percent (n = 64) of participants identified as non-smokers. In response to the question, "What concerns do you have about your health?", broad issues of concern and several comments included sleep (n = 4), hearing (n = 3), and aging (n = 3).

In the preseason survey, participants were asked about the frequency of vigorous and moderate physical activity during a typical week when not fishing ("off-season"). Over half of survey participants (n = 35, 53%) described vigorous physical activity four or more times a week. Two-thirds of survey participants (n = 44) reported participating in light to moderate physical activity four or more times a week. During the mid-season survey, these results were 24% (n = 9) and 45%(n = 17), respectively. This decline in aerobic activity was statistically significant when compared among fishermen who completed both surveys (Table 2).

On the preseason survey, 71% of all respondents (n = 47) rated their overall health as "excellent" or "very good." Physical exams and health assessments were performed on 20 participants. The

Table 2. Health behavior survey responses preseason vs mid-season.

		Preseason survey N = 66 (%)	Matched preseason N = 38 (%)	Mid-season survey N = 38 (%)	P-value of difference
Pain meds	Most days	2	0	8	0.26
	Some days	36	42	34	
	Never	62	58	58	
Mood meds	Most days	8	5	3	0.97
	Some days	6	8	10	
	Never	85	84	87	
Alcohol drinks/week	1 or less	32	29	29	0.03
	2–4	27	26	42	
	5 or more	41	45	29	
Activity level (moderate)	2 or less	12	13	34	.008
	3	18	18	21	
	4 or more	70	68	45	
Activity level (vigorous)	2 or less	30	29	63	.002
	3	17	21	13	
	4 or more	53	50	24	
Regularity of sleep	Highly variable	0	0	34	0.00
	Somewhat vary	29	34	55	
	Pretty regular	68	63	8	
Work hours/day	<8	39	42	5	0.00
	8–10	20	11	8	
	10+	20	24	87	
	Missing/unknown	21	24	0	
Any injury		67	71	68	0.80
Upper extremity injury		50	50	63	0.16
Lower extremity injury		41	47	26	0.02
Axial skeleton injury[a]		30	34	34	0.76
Any interference		76	84	76	0.53
Upper extremity interference		53	53	71	0.09
Lower extremity interference		50	58	37	0.76
Axial skeleton interference		39	42	32	0.78
Steps/day[b]		–	12,357 steps	8,630 steps	0.12
Hours sleep/day[b]		–	7.4 hours	5.6 hours	0.02

[a]Axial skeleton refers to the skeleton of the head, neck, and trunk

[b]Acitgraphy data, n = 8. Averages are per 24 hours, averaged over 3 days, before and during fishing season. The "during fishing season" data may include days that were not actually spent at sea.

step test indicated that when standardized by age and sex, 47% (n = 9) of fishermen had good to excellent fitness, 42% (n = 8) were in the average range, and 10% (n = 2) in the poor to very poor range. One fisherman did not participate due to physical limitations.

We obtained valid data on steps per day from eight subjects (Figure 1). Before fishing, six of eight (75%) walked more than 10,000 steps per day; during fishing, three of eight (38%) exceeded this threshold.

Sleep quality and duration

In the preseason survey, participants were asked about sleep habits. Sixty-eight percent (n = 45) responded that they regularly slept 6–8 hours per night while no respondents (0%) reported 24 hours or more without sleep. On the mid-season survey, only 8% (n = 3) reported 6–8 hours of sleep per night while 34% (n = 13) reported 24 hours or more without sleep. This difference in sleep regularity and quantity was statistically significant among fishermen who completed both surveys (Table 2).

The preseason survey assessed six risk factors for OSA. One participant reported prior OSA diagnosis. Of the remaining 65 participants, 32 met criteria for further evaluation for OSA by a sleep specialist (49%) due to multiple risk factors. The average age of those meeting criteria for further evaluation was 56 while the average age of those not meeting criteria was 43. The prevalence of these characteristics is shown in Table 3.

Based on FitBit™ data, three of eight participants (38%) averaged at least eight hours of sleep at night before fishing season, and one of eight (13%) averaged eight hours during fishing season (Figure 2). Among all eight participants, they averaged nearly 7 hours of sleep each night before fishing season and about 5.5 hours each night during fishing season.

Table 3. Survey responses of sleep apnea characteristics.

Risk factor	n[a]	%
Male gender	61/66	92
Age >50	37/66	56
BMI ≥35	3/65	5
Collar size ≥40 cm	35/54	65
History of —		
Snoring loudly	16/60	27
Hypertension treatment	6/50	12
Apneic episodes	Not asked	n/a
Daytime tiredness	Not asked	n/a

[a]n may be less than 66 if participants omitted responses.

Noise exposure and hearing loss

Hearing loss was evaluated on the initial survey with questions like: "Do you have any hearing loss?" and "If yes, does your hearing loss interfere with work?". Fishermen were also asked to select specific loud hobbies or activities in which they participated regularly. Half of respondents (n = 33, 50%) reported hearing loss and among those, all respondents (100%) reported difficulty hearing through ambient noise. Only 18% (n = 6) of those reporting hearing loss described work interference. More than 80% (n = 54) of participants reported loud hobbies including snowmobiling, hunting, and woodworking.

Most fishermen who participated in the physical exam portion had audiograms to evaluate NIHL. The notch indicating a hearing level threshold above 20 dBA at 4kz was noted in either one or both ears in 80% of participants (n = 12/15).

Musculoskeletal disorders

Musculoskeletal disorders were addressed multiple times in the preseason survey. In response to the open-ended question, "What concerns do you have about your health," the regions of concern included back (n = 4), knee (n = 3), fingers (n = 2), shoulder (n = 2), and muscles (n = 2). Another item addressed minor or major injury in specific body regions during the past 3 months. Limitation of home or work activities was also addressed. Respondents were asked similar questions during the mid-season survey; however, the reference time was during the past 1 month. Table 2 includes a summary of the prevalence of injury and interference in each body region at both study time points.

On the mid-season survey, 68% (n = 26) reported some prior injury with 92% of these injured reporting an upper extremity injury. With regard to interference with work, 76% (n = 29) reported interference with work activities, with 93% reporting interference due to an upper

extremity injury. These differences between preseason and mid-season responses to injury and interference with work were both statistically significant when compared between fishermen who completed both surveys (Table 2). The subset of participants who underwent physical exams had an opportunity to discuss prior injuries during the medical history component. Many fishermen had evidence of upper extremity injuries: of the 20 physical examinations, 8 had symptoms of rotator cuff tendonitis of the shoulder, 4 had symptoms of carpal tunnel syndrome, 3 had extensor or flexor tendonitis at the wrist, 3 had injuries to digits of the hand (variety of diagnoses), and 2 had Dupuytren's contracture of the hand, a thickening of tissue between the finger tendons and the palm of the hand. There was also one case each of a biceps tendon tear, labral tear of the shoulder, medial epicondylitis of the elbow, and cervical neuropathy affecting the arm.

Conclusion

We have characterized a small sample of gillnet fishermen in Alaska in order to better understand their chronic health risks. These fishermen are accustomed to episodic work in a cramped, pressured setting. The Area S03E salmon fishing season is generally 4 months in length, from mid-May until mid-September, and income activities for the remainder of the year vary widely among individuals. Vessels are small (28–34 feet in length) with little space for exercise. Boats are diesel or gasoline powered, many with dual engine configurations, which can be a source of noise and exhaust exposure. Personnel usually consist of one skipper. Crew, if used, includes one additional person, resulting in little chance of relief or breaks while fishing. Biweekly fishing periods, regulated in duration and frequency by resources managers, are usually 24–48 hours in duration, with little sleep and unpredictable bursts of heavy activity the norm. Gillnet fishing permits in this area are expensive ($150,000 to $225,000) relative to other Alaska salmon licenses; participants generally own or finance their boats and fishing permits.[20]

In the drift gillnet method, the net, which is regulated at 900 feet in length, is deployed and retrieved via a hydraulically powered drum. Clearing harvested fish from a net requires tugging on the net once aboard, and manually pulling, picking, or cutting fish from the webbing of the net. Vessel harvest poundage per opener can range from 100 to 10,000 lbs. of salmon depending on stage and strength of the run return, species, weather, or individual skill. Picking the fish requires rapid, repetitive movement. Gloves are necessary, but they may limit dexterity and contribute to skin infections if not well maintained. Depending on the number of fish in the net, several hours of standing, picking, and storing individual fish in the fish holds as wells as repairing gear may be required of the fishermen.

Overall, the fishermen in our sample considered themselves healthy and had evidence of above average fitness. Compared to the general Alaskan population, study participants reported less tobacco use, more regular health maintenance visits to health professionals, and higher rates of health insurance.[21] This sample also reported better overall health. This finding is consistent with healthy worker bias and volunteer bias likely skewing this sample toward the most health-conscious subset of gillnet fishermen. The prevalence of overweight or obesity in our sample (70%) was consistent with that of the general adult population of Alaska.[21]

As reported above, participants reported decreased aerobic activity during the fishing season, despite the manually intensive work described above. Differences in aerobic activity were significant for both vigorous activity and moderate physical activity. These findings were supported with participant anecdotes of declining fitness during the fishing season. Fishermen attributed this to the confined space of the fishing vessel, busy work schedules, and excessive fatigue that persisted between fishing periods. Alternative approaches mentioned to the study team included hiking in between fishing periods, practicing yoga in the cabin, or, in one case, swimming around the fishing boat in a wetsuit.

The high prevalence of multiple OSA risk factors in survey respondents is concerning. OSA is a breathing-related sleep disorder characterized by apneic episodes during sleep, excessive daytime sleepiness, and decreased cognitive performance. OSA is a chronic condition with an estimated

prevalence of up to 10–17% of Western men, with prevalence increasing with age.[22] OSA has been recognized as a cause of increased cardiovascular and all-cause mortality.[16] In addition to shortened duration of sleep, poor quality of sleep due to untreated OSA may exacerbate fatigue during the fishing season. With treatment, such as use of a continuous positive airway pressure machine (CPAP), sleep can be restorative and health risks associated with the disease can be reversed. An aging fleet and rising prevalence of obesity indicate that OSA will likely continue to be a serious health condition among this workforce.

Evidence of NIHL in this sample, based on survey responses and physical exam findings, is alarming. The National Institute on Deafness and Other Communication Disorders estimates approximately 15% of Americans between the ages of 20 and 69 have high-frequency hearing loss due to work exposure or leisure activities.[23] The prevalence of hearing loss in this study was much higher, reported by 50% of survey respondents and detected in 80% of exam participants. In addition to engine noise while fishing, most fishermen reported exposure to noise during other occupational and recreational activities, such as snowmobiling, hunting, and woodworking. Most fishermen interviewed reported wearing hearing protection during occupational activities, however, we did not have a method of validating this report. In a recent survey of hearing protection and occupational noise exposure, 18.7% of adults exposed to loud noise and 43.6% of adults exposed to very loud noise reported always wearing hearing protection.[24]

Musculoskeletal disorders of the upper extremities, consistent with repetitive stress exposure, were common in this sample. In our cohort, 63% of fishermen (n = 24) reported a recent injury to the upper extremity on the mid-season survey. Additionally, 71% of fishermen (n = 27) reported musculoskeletal symptoms of the upper extremity interfering with work during that time period (mid-season). In a paper by Lipscomb et al., 83% of the cohort of fishermen reported musculoskeletal symptoms in at least one body region during the last 12 months. Within that cohort, 38.5% of those with symptoms claimed it severe enough to interfere with work.[4]

Repetitive overhead activity and advancing age are risk factors for rotator cuff tendinopathy. In the 40–60 age group in the general population, the expected prevalence of rotator cuff tendinopathy is 8–14%; however, we found evidence of rotator cuff tendinopathy in 40% (n = 8) of exam participants.[25] This is consistent with the preseason survey results of nearly one-third (n = 21) of respondents reporting shoulder pain. Activities that cause rotator cuff injury for this population include repeatedly pulling heavy anchors onboard by hand and clearing snags and other heavy objects entangled in gear. Conditioning exercise before the fishing season begins, training and experience, and an increased use of automated gear (although space is severely limited on these small vessels) may reduce injury due to repetitive overhead activity. Other repetitive stress injuries such as carpal tunnel syndrome may be reduced with tools such as ergonomically designed fish picks.

This study has limitations. The sample of fishermen is very small and may not be generalizable to the gillnet fleet, nor commercial fishermen as a whole. The participation rate of this study, 11%, requires further thought to the approach to recruitment. Contacting fishermen and soliciting their participation proved difficult, particularly when follow-up survey instruments were indicated. There is evidence of a healthy worker bias in our population, as the healthiest workers volunteered for the various health assessments.

The data collection tools, including the survey and exam, may not be appropriate for other types of commercial fishing. These were relevant to the local setting based on advice from groups such as North Pacific Fishing Vessel Owners' Association, Alaska Marine Safety Education Association, and the United States Coast Guard. Each type of commercial fishing has a unique set of chronic health risks, and different data collection tools may be needed to assess different populations.

Regarding the FitBit™ data, we did not control for differences in where the device was worn (wrist, waist, or lanyard), which may have impacted step accrual. The "during fishing season" data may reflect only one day of fishing and 48 hours of other activity as participants did not record this information. One participant reported that hand movement caused steps to be recorded

when the device was worn on the wrist, even when the participant was sedentary. As mentioned previously, the "during fishing season" data was not limited to days at sea. The three days may have been a combination of time at sea and time in between fishing periods. Additional work validating actigraphy data in this population is needed.

In summary, this study identified several chronic health conditions that have significant relationships to occupational activity in a small sample of gillnet fishermen. Aging and the strain of gillnetting increase the risk of repetitive stress injuries of the upper extremity. OSA, which is associated with aging and obesity, exacerbates fatigue associated with sleep disruption while fishing. Engine noise along with other types of noise exposure common among the fishermen's other occupations and pastimes increases the risk for NIHL.

Health promotion programs targeted toward these conditions may present opportunities for intervention in this population. For instance, screening for and treating OSA before the fishing season could reduce fatigue. Additionally, treating upper extremity disorders could reduce the risk of further injuries and disability at sea. And auditory screening could increase awareness of clinically inapparent NIHL and reinforce the importance of using hearing protection.

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Notes on contributor

Jennifer M. Lincoln, PhD, CSP, is the Director of Alaska Pacific Office, National Institute for Occupational Safety and Health (NIOSH). Dr. Lincoln critically reviewed the study proposal and served as a scientific advisor.

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