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Original Article

Measuring health conditions and behaviours in fishing industry participants and fishing communities using the Behavioral Risk Factor Surveillance Survey (BRFSS)

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We estimate physical health, mental health, and healthcare access conditions and behaviours among fishing industry participants from a public health survey in the United States. Human well-being is an increasingly important consideration in ecosystem models and fishery management. We use a standardized public health survey, the Behavioral Risk Factor Surveillance System, to estimate health-related aspects of well-being in fishing industry participants (including harvest, processing, and wholesaling sectors) in Washington state and compare to reference populations. We find that physical and mental health outcomes and healthcare access among fishing industry participants are broadly similar to other populations. However, fishing industry participants are more frequently affected by conditions that limit activity and tend to engage in potentially unhealthy behaviour at higher rates. Our work fills a gap on health-related well-being outcomes in the human dimensions of fisheries and demonstrates the role that public health surveys can play in the study of well-being in fishing communities.

Keywords: ecosystem-based management, fishing communities, , human health, human wellbeing.

Introduction

The concept of human well-being incorporates many aspects of individuals' and communities' quality of life, including basic material needs, health, security, good social relations, and freedom of choice and actions. Viable fishing communities require good and sustainable levels of well-being, including health, among fishing industry participants, to continue supporting and generating societal benefits from fisheries. Integrated approaches to fisheries management, such as ecosystem-based fisheries management (EBFM), consider fisheries as part of social–ecological systems that take into account inter-relationships between ecological functions and human communities that depend on ecosystem services for their well-being (Levin *et al.*, 2014; Link *et al.*, 2017; Zador *et al.*, 2017; Stephenson *et al.*, 2018). This view focuses not only on biophysical aspects of the system but also equally on understanding its human dimensions, especially the well-being of fishing industry participants and fishing communities (Samhouri *et al.*, 2014; Harvey *et al.*, 2017; DePiper *et al.*, 2017; Marshak *et al.*, 2017; Marshall *et al.*, 2018). At the same time, as Link *et al.* (2017) note, "empirical understanding of social aspects of coastal communities, although improving, is still falling short of what is needed to fully account for social dimensions in integrated ecosystem assessments." Recent work has proposed and reported quantitative measures of economic status, vulnerability,

resilience, and well-being in fishing communities (Jacob *et al.*, 2010, 2013; Jepson and Colburn, 2013; Biedenweg *et al.*, 2014; Himes-Cornell and Kasperski, 2016). However, less is known about health outcomes and associated measures and data. In this article, we estimate physical health, mental health, and healthcare access among fishing industry participants (including workers in the commercial seafood harvesting, processing, and wholesaling sectors) from a public health survey of the general population.

Physical and mental health are important components of human well-being (Biedenweg *et al.*, 2014; Breslow *et al.*, 2016; Breslow *et al.*, 2017) and are particularly important to fishing communities because of the physically and mentally demanding nature of the work and lifestyle. Though human health indicators have not been widely applied in fisheries work, recent papers have begun to investigate health-related issues facing fishing industry participants. Woodhead *et al.* (2018) survey a wide array of articles and identify six health-related topics of study: physical health, mental health, lifestyle factors (i.e. behaviours that may have an impact on health outcomes), external factors affecting health outcomes (e.g. access to healthcare, health and safety practices), accidents and injuries, and occupational factors (occupational traits associated with exposure to health and injury risk). Woodhead *et al.* (2018) find that although health is a critical component of any definition of human well-being, it remains underexplored in fisheries. While numerous papers have examined occupational hazards such as accident, injury, and fatality rates and associated risk factors in the harvest sector (e.g. Windle *et al.*, 2008; Lincoln and Lucas, 2010; Emery *et al.*, 2014; Pfeiffer and Gratz, 2016; Marvasti, 2017; Bovbjerg *et al.*, 2019; Kincl *et al.*, 2019), much less work exists on other health issues within fishing communities, such as, general physical health, mental health, lifestyle and behavioural factors, and healthcare access (Frank *et al.*, 2013; Eckert *et al.*, 2018; Turner *et al.*, 2019). Woodhead *et al.* (2018) finds that nearly all of this work exists in the epidemiology and health literature, which has limited its visibility and usefulness to fisheries and ecosystems research. A lack of systematic data collection is also a barrier to understanding health issues in fishing (King *et al.*, 2015). Furthermore, much of the work on health-related components of well-being has focused narrowly on participants in the fisheries harvest sector. However, backward (sales of inputs to fishing such as boat building and repair, bait, fuel, ice) and forward (purchases of outputs from fishing such as processors, wholesalers, exporters, retailers) linkages between sectors create an economic dependence on and cultural connections to ecosystem services that goes beyond those employed directly in harvest (Jacob *et al.*, 2001; Kent and Himes-Cornell, 2016).

In this article, we estimate the prevalence of physical and mental health outcomes and healthcare access rates among fishing industry participants in the state of Washington, United States, using an annual public health survey, the Behavioral Risk Factor Surveillance System (BRFSS). We compare these estimates to those in reference populations to identify health issues that may be of particular concern to fishing communities.

Our work is a contribution to our understanding of human well-being in fishing communities. Research on fishing communities typically includes both work on communities as shared geographically bounded places where commercial fishing is socially and economically salient (Sepez *et al.*, 2006 ; Himes-Cornell and Kasperski, 2016) and research on occupational community or communities of practice, where shared occupations, target species or specialized information among fishers build and maintain social bonds (Orth, 1987; Clay and Olson, 2007; Ross, 2013; Cramer *et al.*, 2018). Several previous analyses of vulnerability and well-being for fishing communities have focused on social and demographic information for the entire populations of geographically bounded communities in which fishing activity occurs (Colburn and Jepson, 2012; Jacob *et al.*, 2013). However, a community can be understood in non-geographic terms and be defined according to group identification, a sense of "togetherness", or a shared understanding of the nature of the fishing industry and where community members can be widely geographically dispersed (Brookfield *et al.*, 2005; Ross, 2013; Cramer *et al.*, 2018).

Our analysis targets the specific "community of practice" or "occupational community" that exists both directly within and across multiple, geographically based fishing communities of Washington state and provides health information about industry participants who reside in the roughly 40 Washington municipalities that have typically met thresholds for engagement with, and reliance on commercial fishing (Norman *et al.*, 2007). Because the survey respondents identify their occupation, we can define a community of practice or occupational fishing community as participants in the commercial seafood harvesting, processing, and wholesaling industry in the state of Washington, United States. We can then compare outcomes in fishing industry participants to reference populations, which gives a more complete understanding of conditions affecting fishing communities than stand-alone surveys or interviews.

Data and methods

We use data from the Washington BRFSS survey to estimate the prevalence of specific health outcomes across three populations in Washington state, United States: (i) fishing industry participants, (ii) natural resource industry workers (not in the fishing industry), and (iii) the general working population (those not in the fishing or natural resource industries). In this section, we describe the BRFSS survey, the three populations of interest, and the methods of estimating and comparing prevalences. The full list of survey questions is provided in the "Washington Behavioral Risk Factor Surveillance System 2011–2016 Combined File Codebook", which is included in the Supplementary Material.

Fishing industry in Washington state

Washington is located on the Pacific coast of the United States. In 2016, Washington had the sixth highest commercial fishing landings revenue (out of 23 coastal states) and accounted for about 4% of landings revenue in the United States. Local fisheries in Washington consist of a diverse set of operations with much of this revenue landed in the clam and oyster, Dungeness crab, salmon, and albacore tuna fisheries (NMFS, 2018). Washington ports are also the home ports for a significant portion of the catcher-processor fleet targeting Pacific hake. In addition, the port of Seattle is strongly connected to the much higher revenue fisheries in the state of Alaska. A recent survey found that 226 fishing vessels, out of ∼300 that used Port of Seattle facilities, fished in Alaska waters and many harvesting and processing workers in Alaskan fisheries are Washington residents (CAI, 2019). Seafood harvesting, processing, and shipping companies doing business in Alaskan fisheries are headquartered in Washington and processing facilities receive Alaskan fish.

Behavioral Risk Factor Surveillance System

The US Centers for Disease Control and Prevention's (CDC) BRFSS is an annual, state-based, random-digit-dialled, landline, and cellphone telephone survey. The survey collects self-reported data on health conditions and behaviours of the noninstitutionalized US civilian population (aged 18 years or older) with core questions regarding health-related risk behaviours, chronic health conditions, and use of preventive services, as well as demographic questions such as age, sex, race/ethnicity, educational level, and annual household income. The BRFSS survey is conducted in all 50 US states and four US territories. In addition to the CDC core questions, states may include additional questions on their survey. In 2016, there were 23 BRFSS modules available for states' optional use, including Industry and Occupation. BRFSS was established in 1984 and currently completes >400 000 interviews each year, making it the largest continuously conducted health survey in the world (https://www.cdc.gov/brfss/index.html).

We use response-level BRFSS data from Washington state from 2011 to 2016, obtained from the Washington State Department of Health. During 2011 to 2016, there were 81 710 BRFSS survey respondents in Washington state, representing a response rate of between 31% and 44%. Washington began administering the optional Industry and Occupation module in 2011, which allows us to identify respondents as participants in the fishing industry and as members of two reference populations. We included in this study 40 443 respondents that reported being currently employed for wages, self-employed, or out of work for <1 year. We report on demographic and health outcomes measures for fishing industry participants and compare those outcomes to the two reference populations. Our well-being measures contain information on respondents' physical health, behaviours that affect health and well-being, mental health, and access to health care. The BRFSS survey questions used to construct our well-being outcomes are listed in Table 1.

Fishing industry and reference populations

We define fishing industry participants and the two reference populations using responses to BRFSS questions on industry and occupation. Comparing health outcomes across populations is an important component of epidemiological studies and can identify issues that may be particularly relevant to well-being in fishing communities. For example, higher prevalence of a specific disease among fishing industry participants may suggest public health or fishery management policies targeted towards fishing communities. For the survey respondents who are currently "employed for wages", "self-employed", or "out of work for <1 year", interviewers ask the following questions to categorize industry and occupation, respectively: "What kind of business or industry do you work in?" and "What kind of work do you do?" and if needed, "What is your job title? What is your main job?" The Washington State Department of Health codes narrative text responses using 2000 and 2002 Census Industry and Occupation codes with National Institute for Occupational Safety and Health Industry and Occupation Coding System software developed by the National Institute for Occupational Safety and Health (https://www.cdc.gov/niosh/topics/coding/default.html) and manually. Respondents' occupations are grouped into 11 industry categories.

We constructed our fishing industry participant population using the industry and occupation codes and the raw text responses to questions regarding industry and occupation. We first generated a candidate set of 247 responses that met at least one of the following criteria: (i) assigned industry codes of "0280: Fishing" or "1280: Seafood and other miscellaneous foods n.e.c." (175 responses), or (ii) assigned an occupation code of "45-3011: Fishers and Related Fishing Workers" (42 responses), or (iii) answer to industry or occupation questions included the sequence of letters "fish" (176 responses). From this initial set, we manually identified respondents who clearly worked in the commercial fishing or seafood processing industry. The resulting set of 123 respondents is our sample of fishing industry participants. The candidate list of responses and our classification as fishing and non-fishing are included in the Supplementary Material.

We constructed two reference populations to compare well-being outcomes between groups. The first reference population, natural resource workers, consists of workers classified by the Washington State Department of Labor and Industries as working in Agriculture, Forestry, Fishing, Hunting, or Mining and not included in our fishing industry participants population. The sample representing natural resource workers consists of 1393 responses. The second reference population, the general working population, consists of working adults who were not included in the fishing or other natural resource workers groups. The sample representing the general working population consists of 38 927.

Table 2 displays unweighted sample frequencies by group and year and weighted population size estimates by group over the 2011–2016 study period. We estimate a total population size of 9820 fishing industry participants. For comparison, the National Marine Fisheries Service (NMFS) independently estimated that the number of jobs in the fishing industry in Washington averaged 10 294 from 2011 to 2016 (NMFS, 2018). This average includes the commercial harvesters and seafood processors and dealers sectors, which correspond to our definition of fishing industry participants. The closeness of our estimate of the number of fishing industry participants to the NMFS estimate (the standard error of our statistically based estimate of fishing industry population size is 1345 and the difference between our estimate and the NMFS estimate is <500) provides some evidence that the BRFSS sample is representative of fishing industry participants.

In federally managed US fisheries, including those adjacent to Washington state, the agency charged with fisheries management has responded to its community-oriented legal mandates by settling on a place-based definition of community that also acknowledges the centrality of individual fishing industry participants and livelihoods within and across those communities. Agency regulations further define a fishing community as "... substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and United States fish processors that are based in such community" [Code of Federal Regulations, Title 50, section 600.345(3)]. Accordingly, our work recognizes that fishing communities are geographically situated places which, by definition, include distinct populations of fishing industry participants. Our analysis of health survey data seeks to examine health outcomes for the "vessel owners, operators and crew and United States fish processors" specified in the regulatory language relevant to fishing communities.

Table 1. BRFSS survey questions used to describe outcome variables.

Outcome variables	Question
Physical health	
Good or better health	*Would you say that in general your health is: Excellent, Very good, Good, Fair, or Poor?*
Overweight or obese (BMI > 25.0)	*Body mass index (BMI), calculated from self-reported height and weight*
Diabetes	*(Have you ever been told by a doctor or health professional) you have diabetes?*
Heart disease	*(Have you ever been told by a doctor or health professional) you had angina or coronary heart disease?*
Asthma	*(Have you ever been told by a doctor or health professional) you had asthma?*
Cancer	*(Have you ever been told by a doctor or health professional) you had any . . . types of cancer (other than skin cancer)?*
Arthritis	*(Have you ever been told by a doctor or health professional) you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?*
Limited activity, currently	*Are you limited in any way in any activities because of physical, mental, or emotional problems?*
Use special equipment, currently	*Do you now have any health problem that requires you to use special equipment, such as a cane, a wheelchair, a special bed, or a special telephone?*
Health-affecting behaviours	
Any exercise (past month)	*During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?*
Current smoker	*Do you now smoke cigarettes every day, some days, or not at all? Considered current smoker if every day or some days*
Alcohol (at least one drink past 30 d)	*Adults who reported having had at least one drink of alcohol in the past 30 d*
Binge drinking	*Binge drinking calculated variable: considering all types of alcoholic beverages, how many times during the past 30 d did you have X (X = 5 for men; X = 4 for women) or more drinks on an occasion?*
Marijuana (past 30 d)	*Used marijuana in past 30 d*
Seatbelt (always or nearly always)	*How often do you use seat belts when you drive or ride in a car? Would you say: Always; Nearly Always*
Mental health	
Serious mental illness	Estimated proportion scoring above a threshold on a Serious Mental Health Index (Kessler Psychological Distress Scale, score > 13). This index is computed based on responses to six questions on the survey
Medication or treatment for mental health condition	*Are you now taking medicine or receiving treatment from a doctor or other health professional for any type of mental health condition or emotional problem?*
Depressive disorder	*(Have you ever been told by a doctor or health professional) you have a depressive disorder including depression, major depression, dysthymia, or minor depression?*
Healthcare access	
Aged 18–64 with healthcare coverage	*Do you have any kind of health care coverage, including health insurance, prepaid plans such as HMOs, government plans such as Medicare or Indian Health Service?*
Check-up—within past 2 years	*About how long has it been since you last visited a doctor for a routine checkup? A routine checkup is a general physical exam, not an exam for a specific injury, illness, or condition*
Unable to see a doctor because of cost (past 12 months)	*Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?*
Have a personal doctor or healthcare provider?	*Do you have one person you think of as your personal doctor or health care provider?*

Table 2. Washington BRFSS sample sizes by population and year.

	Unweighted sample frequencies							Weighted estimate of total population 2011–2016 (standard error)
Population	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**All years**	
Fishing industry participants	21	25	18	14	28	17	123	9 820 (1 345)
Natural resource industry workers	260	173	200	178	313	269	1 393	102 894 (4 158)
General working population	6 740	7 620	5 389	4 855	7 410	6 913	38 927	3 120 092 (12 095)
All working adults	7 021	7 818	5 607	5 047	7 751	7 199	40 443	3 232 805 (13 710)
All WA BRFSS respondents	14 769	15 312	11 162	10 092	16 116	14 259	81 710	5 408 170 (15 801)

Estimation methods

Responses in general population surveys are weighted according to the probability that each respondent will be interviewed so that estimated prevalences can be generalized to populations of interest. BRFSS survey weights are calculated so that sample responses are representative of the adult population of Washington across multiple strata: age, sex, race, ethnicity, geographic area, telephone ownership, education level, marital status, and home ownership (https://www.cdc.gov/brfss/data_documentation/pdf/UserguideJune2013.pdf). Survey weights for each response are calculated by the Washington State Department of Health and are provided with the data. We estimate population size for each of our three populations of interest by summing the sampling weights over all survey respondents in each population (Lumley, 2010, chapter 1). We generate weighted estimates of the proportion of each

population that matches the demographic characteristics of interest and generate prevalence estimates for well-being outcomes. Prevalence is defined as the proportion of members in a population reporting a given condition, such as general health status or having a specific disease. Prevalence is estimated as the survey-weighted sum of the number of respondents reporting the condition, divided by the estimated total population size. We test for differences between populations using estimated odds ratios derived from a logistic regression model. An odds ratio of 1 indicates that there is no difference in health outcomes between the reference population and the fishing industry population. An odds ratio of much >1 indicates that an outcome is more likely in the fishing industry population. More detail on model specification and interpretation of the coefficients is provided in the Supplementary Material.

Health outcomes in the fishing industry population may be affected by the demographic make-up of the population. For example, if a specific disease is more prevalent among men, a population that is predominantly male may also be more likely to have that disease. As a practical matter, the small number of fishing industry participants in our sample (because the fishing industry is such a small component of the larger economy) makes it difficult to control for demographic confounders directly in logistic regression model without losing statistical power. To better understand any observed differences between fishing industry participants and the reference populations, we estimate the effect of three demographic variables on outcomes in the general working population. As we show, the fishing industry differs from the general working population in its demographic make-up in specific ways (sex, race, and language of the interview). Therefore, if the demographic variables affect the prevalence of health outcomes in the reference population, then the demographic make-up of fishing industry participants is likely to be a reason for any observed differences in health outcomes. As a conceptual matter, we are primarily interested in comparing unadjusted prevalences between populations. Our objective is to estimate well-being within the fishing community and how they compare to society at large. The demographic composition of the fishing community is one of its attributes and removing it may obscure real differences. Our simple, graphic analysis (see Figure 5) helps explain why fishing industry participants may have different outcomes but does not eliminate those differences.

When interpreting our results, we follow Washington State Department of Health guidelines that consider estimates with a relative standard error (standard error/estimate, i.e. the coefficient of variation) of >0.25 to be unstable. We estimate models for each individual question and for each comparison between fishing industry participants. We use the R package *survey* (Lumley, 2019) to carry out the analysis (Lumley, 2010).

Results

Demographic composition of fishing and reference groups

We compare differences in the demographic make-up of fishing industry participants to the two reference groups. Figure 1 shows the estimated percentages and standard errors of each population in specific categories of race, sex, age, military veteran status, education, income, marital status, and number of children. We can assess the magnitude of the differences between fishing industry workers and the two reference populations by comparing the degree of overlap in the standard errors and confidence intervals in Figure 1. Additional details on the results, including significance levels of the odds ratios, are presented as tables in the Supplementary Material. Relative to the general working population, a greater proportion of fishing industry participants are male, non-white, and speak Spanish for the BRFSS interview. Fishing industry participants are also somewhat less likely to be married. Relative to other natural resource industries, fishing industry participants are somewhat more likely to be male but are less likely to be non-white and speak Spanish.

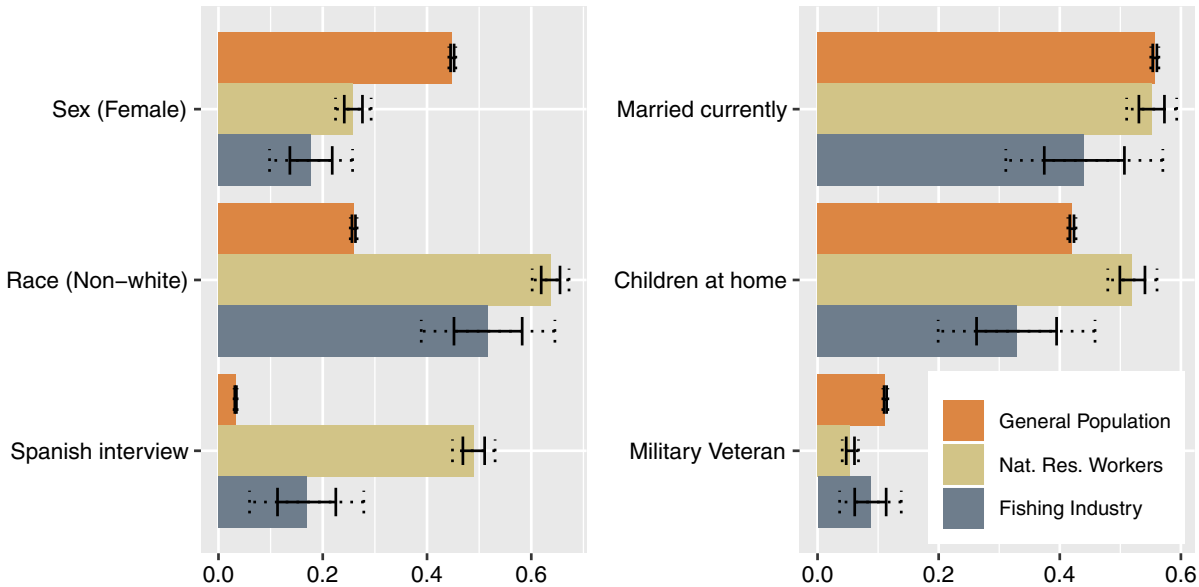

Figure 1. Demographic composition of the fishing industry population and reference populations: estimated proportions (prevalence) of demographic responses. Solid error bars represent 1 standard error; dotted error bars represent 95% confidence interval.

Health outcomes

Figure 2 compares physical health outcomes between the three populations and shows that for many conditions, fishing industry participants report physical health outcomes that are broadly similar to the general working population. However, fishing industry participant participants report worse health outcomes in that they are less likely to self-report as being in "Good" or better health and are somewhat more likely to limit their activities as a result of physical, mental, or emotional problems. Fishing industry participants report a better outcome in that they are less likely to be overweight or obese. Figure 3 indicates that fishing industry participants tend to engage in some potentially unhealthy behaviours at higher rates than both reference populations. In particular, fishing industry participants are much more likely to smoke and use marijuana than either reference group. Fishing industry participants also appear to be somewhat more likely to drink alcohol relative to other natural resource workers and more likely to binge drink than the general working population. Fishing industry participants are more likely to exercise than other natural resource workers, however.

Figure 3 indicates that the prevalence of serious mental illness and depressive disorder is similar across the three populations. Low prevalence estimates contribute to the relative standard error being above the stability threshold for all three mental health outcomes in the fishing industry population.

Figure 4 shows healthcare access outcomes across groups. Fishing industry participants tend to have less favourable healthcare access relative to the general working population, having healthcare coverage at lower rates and being less likely to have a personal doctor. In contrast, fishing industry participants have healthcare coverage at a higher rate than other natural resource workers.

Possible effect of differences in demographic composition

Our results show that some health outcomes for fishing industry participants differ from reference populations. These differences could be due to specific factors that determine health status among fishing industry participants or they could be due to differences in the demographic make-up of each population. Males, non-whites, and Spanish speakers are over-represented among fishing industry participants compared with the general working population (see Figure 1). Figure 5 shows the estimated effect of these demographic variables on the general working population. An estimated odds ratio different than 1 indicates that the demographic variable affects health outcomes and thus could explain part of the observed differences between the fishing industry participants and the general working population.

Fishing industry participants are less likely to report being in "good" or better health and to have had a recent check-up than the general working population Figure 5 suggests that these results may be due to the fact that fishing industry participants are more likely to be male, non-white, and speak Spanish during the BRFSS interview. Each of those three groups is also less likely to be in "good" health and to have had a recent check-up in the reference population (i.e. odds ratios <1). For other outcomes

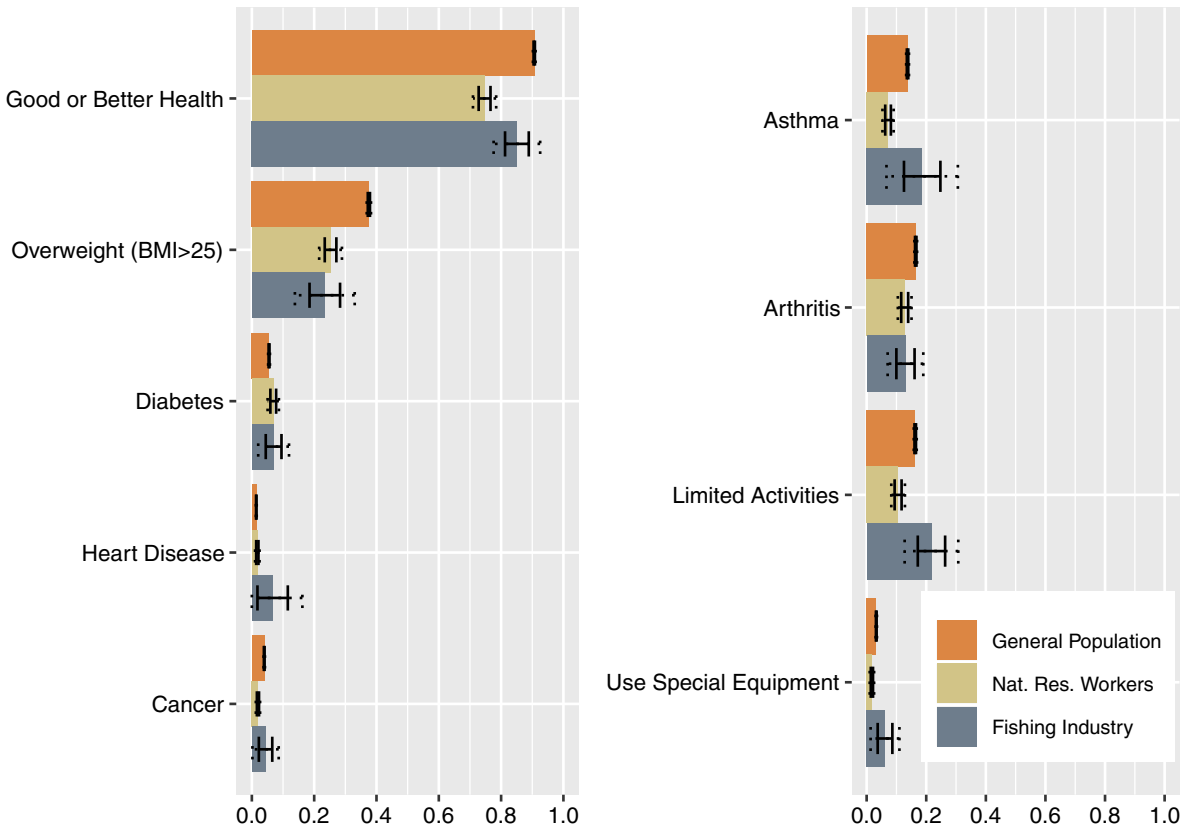

Figure 2. Physical health outcomes: estimated proportions (prevalence) by population. Solid error bars represent 1 standard error; dotted error bars represent 95% confidence interval.

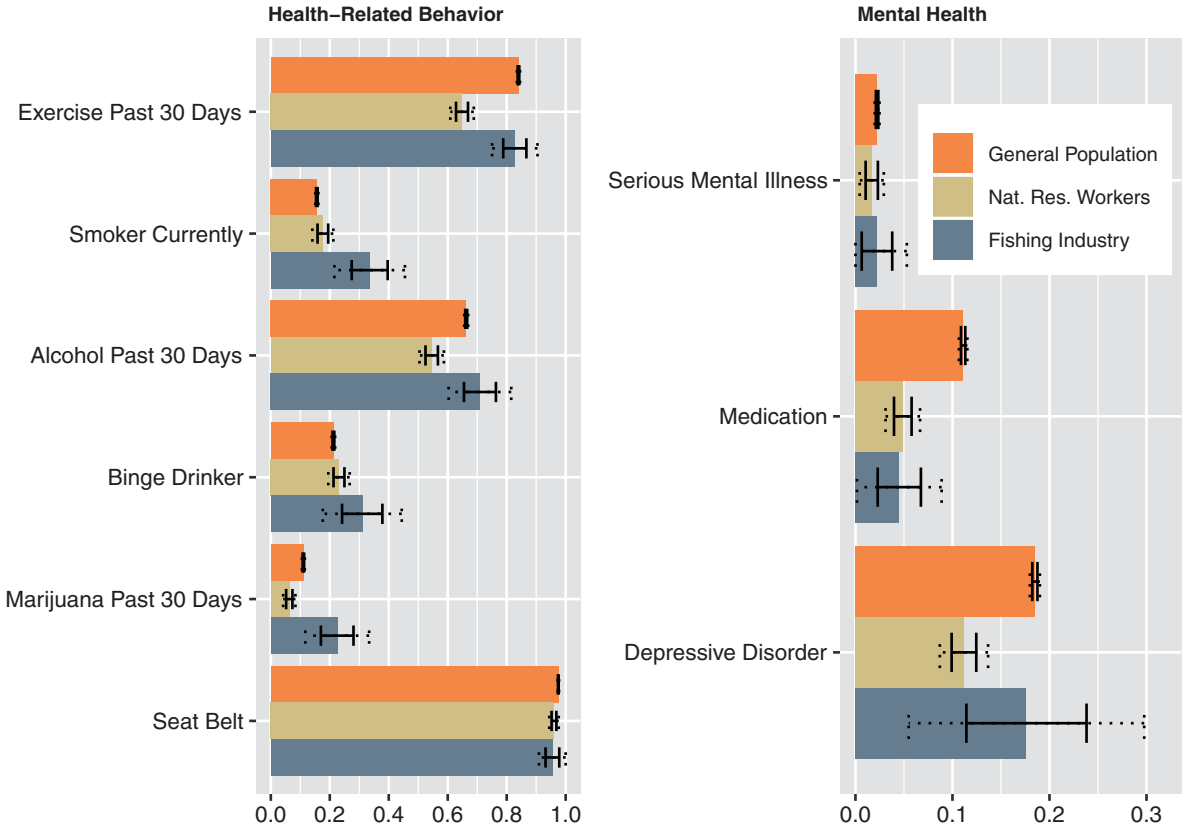

Figure 3. Health-affecting behaviours and mental health outcomes: estimated proportions (prevalence) by population. Solid error bars represent 1 standard error; dotted error bars represent 95% confidence interval.

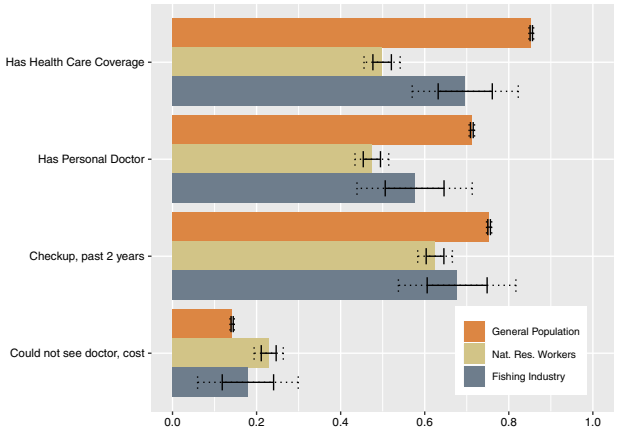

Figure 4. Healthcare access outcomes: estimated proportions (prevalence) by population. Solid error bars represent 1 standard error; dotted error bars represent 95% confidence interval.

where fishing industry participants differ from the general working population, evidence that differences are due to demographic composition is less clear. For example, we estimate that fishing industry participants are much more likely to smoke than the general working population. While this is also true of men in the general working population, non-whites and respondents who spoke Spanish during the BRFSS interview were less likely to smoke. Therefore, the magnitude and direction of demographic effects is unclear in this case.

Discussion

In this article, we estimate the prevalence of physical health outcomes, mental health outcomes, health-affecting behaviours, and healthcare access among fishing industry participants in the state of Washington. The estimated prevalences and comparisons to reference groups are of interest to fisheries managers and show the type of data and analysis that are available in analysing well-being in fishing communities. In addition, we identify at least four notable results on health-related components of well-being in fishing communities.

First, fishing industry workers less frequently report being in "good or better health" than the general working population and are somewhat more likely to be affected by conditions that limit activity. These results are consistent with recent work by Turner *et al.* (2019) , which shows that harvest sector workers report being in "poor general health" and have "limiting long-term illness" at rates that are among the worst of any occupational groups. The finding of limited activity and (to a less conclusive extent) the use of special assistive equipment are consistent with the consequences of fishing and industrial processing work as physically demanding and occurring in noisy environments (e.g. Windle *et al.*, 2008).

Second, we find that fishing industry participants tend to engage in potentially unhealthy behaviour (smoking, marijuana use,

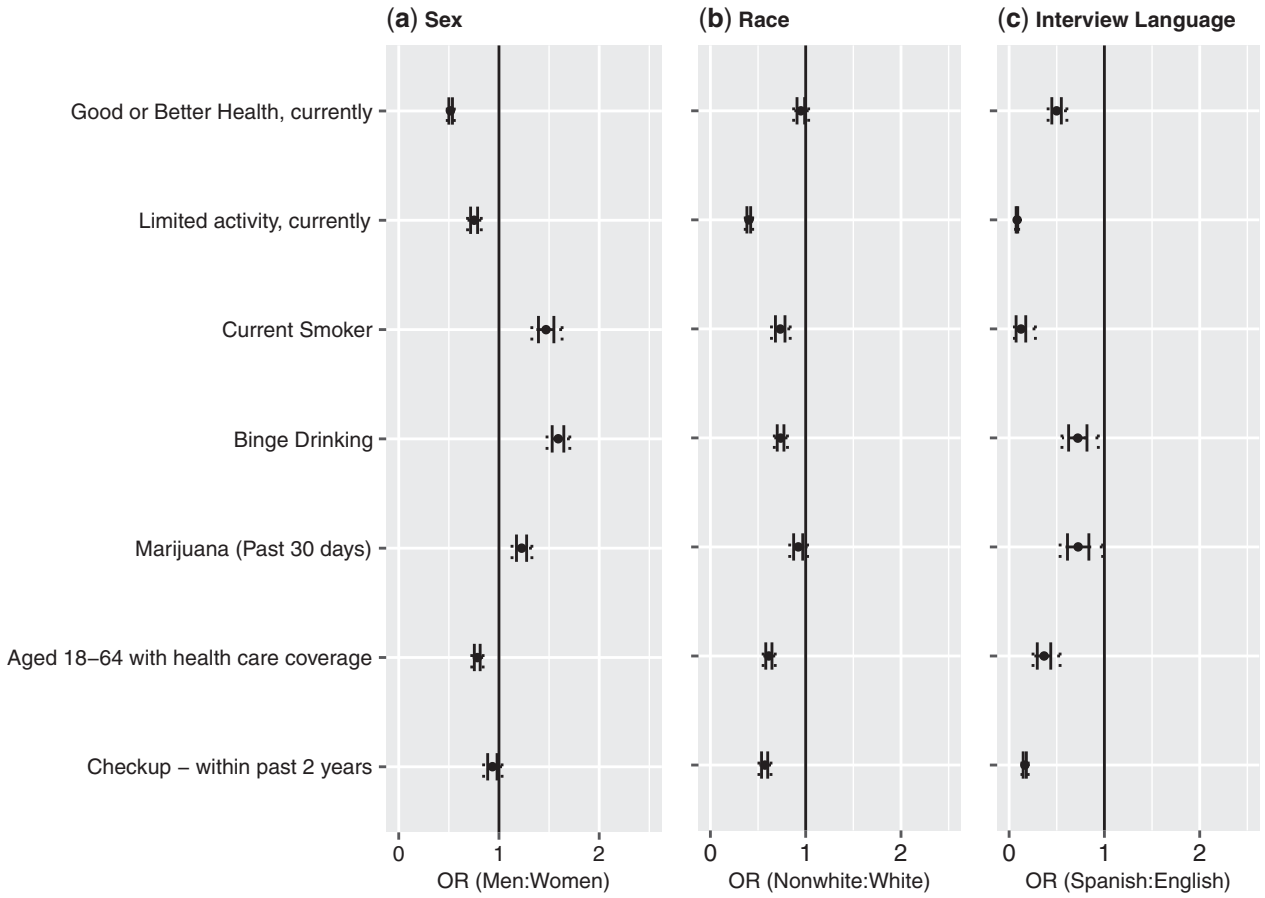

Figure 5. Effect of demographic composition on health outcomes in the general working population. Each point is the odds ratio of the group over-represented in the fishing industry participants population. Solid error bars represent 1 standard error; dotted error bars represent 95% confidence interval.

alcohol use) at higher rates than either reference population. Taken together with previous studies (Lawrie *et al.*, 2004; Fort *et al.*, 2010; Fort *et al.*, 2016; Laraqui *et al.*, 2017), this may indicate that controlled substance use may be an issue of concern for fishing communities and fishing industry participants.

Third, we find that fishing industry participants are covered by health insurance at lower rates than the general working population. Employment structures in the fishing industry (self-employment, contract work, or employment with firms that did not provide health insurance) may be more likely to necessitate workers purchasing relatively expensive individual health insurance if they want coverage. Previous studies have found relatively low rates of health insurance coverage in the fishery harvest sector due to low rates of employer-provided insurance (Crosson, 2016). Other, non-harvest fishing industry sectors, such as processing or wholesaling, may also have similar employment structures. Provisions of the US Affordable Care Act that required individuals to have health insurance and provide subsidies for purchasing health insurance took effect in 2014, the midpoint of our study period. Future work could examine the effect of this law on health outcomes in fishing communities (Crosson, 2016).

Fourth, our study also describes important components of the demographic make-up of fishing industry participants in Washington state. Relative to the general population, fishing industry participants are predominately male and include a greater proportion of non-white people and Spanish speakers. These differences from the general working population are similar in type to other natural resource workers. Some of our observed differences in health outcomes may be due to differences in demographic factors between groups, and we report evidence that this may be the case for self-reported health status and whether respondents have had a check-up recently. The relatively small number (123) of fishing participants in this survey makes it difficult to control for demographics directly. The fishing industry is such as small component of the wider economy that any survey of the general population will have a small sample of these workers. However, our sample is likely representative of our community of practice, as we show by comparing our population estimates with "Fisheries Economics of the United States" estimates, and our observation that the fishing industry is predominately male and that non-white groups are over-represented seems plausible. Therefore, our sample likely does provide an accurate picture of health outcomes in the fishing community.

Fifth, our results provide context for well-being in fishing communities. Human dimensions indicators are used in social impact assessment of management actions, either as outputs of quantitative models or more subjectively when evaluating potential impacts of policy. However, human well-being conditions in

fishing communities are not necessarily fully manageable and are at least partly determined by broader social, economic, political, and institutional forces in a society (Jentoft, 2006; Himes-Cornell and Kasperski, 2016; DePiper *et al.*, 2017). When evaluating the social impacts of fisheries policy, it is important to understand fishing communities within a broader societal context. Our results show that across many health aspects, members of practice-based fishing communities do not differ much from members of other occupational communities. In cases where there are differences, such as in rates of psychoactive substance use and healthcare coverage, it is unclear how much of a role fishery management can play in alleviating community health issues. In such cases, support for sustainable fishing communities may be directed at public health issues rather than providing economic or regulatory assistance directly to the fishing industry.

Our work has some limitations. First, though the BRFSS data specifically targets the health outcomes and occupational fishing community members of interest, we are not able to distinguish between fishing industry sectors (e.g. harvesting, processing) or between geographically defined communities within the larger fishing industry. Health issues may differ between industry sectors due to differing physical or mental demands of specific jobs. Health outcomes could also differ between geographical communities within the larger region either because of differences in fishing and industry condition or because of differing economic and social contexts. Future work using the BRFSS or other general population surveys could perform detailed analysis of respondents' narrative descriptions of their occupation and develop larger sample sizes (e.g. by expanding the geographic area or time periods covered) to study differences at finer definitions of occupation. Also, because the BRFSS is designed to monitor health outcomes at the industry and occupation levels (i.e. workers in the fish harvesting and fish processing/wholesaling sectors), these data cannot distinguish between fisheries. Health impacts could vary across participants in different fisheries. Second, the BRFSS is not designed specifically for fishing communities and, therefore, does not ask detailed questions about injuries and health issues that may be unique to these communities. For example, previous work on occupational injury suggests that musculoskeletal issues may be a common complaint among fishing industry participants (e.g. Eckert *et al.*, 2018). The BRFSS questionnaire limits the coverage of musculo-skeletal issues to more general questions regarding arthritis, limited physical activity, joint pain, and injuries from falls (see the BRFSS questionnaire in the Supplementary Material). The more general questions in the BRFSS survey allow for comparisons with wider populations, however, and fill a gap in the literature on more general health status and issues within fishing communities.

Conclusions

The concept of human well-being in social–ecological systems is broad based and incorporates factors such as health, security, and social relationships. Developing and tracking indicators of all of the components of well-being is expensive, and managers are faced with numerous competing information needs.

Much progress has been made in applying occupational safety data to fisheries, both for analysis and implementing safety-at-sea measures, but little work has used population scale surveys to assess broader measures of human well-being in fishing communities and compare outcomes with wider populations. We have used a novel (to the ecosystem-based management and fisheries literature) data set to estimate these outcomes in fishing industry participants.

Our results on health outcomes, and other similar metrics of human well-being, may not be well-suited for evaluating impacts of fishery-specific, tactical management actions. Many general human health issues may manifest over a long period of time or result from cumulative exposure to specific drivers, and so any response to specific management actions may be difficult to identify. More importantly, human well-being metrics and underlying conditions in fishing communities are at least partly determined by broader social, economic, political, and institutional forces in a society (Jentoft, 2006; Himes-Cornell and Kasperski, 2016; DePiper *et al.*, 2017). However, understanding human health and well-being conditions in fishing communities is important in evaluating strategic management objectives. In an integrated ecosystem management framework, cumulative performance across multiple decisions, plans, fisheries, or jurisdictions can and should be assessed (Stephenson *et al.*, 2018). Indicators of general health status among fishing industry participants are useful in evaluating system-wide sustainability in terms of human well-being objectives. Simply put, if a fishery social–ecological system is functioning well, then it should be that health among fishing community members is about as good as in comparable components in society. Poor health or well-being outcomes indicate a need for change or reorganization of the system and suggest more structural issues (e.g. perennially low incomes, inequality, geographic isolation, demographic changes).

Standardized public health surveys of the general population, such as the BRFSS in the United States, are good sources of information on fishing community well-being in several ways. Because the surveys are designed to characterize more general populations, they allow for comparisons between fishing communities and reference groups. This allows us to identify conditions that are unique to fishing communities. National level surveys also offer the possibility of comparing outcomes between regions, depending on the survey design. Furthermore, as Link *et al.* (2017) note "collecting 'more' of the social and economic data may result in a trade-off relative to biological or ecological data collection." Public health surveys such as the BRFSS are administered routinely by public health agencies. These surveys are therefore a very cost-effective way of obtaining social and economic data, as any additional costs required to use these data for EBFM purposes, including accessing and analysing the data and coordinating with partner agencies, are small relative to conducting specific, one-time surveys of fishing communities. Because these surveys are regularly conducted, time series of health indicators could also be developed. Future work should develop larger sample sizes for more robust analysis. One way to do this is for more public health agencies to ask about occupation in population-wide surveys. For example, more US states could consider adding the standard industry and occupation module to their BRFSS.

Supplementary data

Supplementary material is available at the *ICESJMS* online version of the manuscript.

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