

## Differences in perceptions of COVID-19 risks in a fishing community in Alaska, 2020–2021

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### ABSTRACT

Bristol Bay in Alaska is home to the world's largest commercial salmon fishery. During an average fishing season, the population of the Bristol Bay region more than doubles as thousands of workers from out of state converge on the fishery. In the months leading up to the 2020 commercial fishery opening, as the COVID-19 pandemic exploded worldwide, great uncertainty existed about the health risks of opening the fishery. Bristol Bay residents had not yet experienced any cases of COVID-19, yet the livelihoods of most were closely tied to the commercial fishery opening. To better understand how COVID-19 risk perceptions affected decisions to participate in the fishery, we administered an online survey to community members and fishery participants. We collected standard socioeconomic data and posed questions to gauge risk perceptions related to COVID-19. We find that COVID-19 risk perceptions vary across race/ethnic groups by residency and income. People with below median income who are members of minority groups—notably, non-resident Hispanic workers and resident Alaska Native respondents—reported the highest risk perceptions related to COVID-19. This study highlights the important linkages among risk perceptions, socioeconomic characteristics, and employment decisions during an infectious disease outbreak.

### 1. Introduction

The COVID-19 epidemic altered the social fabric of the world. It is estimated that 18.2 million people worldwide died from the virus between January 1, 2020, and December 31, 2021, with over 1.1 million deaths in the United States alone [1]. In 2020, the global economy contracted by 3.3% [2], and personal consumption spending in the United States fell by 12.6% between February and April 2020 [3].

During this same period, in a relatively isolated corner of Alaska, community members, policymakers, and fishermen debated opening the world's largest commercial sockeye salmon fishery [4]. Opening the fishery would mean welcoming thousands of out-of-state fishing industry workers (permit holders, fishing crew, and processors) into communities that had remained free from COVID-19 cases up to spring 2020, just prior to the start of the commercial fishery [5]. Keeping the fishery closed would likely lead to a significant negative income shock to thousands of households who depend on the commercial fishery, both in

the Bristol Bay region and farther afield. Factoring into this decision were the limited healthcare options in remote communities; the Bristol Bay region has only one major hospital, with 16 beds and two ventilators. The impacts of the 1919 influenza epidemic that devastated the adult Alaska Native population of Bristol Bay villages [6,7] are still felt today, as the epidemic wiped out as many as 40% of the local population at the time, disrupting family structures and cultural practices. The people of Bristol Bay also remember more minor epidemics, such as tuberculosis, that were prevalent in western Alaska until the 1950s [6]. Alaska Native communities suffered from pandemics disproportionately relative to other areas of the United States in terms of per capita mortality, and this factored into local considerations [7].

Despite the uncertainty related to COVID-19, Native and non-Native community organizations - including the Bristol Bay Borough government - supported the State of Alaska's decision to open the fishery. In late spring 2020, shortly after the decision to open the fishery, we administered an online survey to Bristol Bay fishery participants and

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residents to better understand how the perceived risk of COVID-19 influenced decision-making, such as whether to participate in the fishery that season. Our survey included questions about individual and household income and health characteristics, risk perceptions related to COVID-19, and the level of support for the commercial fishery's opening under various mitigation measures. Using these data, we examined how risk perceptions and individual socioeconomic characteristics are associated with an individual's decision to participate in the fishing industry during the first year of the COVID-19 pandemic. We found that risk perceptions are generally higher for Alaska Native residents and for out-of-state processor workers (most of whom are Hispanic), and we found that the highest concerns about severe illness are associated with membership in a racial/ethnic minority and among those with lower perceived job choice, lowest income, and non-resident status.

### 1.1. The Bristol Bay region of Alaska

The Bristol Bay wild commercial sockeye salmon fishery produces more value than any other wild salmon fishery worldwide and does so in just a few weeks during the summer [8]. During that time, wild anadromous sockeye salmon return from the ocean to spawn in the freshwater where they had hatched. The bulk of harvests and related processing occurs in about four intense weeks [9]. As in other fisheries, employees in commercial processing facilities and crew members on small fishing vessels work in close proximity and often in wet and challenging conditions. Consequently, practices to protect workers from COVID-19 that are common in other workplaces—such as social distancing and wearing masks and other personal protective equipment—are not practical in the Bristol Bay fishery. Therefore, in 2020, fishery managers implemented other measures to minimize the possibility of a mass outbreak and to reduce the likelihood of a spread to residents of the Bristol Bay region [10]. The measures included quarantine and mandatory tests before flying to the region, frequent testing upon arrival, quarantine flags, restricted shore access, and isolating processing workers and crew members to designated areas outside communities [4]. Although protective measures were effective in minimizing the likelihood of a large outbreak, individual fishery participants understood that they nevertheless faced a significant likelihood of being infected with COVID-19.

In 2020, about 36 commercial salmon processors and buyers were operating in Bristol Bay [11]. Of these, 26 were shore-based processing facilities [11]. Of those who participate in the Bristol Bay fishery, a large share are seasonal workers from other states and countries. In an average season, there are about 5540 processing workers, only 1.6% of whom are local, and about 10% are Alaska residents [12]. In 2020, there were 4908 processing workers, of whom 0.8% were local, with 6.6% from Alaska [13]. Overall, participation in the fishery decreased considerably in 2020 relative to previous years [14]. Because of international travel restrictions enacted in early 2020, a larger workforce share, compared to an average year, was from other U.S. states to replace the loss of international workers, who make up 25%–35% of the processing workforce in most years [15]. Estimating the number of fishing captains and crew members is made challenging because many are self-employed, however in 2019 it was estimated that 24% of all fishermen (captain and crew) were from Bristol Bay, and 54% were from Alaska [12]. Because of the lower use of international workers in these positions, the percentages for crew and captains were similar in 2020 [16,17].

Commercial fishing in Bristol Bay is capital-intensive. Fishers often have boat payments, which require considerable annual maintenance and equipment upgrades and permit payments that can often cost more than a boat (average permit cost: \$225,000) [18]. During the pandemic, the Paycheck Protection Program (PPP) instituted under the Coronavirus Aid, Relief and Economic Security (CARES) Act required three years of business history. Some captains, especially newer entrants to the fishery, interviewed for this project were unable to provide the

necessary paperwork to secure a PPP loan during the 2020 season and had to rely on earnings to make payments for boats and permits. Nevertheless, even with low projected prices to be paid, many fishers chose to participate in the season. In 2020, 1521 gill nets were fished, slightly down from a previous 5-year average of 1548 permits fished (1605 in 2019). In addition, the average gross for each boat in 2020 was \$113,625, down from a previous 5-year average gross of \$138,092 and a 2019 average gross of \$173,571. The year 2020 saw a major impact on the economic value of fishing because of a large reduction in demand for fish caused by restaurant and port closures. Bristol Bay was also affected by a reduced demand for sportfishing during 2020; throughout Alaska, the decline in sportfishing led to an estimated loss of \$500 million to the Alaskan economy [19].

### 1.2. Socioeconomic factors and the coronavirus pandemic in 2020

With respect to COVID-19, higher-density living conditions, such as those found in close-quarters working environments in the Bristol Bay fishery, and poverty have been identified as risk factors for respiratory infection [20]. Minority populations, including African American and Hispanic, are more likely to live in poorer households [21] and in higher-density living conditions [22]. Recent coronavirus-related studies find that people who are Black or Hispanic have the highest risk factors for serious illness and the highest mortality rates for COVID-19 relative to other ethnic groups [23]. For instance, Karmakar, Lantz, & Tipirneni (2021) found that U.S. counties with higher percentages of racial/ethnic minority populations experienced a higher burden of COVID-19 incidence and mortality—specifically, counties with higher percentages of people identifying as African American, Hispanic or Latinx, American Indian or Alaskan Native (AIAN), and Asian [24]. Similarly, Samuel et al. (2021) reported a higher risk of hospitalization and mortality in counties with a relatively higher proportion of African American and Hispanic residents with less than a high school degree [25]. Studies analyzing individual-level data had similar findings regarding race and ethnicity—that is, minority populations experienced a higher disease burden compared to White populations, and this difference persists after adjusting for area deprivation index [23]. Lo et al. (2021) also found that the risk of contracting COVID-19 was unequally distributed, disproportionately targeting racial and ethnic minority groups. Moreover, lower education and lower income as individual risk factors were also associated with a higher risk of COVID-19 infection [26].

Furthermore, in a systematic review, Khanijahani et al. (2021) found that socioeconomic factors were associated with worse outcomes for COVID-19, noting that “despite the significant incongruity among the studies, most of them showed that racial/ethnic minority groups had higher risks of COVID-19 infection and hospitalization, confirmed diagnosis, and death.” They further noted that “most of the studies cited factors such as low level of education, poverty, poor housing conditions, low household income, speaking in a language other than the national language in a country, and living in overcrowded households as risk factors of COVID-19 incidence/infection, death, and confirmed diagnosis” [27].

Essential workers (including fishermen and processors) tend to be disproportionately ethnic minorities, and they are more likely to work near others, putting them at greater risk of infection and serious illness [28]. During the pandemic, this was particularly true. Aswaf (2022), for instance, noted that the number of Hispanic workers in the farming, fishing, and forestry occupational category (from May 2020 through July 2021) was 134% greater than those in the total workforce and that their odds of teleworking were 85% less than workers in managerial occupations [29]. Similarly, Rogers et al. (2020) highlighted the disparities in the racial composition of essential workers, documenting significantly higher COVID-19 death rates among non-Hispanic Black and Hispanic essential workers relative to non-Hispanic White essential workers. Seafarers in the global fishing industry were particularly

disadvantaged during 2020 and 2021 because of greater restrictions on shore services and limitations on crew changes; in fact, a large number of seafarer crews were reported stranded at sea [30]. Related health information was known to the general public early in the pandemic. National surveys conducted in March 2020 revealed that people who are Black or Hispanic had a stronger perception of COVID-19 as a threat to their health than did people who are White [31].

## 2. Data

Our online Qualtrics surveys were designed in collaboration with local leaders, community members, and commercial fishery participants. The survey was advertised through an established network of residents who could help distribute the survey. In addition, all post boxes in Dillingham received an advertisement with a QR code for the survey. Our local researchers also put up fliers at fishing and processing facilities in Dillingham. This study was deemed exempt from formal Institutional Review Board review by the Office of Research Protections of the Pennsylvania State Universities and the Universities of Alaska Anchorage and Fairbanks.

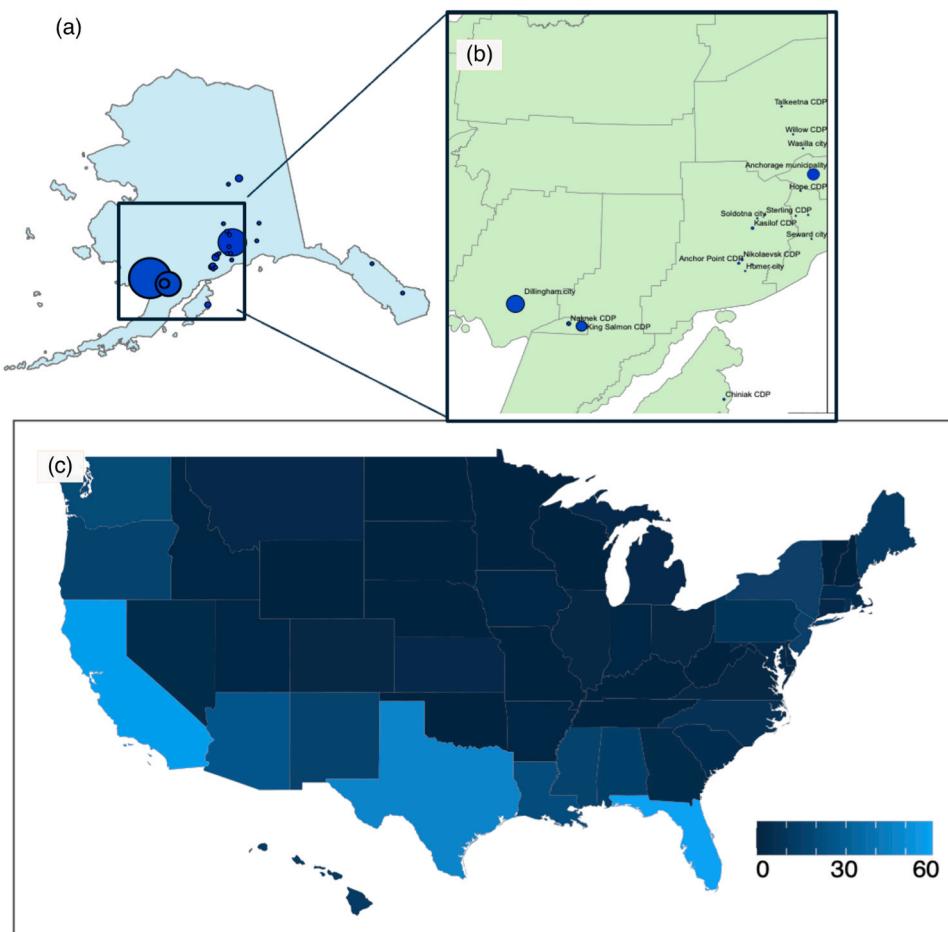
We collected demographic data, including age, gender, income, educational attainment, race, ethnicity, group quarters, and place of residence (including Bristol Bay communities), along with identifying the respondent as a resident or non-resident of Bristol Bay and whether they participated in the fishery (e.g., crew, processor, captain, or permit holder). The survey was conducted from May through July 2020. Survey respondents received a gift card for participation in the survey. The average payment was \$22.06, and payments varied in light of responses

to a risk elicitation question. We checked IP addresses of respondents, eliminated duplicates, and ran other checks for invalid survey responses, such as question response consistency and duplicate payment emails. After eliminating robot and duplicate responses, we had 927 valid responses to the online survey.

Of the survey's 927 respondents, 420 were from the Bristol Bay region. Eighty-seven respondents were from other parts of Alaska, and 420 respondents were from states outside Alaska. No survey respondents listed their home country as being outside the United States in summer 2020. Place of residence of respondents is shown in Fig. 1.

In addition to place of residence, we asked questions related to race/ethnicity, gender, educational attainment, and other personal characteristics. Of survey respondents, 26.1% identified as non-Hispanic White, 10.1% identified as non-Hispanic Black, 15.7% identified as Alaska Native, 48.2% identified as Hispanic, and 73.6% were male. By place of residence, 29% of Bristol Bay residents identified as Hispanic, with 16% of residents from greater Alaska identified as Hispanic, and 74% of out-of-state workers identified as Hispanic. The survey overrepresented Hispanics—in the Bristol Bay Borough and Dillingham Census area population, Hispanic people comprised 3.1% of all Census respondents in 2020 [32]. Regarding educational attainment, 680 respondents had at least a high school diploma, and 296 respondents had an associate's degree or higher.

To investigate concerns related to COVID-19, we also asked respondents to report perceived likelihood and concern about exposure, severe illness, or death. To measure employment opportunities, we asked questions about the potential for other work opportunities and the importance of income from the Bristol Bay fishery to household income:



**Fig. 1.** Place of residence of respondents. Inset (a) shows distribution of residence within Alaska, (b) shows distribution within Bristol Bay, and (c) shows residence by state of non-Alaskan respondents.

- COVID-19 exposure:** On a scale of 0–10, with 0 being unlikely and 10 being highly likely, how likely do you think it is that you or someone else working for the processor or fishing crew will be exposed to COVID-19 during the 2021 commercial fishing season? (asked of captains, crew, and processors)
- COVID-19 infection:** On a scale of 0–10, if someone working for the processor or fishing crew contracts COVID-19, how likely do you think it is that you will contract the virus? (asked of captains, crew, and processors)
- COVID-19 serious illness:** On a scale of 0–10, if you contract COVID-19, how likely do you think it is that you will experience serious health complications? (asked of captains, crew, processors, and all other residents)
- Employment alternatives:** If you didn't work for a Bristol Bay processor (crew), could you have found other employment this summer (Likert-scale response, where 1 = definitely not, and 5 = definitely yes)? (asked of crew and processors)
- Employment earnings:** Compared to other summer employment opportunities, the amount of money you can earn working for a processor in 2021 is ... (Likert scale, where 1 = definitely not as great as other options, and 5 = definitely greater than other options)
- Employment and health:** On a scale of 0–10, where 0 means I don't agree at all, how much do you agree with the following statement? "Coming to work is more important to me than my health." (asked of crew, processors, and all other residents)

**Table 1** presents descriptive statistics for respondents' residence status, income, presence of comorbidity, education level, work status in the fishing industry, gender, and family status. Each characteristic is calculated by race/ethnicity. As indicated in **Table 1**, Hispanic respondents had the lowest percentage of Alaska residence. More than half of the respondents who are White or Black have income greater than the median, with more than half of Alaska Native or Hispanic respondents having below median income.

**Table 2** presents summary statistics about the response to the six outcome variables, by race/ethnicity. Here we see that respondents who are Alaska Native and Hispanic had higher mean responses for concern about severe disease than non-Hispanic White or non-Hispanic Black respondents. Alaska Native and Hispanics also lower average scores for perceived opportunity for other work opportunities outside of fishing than non-Hispanic White or Black respondents did.

**Table 1**  
Demographics and socioeconomic statuses of survey respondents by race/ethnicity.

Variable	Non-Hispanic White	Non-Hispanic Black	Non-Hispanic AIAN <sup>b</sup>	Hispanic	Total
Alaska resident	170 (70.8%)	59 (63.4%)	144 (100%)	131 (29.6%)	504 (54.8%)
Income	175 (> \$67,500)	67 (73.0%)	56 (72.0%)	127 (38.9%)	425 (28.7%)
Comorbidity	26 (26.4%)	4 (4.3%)	16 (11.1%)	39 (8.8%)	85 (9.2%)
Education	214 (> High School)	63 (89.2%)	103 (67.7%)	295 (71.5%)	675 (66.6%)
Work in fishing	201 (83.8%)	89 (95.7%)	119 (82.6%)	439 (99.1%)	848 (92.2%)
Male	181 (75.4%)	60 (64.5%)	76 (52.8%)	350 (79.0%)	667 (72.5%)
Has children	182 (75.8%)	67 (72.0%)	114 (79.2%)	419 (94.6%)	782 (85%)
Total	240 (26.1%)	93 (10.1%)	144 (15.7%)	443 (48.2%)	920 (100%)

<sup>a</sup> American Indian Alaska Native

**Table 2**

Descriptive statistics of outcome variables for regression models by race/ethnicity.

	Non-Hispanic White	Non-Hispanic Black	Non-Hispanic AIAN <sup>a</sup>	Hispanics
Perceived risk of exposure (0-10)	4.6 (1.25) [205]	4.7 (1.46) [89]	5.70 (1.63) [122]	6.01 (1.54) [439]
Perceived risk of disease (0-10)	5.54 (1.61) [205]	6.00 (1.42) [89]	6.52 (1.62) [122]	4.60 (2.51) [439]
Perceived risk of severe disease (0-10)	4.16 (1.98) [232]	3.62 (1.90) [93]	5.16 (2.69) [143]	6.10 (2.04) [442]
Opportunity for other work (1-5)	3.61 (0.77) [185]	3.21 (0.88) [89]	2.63 (0.97) [114]	2.75 (1.16) [412]
Work is good earning opportunity (1-5)	4.2 (0.78) [185]	4.52 (0.83) [89]	4.52 (0.60) [114]	4.33 (0.61) [412]
Values work over health (0-10)	5.95 (2.37) [222]	5.52 (2.07) [92]	4.27 (2.13) [143]	5.04 (1.96) [411]

Notes:

<sup>a</sup> American Indian Alaska Native.

Standard deviations are in (SD). Sample sizes are in [N]. The responses about perception of risk of exposure, risk of disease, risk of severe disease and agreeing with the statement that you value work over health are in a scale of 0–10, with 0 being unlikely, and 10 being highly likely (asked of captains, crew, and processors). The responses about perception of risk of severe disease are in a scale of 0–10, with 0 being unlikely, and 10 being highly likely (asked of captains, crew, and processors). The response about opportunity for other work are on a Likert-scale response where 1 = definitely not, and 5 = definitely yes (asked of crew and processors). The responses about employment alternatives if unable to work in the fishing industry are a Likert-scale response, where 1 = definitely not, and 5 = definitely yes (asked of crew and processors).

### 3. Analysis and results

We used simple ordinary least squares regression analysis with robust standard errors to explore links between risk perceptions and decisions to participate in the fishery. Dependent variables used in the analysis include the three COVID-19 questions related to exposure, infection, and serious illness, along with the three questions related to employment. Regression results are presented in [Tables 3 and 4](#). We begin by discussing relationships between socioeconomic characteristics and COVID-19 risk perceptions ([Table 3](#)) and employment opportunities ([Table 4](#)).

In general, we found that perceived risk of exposure to COVID-19, infection risk, and risk of serious disease ([Table 3](#)) is associated with several factors, including income, race/ethnicity, place of residence, and living with children. Alaska Native and Hispanic respondents consistently expressed greater concerns about exposure risk than non-Hispanic White respondents. Furthermore, respondents with children and relatively lower incomes also indicated relatively greater concern about likelihood of infection, exposure, and serious illness. Respondents with a known comorbidity also indicated a higher concern about risk of serious illness. Gender was not associated with perceived risk of exposure, infection, or severe illness. Across all three categories—perceived risk of exposure, infection, and serious illness—respondents indicating an Alaska residency had a lower perception of risk than those from outside the state. Captains showed a slightly lower concern about being infected if exposed compared to processors. Those working in the fishing industry, whether processor, crew, or captain, indicated a lower perceived risk of severe illness, compared to Bristol Bay residents not directly working in the fishing industry.

In [Table 4](#), we highlight socioeconomic characteristics associated

**Table 3**

Estimated Responses to questions about perceived risk of exposure to COVID-19, risk of infection if exposed, and risk of severe illness if infected among resident community members and resident and non-resident fishing industry workers.

Outcome:	Risk of exposure	Infection, if exposed	Severe symptoms, if infected
Range:	1-10	1-10	1-10
Sample Frame	Captains, Fishers, Processors	Captains, Fishers, Processors	Captains, Fishers, Processors, Residents
N	848	848	910
Constant	4.81 (4.39, 5.22)	5.45 (5.00, 5.90)	6.08 (5.38, 6.79)
> Median income <sup>a</sup>	-1.04 (-1.24, -0.84)	-0.48 (-0.70, -0.26)	-1.93 (-2.20, -1.66)
Race (non-Hispanic White = ref)			
Non-Hispanic Black	0.13 (-0.2, 0.45)	0.49 (0.14, 0.85)	-0.25 (-0.68, 0.18)
AIAN <sup>b</sup>	0.91 (0.59, 1.22)	1.04 (0.70, 1.39)	0.54 (0.14, 0.94)
Hispanic	0.50 (0.26, 0.75)	0.36 (0.10, 0.63)	0.72 (0.39, 1.04)
Do you reside in Alaska	-0.63 (-0.84, -0.42)	-0.78 (-1.01, -0.55)	-0.78 (-1.07, -0.50)
Do you have one or more comorbidity?	-0.41 (-0.77, -0.05)	-0.39 (-0.78, 0.00)	0.96 (0.52, 1.40)
Education Greater than High School	0.08 (-0.12, 0.28)	0.18 (-0.04, 0.4)	0.08 (-0.19, 0.36)
Industry Category			
Resident Processor	(NIU) Reference	(NIU) Reference	Reference -1.87 (-2.43, -1.31)
Crew	0.2 (-0.05, 0.46)	0.22 (-0.06, 0.5)	-2.20 (-2.78, -1.62)
Captain Owner	0.13 (-0.21, 0.47)	-0.40 (-0.77, -0.03)	-1.74 (-2.39, -1.09)
Any Children?	1.28 (1.01, 1.56)	1.06 (0.76, 1.35)	1.94 (1.60, 2.29)
Male (Female reference)	-0.24 (-0.51, 0.04)	-0.11 (-0.41, 0.18)	0.17 (-0.18, 0.52)

Notes:

<sup>a</sup> The median income of \$67,500 was used.

<sup>b</sup> American Indian Alaska Native

Results are on a 0-10 scale with a 95% confidence interval

with employment opportunities. African Americans, Alaska Native, and Hispanic respondents indicated that their alternative employment opportunities (columns 1 and 2) were significantly less than non-Hispanic White respondents did. Similarly, African Americans, Alaska Native, and Hispanic respondents considered personal health to be more important than work, as compared to non-Hispanic Whites. Males expressed higher confidence in finding other work opportunities, and that work was more important than health. All industry categories considered work to be more important than health, compared to non-industry residents. Full results for questions about work are found in **Table 4**.

In **Table 5**, we explored in more detail factors correlated with relatively higher risk perceptions of serious illness, particularly with respect to race and income. We regressed responses to the question about serious illness due to COVID-19 on interaction terms for race/ethnicity and income, stratified by residence and other employment opportunities and report the marginal values for estimates.

We found that non-resident Hispanic respondents (mean 7.23; 95% CI: 7.03, 7.43) and resident Alaska Native respondents (mean 6.00; 95% CI: 5.58, 6.42) making below median income had a greater perception of perceived risk for serious COVID-19 illness compared to all other race/ethnic groups (**Table 5a**). Also, we found that among residents, those below median income had a stronger perception of risk for each category of race/ethnicity compared to residents with above median income.

Similarly, as shown in **Table 5b**, marginal values of risk perceptions are highest for those with few alternative employment opportunities and

**Table 4**

Responses to questions about opportunities for other employment (outside of fishing industry), earning potential of fishing work compared to other possible work, and feelings about whether work is more important than health, among resident community members and resident and non-resident fishing industry workers.

Outcome:	Other employment. (1-5 scale)	Earning opportunity (1-5 Scale)	Work more important to health (1-10 scale)
Range	1-5	1-5	0-10
Sample Frame	Captains, Fishers, Processors (1-5)	Captains, Fishers, Processors (1-5)	Captains, Fishers, Processors, Residents (1-10)
N	799	799	868
Constant	2.88 (2.59, 3.18)	4.49 (4.27, 4.70)	1.54 (0.83, 2.25)
> Median income <sup>a</sup>	0.73 (0.59, 0.88)	0.06 (-0.05, 0.17)	0.99 (0.70, 1.27)
Race (non-Hispanic White = ref)			
Non-Hispanic Black	-0.37 (-0.6, -0.14)	0.30 (0.13, 0.47)	-0.78 (-1.23, -0.33)
AIAN <sup>b</sup>	-0.86 (-1.09, -0.63)	0.44 (0.27, 0.61)	-1.67 (-2.09, -1.26)
Hispanic	-0.33 (-0.51, -0.15)	0.17 (0.04, 0.3)	-0.73 (-1.08, -0.38)
Do you reside in Alaska	0.55 (0.39, 0.7)	-0.19 (-0.31, -0.08)	1.03 (0.72, 1.35)
Do you have one or more comorbidity?	0.48 (0.23, 0.74)	-0.1 (-0.28, 0.09)	0.52 (0.08, 0.97)
Education Greater than High School	-0.10 (-0.24, 0.04)	0.13 (0.02, 0.23)	-0.45 (-0.73, -0.17)
Industry Category			
Resident Processor	(NIU) Reference	(NIU) Reference	Reference
Crew	-0.07 (-0.25, 0.11)	0.03 (-0.10, 0.17)	3.66 (3.11, 4.22)
Captain Owner	-0.24 (-0.54, 0.06)	0.08 (-0.14, 0.30)	3.55 (2.97, 4.13)
Any Children?	-0.32 (-0.51, -0.12)	-0.34 (-0.48, -0.2)	2.41 (1.69, 3.12)
Male (Female reference)	0.26 (0.07, 0.46)	-0.08 (-0.22, 0.07)	0.42 (0.06, 0.78)

Notes:

<sup>a</sup> The median income of \$67,500 was used.

<sup>b</sup> American Indian Alaska Native.

relatively low incomes. Of the low-income/few employment options group, Alaska Native (mean 7.13; 95% CI: 6.79, 7.48) and Hispanic respondents (mean 7.45; 95% CI: 7.28, 7.61) had the highest reported values of perceived risk of serious illness. Results from **Tables 5a** and **5b** are shown in **Fig. 2**. All analyses were conducted in Stata/MP 17.0, using robust standard errors.

#### 4. Conclusions and Discussion

This study centers on the Bristol Bay region of Alaska, home to the world's largest sockeye salmon commercial fishery during the early months of the COVID-19 pandemic. During this time frame, the Bristol Bay borough and Dillingham census area reported only 22 cases of COVID-19 [33], and there were no reports of outbreaks within the community. However, in addition to risks of the impacts of the disease, community members and leaders were concerned about potential underreporting. During that early period of the pandemic, there were no over-the-counter rapid antigen tests, which received an emergency use authorization in December 2020 [34], so underreporting may have been an issue. However, whether by chance or out of the concerns and actions of the community, there were no reports of major outbreaks in the fishing community during the survey period. Our survey of 927 people found that concerns about COVID-19 and the constraints on job choice

**Table 5**Perceived serious health complications if contracted COVID-19<sup>a</sup> by race/ethnicity, residence, income, and employment opportunities.

Income	Non-resident of Alaska				Resident of Alaska				
	Race/Ethnicity	Est	95% low	95% high	Income	Race/Ethnicity	Est	95% low	95% high
Below median income <sup>b</sup>	Non-Hispanic White	3.43	2.47	4.39	Below median income	Non-Hispanic White	5.29	4.70	5.89
	Non-Hispanic Black	4.67	3.43	5.90		Non-Hispanic Black	4.00	2.89	5.11
	Non-Hispanic AIAN <sup>c</sup>	NIU <sup>d</sup>		Above median income	Non-Hispanic AIAN	6.00	5.49	6.51	
	Hispanic	7.23	7.07	7.39	Hispanic	5.06	4.61	5.52	
Above median income	Non-Hispanic White	3.45	2.97	3.92	Non-Hispanic White	4.18	3.84	4.52	
	Non-Hispanic Black	3.00	2.42	3.58	Non-Hispanic Black	3.39	2.94	3.84	
	Non-Hispanic AIAN	NIU <sup>d</sup>			Non-Hispanic AIAN	3.84	3.17	4.51	
	Hispanic	4.51	3.92	5.10	Hispanic	4.20	3.86	4.55	
If not working in Bristol Bay, could you have found other employment? <b>Definitely Not, Probably Not (n = 317)</b>					If not working in Bristol Bay, could you have found other employment? <b>Maybe, Yes, Probably Yes (n = 593)</b>				
Income	Race/ethnicity	Est	95% low	95% high	Income	Race/ethnicity	Est	95% low	95% high
Below median income <sup>b</sup>	Non-Hispanic White	5.00	3.12	6.88	Below median income	Non-Hispanic White	4.64	4.07	5.22
	Non-Hispanic Black	5.92	4.54	7.30		Non-Hispanic Black	3.21	2.41	4.02
	Non-Hispanic AIAN <sup>c</sup>	7.14	6.71	7.57		Non-Hispanic AIAN	4.43	3.60	5.27
	Hispanic	7.45	7.32	7.58		Hispanic	5.45	5.06	5.83
Above median income	Non-Hispanic White	4.36	3.43	5.30	Above median income	Non-Hispanic White	3.94	3.65	4.24
	Non-Hispanic Black	3.33	2.32	4.35		Non-Hispanic Black	3.30	2.90	3.69
	Non-Hispanic AIAN	2.33	1.45	3.22		Non-Hispanic AIAN	4.13	3.38	4.88
	Hispanic	4.00	2.87	5.13		Hispanic	4.37	4.03	4.71

Notes: <sup>a</sup> The survey question is: "On a scale of 0–10, if you contract COVID-19, how likely do you think it is that you will experience serious health complications?" The questions were asked to captains, crew, processors, and residents.

<sup>b</sup>The median income of \$67,500 was used.

<sup>c</sup>American Indian Alaska Native.

<sup>d</sup> No non-Hispanic AIAN respondents resided outside of the state of Alaska.

are associated with residence, income, and race/ethnicity. Overall, non-resident workers who make less than the median income and are members of ethnic minorities (non-Hispanic Black, non-Hispanic AIAN, and Hispanic) had greater concerns about exposure to COVID-19, contracting COVID-19, and suffering severe effects from it. These concerns are consistent with existing research that finds ethnic minority populations are at greater risk of serious illness due to COVID-19. Further, these same racial groups perceived fewer outside employment opportunities or jobs with wages equivalent to jobs in the fishing industry.

Combining these factors, we found that, of all race/ethnic groups, those reporting the highest concern for serious illness were Alaska Native and Hispanic respondents, who also reported relatively low incomes and few outside employment opportunities—that is, lower income, higher-risk people participated in the fishery largely because it was the best income-earning opportunity available. Although fishermen have been known to be less risk-averse than the average person in previous studies in Vietnam [35] and the U.S. state of Maine [36], it seems reasonable to conclude that lower-income respondents who perceived higher-than-average risk of serious illness would have taken other employment opportunities had they been available.

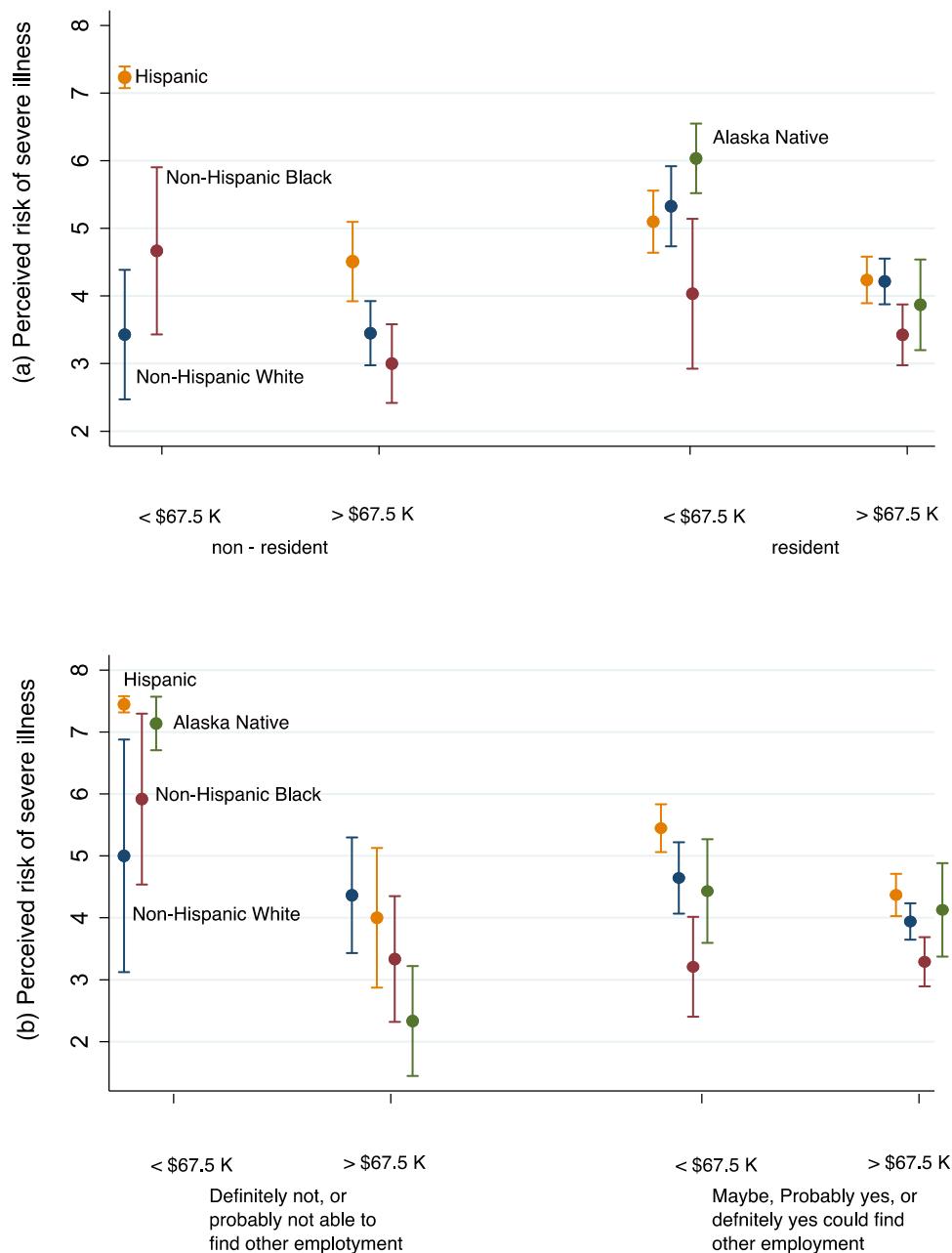
Previous research has found that perception of infection risk and risk of severe outcomes for COVID-19 are higher in people who are Black [37] and people who are Hispanic [38]. Overall, these perceptions align with actual risk; specifically, risk of infection and of ICU admission were higher in people who are Black or Hispanic compared to people who are White [23,39]. Our evidence here suggests that Alaska Native and Hispanic respondents, who generally make less than median income, perceived COVID-19 illness as a serious threat but still chose to work in an environment where the likelihood of exposure to COVID-19 was quite high. Their decisions were driven in large part by income and employment considerations. While COVID-19 cases were generally low during this study, and females were under-sampled, future work using other data sources might further examine the intersection between gender, occupation, and COVID-19 case counts. Additionally, given the importance of this income to seasonal international workers who participate in the fishing industry, future work would benefit by exploring their views on risk and benefits of disease and employment.

The risk perceptions and income needs of fishermen and processor workers in our survey may explain why compliance and support for the 2020 COVID-19 mitigation procedures were so great. Local municipalities, the Bristol Bay Borough, and the State of Alaska implemented the guidelines described in the introduction and, by all accounts, fishermen complied with the mitigation procedures at multiple levels [40]. Indeed, in our survey, satisfaction with the Bristol Bay Borough's mitigation procedures was high, with a mean score of 6.4 on a scale of 0–10 (SD = 1.4), and high marks were given to processors (mean = 6.9; SD = 1.2) and to the State of Alaska (mean = 6.6, SD = 1.3).

This study adds further detail to the research into COVID-19 risk perceptions and associated employment choices among fishermen working in a relatively high-risk industry. This work highlights the necessity for a better understanding of the linkages between risk perceptions during an infectious disease outbreak and employment and income considerations in order to design effective public health policy. These considerations are particularly important when employment opportunities and disease risk vary across factors of race, ethnicity, and income.

#### CRediT authorship contribution statement

**Morrison Luke Smith:** Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Guangqing Chi:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. **Hannah Hennighausen:** Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Davin Holen:** Conceptualization, Data curation, Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. **Howe E Lance:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.



**Fig. 2.** Perceived risks of severe illness by race/ethnicity. Marginal responses for non-Hispanic White, non-Hispanic Black, Alaska Native, and Hispanic to the question “On a scale of 0–10, if you contract COVID-19, how likely do you think it is that you will experience serious health complications?” (a) by residence (Alaska resident versus non-resident) and income (higher or lower than median income of \$67,500) (b) by perceived employment opportunities (definitely not or probably not versus maybe, probably yes, yes) and income.

#### Declaration of Competing Interest

none.

#### Data Availability

The de-identified data are available at <https://doi.org/10.18739/A2Q814T7M>.

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