INTERNATIONAL JOURNAL OF CIRCUMPOLAR HEALTH
2022, VOL. 81, 2021684
https://doi.org/10.1080/22423982.2021.2021684

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Evolving perceptions of COVID-19 vaccines among remote Alaskan communities

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ABSTRACT

Given the dynamic nature of the ongoing pandemic, public knowledge and perceptions about COVID-19 are evolving. Limited transportation options, inconsistent healthcare resources, and lack of water and sanitation infrastructure in many remote Alaskan communities located off the road system have contributed to the experience of the COVID-19 pandemic in these areas. We used longitudinal surveys to evaluate remote Alaskan residents' early vaccine acceptance, vaccine uptake and motivations, risk perceptions regarding COVID-19 vaccines, and likelihood of getting a booster. Slightly over half of respondents showed early vaccine acceptance (November/December 2020), with the highest rate among those over the age of 65 years. However, by March 2021, 80.7% of participants reported receiving the COVID-19 vaccine or planning to get one. Of the unvaccinated, reasons for not getting a vaccine included concerns about side effects and not trusting the vaccine. By September 2021, 88.5% of people had received two doses of a COVID-19 vaccine and 79.7% said they would get the booster (third dose) when it became available. There were misconceptions about vaccine recommendations for pregnant women and effects on fertility and DNA. Although initial vaccine concerns may have subsided, the booster rollout and forthcoming vaccines for youth under 12 years of age present new hurdles for vaccine communication efforts.

ARTICLE HISTORY
Received 9 November 2021
Revised 13 December 2021
Accepted 17 December 2021

KEYWORDS
(3 to 5): rural; alaska; COVID-19; Alaska Native; vaccine

Introduction

Since its emergence in December 2019, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV -2), the causative agent of the respiratory illness known as coronavirus disease 2019 (COVID-19) [1], has spread to nearly every country in the world[2]. Despite the widespread nature of the virus, the experience of the COVID-19 pandemic has varied dramatically, depending on local governmental and public health response, [3–5] household characteristics, [6–9] and personal beliefs and preventative actions [10–12]. In addition, our growing understanding of the virus and its long-term health consequences, shifting prevention guidelines, expansion of vaccination options, and the evolution of the virus and related strains have contributed to the unfolding story of the pandemic. As a result, the public is grappling with a deluge of scientific information, and misinformation, from which they must form their understanding and opinions about how to protect their health and the health of their families [13–16]. Given the dynamic nature of the ongoing pandemic, it is likely that public knowledge and perceptions of the COVID-19 virus, COVID-19 vaccines, and the perceived risk of the two has evolved over the course of the last several months.

Alaska is the largest state in the U.S, (bigger than the next three largest states, Texas, California, and Montana, combined) but has fewer than three times the road miles of Rhode Island, the smallest state in the U.S[17]. The Alaskan road system covers a small portion of the state, connecting major population centres along a central corridor. While over half of Alaskans live in the urban areas of Anchorage, Fairbanks, and Juneau, most Alaskan communities have less than 1,500 people. Nearly 20% of the state population (~131,400, State of Alaska 2019) lives in remote communities off the road system, requiring residents to travel by ferry, plane, or snowmobile to reach outside destinations. Limited road access and inconsistent and often limited healthcare options have been consistent challenges to the distribution of vaccines [18] and ensuring adequate testing and treatment for COVID-19 in many remote Alaskan communities [19,20].

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Lack of water and sanitation infrastructure in these areas has been an additional obstacle to limiting the spread of the virus [21,22].

It is within this context of remote Alaskan communities that we assessed the evolving perceptions of COVID-19 vaccines over the course of ten months during the pandemic (November 2020-September 2021). Local COVID-19 response efforts and public health messaging rely on an accurate and up-to-date understanding of the public's knowledge, attitudes, and practices regarding the virus and preventative practices. We used repeated, longitudinal surveys to evaluate residents' early vaccine acceptance, vaccine uptake and motivations, risk perceptions and knowledge about COVID-19 vaccines, and likelihood of getting a booster vaccine.

Methods

Research context

This work is part of a larger longitudinal study of the impact of COVID-19 on the daily life of people living in remote Alaskan communities. The parent study began in September 2020, five and half months after the Governor of Alaska issued the first COVID-19 health mandate. At the start of the study, we conducted 23 key informant interviews with residents in remote Alaskan communities in leadership positions, who were involved in the COVID-19 response, and/or who could provide a cultural perspective of ongoing events in their community. These conversations, along with consultation of tribal and state representatives involved in Alaska's pandemic response, guided the development of three waves of online surveys for individuals living in remote Alaskan communities. The surveys included questions regarding life changes due to COVID-19, coping strategies, emotions and worries related to the virus, perceived risks, sources of information, vaccine and testing perceptions, and demographic questions regarding age, gender, level of education, household income, occupation, healthcare access, number of people living in the household, and access to water and sanitation services. Here we focus on the evolving perceptions of COVID-19 vaccines between November 2020 and September 2021 including safety, concerns, acceptance, motivations for getting vaccinated, and knowledge regarding the safety of COVID-19 vaccines and the benefits of vaccination in preventing secondary infection.

Study participants

Participants were recruited for the online survey by disseminating a recruitment email via local contacts in remote communities and through a Facebook advertisement targeting people living in remote Alaskan communities and who were 18 years of age or older [23,24]. Participants could optionally provide contact information if they wanted to be included in a $75 gift card drawing for participant compensation, and/or wanted to participate in a follow-up interview. Using the participant ZIP code, we limited responses to those from remote communities located off the road system (but including those on the marine highway system). We also excluded responses from Juneau because while located off the road system, this is a large community (pop. 32,200) with more healthcare and travel resources when compared to other remote Alaskan communities. Respondents had to be at least 18 years of age and were asked to provide written, informed consent about the survey and project before they could access the survey. This study was approved by the Alaska Area IRB (Protocol #1,590,924-7) and the Alaska Native Tribal Health Consortium Health Research Review Committee, and the Southcentral Foundation Review Committee (concept review).

Data collection

Data were collected via three survey waves. Wave 1: November 9 through 15 December 2020; Wave 2: March 9 to 25 March 2021; Wave 3: September 2–27) (Figure 1). Questions on each survey regarding vaccine perceptions were developed within the context of the unfolding pandemic and focused on current questions in the public health community at the time of each survey.

In the first survey wave, which was conducted prior to approval of a COVID-19 vaccine in the U.S., we asked participants to respond to a series of five questions about the likelihood of accepting a COVID vaccine ("If a COVID vaccine were available, would you get a vaccine for [yourself, your children,]?" and "If a COVID vaccine were available, would you encourage [your parents or older family members, other family members, friends] to get the vaccine?"). Responses were recorded on a five-point Likert scale ("Definitely", "Probably", "Maybe/Not sure", "Probably not", "Definitely not"). We also asked an open-ended question about vaccine concerns ("Do you have any concerns about getting a COVID vaccine for yourself or your family members? If so, what are they?").

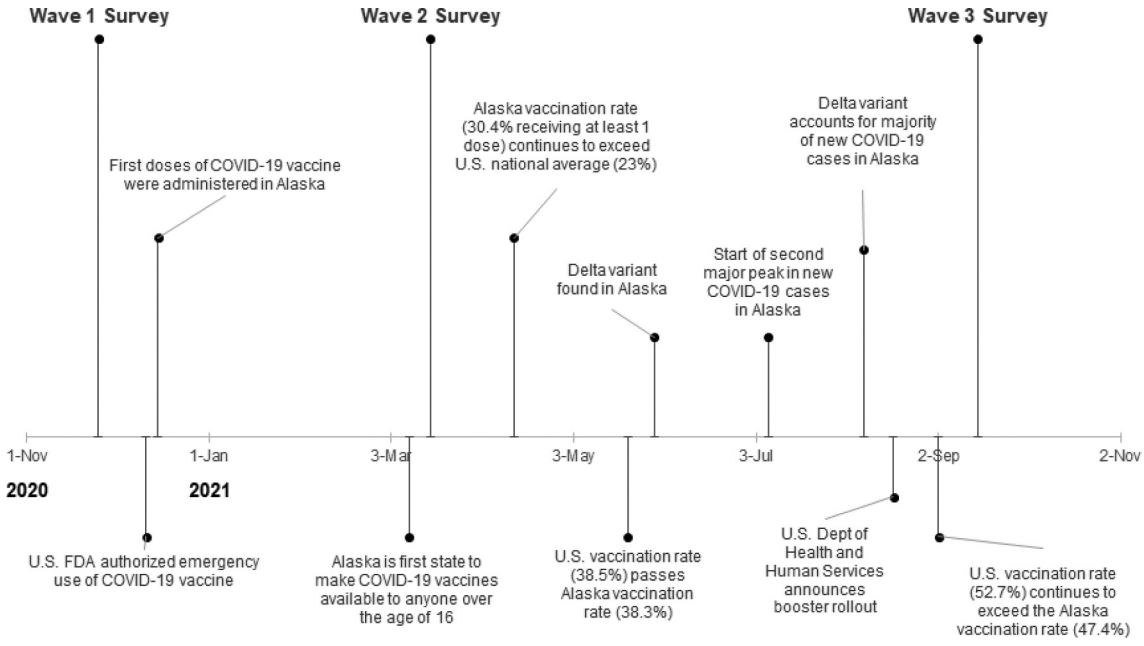

Figure 1. Timeline of study survey waves and major COVID-19 related events in Alaska [48–51].

In the second survey wave, when vaccine distribution in Alaska was well underway in remote communities, we asked whether respondents had received a COVID-19 vaccine, and how easy they found the process of getting a vaccine. Of the people who had received at least one dose of vaccine, we asked what motivated them most to get vaccinated. We also asked respondents who said they did not plan to get vaccinated why this was the case.

In the third survey wave, when the COVID-19 delta variant had become the dominate strain both nationally and within Alaska and after the U.S. Department of Health and Human Services had recommended boosters for all vaccinated people, we focused on risk perceptions and knowledge of COVID-19 vaccines, and the likelihood of getting a booster vaccine using similar language to the first survey. Study data were collected and managed using REDCap electronic data capture tools hosted at the University of Alaska Anchorage[25].

Analysis

We developed post-stratification rates to correct for response bias in this nonprobability-based sample. We utilised population data from the Alaska Department of Labour and Workforce Development that included census-based estimates of population by borough, stratified by age, sex, and race to construct post-stratification weights to statistically adjust survey responses to more closely match the distribution of the population living in remote Alaskan boroughs.

Vaccine acceptance responses were collapsed into three categories for descriptive analysis: "Definitely/Probably yes", "Maybe/Not sure", and "Probably/Definitely not"). Age was categorised into the following groups: 18–24, 25–54, 55–64 and 65 years or older. All other demographic questions were collected using predefined multiple-choice options. Responses to the series of 28 "yes/no" questions related to COVID-19 impacts on household activities were used to create a "COVID impact" score by summing the number of questions where participants responded that their household had been affected. Using tertiles of the continuous COVID impact scores in the dataset, we categorised the scores into "low", "medium", and "high" impact.

We tested the association between demographic or COVID-related variables in the dataset and the participant's response to the likelihood of getting a COVID-19 vaccine using a Rao-Scott Chi-Square test[26]. For significant results, we conducted post hoc, pairwise comparisons when demographic variables include more than two categories. We tested associations with age, sex, annual household income, education, race, whether someone in the household had a COVID-19 infection, and having a "high" COVID impact score. Data were analysed in SAS, Version 9.4 (SAS Institute Inc., Cary, NC).

The open-ended survey questions about vaccine concerns were coded using inductive analysis, with codes originating from the data itself. Discrete themes were identified through an iterative process of refining categories, which was used to create a codebook[27].

The codebook was then used to code all responses to the open-ended questions.

Results

Description of sample population

We collected 1,020 survey responses (Wave 1 (W1): n = 107; Wave 2 (W2): n = 508; Wave 3 (W3): n = 405) from 114 unique remote Alaskan communities off the road system (W1: 34 communities; W2: 106 communities; W3: 92 communities) (Table 1, Figure 2). Most participants were female (W1: Male = 18.7%, n = 20 Female = 81.3%, n = 87; W2: Male = 23.8%, n = 121, Female = 76.2%, n = 387; W3: Male = 30.1%, n = 122, Female = 69.9%, n = 283), and the mean age of respondents was 43.2 years (SD = 14.0) in Wave 1, 44.5 (SD = 14.8) in Wave 2, and 43.3 (SD = 15.3) in Wave 3. Approximately half of respondents to Wave 1 were Alaska Native people (48.6%, n = 52), and over half of respondents to the subsequent surveys were Alaskan Native people (W2: 61.8%, n = 314; W3: 59.8%, n = 242). Overall, our unweighted survey samples overrepresented females, 25–54 year olds, and Alaska Native people compared with the census-based estimates of age, sex, and race in remote Alaskan communities.

Moving forward, weighted results are presented in the text, and unweighted demographic variables are included in Table 1 for comparison. The proportion of respondents working full-time was slightly lower in Wave 2 (53.3%) and Wave 3 (50.6%) compared to Wave 1 (61.2%). The proportion of respondents who were unemployed (not due to COVID-19) increased from 2.2% in Wave 1 to 10.1% in Wave 2, and then decreased slightly in Wave 3 (6.0%). Less than 3% of respondents across all survey waves live in a community without access to a hospital, health centre, or community health aid clinic. Between 27.8 and 35.7% of participants reported that they did not have a room in their home where they could isolate a family member who had been exposed or had tested positive for COVID-19. Most participants live in a home with a flushing toilet (76.9–92.6%) and functional piped water (72.1–75.5%). Most participants were able to consistently get water from their primary source in the prior month (77.3–90.6%), but between 9.4–22.6% reported at least one day in the prior month that they could not get water from their primary source because it was closed, shut down, or disconnected. Between 1.9–3.0% of participants reported lack of water access for more than 10 days in the prior month. The majority of participants reported having a good internet connection, "all" or "some" of the time for all their household needs (84.6–94.3%).

Wave 1 survey: early COVID-19 vaccine perceptions

When asked in Wave 1 (before there was an approved COVID-19 vaccine in the U.S.), "If a COVID vaccine were available, would you get a vaccine for [yourself, your children] or encourage [your parents, other family members, or your friends] to get the vaccine", over half of respondents gave positive responses ("Definitely/Probably Yes") for all groups except when asked about giving the vaccine to their children (Figure 3). Approximately 46% said they would "definitely" or "probably" get a vaccine for their children. A slightly larger proportion of respondents said they would "definitely" or "probably" encourage their parents to get the vaccine (60.2%) compared to getting it for themselves (55.9%) or encouraging other family members (55.4%) or friends (53.8%) to get it.

Between 30–37% respondents expressed uncertainty ("maybe/not sure") about whether they would get a vaccine for themselves (30.7%) or children (37.3%) or encourage their parents (30.1%), other family members (35.0%), or friends (35.9%) to get the vaccine. Less than 17% of respondents said they would "probably not" or "definitely not" get a vaccine for their children. The proportion of participants giving this negative response fell to 13.5% when asked about getting a vaccine for themselves and was 10% when asked about encouraging a vaccine for their parents, other family members, and friends.

In univariate analyses of associations between demographic factors (age, sex, race, education, and income) and their likelihood of vaccine acceptance, participant responses only varied significantly by age (Table 2, other results not shown). Respondents over the age of 65 years were more likely to respond that they would get the vaccine for themselves or their children and that they would encourage their parents, other family members, or friends to get the vaccine. Vaccine acceptance did not vary significantly by any other age group.

Vaccine acceptance did not vary significantly by the impact of COVID-19 on a household (measured through our COVID-19 impact score). We found that participants who had a previous COVID-19 infection in their households were more likely to respond that they would "definitely yes" or "probably yes" encourage their parents to get a vaccine than participants who had not had a COVID-19 infection in their household ($X^2(1, N = 98) = 10.6$, $p = 0.001$). This variation was not significant when asked about getting a vaccine for yourself or your children or encouraging other family members or friends to get the vaccine.

When asked, "Do you have any concerns about getting a COVID vaccine for yourself or your family

Table 1. Demographic characteristics of survey respondents.

	Weighting variables	Survey 1 (n = 107)			Survey 2 (n = 508)			Survey 3 (n = 405)		
Sex	Proportion in remote Alaskan communities	No. of subjects in sample	Unweighted proportion	Weighted proportion	No. of subjects in sample	Unweighted proportion	Weighted proportion	No. of subjects in sample	Unweighted proportion	Weighted proportion
Male	54.3	20	18.7	48.0	121	23.8	53.5	122	30.1	53.0
Female	45.7	87	81.3	52.0	387	76.2	46.5	283	69.9	47.0
Age										
18–24	11.5	8	7.5	5.4	41	8.1	10.7	40	9.9	10.6
25–54	53.8	75	70.1	60.8	324	63.8	56.5	257	63.5	57.4
55–64	19.0	14	13.1	16.9	89	17.5	18.2	62	15.3	17.2
65+	15.7	10	9.3	16.9	54	10.6	14.6	46	11.4	14.8
Race										
African American	1.7	1	0.9	0.1	6	1.2	1.4	7	1.7	1.3
Alaska Native	41.8	52	48.6	42.6	314	61.8	43.4	242	59.8	44.1
Asian	8.6	2	1.9	4.1	10	2.0	6.4	6	1.5	5.0
White	42.0	43	40.2	49.3	128	25.2	43.5	119	29.4	44.2
Latino	4.5	0	0.0	0.0	1	0.2	1.2	1	0.3	1.2
More than one	5.3	9	8.4	3.9	49	9.6	4.1	30	7.4	4.2
Education										
8th grade or less	–	0	0.0	0.0	1	0.2	0.3	1	0.3	0.4
Did not finish high school	–	2	1.9	1.0	17	3.3	2.9	20	5.0	5.4
High school or GED	–	10	9.3	16.3	143	28.1	23.0	136	33.7	28.9
Some college, Associate's, or vocational program	–	55	51.4	45.5	216	42.5	40.9	149	36.9	32.5
College degree, post-graduate, or professional school	–	40	37.4	37.3	131	25.8	32.8	98	24.3	32.9
Missing	–	–	–	–	–	–	–	*1*	*0.2*	*0.3*
Annual Income										
< $10,000	–	6	5.6	2.6	76	15.0	11.7	60	15.0	11.8
$10,000-$29,999	–	15	14.0	14.6	122	24.0	27.4	78	19.5	18.5
$30,000-$49,999	–	21	19.6	16.3	76	15.0	10.8	99	24.7	26.7
$50,000-$69,999	–	18	16.8	17.3	82	16.1	14.1	57	14.2	12.5
$70,000-$89,999	–	14	13.1	13.0	55	10.8	11.9	41	10.2	10.8
$90,000 and over	–	31	29.0	33.7	90	17.7	23.0	66	16.5	19.7
Missing	–	*2*	*1.9*	*2.4*	*7*	*1.4*	*1.0*	*4*	*1.0*	*1.1*
Employment										
Working (full-time, year-round)	–	68	63.6	61.2	251	49.4	53.3	199	49.5	50.6
Working (part-time, year-round)	–	17	15.9	14.2	63	12.4	8.2	57	14.2	13.4
Seasonal employment	–	4	3.7	3.2	21	4.1	6.4	23	5.7	7.1
Unemployed (not due to COVID-19)	–	4	3.7	2.2	65	12.8	10.1	33	8.2	6.0
Laid off or looking for work due to COVID-19	–	1	0.9	0.5	25	4.9	3.7	22	5.5	6.0
Unable to work due to disability	–	1	0.9	0.6	11	2.2	4.6	17	4.2	4.2
Homemaker	–	2	1.9	0.8	21	4.1	2.9	15	3.7	2.1
Retired	–	9	8.4	16.6	42	8.3	9.1	30	7.5	10.0
Student	–	1	0.9	0.7	9	1.8	1.7	6	1.5	0.8
Missing		–	–	–	–	–	–	*3*	*0.7*	*0.8*
Healthcare Access*										
Hospital	–	58	54.2	51.1	191	37.6	46.1	139	34.6	39.3
Health centre	–	36	33.6	32.9	132	26.0	31.5	128	31.8	40.3
Community health aid clinic	–	48	44.9	51.9	301	59.3	55.1	250	62.2	60.5

(*Continued*)

Table 1. (Continued).

	Weighting variables	Survey 1 (n = 107)			Survey 2 (n = 508)			Survey 3 (n = 405)		
None of the above	–	3	2.8	1.9	12	2.4	3.0	10	2.5	2.4
Isolation Room in Home										
Yes	–	74	69.2	71.2	306	60.2	61.5	242	61.0	64.3
No	–	31	29.0	27.9	184	36.2	35.5	155	39.0	35.7
Missing	–	*2*	*1.9*	*2.4*	*18*	*3.5*	*3.1*	*8*	*2.0*	*2.2*
Sewer service										
Flushing toilet	–	98	91.6	92.6	419	82.5	85.5	315	79.0	76.9
PASS**	–	1	0.9	0.7	2	0.4	0.4	17	4.3	5.3
Honey bucket	–	6	5.6	5.9	56	11.0	8.1	46	11.5	11.9
Outhouse	–	0	0.0	0.0	13	2.6	3.2	16	4.0	5.0
Other***	–	1	0.9	1.2	0	0	0	5	1.3	0.9
Missing	–	*1*	*0.9*	*0.6*	*18*	*3.5*	*3.1*	*6*	*1.5*	*1.7*
Water service										
I haul my own water	–	9	8.4	7.7	69	13.6	11.4	54	13.5	13.4
Piped water, connected and working	–	86	80.4	75.5	367	72.2	74.7	302	75.3	72.1
Piped water, disconnected and/or not working	–	2	1.9	4.1	10	2.0	1.2	10	2.5	2.6
Truck haul delivery	–	8	7.5	11.5	30	5.9	7.1	28	7.0	9.9
Other****	–	1	0.9	1.0	14	2.8	2.1	7	1.8	2.0
Missing	–	*1*	*0.9*	*1.2*	*18*	*3.5*	*3.5*	*4*	*1.0*	*1.1*

*Participants could select more than one response.
**Portable Alternative Sanitation System (PASS) is a stand-alone water and sewer unit designed for remote Arctic communities.
***__Survey 1__: 1 participant reported having a toilet that requires hauling water to flush.
****Several participants reported getting water from an underground spring/cistern, rain water catchment, a well, bottled water, or mountain water but did not specify if they haul it or if it is piped to their home.

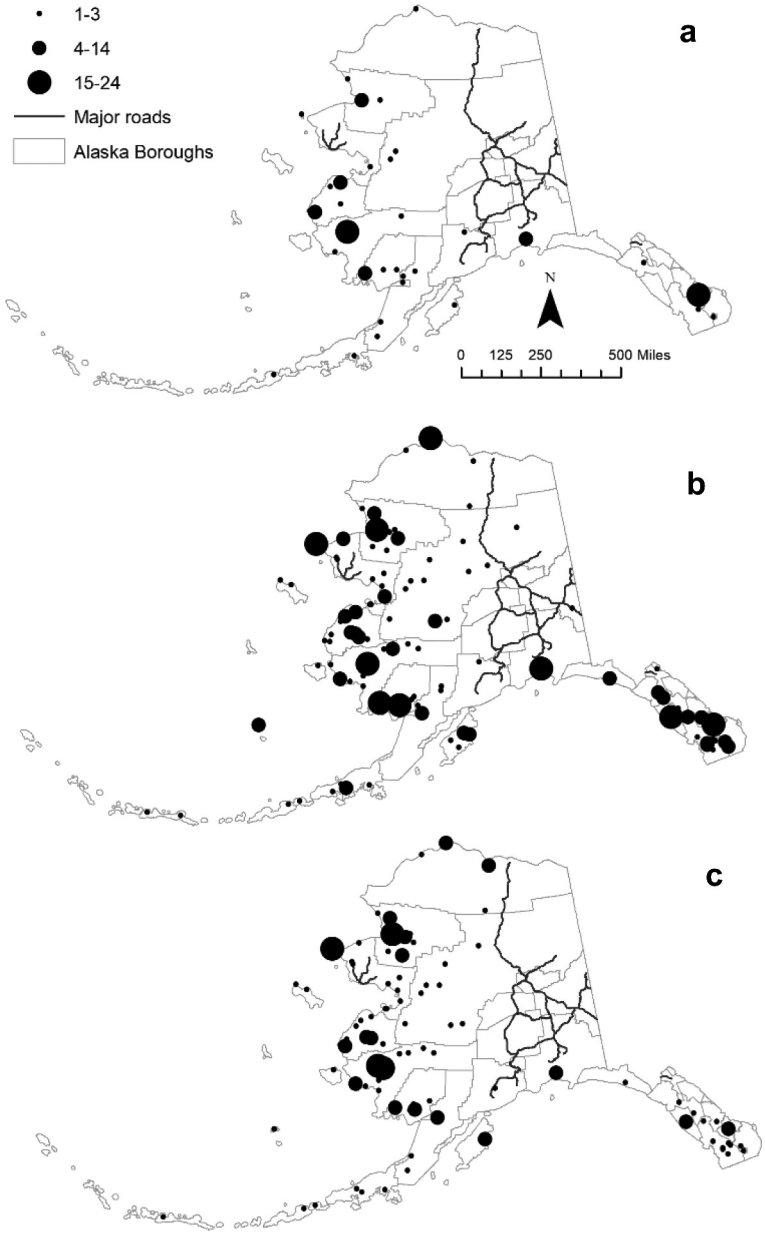

Figure 2. Map of the number of survey respondents by ZIP code. A) Wave 1 (Nov-Dec 2020), B) Wave 2 (March 2021), and C) Wave 3 (Sept 2021).

members? If so, what are they?" more than one third of participants (34.5%, n = 39) did not provide an answer to this open-ended question, and 8.8% (n = 10) stated that they had no concerns about a COVID-19 vaccine. Of the 58 participants who described concerns about the COVID-19 vaccine, the most cited concern was safety (33.6% of all concerns mentioned) (Table 3). Safety concerns reported by participants included possible unknown side effects, a perceived lack of sufficient testing of the vaccine, and rushed production. Other participants cited concerns about vaccine efficacy (8.8% of concerns mentioned), including lack of testing and rushed production that limited the time for drug trials. In addition to concerns about the vaccine itself, participants discussed concerns related to the distribution logistics and political or outsider involvement in the vaccine distribution. Some participants cited lack of trust in politicians or more generally, of the vaccine distribution process. Others were concerned that there might not be fair and efficient distribution of the vaccine to remote Alaskan communities. Unwillingness to get any vaccine was only mentioned twice.

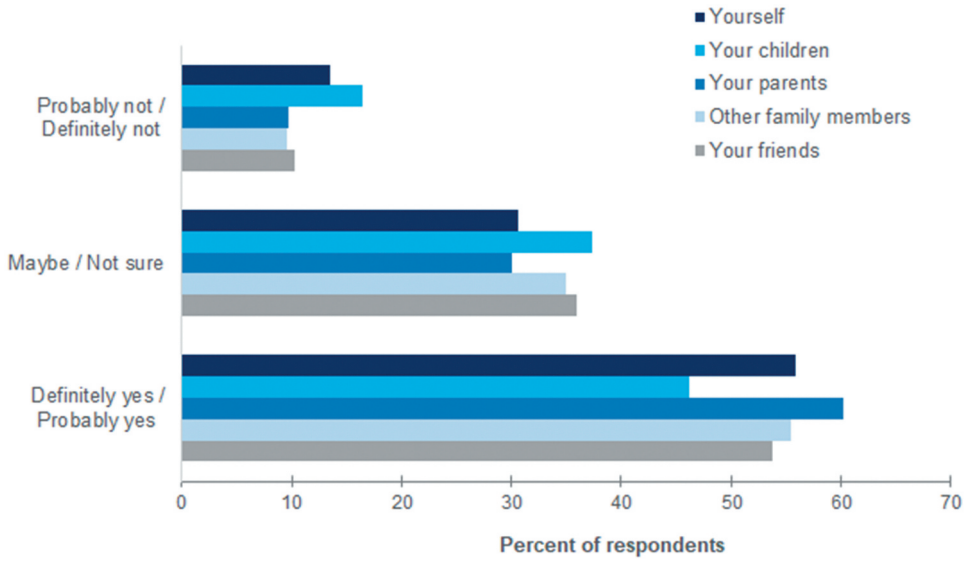

Figure 3. Likelihood of getting a COVID-19 vaccine for yourself or your children, or encouraging your parents, other family members, and friends to get it (Wave 1).

Table 2. Weighted Rao-Scott Chi-square for vaccine acceptance for yourself, your children, your parents, other family members, and your friends by age of respondent (Wave 1).

Age	Yourself	Your children	Your parents	Other family members	Your friends
18–24 (ref)	–	–	–	–	–
25–54	$X^{[2]}$ (2, N = 107) = 3.3, p = 0.19	$X^{[2]}$ (2, N = 94) = 2.4, p = 0.30	$X^{[2]}$ (2, N = 106) = 1.0, p = 0.60	$X^{[2]}$ (2, N = 107) = 2.8, p = 0.25	$X^{[2]}$ (2, N = 105) = 4.3, p = 0.12
55–64	$X^{[2]}$ (2, N = 107) = 1.1, p = 0.57	$X^{[2]}$ (2, N = 94) = 2.3, p = 0.32	$X^{[2]}$ (2, N = 106) = 2.9, p = 0.24	$X^{[2]}$ (2, N = 107) = 0.77, p = 0.68	$X^{[2]}$ (2, N = 105) = 0.93, p = 0.63
65+	**$X^{[2]}$ (2, N = 107) = 87.6, p < 0.0001**	**$X^{[2]}$ (2, N = 94) = 118.8, p < 0.0001**	**$X^{[2]}$ (2, N = 106) = 41.5, p < 0.0001**	**$X^{[2]}$ (2, N = 107) = 76.9, p < 0.0001**	**$X^{[2]}$ (2, N = 105) = 123.3, p < 0.0001**

Wave 2 survey: COVID-19 vaccine Rollout

By March 2021, 80.7% of participants in Wave 2 reported that they either had received at least one dose of the COVID-19 vaccine (75.7%) or planned to get vaccine if they had not already (5.0%). Approximately 7% of people said they were unsure if they would get a vaccine, and 7.9% said they were not planning to get a vaccine. Of the people who had received at least one dose of COVID-19 vaccine, 93.9% said it was very or somewhat easy to get a vaccine. In contrast, of the small number of people who had not received a vaccine but planned to get one, only 48.3% said it would be very or somewhat easy to get a vaccine, and 45.7% said it would be somewhat or very difficult. Reasons cited for difficulty getting a vaccine included having to travel too far, not knowing where to get a vaccine, not being eligible, or not knowing where to make an appointment.

Of the people who had received at least one dose of COVID-19 vaccine, the majority said they were most motivated to get vaccinated to protect their health (36.5% of participants) or the health of their friends and family (34.2%). Other participants reported their primary motivation for getting vaccinated was to protect the health of their community (12.9%), to resume travelling (6.2%), to resume social activities (4.0%), encouragement from others (2.2%), to get back to school/work (1.6%), or to protect the health of co-workers (1.4%).

Of the 7.5% of respondents who said they would not get a vaccine, there were several reasons for their hesitancy (respondents could select more than one reason). Most commonly, participants said that they did not believe that they need a COVID-19 vaccine (17% of responses), that they were concerned about the side effects (13.3% of responses), or that they did not trust the COVID-19 vaccine (10.5% of responses). Others reported that did not trust the people distributing the vaccines (7.1% of responses), or that they wanted to wait to see if it was safe and maybe get it later (5.3% of responses). Less than 5% of the responses regarding reasons participants were avoiding the vaccine included

Table 3. Major themes and sub-themes of responses to an open-ended question about concerns regarding getting a COVID-19 vaccine for yourself or your family members (Wave 1).

Theme/Sub-Theme	Count	% of Responses
SAFETY	**38**	**33.6**
Unknown side effects	23	20.4
Lack of testing	8	7.1
Rushed production	2	1.8
Safety (unspecified)	5	4.4
EFFICACY	**10**	**8.8**
Lack of testing	4	3.5
Rushed production	1	0.9
Efficacy (unspecified)	4	3.5
LACK OF TRUST	**7**	**6.2**
Lack of trust in politicians	4	3.5
Lack of trust in outsider involvement	1	0.9
Lack of trust (unspecified)	2	1.8
DISTRIBUTION	**7**	**6.2**
Remote Alaska	3	2.7
Under 18 years	2	1.8
Distribution (unspecified)	2	1.8
STAND-ALONE THEMES	-	-
Rushed production (unspecified)	3	2.7
Want to see how it goes first	3	2.7
No vaccines	2	1.8
Personal Health Condition	1	0.9
Miscellaneous	1	0.9

not liking any vaccine (2.9%), concern about the cost of the vaccine (2.3%), belief that other people needed it more (2.9), or not knowing if it would work (1.2%).

Wave 3 survey: COVID-19 and COVID-19 vaccine knowledge, attitudes, and practices

In September 2021, much of the conversation about COVID-19 had shifted to vaccine acceptance and strategies to increase vaccination rates. Part of these efforts included understanding misconceptions about the COVID-19 vaccine. In Wave 3, 82.9% of participants incorrectly stated that the "COVID-19 vaccine is not recommended if you're young and healthy" (Table 4). The second most common misconception was regarding vaccine recommendations for those who are pregnant, with 22.8% of participants saying that it is not recommended and 26.5% saying that were unsure about the recommendations. Almost one-third of participants (28.1%) were not sure if COVID-19 vaccines affect fertility, and 19.2% were not sure if the vaccine affect your DNA.

Table 4. Participant responses to true/false question about COVID-19 vaccines (Wave 3).

Question	% Incorrect Response	Not sure
The COVID-19 vaccine is not recommended if you're young and healthy	82.9	9.8
COVID-19 vaccines are recommended for pregnant people.	22.8	26.5
You don't need a COVID-19 vaccine if you've already had COVID-19.	14.9	7.7
The COVID-19 vaccine for free for everyone in the U.S. who is eligible.	11.1	7.3
COVID-19 vaccines do not affect fertility.	11.1	28.1
COVID-19 vaccines do not affect your DNA.	10.8	19.2
Teenagers can get a COVID-19 vaccine.	7.2	8.6
You can still get COVID-19 even if you've received a COVID-19 vaccine.	6.7	5.6

Despite these misconceptions, 88.5% of respondents reported receiving two doses of a COVID-19 vaccine. Of those who were not vaccinated (n = 54), 38.5% of participants said they were "probably not" or "definitely not" planning to get the vaccine. Reasons for avoiding the vaccine included chronic health conditions (they were not sure their body could handle it), unknown side effects, natural antibodies from previous COVID-19 infection, because they were pregnant or breastfeeding, or because of low concern about COVID-19. Of the 180 participants with children between the ages of 12–17, 63.8% reported that their children were vaccinated.

Among those who had received two doses of a COVID-19 vaccine (n = 340), 79.7% said they would "probably" or "definitely" get a COVID-19 booster (third dose) when it became available (Figure 4). Between 68.4 and 75.5% of people said they would encourage their parents, older family members, and friends to get the booster. Less than 20% of people expressed uncertainty about the booster, and between 10–12% said they would "definitely not" or "probably not" encourage their parents (9.9%), other family members (10.2%), or friends (11.9%) to get the booster. Only 4.9% of participants gave this negative response when asked about getting a booster for themselves. Most people said they did not have concerns about the COVID-19 booster (88.0%), but of the 12% who did, these concerns included chronic health issues, unknown side effects, side effects from previous COVID-19 vaccinations, no mention of the booster they received their original vaccinations, and allergies. Of note, when asked about their primary source of news and information about COVID-19, most participants said social media (35.7%) or television (28.1%) with a smaller proportion accessing information in newspapers (16.9%), by radio (4.6%), word of mouth (4.4%), or another source (10.3%).

Discussion

Residents of remote Alaskan communities have been a been a priority for COVID-19 vaccination outreach due to inconsistent and limited healthcare options close to home, lack of water and sanitation in some communities, and the logistical challenges of vaccine distribution. Based on our results, baseline acceptance rates for COVID-19 vaccines for all adult demographic groups in remote Alaskan communities were 54–60%, prior to U.S.

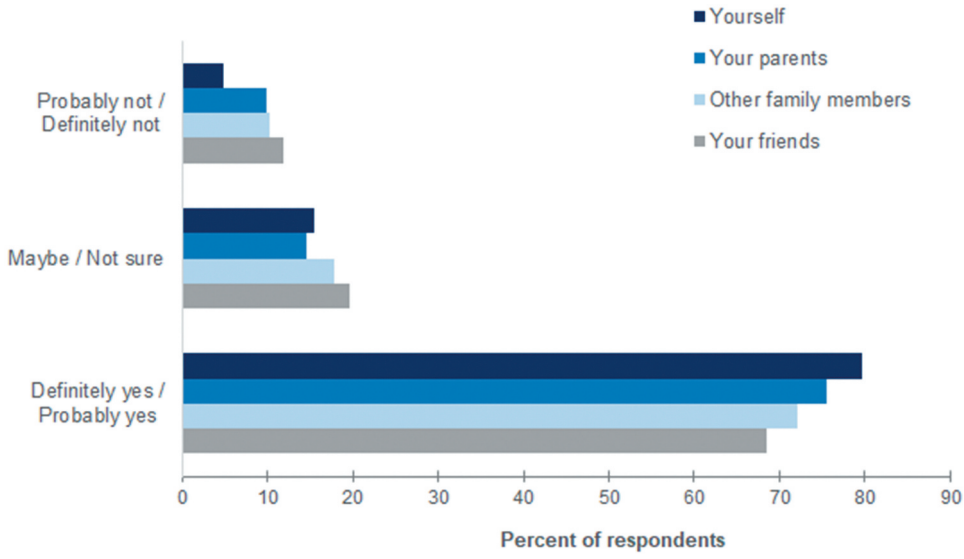

Figure 4. Likelihood of getting a COVID-19 booster for yourself, or encouraging your parents, other family members, and friends to get it (Wave 3).

Food and Drug Administration approval of a COVID-19 vaccine for emergency use in December 2020. About a third of residents expressed uncertainty in the vaccine at this time, and 10–14% said they would not get the vaccine for at least one adult demographic group. There was slightly more hesitancy around giving a COVID-19 vaccination to children; only 46% said they would likely do so and 17% said they would not. Within three months of the beginning of the vaccine rollout in Alaska, we saw a shift in the distribution of vaccine acceptance. A higher percentage of survey participants got the vaccine (81%) than we might have expected based on the initial acceptance rates. The proportion of people who reported uncertainty in the vaccine dropped from about a third to 7%, and the proportion of people who said they would not get the vaccine dropped slightly to 8%. By September 2021, the rate of vaccination (2 doses) among participants had increased to 88%, and of these people, 80% they would likely get the booster when it became available. At this time, there were prevalent misconceptions about the vaccine recommendation for pregnant women, and the effects of the vaccine on fertility and DNA.

Unsurprisingly, factors affecting vaccine hesitancy has become an important topic of research across many jurisdictions over the course of the COVID-19 pandemic. Early in the pandemic, prior to an approved COVID-19 vaccine (May 2020), a study of U.S. adults found that 67% of people would accept a COVID-19 vaccine if it were recommended to them[28]. As in our study in remote Alaska, they found that older adults were more likely to accept a vaccine; however, unlike our results, they also found that having a college degree increased the likelihood of vaccine acceptance. Just a couple months later, a similar study in the U.S. found a higher rate of vaccine acceptance (72% saying they were likely or somewhat likely to get a vaccine) and that people living in rural communities expressed more hesitancy than their urban counterparts[29]. Perhaps most relevant for comparison to the present study, the Urban Indian Health Institute conducted a survey around the same time as our Wave 1 survey (December 2020) among U.S. adults identifying as American Indian/Alaska Native[30]. They found that 75% of survey participants were willing to receive a COVID-19 vaccine, although it should be noted that they began their survey the day that the Food and Drug Administration approved the first COVID-19 vaccine. Like our study, they found the highest acceptance rate among older adults. Regionally, they found that the percentage of respondents willing to get a vaccine ranged between 64–86% with 80% of Alaskan participants reporting willingness to get vaccinated. Similar to our finding regarding motivations for getting vaccinated, they found that 74% of participants believed that getting a vaccine was their responsibility to their community. Similar concerns about the vaccine were expressed by respondents to their survey including rushed clinical trials, lack of trust in government organisations, and concerns about vaccine effectiveness.

There is very little literature on acceptance of non-COVID-19 vaccines among individuals living in remote Alaska; however, previous immunisation rates for other vaccine-preventable diseases may offer a comparison for prior vaccine acceptance in these communities. In 2019–20, the adult immunisation rate for seasonal influenza was

33.8% in remote Alaskan communities and 34.5% in Alaska communities on the road system, compared to 51.8% in the U.S. population[31]. The Tdap or Td immunisation rate in 2019 was 70.9%, 71.9%, and 70.5% for these comparison groups, respectively[32]. The rate of immunisation among children between 19–35 months for the combined 7-vaccine series as of June 2021 was 50.6% and 50.8% in remote and road-system communities in Alaska, respectively[33]. These data indicate that for other vaccine-preventable diseases, there is little variation in acceptance rates between communities on and off the road system in Alaska. However, by September 2021, the percentage of the eligible population who had received at least one COVID-19 vaccine was higher among remote Alaskan communities (73.3%) than among Alaskan communities on the road system (58.8%) [34]. And although the rate of early COVID-19 vaccine acceptance was lower among our sample of remote Alaskans compared to a sample of 13,426 people across 19 countries, where 71.5% of participants said they would be very or somewhat likely to get a COVID-19 vaccine[35], the large proportion of remote Alaskan adults who received the vaccine indicates that initial concerns likely subsided somewhat once the rollout began.

The stronger initial hesitancy observed among remote Alaskan residents regarding the COVID-19 vaccine could be due to concerns related to a history of unethical health research conducted on members of the Alaska Native community (42% of the remote Alaskan population) [36,37]. Many people cited the lack of testing or concerns about safety as reasons for their uncertainty about the vaccine. Alaska used a multi-pronged vaccine campaign, including distribution via the tribal health system, which allowed rapid rollout across a large geographic area[38]. In rural communities, anyone above the age of 16 years was eligible for a vaccine early on, and several small remote communities vaccinated most of their population within two months[39]. These early successes may have supported higher vaccination rates among remote Alaskans compared to those living in communities on the road system.

A continued increase in vaccination rates can likely be attributed to a combination of efforts by the State of Alaska, the Alaska Native Tribal Health Consortium, and local communities to correct misconceptions, share stories of people who changed their mind and received a vaccination after initial hesitancy, develop COVID-19 materials in Native languages, and provide financial incentives for vaccination [40–42]. Despite the high rates of vaccine acceptance, there are still remote Alaskans with concerns about the vaccine, and our results suggest that vaccination rates may be lower among 12–17 years than among the adult population. Identifying a locally trusted source of information to distribute key messages about COVID-19 vaccine safety and efficacy is likely as important as refining the content of the information[35]. Facebook and social media are a key source of information for many remote Alaskans. In the U.S., Twitter is a major source of anti-vaccination communication [43] and use of Facebook can contribute to polarisation about vaccines through validating a user's pre-existing opinions[44]. Key strategies to avoid negative messaging include monitoring these networks, explicitly addressing disinformation[45], and providing communities with accurate outreach information that can easily be shared on these platforms. Others have suggested that using a prosocial framing of the positive impacts of getting a COVID-19 vaccine for the broader community may have a stronger impact on vaccine acceptance than personal protection [45,46], although this was not the case in our data.

There are several limitations to the present study. We recruited people through Facebook and local contacts in remote Alaska. Although this is likely one of the most effective methods for recruiting a diverse population within these communities[23], it may limit participants who are not on Facebook, who do not have any access to the internet, or who are not literate in the English language. Although our study benefited from longitudinal assessments, which allowed us to track the dynamic perceptions and knowledge of remote Alaskan residents, we recruited a new sample for each survey wave so cannot be sure that the results of each survey are directly comparable.

We are living through an unprecedented event, both in terms of the ongoing global pandemic as well as the speed and quantity of information and misinformation. Transparency and clear communication through trusted local leaders during vaccine dissemination may increase vaccine acceptance in remote Alaskan communities. Ongoing monitoring of vaccination rates across demographic groups and by geography as well as ongoing surveys of resident's evolving knowledge, attitude, and practices will be important to support targeted COVID-19 outreach. Tribal authority to distribute vaccines and drawing on Indigenous knowledge [47] is an important component of an efficient and locally accepted vaccination programme for COVID-19 and other vaccine-preventable diseases in remote Alaska.

Acknowledgments

We also want to acknowledge and thank the many residents of remote Alaskan communities who shared information about or participated in this study. Thank you also to Rebecca Van Wyck for her help putting our survey instruments online and to Christine McDonald, Tricia Howe, and Jordan Randolph for their help disseminating surveys. Thanks to Tom Hennessy and Leisha Nolan for their reviews of early drafts of our survey instruments.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was funded by the National Science Foundation RAPID Grant #2033192.

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References

[1] Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395(10223):497–506.
[2] Johns Hopkins University of Medicine. Coronavirus Resource Center. Published 2021. cited 2021 Aug 23. https://coronavirus.jhu.edu/map.html
[3] Glenn J, Chaumont C, Villalobos Dintrans P. Public health leadership in the times of COVID-19: a comparative case study of three countries. Int J Public Leadersh. 2020;17 (1):81–94.
[4] Kapucu N, Moynihan D. Trump's (mis)management of the COVID-19 pandemic in the US. Published online 2021. DOI:10.1080/01442872.2021.1931671.
[5] Cheng C, Barceló J, Hartnett AS, et al. COVID-19 government response event dataset (CoronaNet v.1.0). Nat Hum Behav. 2020;4(7):756–768.
[6] Chin T, Kahn R, Li R, et al. US-county level variation in intersecting individual, household and community characteristics relevant to COVID-19 and planning an equitable response: a cross-sectional analysis. BMJ Open. 2020;10(9):e039886.
[7] Mikolai J, Keenan K, Kulu H. Intersecting household-level health and socio-economic vulnerabilities and the COVID-19 crisis: an analysis from the UK. SSM - Popul Heal. 2020;12:100628.
[8] Brandén M, Aradhya S, Kolk M, et al. Residential context and COVID-19 mortality among adults aged 70 years and older in Stockholm: a population-based, observational study using individual-level data. Lancet Heal Longev. 2020;1(2):e80–e88.
[9] Rodriguez-Lonebear D, Barceló NE, Akee R, et al. American Indian Reservations and COVID-19: correlates of early infection rates in the pandemic. J Public Heal Manag Pract. 2020;26(4):371.
[10] Kearns N, Shortt N, Kearns C, et al. How big is your bubble? Characteristics of self-isolating household units ('bubbles') during the COVID-19 Alert Level 4 period in New Zealand: a cross-sectional survey. BMJ Open. 2021;11(1):e042464.
[11] Lake J, Gerrans P, Sneddon J, et al. We're all in this together, but for different reasons: social values and social actions that affect COVID-19 preventative behaviors. Pers Individ Dif. 2021;178:110868.
[12] Stosic MD, Helwig S, Ruben MA. Greater belief in science predicts mask-wearing behavior during COVID-19. Pers Individ Dif. 2021;176:110769.
[13] Nazione S, Perrault E, Pace K. Impact of information exposure on perceived risk, efficacy, and preventative behaviors at the beginning of the COVID-19 pandemic in the USA. Health Commun. 2021;36(1):23–31.
[14] Falcone R, Sapienza A. How COVID-19 changed the information needs of Italian citizens. Int J Environ Res Public Health. 2020;17(19):1–19.
[15] Drylie-Carey L, Sánchez-Castillo S, Galán-Cubillo E. European leaders unmasked: COVID-19 communication strategy through Twitter. Prof la Inf. 2020;29(5):1–15.
[16] Pine KH, Lee M, Whitman SA, et al. Making sense of risk information amidst uncertainty: individuals' perceived risks associated with the COVID-19 pandemic. In: *Conference on Human Factors in Computing Systems – Proceedings*, ACM. Vol 15, 2021. doi:10.1145/3411764.3445051
[17] U.S. Department of Transportation. Functional system lane-length. Published 2017. cited 2021 Aug 23. https://www.fhwa.dot.gov/policyinformation/statistics/2017/hm60.cfm
[18] Herz N. In rural Alaska, COVID-19 vaccines hitch a ride on planes, sleds and water taxi. *Alaska Public Media*. Published Jan 8, 2021. cited Aug 23, 2021. https://www.alaskapublic.org/2021/01/08/in-rural-alaska-covid-19-vaccines-hitch-a-ride-on-planes-sleds-and-water-taxi/
[19] Herz N. Alaska's geography poses unique challenge in getting COVID-19 vaccine, treatments to rural areas. *Alaska Public Media*. Published Nov 20, 2020. cited Aug 23, 2021. https://www.alaskapublic.org/2020/11/20/alaskas-geography-poses-unique-challenge-in-getting-covid-19-vaccine-treatments-to-rural-areas/
[20] Hollander Z. Two new COVID-19 deaths tied to rural Alaska. *Anchorage Daily News*, Published , 2020. Accessed 2020. Accessed , 2021 , 2020. Accessed. https://www.adn.com/alaska-news/2020/07/27/coronavirus-infections-reported-in-rural-alaska-are-most-recent-to-prove-fatal/
[21] Eichelberger L, Dev S, Howe T, et al. Implications of inadequate water and sanitation infrastructure for community spread of COVID-19 in remote Alaskan communities. Sci Total Environ. 2021;776:145842.
[22] Treinen L. After early success in containment, there's now rapid coronavirus spread in rural Alaska. *Alaska Public Media*. Published Oct 14, 2020. cited Aug 23, 2020. https://www.alaskapublic.org/2020/10/14/after-early-success-in-containment-a-rapid-spread-in-rural-alaska/

[23] King DB, O'Rourke N, De Longis A. Social media recruitment and online data collection: a beginner's guide and best practices for accessing low-prevalence and hard-to-reach populations. Can Psychol. 2014;55(4):240–249.
[24] Whitaker C, Stevelink S, Fear N. The use of Facebook in recruiting participants for health research purposes: a systematic review. J Med Internet Res. 2017;19(8):e7071.
[25] Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: building an international community of software platform partners. J Biomed Inform. 2019;95:103208.
[26] Rao J, Scott A. On simple adjustments to chi-square tests with sample survey data. Ann Stat. 1987;15(1):385–397.
[27] Bernard H, W A, Ryan G. Analyzing Qualitative Data. SAGE; 2017.
[28] Malik AA, McFadden SM, Elharake J, et al. Determinants of COVID-19 vaccine acceptance in the US. EClinicalMedicine. 2020;26:100495.
[29] Khubchandani J, Sharma S, Price JH, et al. COVID-19 Vaccination Hesitancy in the USA: a rapid national assessment. J Community Health. 2021;46(2):270–277.
[30] Urban Indian Health Institute. Results from a national COVID-19 vaccination survey: strengthening vaccine efforts in Indian Country. Urban Indian Health Institute; 2021.
[31] Centers for Disease Control and Prevention. FluVaxView. Published 2019. cited 2021 Aug 30. https://www.cdc.gov/flu/fluvaxview/index.htm
[32] Centers for Disease Control and Prevention. AdultVaxView. Published 2019. cited 2021 Aug 30. https://www.cdc.gov/vaccines/imz-managers/coverage/adultvaxview/index.html
[33] Alaska Department of Health and Social Services. VacTrAK data. Combined childhood 7-vaccine series coverage. 19–35. months.
[34] Alaska Department of Health and Social Services. Coronavirus response hub - vaccination progress table. Published 2021. cited 2021 Sept 1. https://alaska-coronavirus-vaccine-outreach-alaska-dhss.hub.arcgis.com/datasets/vaccination-progress-table/explore
[35] Lazarus JV, Ratzan SC, Palayew A, et al. A global survey of potential acceptance of a COVID-19 vaccine. Nat Med. Published online 2020 Oct 20. DOI:10.1038/s41591-020-1124-9.
[36] Beans JA, Saunkeah B, Woodbury RB, et al. Community protections in American Indian and Alaska Native participatory research-a scoping review. Soc Sci. 2019;8(4):127.
[37] Hiratsuka V, Beans J, Robinson R, et al. Self-determination in health research: an Alaska Native example of tribal ownership and research regulation. Int J Environ Res Public Health. 2017;14(11):1324.
[38] Herz N. The Trump administration joined with tribes to get vaccines to rural and Indigenous Alaskans. Here's how. *Alaska Public Media*. Published Jan 14, 2021. cited Jan 14, 2021.https://www.alaskapublic.org/2021/01/14/the-trump-administration-joined-with-tribes-to-get-vaccines-to-rural-and-indigenous-alaskans-heres-how/
[39] Herz N. Unscathed: these Alaska villages are reaching herd immunity – without a single case of COVID. *Alaska Public Media*. Published 2021. https://www.adn.com/alaska-news/rural-alaska/2021/02/27/unscathed-these-alaska-villages-are-reaching-herd-immunity-without-a-single-case-of-covid-19/
[40] Alaska Native Tribal Health Consortium (ANTHC). COVID-19 vaccine materials in Alaska Native languages. 2021. cited 2021 Oct 1. https://anthc.org/covid-19-vaccine-materials-in-alaska-native-languages/
[41] Alaska Native Tribal Health Consortium (ANTHC). Elders share their stores after receiving COVID-19 vaccine. Published 2021. cited 2021 Oct 1. https://www.youtube.com/watch?v=06bonSJZ__U
[42] Alaska Public Media. Alaska announces weekly $49,000 lottery to encourage COVID-19 vaccination. Published 2021 Sept 2. https://www.alaskapublic.org/2021/09/02/alaska-announces-weekly-49000-lottery-to-encourage-getting-a-covid-vaccine/
[43] Tomeny TS, Vargo CJ, El-Toukhy S. Geographic and demographic correlates of autism-related anti-vaccine beliefs on Twitter, 2009-15. Soc Sci Med. 2017;191:168–175.
[44] Schmidt AL, Zollo F, Scala A, et al. Polarization of the vaccination debate on Facebook. Vaccine. 2018;36(25):3606–3612.
[45] Chou W-YS, Budenz A. Considering Emotion in COVID-19 vaccine communication: addressing vaccine hesitancy and fostering vaccine confidence. Health Commun. 2020;35(14):1718–1722.
[46] Jordan J, Yoeli E, Rand DG. Don't get it or don't spread it? Comparing self-interested versus prosocial motivations for COVID-19 prevention behaviors. Published online 2020. DOI:10.31234/osf.io/yuq7x.
[47] Petrov AN, Welford M, Golosov N, et al. Lessons on COVID-19 from Indigenous and remote communities of the Arctic. Nat Med. 2021;27:1–2. Published online 2021 Aug 23. DOI:10.1038/s41591-021-01473-9.
[48] Mathieu E. State-by-state data on COVID-19 vaccinations in the USA. Our World in Data. Published 2021. cited 2021 Sept 3. https://ourworldindata.org/us-states-vaccinations
[49] Alaska Department of Health and Social Services. Ak COVID-19 Cases Dashboard. Published 2021. cited 2021 Sept 3. https://experience.arcgis.com/experience/2d19dc2b5c7e4b399ff6495a8950493d/
[50] Drown D, Parker J, Smith L, et al. Alaska COVID-19 Genomic Surveillance. Situation Report. 2021. 2021. Sept 1. Published 2021. cited Sept 1. http://dhss.alaska.gov/dph/epi/id/siteassets/pages/HumanCoV/AKSeqCon_GenomicSituationReport.pdf
[51] State of Alaska. 2019. Population Estimates. Department of Labor and Workforce Development. Published 2020. https://live.laborstats.alaska.gov/pop/index.cfmP