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Characterizing intentions to receive the COVID-19 vaccine among the general population in British Columbia based on their future intentions towards the seasonal influenza vaccine



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ABSTRACT

Introduction: This study assessed the relationship between intention to receive a COVID-19 vaccine and intention to receive a seasonal influenza vaccine, as well as how intention to receive a COVID-19 vaccine has changed during the pandemic.

Methods: Residents of British Columbia aged 25–69 years were invited to complete an online cross-sectional survey from August 2020 - March 2021. Mixed-effects logistic regression models assessed the relationship between intention to receive a COVID-19 vaccine and intention to receive the seasonal influenza vaccine. A generalized additive mixed model was used to investigate changes in COVID-19 vaccine intention during the pandemic (August 2020–March 2021). The relationship between intention to receive a COVID-19 vaccine and retrospective overall perceived value of vaccines prior to and during the pandemic was also considered.

Results: Of 6,333 participants, 80.2 % of participants were 'somewhat or very likely' to receive a COVID-19 vaccine and 69 % of participants reported intending to receive a seasonal influenza vaccine. In multivariable modeling, intention to receive a COVID-19 vaccine was strongly associated with intention to receive a seasonal influenza vaccine (aOR = 4.25, 95 %CI 3.33–5.43). Intention to receive a COVID-19 vaccine increased over the study period ($p < 0.0001$), with the largest increase coinciding with the announcement of forthcoming approvals of COVID-19 vaccines in November 2020 (aOR = 1.45, 95 %CI 1.11–1.91).

Conclusion: Intention to receive the COVID-19 vaccine was associated seasonal influenza vaccine intention, which is an important relationship to measure for implementation and future planning of COVID-19 booster doses. We found an increase in the intention to receive a COVID-19 vaccine after public announcements of forthcoming vaccine approval, which highlights the importance of ongoing monitoring and reporting of vaccine uptake, and the potential impact of emerging vaccine safety and efficacy information may have on vaccine acceptance.

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Introduction

In March 2020, the World Health Organization (WHO) declared a pandemic of severe acute respiratory syndrome coronavirus (SARS-CoV-2), the cause of coronavirus disease of 2019 (COVID-19) [1]. The development, implementation, and uptake of vaccines

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against COVID-19 is critical to disease prevention and control of the pandemic. The success of a vaccine relies on both effectiveness and population-wide uptake [2]. A vital element in determining the potential uptake of COVID-19 vaccines is the public's overall acceptance and confidence in vaccines, which may be impacted by public health messaging, or misinformation, regarding the spread of the virus and safety of novel vaccine [3].

During the COVID-19 pandemic there has been increased awareness of the vaccine development process and of the importance of vaccines for controlling infectious diseases, which may impact COVID-19 vaccine uptake, but also uptake of other vaccines, such as the seasonal influenza vaccine. In Canada, a seasonal influenza vaccine is recommended for everyone six months of age and over [4] and is available every fall (from September to November) prior to the historical annual start of the influenza season in the northern hemisphere. In British Columbia (BC), the seasonal influenza vaccine is covered by the provincial medical service plan for many priority populations and delivered through public health and family health care clinics. Eligible individuals not included on the priority population list have been able to receive seasonal influenza vaccine for purchase at most pharmacies, however, for the 2021–2022 seasonal influenza vaccine program, all eligible individuals are provided the influenza vaccine free of charge [5]. In addition, BC requires all healthcare workers to be immunized against influenza annually, or else they are required to wear a mask within all healthcare facilities for the duration of influenza season. Despite wide availability of seasonal influenza vaccine, only 42 % of Canadians 18–64 years of age received the vaccine in 2019–2020, which was similar to the previous 2018/2019 year [6]. Investigating the relationship between intention to receive a COVID-19 vaccine and future seasonal influenza vaccine uptake, while considering changes in the perceived value of vaccines over the course of the pandemic, will help to inform government and public health immunization programs for ongoing COVID-19, seasonal influenza, and future COVID-19 booster vaccination campaigns [7].

The objectives of this analysis were to: 1) assess the relationship between intention to receive a COVID-19 vaccine and intention to receive a seasonal influenza vaccine, 2) estimate if there was a change in the intention to receive a COVID-19 vaccine by time over the course of the pandemic, and 3) explore retrospective changes in the perceived value of vaccines pre-pandemic compared to during the pandemic.

Methods

The COVID-19 Rapid Evidence Study of a Provincial Population Based Cohort for Gender and Sex (RESPONSE), was a population-based study aimed at measuring the prevalence of COVID-19 and the pandemic impacts based on sex and gender, led by the investigators at Women's Health Research Institute. Characterization of the psychosocial impact of the pandemic, and the sociodemographic factors related to intention to receive a COVID-19 vaccine have been published previously [8–9]. This study was approved by The University of British Columbia Research Ethics Board (H20-01421).

Participant's recruitment and characteristics

Prospective participants were 25–69-years of age, living in British Columbia. Index participants were recruited from existing large research cohorts who had provided consent to be contacted for future research. Eligible individuals were sent an email invitation to participate in an online cross-sectional survey and completed informed consent prior to participating. To diversify sex and gender representation, respondents were asked to pass on

the invitation to a household member who identified as a different gender (Household Participants). In addition, recruitment of the general public occurred through social media, patient research networks, and stakeholder and community websites. All participants from the research cohort received up to three email reminders, and all participants who completed the survey were eligible for entry into a gift card draw. Recruitment was open from August 20, 2020–March 1, 2021. The target for recruitment for the overall RESPONSE study was 750 participants in each of nine five-year age strata, based on an estimated COVID-19 prevalence of 2 % at the time of the study [8].

Survey design and measurement

The online survey was comprised of six modules, each focusing on a different topic [8–9]. Data from the vaccine module and core demographic module were included in this analysis. For each participant, we collected age, sex, gender, Indigenous ancestry, ethnicity, education, household composition, existing chronic health conditions, and self-reported essential worker status (including health care workers). General vaccine hesitancy was measured using the validated 9-item, 2-factor Vaccine Hesitancy Scale (VHS) developed by the WHO Sage Working Group on vaccine hesitancy [10].

Intention to receive a COVID-19 vaccine was measured based on responses to a 5-point Likert scale (very unlikely to very likely) to the question: "If a safe and effective COVID-19 vaccine were available and recommended for you, how likely are you to receive it?". Intention to receive an influenza vaccine was measured by asking whether participants intended to receive a seasonal influenza vaccine in the future (yes/no). Past receipt of seasonal influenza vaccine was measured by how often they had received the seasonal influenza vaccine in the past 5 years. Impact of the pandemic on participants' valuation of vaccines was measured using a two-part question on a 5-point sliding scale ("no value" to "value a lot"): "Thinking back to before the beginning of the pandemic (December 2019), how much did you value vaccines?", and "Today, how much do you value vaccines?".

The survey was pre-tested for face validity and comprehension, pilot tested, and a final version was designed and implemented online using the REDCap (Research Electronic Data Capture) platform [11].

Analysis

This analysis only includes data from those who fully completed the vaccine survey module. The primary outcome, intention to receive a COVID-19 vaccine was dichotomized from the 5-point Likert scale, with those who responded 'very' or 'somewhat likely' to receive a vaccine coded as "intending to vaccinate" and those who responded 'neutral', 'unlikely', or 'very unlikely' coded as "not intending to vaccinate".

Receipt of the seasonal influenza vaccine in the last 5 years was categorized into three groups based on past vaccination behavior: 'always/almost always: 3,4 or 5 times in the last 5 years' vs 'sometimes: 1–2 times in the last 5 years', vs 'never/don't know'.

The relationship between intention to receive a COVID-19 vaccine and intention to receive the seasonal influenza vaccine was investigated using bivariable and multivariable generalized estimating equations (GEE) to account for household clustering, and adjusted based on a priori variables including age, sex, education, identifying as a visible minority, occupation, vaccine hesitancy, change in perceived value of vaccines during the pandemic, past seasonal influenza vaccine receipt and a time-dependent variable based on date of survey completion. Adjusted odds ratios were

calculated to identify factors associated with intention to receive the COVID-19 vaccine.

A time-dependent variable using the date of survey completion was included in the GEE models based on the outcome of the generalized additive mixed logistic regression analysis of COVID-19 vaccine intention through the pandemic from August 2020 to March 2021. To ensure accurate time categorization, surveys were excluded if the time between opening the core demographic module and continuing to the subsequent survey module was >7 days. The time-dependent variable was then dichotomized as pre/post November 17th, 2020 for inclusion in GEE regression analysis. The dichotomization of pre/post November 17th 2020 was based on the results of the generalized additive mixed model and the approximate timing of the initial release of vaccine development and approval information for the Pfizer, Moderna, and AstraZeneca vaccines in Canada, and around the world [12–13]. The information related to the safety of both mRNA vaccines and immunogenicity findings of mRNA study results were published on and around November 17th, 2020, around the same time as manufacturing companies completed the rolling review process with Health Canada [13–14].

The impact of the pandemic on the perceived value of vaccines in general was measured using a combined variable that was based on a score change in the valuation of vaccines pre- and during pandemic. The perceived value of vaccines had four levels: those who had a positive valuation pre- and during-COVID-19 pandemic, those with a negative valuation pre- and during-COVID-19 pandemic, and those with valuation that changed to either positive or negative during the pandemic. We explored how changes in participant’s overall valuation of vaccines from before the pandemic to during the pandemic was related to COVID-19 vaccine intention

over-time and stratified by intention to receive a future influenza vaccine. All analyses were carried out in R v.4.0.2. [15].

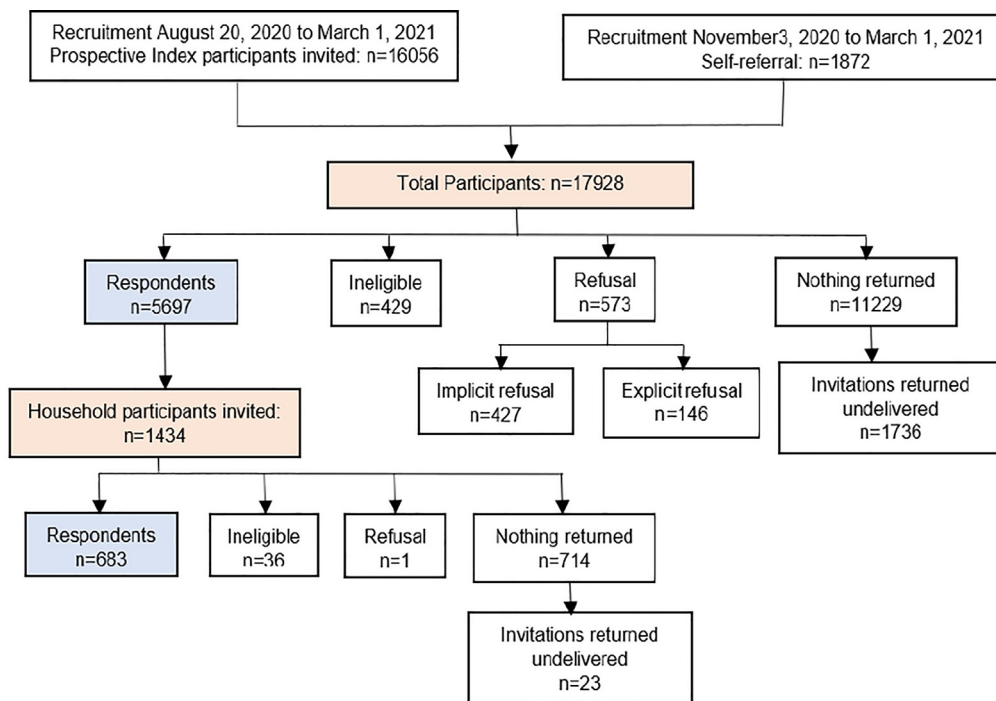
Results

Survey respondents

Between August 2020 and March 2021 survey invites were emailed to 16,056 prospective Index Participants, with an additional 1,434 survey invites forwarded to household members of a different sex or gender. There were also 1,872 participants recruited from the general public, resulting in 19,362 total prospective participants. Out of these total prospective participants, a total of 6,380 participants between the ages of 25–69 years old completed the core demographic and vaccine modules of the survey, of which 5,697 (89.3 %) were Index participants, and 683 (10.7 %) were Household participants (Fig. 1). A total of 6,333 participants were included in the analysis after removing participants who did not complete the main outcome question (intention to receive a COVID-19 vaccine) and who completed the survey modules >7 days apart (n = 47). The majority of completed surveys (5,109/6,380 (80.1 %)) were received prior to the November 17, 2020 media release and subsequent approval announcements about COVID-19 vaccines (December 9, 2020 for Pfizer vaccine) [13–14].

Participant characteristics

The mean age of participants was 48.1 years (SD = 12.1). Most participants reported female sex-at-birth (87.1 %), with 1.2 % identifying as gender diverse (Table 1). The majority of participants



- Total Prospective Participants = 19,362
- Total number of eligible respondents = 6380

Fig. 1. A flow diagram depicting prospective participants and respondents to the RESPONSE study, August 2020 - March 2021.

Table 1
Demographic summary of participants by intention to receive the COVID-19 vaccine.

	Likely to receive COVID-19 vaccine			p value
	Total No. 6,333	No No. 1,252	Yes No. 5,081	
Age				
25–29	462 (7.3 %)	61 (13.2 %)	401 (86.8 %)	<0.0001
30–39	1,342 (21.2 %)	263 (19.6 %)	1,079 (80.4 %)	
40–49	1,522 (24.0 %)	331 (21.7 %)	1,191 (78.3 %)	
50–59	1,585 (25.0 %)	370 (23.3 %)	1,215 (76.7 %)	
60–69	1,422 (22.5 %)	227 (16.0 %)	1,195 (84.0 %)	
Sex				
Female	5,517 (87.1 %)	1,123 (20.4 %)	4,394 (79.6 %)	0.001
Male	809 (12.8 %)	126 (15.6 %)	683 (84.4 %)	
Missing	7 (0.1 %)	3 (42.9 %)	4 (57.1 %)	
Gender				
Woman	5,459 (86.2 %)	1,117 (20.5 %)	4,342 (79.5 %)	0.002
Man	799 (12.6 %)	124 (15.5 %)	675 (84.5 %)	
Gender-diverse	75 (1.2 %)	11 (14.7 %)	64 (85.3 %)	
Indigenous				
Indigenous	217 (3.4 %)	75 (34.6 %)	142 (65.4 %)	<0.0001
Not Indigenous	5,810 (91.7 %)	1,103 (19.0 %)	4,707 (81.0 %)	
Prefer not to answer	51 (0.8 %)	16 (31.4 %)	35 (68.6 %)	
Missing	255 (4.0 %)	58 (22.7 %)	197 (77.3 %)	
East Asian				
No	5,789 (91.4 %)	1,139 (19.7 %)	4,650 (80.3 %)	0.91
Yes	504 (8.0 %)	100 (19.8 %)	404 (80.2 %)	
Missing	40 (0.6 %)	13 (32.5 %)	27 (67.5 %)	
Southeast Asian				
No	6,256 (98.8 %)	1,232 (19.7 %)	5,024 (80.3 %)	1
Yes	37 (0.6 %)	7 (18.9 %)	30 (81.1 %)	
Missing	40 (0.6 %)	13 (32.5 %)	27 (67.5 %)	
Hispanic/Latinx				
No	6,195 (97.8 %)	1,217 (19.6 %)	4,978 (80.4 %)	0.52
Yes	98 (1.5 %)	22 (22.4 %)	76 (77.6 %)	
Missing	40 (0.6 %)	13 (32.5 %)	27 (67.5 %)	
South Asian				
No	6,141 (97.0 %)	1,197 (19.5 %)	4,944 (80.5 %)	0.02
Yes	152 (2.4 %)	42 (27.6 %)	110 (72.4 %)	
Missing	40 (0.6 %)	13 (32.5 %)	27 (67.5 %)	
Black				
No	6,254 (98.8 %)	1,225 (19.6 %)	5,029 (80.4 %)	0.02
Yes	39 (0.6 %)	14 (35.9 %)	25 (64.1 %)	
Missing	40 (0.6 %)	13 (32.5 %)	27 (67.5 %)	
White				
Yes	5,286 (83.5 %)	995 (18.8 %)	4,291 (81.2 %)	0.0001
No	1,007 (15.9 %)	244 (24.2 %)	763 (75.8 %)	
Missing	40 (0.6 %)	13 (32.5 %)	27 (67.5 %)	
Education				
More than High School	5,540 (87.5 %)	1,032 (18.6 %)	4,508 (81.4 %)	<0.0001
High School or less	783 (12.4 %)	219 (28.0 %)	564 (72.0 %)	
Missing	10 (0.2 %)	1 (10.0 %)	9 (90.0 %)	
Occupation				
No	4,244 (67.0 %)	796 (18.8 %)	3,448 (81.2 %)	<0.0001
Yes, healthcare worker	903 (14.3 %)	149 (16.5 %)	754 (83.5 %)	
Yes, other essential worker	1,182 (18.7 %)	305 (25.8 %)	877 (74.2 %)	
Missing	4 (0.1 %)	2 (50.0 %)	2 (50.0 %)	
Number of Adults in Household				
One	1,466 (23.1 %)	319 (21.8 %)	1,147 (78.2 %)	0.0002
Two	3,515 (55.5 %)	629 (17.9 %)	2,886 (82.1 %)	
Three or more	1,335 (21.1 %)	297 (22.2 %)	1,038 (77.8 %)	
Missing	17 (0.3 %)	7 (41.2 %)	10 (58.8 %)	
Household Children < 5				
None	5,470 (86.4 %)	1,076 (19.7 %)	4,394 (80.3 %)	0.65
One	525 (8.3 %)	97 (18.5 %)	428 (81.5 %)	
Two or more	206 (3.3 %)	44 (21.4 %)	162 (78.6 %)	
Missing	132 (2.1 %)	35 (26.5 %)	97 (73.5 %)	
Household Children 5–17				
None	4,362 (68.9 %)	820 (18.8 %)	3,542 (81.2 %)	0.05
One	926 (14.6 %)	199 (21.5 %)	727 (78.5 %)	
Two or more	927 (14.6 %)	199 (21.5 %)	728 (78.5 %)	
Missing	118 (1.9 %)	34 (28.8 %)	84 (71.2 %)	
Chronic Health Conditions				
None	3,135 (49.5 %)	630 (20.1 %)	2,505 (79.9 %)	0.53
One or more	3,189 (50.4 %)	620 (19.4 %)	2,569 (80.6 %)	
Missing	9 (0.1 %)	2 (22.2 %)	7 (77.8 %)	

Table 1 (continued)

	Likely to receive COVID-19 vaccine			p value
	Total No. 6,333	No No. 1,252	Yes No. 5,081	
Intend to get seasonal influenza vaccine				
No	1,131 (17.9 %)	575 (50.8 %)	556 (49.2 %)	<0.0001
Yes	4,370 (69.0 %)	483 (11.1 %)	3,887 (88.9 %)	
Missing	832 (13.1 %)	194 (23.3 %)	638 (76.7 %)	
Received seasonal influenza vaccine in the past 5 years				
Always/almost always	3,509 (55.4 %)	404 (11.5 %)	3,105 (88.5 %)	<0.0001
1–2 times	1,160 (18.3 %)	234 (20.2 %)	926 (79.8 %)	
Never/Don't know	1,662 (26.2 %)	614 (36.9 %)	1,048 (63.1 %)	
Missing	2 (0.0 %)	0 (0.0 %)	2 (100.0 %)	
Pandemic impact on perceived value of vaccines				
Negative change	134 (2.1 %)	82 (61.2 %)	52 (38.8 %)	<0.0001
No change - negative	293 (4.6 %)	237 (80.9 %)	56 (19.1 %)	
No change - positive	5,320 (84.0 %)	814 (15.3 %)	4,506 (84.7 %)	
Positive change	570 (9.0 %)	116 (20.4 %)	454 (79.6 %)	
Missing	16 (0.3 %)	3 (18.8 %)	13 (81.2 %)	
Do you think you had COVID-19				
No	5,475 (86.5 %)	1,055 (19.3 %)	4,420 (80.7 %)	0.02
Yes	857 (13.5 %)	196 (22.9 %)	661 (77.1 %)	
Missing	1 (0.0 %)	1 (100.0 %)	0 (0.0 %)	
WHO scale: Lack of Confidence in Vaccines				
Mean (SD)	1.3 (±0.6)	1.7 (±0.9)	1.2 (±0.5)	<0.0001
Missing	30 (0.5 %)	9 (0.7 %)	21 (0.4 %)	
WHO scale: Vaccine Risks				
Mean (SD)	3.0 (±1.1)	3.5 (±1.0)	2.9 (±1.0)	<0.0001
Missing	36 (0.6 %)	10 (0.8 %)	26 (0.5 %)	

identified as non-Indigenous (91.7 %) and White (83.5 %), and 87.5 % reported having more than a high school education. Essential healthcare workers made up 14.3 % of respondents, with an additional 18.7 % reporting working as essential non-healthcare workers (Table 1).

COVID-19 vaccine intention

Overall, 80.2 % of participants (n = 5,081) reported being ‘some-what or very likely’ to receive a safe and effective COVID-19 vaccine when available, and 69 % of participants (n = 4,370) reported intending to receive a seasonal influenza vaccine in the future (Table 1). About half of participants (55.4 %, n = 3,509) reported having “always/almost always” received a seasonal influenza vaccine in the past five years, and 26.2 % (n = 1,662) indicated they had never received a seasonal influenza vaccine in the past 5 years. Of those intending to receive a seasonal influenza vaccine in the future, 88.9 % also reported intending to receive COVID-19 vaccine.

Factors associated with intentions to receive a COVID-19 vaccine

Bivariate analysis found that those who had received a seasonal influenza vaccine in the past, those who intended to receive a seasonal influenza vaccine in future, and those who completed the survey after November 17, 2020, had higher odds of intending to receive a COVID-19 vaccine (Table 2). Those who reported a positive perceived value of vaccines or had a positive change in their perceived value of vaccines, had much higher odds of intending to receive a COVID-19 vaccine. In addition, intention to receive a COVID-19 vaccine was significantly associated with being male, older age, and having higher vaccine confidence and lower perceived risk of vaccines based on the WHO vaccine hesitancy scale (p < 0.001, Table 1).

In multivariable modeling, individuals intending to receive a seasonal influenza vaccine had higher adjusted odds of intending to receive a COVID-19 vaccine (adjusted odds ratio (aOR) = 4.25;

Table 2

Bivariable models for intention to receive COVID-19 vaccine for key predictors related to seasonal influenza vaccine predictors, perceived value of vaccines, and date of survey completion (pre- and post- November 17th, 2020), based on the survey responses collected from August 2020 - March 2021.

COVID-19 vaccine intentions			
Predictors	Odds Ratios	CI	p value
Date of Survey Completion			
Pre-Nov 17th, 2020	Reference		
Post-Nov 17th, 2020	1.63	1.34–1.98	<0.001
Intend to get a seasonal influenza vaccine			
No	Reference		
Yes	8.46	7.25–9.86	<0.001
Received seasonal influenza vaccine in the past 5 years			
Always/almost always	Reference		
1–2 times	0.53	0.43–0.64	<0.001
Never/Don't know	0.17	0.15–0.20	<0.001
Pandemic impact on perceived value of vaccines			
No change - Negative	Reference		
Negative change	2.47	1.45–4.21	0.001
No change - Positive	25.24	17.89–35.61	<0.001
Positive change	17.08	11.36–25.68	<0.001

95 %CI 3.33–5.43), after controlling for factors that included past receipt of influenza vaccine and essential worker status (Table 3). Individuals who responded to the survey after the November 17th, 2020 vaccine announcements were significantly more likely to intend to receive COVID-19 vaccine than those who responded prior to the November 17th, 2020 announcements (aOR = 1.45 95 %CI 1.11–1.91). Individuals who reported a retrospective positive perceived value of vaccines both pre- and during the pandemic (aOR = 6.55; 95 %CI 4.40–9.75) and those with a positive change in their perceived value of vaccines during the pandemic (aOR = 7.86; 95 %CI 4.98–12.40) had much higher odds of intending to receive a COVID-19 vaccine (Table 3), compared to those who reported a negative perceived value of vaccines. In addition, individuals who were male, older in age, had overall higher vaccine confidence (on the WHO VHS), and a lower perceived risk of vaccines were more likely to intend to receive a COVID-19 vaccine.

Table 3
Multivariable model for intention to receive COVID-19 for survey responses collected between August 2020 and March 2021.

COVID-19 Vaccine Intentions				
Predictors	Adjusted Odds Ratio	CI	p value	
Age				
60–69	Reference			
25–29	1.41	0.88–2.25		0.15
30–39	0.87	0.66–1.14		0.30
40–49	0.91	0.71–1.17		0.47
50–59	0.74	0.58–0.94		0.02
Sex				
Female	Reference			
Male	1.35	1.04–1.75		0.023
Education				
More than High School	Reference			
High School or less	0.88	0.69–1.12		0.292
Visible minority				
Non-visible minority	Reference			
Visible minority	0.91	0.73–1.12		0.365
Occupation				
Non-essential worker	Reference			
Yes, healthcare worker	0.81	0.63–1.04		0.095
Yes, other essential worker	0.68	0.56–0.83		<0.001
WHO scale: Lack of Confidence in Vaccines	0.6	0.53–0.68		<0.001
WHO scale: Vaccine Risks	0.7	0.64–0.76		<0.001
Date of survey completion				
Pre- Nov 17th	Reference			
Post- Nov 17th	1.45	1.11–1.91		0.007
Intend to get a seasonal influenza vaccine				
No	Reference			
Yes	4.25	3.33–5.43		<0.001
Received a seasonal influenza vaccine in the past 5 years				
Always/almost always	Reference			
1–2 times	1.07	0.83–1.37		0.617
Never/Don't know	0.94	0.72–1.23		0.642
Pandemic impact on perceived value of vaccines				
No change - Negative	Reference			
Negative change	1.74	0.96–3.17		0.068
No change - Positive	6.55	4.40–9.75		<0.001
Positive change	7.86	4.98–12.40		<0.001

COVID-19 vaccine intention throughout the pandemic

The generalized additive mixed model, measuring changes in COVID-19 vaccine intention over the course of the survey completion (August 2020 - March 2021), identified a significant non-linear relationship between date of survey completion and COVID-19 vaccine intention ($p < 0.0001$). Intention to vaccinate increased in mid-November 2020 (Fig. 2), with November 17, 2020 being selected as the dichotomous time cut-off inclusion in the regression analysis. November 17th, 2020 was used as the dichotomous cut-point due to the initial release of information regarding the development and approval of the mRNA vaccines by Health Canada [13].

Valuation of vaccines in relation to time

Overall, 9.0 % of the participants ($n = 570$) reported a retrospective positive change in their perceived value of vaccines during the pandemic. We measured COVID-19 vaccine intention over time (pre- and post-November 17, 2020) stratified by seasonal influenza vaccine intentions and by the retrospective change in the overall reported perceived value of vaccines before and during the pandemic (Fig. 3). Overall, the adjusted percent of those intending to receive COVID-19 vaccine was higher among those intending to receive seasonal influenza vaccine compared with those not intending to receive seasonal influenza vaccine. Among all groups, regardless of change in valuation of vaccines, the adjusted percent of those intending to receive COVID-19 vaccine had increased with

time when compared before and after the November 17, 2020 vaccine announcement.

Discussion

Overall, intention to receive a COVID-19 vaccine was > 80 % in this BC population cohort. In addition, of the 69.0 % of participants who indicated they intended to receive a future seasonal influenza vaccine, ~90 % intended to also receive a COVID-19 vaccine. The strong association between future seasonal influenza vaccine intention and COVID-19 vaccine intention remained after adjusting for other key factors previously identified as associated with vaccine intention [8].

Our findings indicate that in this cohort, future intention to receive an influenza vaccine is strongly associated with intention to receive a COVID-19 vaccine. The positive association between intention to receive influenza vaccine and intention to receive COVID-19 vaccine early in the pandemic was also observed in the UK, albeit the intention to receive a COVID-19 vaccine in those who intended to receive influenza vaccine was overall lower (60.5 %) in the UK sample [16]. Given booster COVID-19 vaccine doses are now being recommended [7], with the potential for future seasonal doses similar to seasonal influenza vaccines, there is an opportunity to leverage vaccine intention to encourage uptake of COVID-19 vaccines, as well as the seasonal influenza vaccine [17], with the potential for safe and effective concomitant vaccine delivery of seasonal vaccines in the future [18].

The overall reported intention to receive a future seasonal influenza vaccine (69.0 %), is a marked increase from 55 % that said they

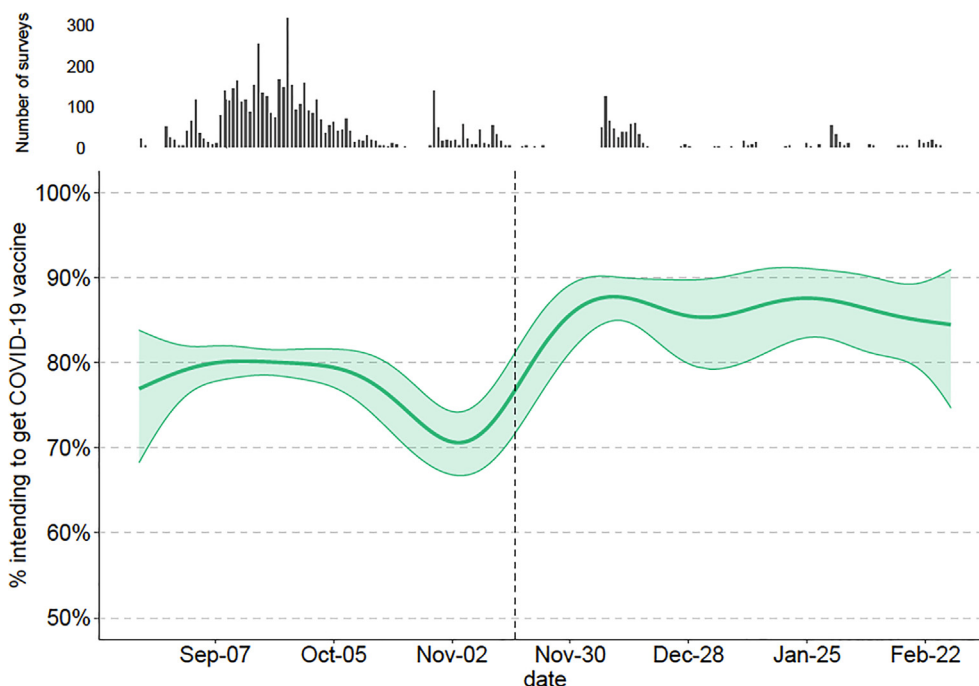


Fig. 2. Plot depicting the number of surveys returned over the study time (upper plot) and the significant non-linear relationship of average intention to receive COVID-19 vaccine and time, with shaded area indicating the 95 % CI around the estimates of vaccine intentions. The dashed vertical line indicates Nov 17th, 2020, which signifies the time around which the information regarding development and approval of the mRNA vaccines was released in Canada.

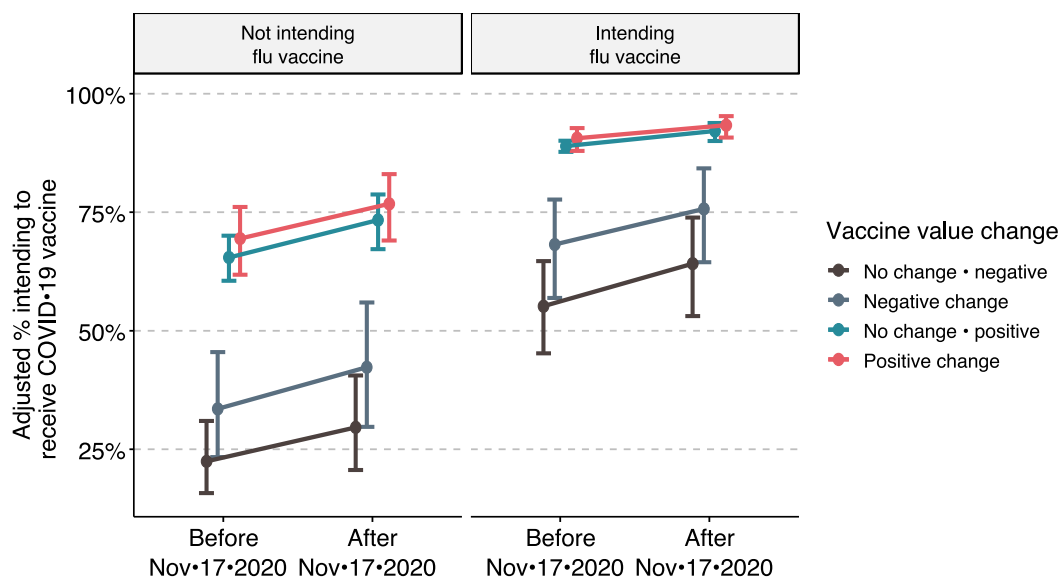


Fig. 3. Plot depicting the change in COVID-19 vaccine intention (%) pre-and post-Nov 17, 2020, by retrospective categorization of reported perceived value of vaccines, stratified by seasonal influenza (flu) vaccine intentions. Error bars indicate 95 % CI.

regularly receive influenza vaccine, and a significant increase from the estimated uptake rate of 42 % for the seasonal influenza vaccine just prior to the pandemic in Canada (from the 2019–2020 Seasonal Influenza Vaccination Coverage Survey), however, is still below the national target levels of 80 % [6]. It is important to note that in BC there is a requirement for healthcare workers to be immunized against influenza yearly, otherwise, they are required to wear a mask within all healthcare facilities for the duration of the influenza season. This immunization policy may have increased the seasonal influenza vaccination rate in our cohort, as ~ 15 % of the cohort reported being a healthcare worker.

Historical receipt of seasonal influenza vaccines was predictive of pandemic vaccine receipt in the last influenza pandemic of 2009

[19]. We found that historical receipt of influenza vaccine was also associated with intention to receive a COVID-19 vaccine, with a graduated relationship based on the frequency of past influenza vaccine receipt. However, once we controlled for sociodemographic factors and other vaccine-intention variables that were previously found to be significant [8], in addition to intention to receive a future seasonal influenza vaccine, we found a non-significant difference in COVID-19 vaccine intention for those who regularly receive the seasonal influenza vaccine compared to those who infrequently received, or have not received the influenza vaccine in the last five years.

Sociodemographic factors and other vaccine intention predictors identified in previous analyses of COVID-19 vaccine intention

remained significantly associated with the intention to receive a COVID-19 vaccine [8]. Previously, we found intention to receive a COVID-19 vaccine was associated with being male, being an essential worker, having more than a high school education, and identifying as a visible minority. After consideration for intention to receive influenza vaccine, change in intention to receive COVID-19 vaccine over time, and retrospective change in the perceived value of vaccines, significant group differences remained based on sex and occupation. Overall, older participants (>60 years of age) were more likely to intend to receive a COVID-19 vaccine, although after adjustment, age was not a strong predictor of COVID-19 vaccine intention.

Over 80 % of study participants indicated they intended to receive a COVID-19 vaccine, with the intention to vaccinate increasing over time, with what was observed as a significant non-linear relationship between COVID-19 vaccine intention and date of participation. This non-linear relationship may be explained by contextual differences during the pandemic, including changing public health restrictions throughout the province in response to cases counts, global trends in COVID-19, emerging variants, rapid development of vaccine candidates [20], and uncertainty regarding vaccine availability. After multiple announcements from Health Canada in mid-November regarding the impending approval of COVID-19 vaccines, the first COVID-19 vaccine received interim use approval on December 9th, 2020 [14]. The release of vaccine product information and clinical trial data, which demonstrated effectiveness and safety, may have been a factor in the observed increase in intention to receive a COVID-19 vaccine over the study period. Another Canadian-wide survey, which examined COVID-19 vaccine intention at the beginning of COVID-19 vaccine rollout, reported that only 9 % of respondents indicated that would not receive a COVID-19 vaccine [21], indicating intention to receive a COVID-19 vaccine may have continued to increase as COVID-19 vaccine rollout commenced. In contrast, vaccine hesitancy toward a COVID-19 vaccine, measured during the same period in another Canadian population, was lowest at the beginning of the pandemic, and increased throughout the summer and fall of 2020, before experiencing a sharp decline in vaccine hesitancy in November 2020 [22]. In BC, as COVID-19 vaccine programs continue, reported vaccine receipt has outpaced initial estimated vaccine intention, with > 90 % of eligible adolescents (12 + years of age) and adults having received at least 1 dose of COVID-19 vaccine, prior to the pediatric (5–11yearsold) COVID-19 vaccine approval announcement in November 2021 [23]. Continued monitoring of vaccine intention and uptake over time will be critical to informing public health messaging and targeting vaccine outreach efforts, as information about long-term vaccine effectiveness, immunity, and safety may continue to impact COVID-19 vaccine intentions and uptake in future.

Vaccine hesitancy has been identified as one of the top threats to global human health [24]. Vaccine hesitancy or acceptance is a spectrum, with one end being vaccine refusers, who are estimated to comprise a small minority (2–4 %) of the population, which is consistent with our findings. We found those who were less vaccine hesitant, as measured by increased confidence in vaccines and lower perceived risk of vaccines, were more likely to intend to receive a COVID-19 vaccine. We also explored if the overall perceived value of vaccines changed for participants due to the pandemic. We found that 9.0 % of the participants retrospectively reported a positive change in their perceived value of vaccines, and 84.0 % reported a sustained positive perceived value of vaccines from before to during the pandemic. Compared to those who held a sustained negative perceived value of vaccines, those with a positive change or a sustained positive perceived value of vaccines, were significantly more likely to intend to receive a COVID-19 vaccine, even after adjustment for key sociodemographic variables.

The antecedents of vaccine hesitancy and acceptance have been theoretically modelled as the “3Cs” by Sage Working Group in 2012, and include confidence, convenience, and complacency, with an extended model adding the components of collective responsibility and calculation [25–27]. The positive change in the perceived value of vaccines during the pandemic may be explained by factors related to a change in complacency (previously not perceiving vaccine preventable diseases as high-risk). We also found a small percentage (2.1 %) of respondents reported a negative change in their perceived value of vaccines, which may be related to factors of confidence (due to a new vaccine) or calculation (the need for extensive information searching). This exploratory analysis of the change in the perceived value of vaccines during the COVID-19 pandemic, suggests a need for further study of the impact of the pandemic on overall perceptions of vaccines. Given that the majority of respondents reported positive attitude towards the vaccines, there is a potential opportunity to leverage the perceived benefits of vaccines overall to increase COVID-19 vaccine uptake, in both those who intend to receive a seasonal influenza vaccine and those who do not. However, recent concerns have arisen about the potential impact of COVID-19 vaccine acceptance on the uptake of other vaccines, notably the seasonal influenza vaccine in countries with varied COVID-19 vaccine uptake [28]. Continuing to monitor the relationship between uptake and intention to receive COVID-19, and seasonal influenza vaccines will help to inform future public health immunization policy and programs.

Limitations

This study has some limitations to consider. The first limitation is the potential for selection bias based on participants being selected from pre-existing research cohorts; it is possible that these participants are more research-minded and less vaccine hesitant. Therefore, they are more likely to receive vaccines or intend to receive a COVID-19 vaccine. Moreover, as the survey was recruited for and delivered online, the sample may be missing responses from individuals with limited Internet access. Our study participants are also predominately women and identify as a non-visible minority, which limits the generalizability of our findings to the overall population in BC.

We may also have some misclassification of self-reported influenza vaccine history, however by grouping vaccine receipt into the three categories we aimed to minimize the impact of recall bias for specific doses received in the last 5 years. The impact of the pandemic on the perceived value of vaccines was measured using a crude examination of a participant's reported perceived value of vaccines at two time points: pre-pandemic and during the pandemic. However, recall biased may have influenced this measure given participants were asked to retrospectively report their perceived value of vaccines pre-pandemic.

The period of time when the survey was administered plays a crucial role in interpreting the findings. The recruitment occurred between August 2020 and March 2021, with the majority of participants completing the survey prior to the vaccine approval announcements, and before the press releases regarding the safety of vaccines. Survey responses received after the approval of the COVID-19 vaccines showed more willingness to receive vaccines among participants, potentially due media coverage and release of vaccine product information, which represented a shift from a conceptualization of a vaccine to the actualization of a vaccine. It is also important to note that in the second half of the study period increased public health control measures came into effect as COVID-19 rates began to increase. In regards to study timing, we did not measure vaccine intentions at the time of information release regarding vaccine safety signals for rare potential side

effects, which may have also impacted intention to receive a COVID-19 vaccine. The dynamic landscape of the pandemic, and vaccine development, illustrates the need for continued monitoring of vaccine intentions and ultimately uptake of vaccine overtime.

Conclusion

Our analysis found that overall COVID-19 vaccine intention was > 80 %, and that intention to receive the seasonal influenza vaccine is associated with intention to receive the COVID-19 vaccine, which is an important relationship to explore for implementation and planning of COVID-19 booster doses. We found an increase in intention to receive a COVID-19 vaccine after public announcements of vaccine approval, which highlights the importance of ongoing monitoring of vaccine uptake, and acceptability, as information on vaccine developments continue to emerge.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: [MS is supported via salary awards from the BC Children's Hospital Foundation, the Canadian Child Health Clinician Scientist Program, and the Michael Smith Foundation for Health Research. MS has been an investigator on projects funded by GlaxoSmithKline, Merck, Pfizer, Sanofi-Pasteur, Seqirus, Symvivo and VBI Vaccines. All funds have been paid to his institute, and he has not received any personal payments. CSR is supported by a fellowship from Michael Smith Foundation for Health Research. MCM is supported by a salary award from the Michael Smith Foundation for Health Research. MCM has been an investigator on a non-vaccine related project funded by GSK/Viiv, and has received honoraria for non-vaccine related activities both personally and paid to her institution from Merck, and Gilead Sciences.].

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