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Social network risk factors and COVID-19 vaccination: A cross-sectional survey study

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ABSTRACT

Background: Social networks have an important impact on our health behaviours, including vaccination. People's vaccination beliefs tend to mirror those of their social network. As social networks are homogenous in many ways, we sought to determine in the context of COVID-19 which factors were most predictive of belonging to a mostly vaccinated or unvaccinated social group.

Methods: We conducted a cross-sectional survey among Canadian residents in November and December 2021. Participants were asked about the vaccination status of their social networks their beliefs relating to COVID-19, and various sociodemographic factors. Respondents were split into three groups based on social network vaccination: low-, medium-, and high-risk. Chi-squared tests tested associations between factors and risk groups, and an ordinal logistic model was created to determine their direction and strength.

Results: Most respondents (81.1 %) were classified as low risk (i.e., a mostly vaccinated social network) and few respondents (3.7 %) were classified as high-risk (i.e., an unvaccinated social group). Both the chi-square test (29.2 % difference between the low- and high- risk groups [1.8 % vs. 31.0 %], $p < 0.001$) and the ordinal logistic model (odds ratio between the low- and high-risk groups: 14.45, $p < 0.01$) found that respondents' perceptions of COVID-19 as a "not at all serious" risk to Canadians was the most powerful predictor of belonging to a predominantly unvaccinated social circle. The model also found that those in mostly unvaccinated social circles also more often reported severe COVID-19 symptoms (odds ratio between the low- and high-risk groups: 2.26, $p < 0.05$).

Conclusion: Perception of COVID-19 as a threat to others may signal communities with lower vaccination coverage and higher risk of severe outcomes. This may have implications for strategies to improve public outreach, messaging, and planning for downstream consequences of low intervention uptake.

1. Introduction

Social networks – the people we interact with – can have an impact on our overall health and wellbeing. Social networks can affect our mental and physical health and can have a significant influence on health behaviour [1,2]. Certain health behaviours seem to be socially transmissible, such as smoking cessation, alcohol consumption, or obesity [2]. Multiple studies have shown that, though genetics also play a role in determining body weight or obesity, within social networks, those with similar body weight and weight-related behaviour tend to form clusters, and that the characteristics of a social network influence individuals' body weight and weight-related behaviour [3,4]. Additionally, a person's chance of becoming obese increases if they have friends who become obese [4].

Another important health behaviour influenced by social networks is vaccine hesitancy. Vaccine hesitancy has been defined as "the reluctance or refusal to vaccinate despite the availability of vaccines" [5]. The causes of vaccine hesitancy are complex, but research has shown that

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social contexts are important [6,7]. One scoping review conducted in 2021 noted that participants held more positive vaccination attitudes and were more likely to get vaccinated when they were frequently exposed to positive attitudes and frequently discussing vaccinations with family and friends [8]. Importantly, the inverse was also true – those who were exposed to negative beliefs were more likely to hold negative beliefs and less likely to get vaccinated [8]. A survey from 2021 found that people who are pro-vaccination tend to perceive others as being pro-vaccination, and skeptics tend to perceive others as skeptics [9]. Therefore, one's choices surrounding vaccination tend to be mirrored in their social network.

Vaccine hesitancy is a critical issue for the control of infectious disease and has been a point of controversy during the COVID-19 pandemic. A scoping review published in 2021 identified several factors that influence views on the COVID-19 vaccine: vaccine acceptance was influenced by factors such as higher education, increased age, and higher income, and vaccine hesitancy was influenced by factors such as unemployment, non-white ethnicity, and younger age [10]. There is some literature on the relationship between social networks and the COVID-19 vaccination specifically. One cross-sectional survey conducted prior to vaccination approval found that individuals with vaccine hesitancy were less likely to be positively influenced by peers or healthcare professionals [11]. One longitudinal study found that family and friends discouraging vaccination was a predictor of lower vaccine uptake [12]. However, most studies focus on specific populations (i.e., students, healthcare workers) [9,13,14], or were conducted before the COVID-19 vaccine was readily available [11,12]. Additionally, there is little work identifying the factors that lead to COVID-19 vaccine hesitancy or acceptance within social networks.

Given the importance of social networks in shaping behaviours surrounding vaccination, it is important to know what the impact social networks had on COVID-19 vaccination uptake. The current study had three main objectives:

1. Determine whether, based on sociodemographic factors, mostly vaccinated social networks were significantly different from somewhat vaccinated and mostly unvaccinated social networks;
2. Determine whether individuals belonging to each social network had:
   a. a vaccination status that matched their social network, relative to other groups; and
   b. distinct beliefs about the COVID-19 situation, including whether desire to conform or social network pressure was a major influence reported by individuals when asked about the decision to remain unvaccinated; and
3. Examine whether study participants of these groups reported significantly different experiences with COVID-19 infections and severe cases, both personally and within their network.

2. Methods

2.1. Study population

This cross-sectional study was conducted among residents of Canada November 16 - December 23, 2021. AskingCanadians, an online data collection company that can be hired to administer surveys, conducted the survey [15]. AskingCandians is a trusted resource for pharmaceutical companies when designing marketing campaigns or gaining perspectives on public opinions. AskingCanadians has more than one million Canadians in its panel who range across socioeconomic strata. Participants are motivated to take part in AskingCanadians' surveys to earn rewards from a variety of retailers [15]. The research team was not involved in compensating the AskingCanadians survey participants.

Potential participants were selected to be nationally representative based on province of residence, biological sex, income level, and visible minority status. Study participants were 18 years or older. The sample size goal of the study was 2,500 survey responses as this sample would provide sufficiently precise estimates while fitting within the practical considerations of this study.

2.2. Questionnaire

The questionnaire was based on similar questionnaires used in other survey studies regarding COVID vaccinations [16,17]. Before launching to the broader survey panel membership, the questionnaire was piloted in field through a one-week soft launch. Panel completion metrics (e.g., time-to-completion, skipped questions, dropped surveys) were assessed to ensure that the questionnaire was technically sound and contained no components preventing users from proceeding toward completion.

The survey questions were designed to explore various beliefs, values, and attitudes toward COVID-19 and COVID-19 vaccines (Appendix 1). Respondents were asked "How many adults do you know in your circle of family or neighbours who do not plan to be vaccinated against COVID-19 for any reason, even though they are eligible and vaccines are available to them?" (Appendix 1, question 26). Potential responses were "All", "Most", "Some", "A few", "None", and "Not sure". Respondents were also asked whether they believed they had COVID-19 (Appendix 1, question 17) and whether they believe this case was severe (Appendix 1, question 19), and similarly whether they knew anyone in their social group who had COVID-19 (Appendix 1, question 22) or a severe case (Appendix 1, question 23). Last, participants were asked how severe of a risk they believed COVID-19 was to themselves (Appendix 1, question 10) and their community (Appendix 1, question 11). Basic sociodemographic questions were also included.

Additionally, vaccinated respondents were asked to provide their reasons for receiving the COVID-19 vaccine (Appendix 1, question 66). One potential reason was "Everyone or most in my social circle were getting the vaccine". Similarly, unvaccinated respondents were asked to provide their reasons for not receiving the vaccine (Appendix 1, question 67). One potential response was "I do not know of anyone in my social circle who received the vaccine". For both these questions, respondents were also able to write in reasons for receiving or abstaining from the vaccine.

For data quality purposes, all respondents who completed the survey faster than 30 % of the median survey length were automatically excluded from the sample. Additionally, open-ended questions were assessed and cases where respondents provided a low-quality answer were removed (*e.g.*, responses that were non-words). This was conducted by the AskingCanadians team.

2.3. Data analysis

Data were collected directly in an online platform and exported as a csv file. Data were then imported into RStudio (2022.07.1) for analysis.

Respondents were ranked into three groups: low, medium, and high risk for vaccine hesitancy. The question "How many adults do you know in your circle of family or neighbours do not plan to be vaccinated against COVID-19 for any reason, even though they are eligible and vaccines are available to them?" was used to categorize respondents. Those who answered "None" or "A few" (i.e., had a mostly vaccinated social network) where classified as low risk. Those who answered "Some" and "Not sure" were classified as medium risk. Those who selected "Not sure" for this question were included in the medium-risk group as they likely had at least some people in their circle vaccinated, but were unsure. Those who answered ("All" or "Most" (i.e., had a mostly unvaccinated social network) were classified as high risk. At the time this survey was being conducted, 89.6 % of Canadians over 12 had received at least one dose of the COVID-19 vaccine [18].

The analysis consisted of four main comparisons: (1) a comparison of sociodemographic factors between groups; (2) a comparison of COVID-19 infection and severity; (3) a comparison of beliefs regarding the seriousness of COVID-19; and (4) the social influence on vaccination

Table 1
Survey participants' personal vaccination status and sociodemographic characteristics, grouped by risk.

Characteristic	Low risk* (81.1 % of total, n = 2,200)	Medium risk * (15.2 % of total, n = 412)	High risk * (3.7 % of total, n = 100)	Absolute difference between high risk and low risk
Vaccination status†				
Vaccinated	2,115 (96.1 %)	302 (73.3 %)	54 (54.0 %)	42.1 %
Unvaccinated	85 (3.8 %)	110 (26.7 %)	46 (46.0 %)	
Gender				
Male	1,014 (46.1 %)	195 (47.3 %)	55 (55.0 %)	8.9 %
Female	1,174 (53.4 %)	214 (51.9 %)	45 (45.0 %)	
Other**	12 (0.5 %)	2 (0.5 %)	0 (0 %)	
Ethnicity†				
White	1,619 (73.6 %)	284 (68.9 %)	64 (64.0 %)	9.6 %
Non-white	581 (26.4 %)	128 (31.1 %)	36 (36.0 %)	
Age†				
Younger than 65	1,532 (69.6 %)	322 (78.2 %)	85 (85.0 %)	15.4 %
65 years and older	668 (30.4 %)	90 (21.8 %)	15 (15.0 %)	
Education***				
High school or less	828 (37.8 %)	177 (43.8 %)	43 (43.4 %)	5.6 %
College-educated	1,364 (62.2 %)	227 (56.2 %)	56 (56.6 %)	
Income***				
Less than $50,000	1,287 (66.6 %)	249 (68.0 %)	51 (58.6 %)	8.0 %
More than $50,000	644 (33.4 %)	117 (32.0 %)	36 (41.4 %)	
Rurality				
Rural	379 (17.2 %)	101 (24.5 %)	21 (21.0 %)	3.8 %
Urban	1,821 (82.8 %)	311 (75.5 %)	79 (79.0 %)	
Immigrant status				
Canadian citizen	2,018 (91.9 %)	371 (90.0 %)	93 (93.0 %)	1.1 %
Permanent resident/non-citizen	178 (8.1 %)	41 (10.0 %)	7 (7.0 %)	
Marital status***				
Married, Common-law	813 (37.0 %)	150 (36.4 %)	34 (34.0 %)	3.0 %
Single	1,381 (62.8 %)	258 (62.6 %)	65 (65.0 %)	2.2 %
Currently employed*†				
Yes	1,038 (47.2 %)	223 (54.1 %)	59 (59.0 %)	11.8 %
No/retired	1,142 (51.9 %)	181 (43.9 %)	39 (39.0 %)	12.9 %

* Low risk: mostly vaccinated social circle; medium risk: somewhat vaccinated social circle; high risk: mostly unvaccinated social circle.
** (Trans, non-binary, two-spirit, gender queer, etc.).
*** Some participants selected "Prefer not to answer".
† Statistically significant difference between groups based on chi-squared test ($p < 0.05$).

choice. The sociodemographic factors we chose to assess were based on research about the COVID-19 vaccine and social networks, and included vaccination status, gender, ethnicity, age, education, household income, immigration status, marital status, current employment status, and rurality (living in a rural versus urban location) [10]. Rural areas were based on the second character of respondents' postal codes (i.e., a zero indicates a rural route for Canada Post) [19]. Additionally, sociodemographic factors were divided into two categories to allow for easier comparison and to ensure sufficient sample size for some groups (e.g., ethnicity was divided into "white" and "non-white"). Chi-squared tests were performed in RStudio (2022.07.1) to distinguish statistically significant differences between the three groups ($p < 0.05$). We report the results of these comparisons first.

To test the extent to which our analysis was sensitive to the approach used, we created an ordinal logistic model with the individual's risk group as the dependent variable. This had the added advantage of being better able to assess the direction and strength of association between factors of interest, and being able to control for potential confounding between them. The model would predict the likelihood of being in a higher risk group, with the "high-risk" factor level ranked the highest and "low-risk" set as the reference level. Data that was grouped into factor levels labelled "not sure" were coded as "NA" and excluded from the model analysis. The proportional odds assumption was checked with the Brandt test at the 5 % level of significance using the "poTest" function from the "car" package in R. Odds ratios with their 95 % confidence intervals were calculated for each factor of interest.

After running the saturated model with all variables of interest and testing the proportional odds assumption, the assumption initially failed. Our variables assessing whether respondents or their social network were infected with COVID-19 and the severity of the infection were heavily correlated. We removed the variables asking whether respondents' social network had been infected and whether they had been infected. We included whether their social circle that was infected had severe symptoms and whether they themselves had severe symptoms if they were infected – this allowed the final model to pass the proportional odds assumption. The level of education variable had low counts within some higher education categories; thus, the variable was aggregated to be "college education" versus "high school or less". Household income levels were also collapsed to be "More than $50,000" versus "Less than $50,000" due to low counts in some income groups. We report the results of the ordinal logistic regression analysis second, then compare the findings of this approach to that of the chi-square.

2.4. Ethics and privacy

Ethics approval was obtained from Conjoint Health Research Ethics Board (ethics ID: REB21-1535). All data transferred by AskingCanadians were deidentified, anonymized, and tokenized before being sent to the research team for analysis.

3. Results

Between 13 November 2021 and 23 December 2021, a total of 4,445 potential participants accessed the survey, and 2,712 (61 %) completed the full questionnaire. Among the study participants, 91.1 % (n = 2,471) were vaccinated and 8.9 % (n = 241) were unvaccinated at the time of the study.

Overall, 81.1 % (n = 2,200) of participants were categorized as low risk, 15.2 % (n = 412) as medium risk, and 3.7 % (n = 100) as high risk.

3.1. Personal vaccination status and sociodemographic characteristics of social networks

Based on chi-squared tests, the risk groups significantly differed on vaccination status ($p < 0.001$), ethnicity ($p = 0.023$), age ($p < 0.001$), education ($p = 0.047$), rurality ($p = 0.002$), and current employment status ($p = 0.002$) (Table 1, Fig. 1, Table A2). There were significant differences between the low-risk (mostly vaccinated social circle) and medium-risk (somewhat vaccinated social circle) groups such that the low-risk group was more likely to be vaccinated (96.1 % vs. 73.3 %, $p < 0.001$), older than 65 (30.4 % vs. 21.8 %, $p < 0.001$), college-educated (62.2 % vs. 56.2 %, $p < 0.001$), live in an urban area (82.8 % vs. 75.5 %, $p < 0.001$), and be currently unemployed or retired (51.9 % vs. 43.9 %, $p = 0.005$) (Table 1, Table A2). There were also significant differences

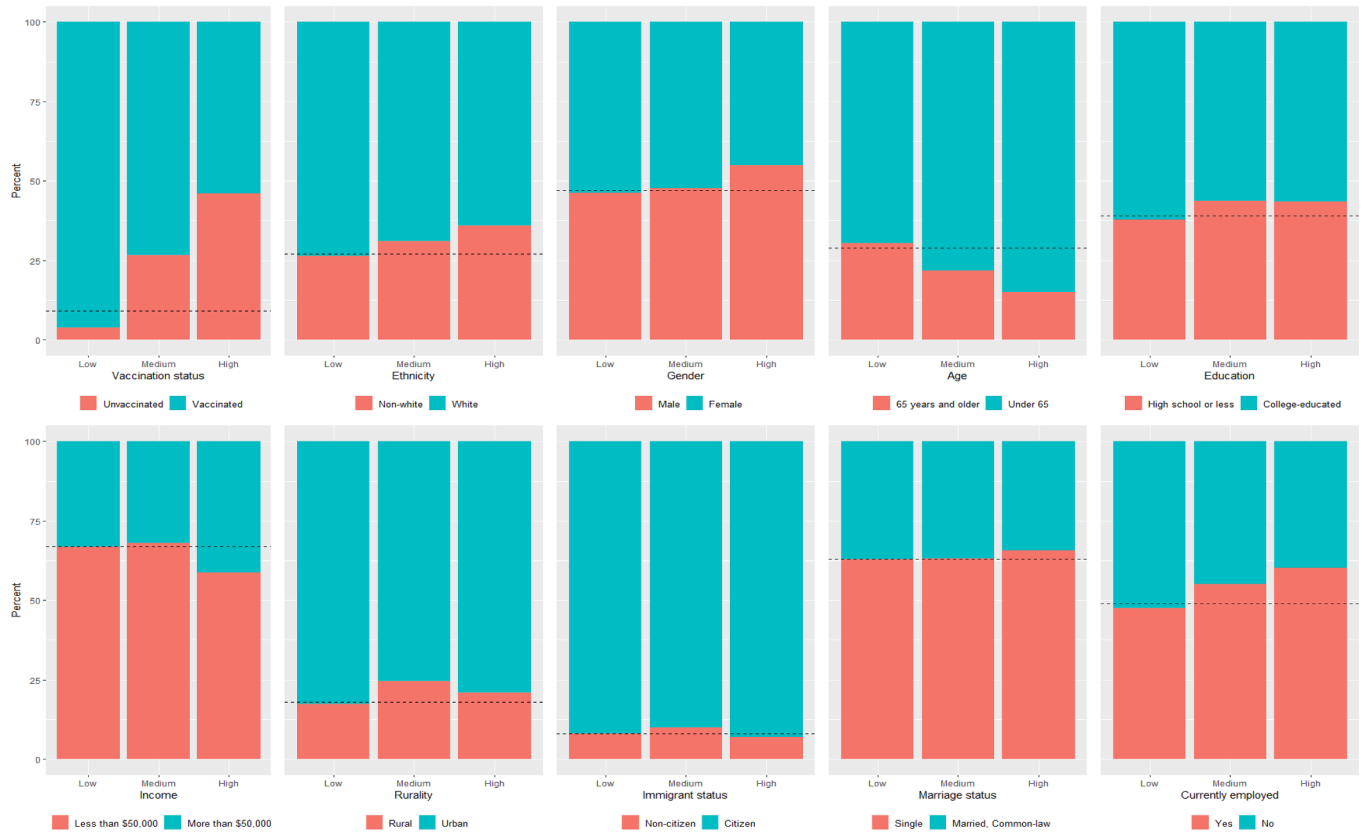

Fig. 1. Personal vaccination status and sociodemographic characteristics of survey respondents.

between the low- and high-risk (mostly unvaccinated social circle) groups such that the low-risk group was significantly more likely to be vaccinated (96.1 % vs. 54.0 %, $p < 0.001$), identify as white (73.6 % vs. 64.0 %, $p = 0.034$), be older than 65 (30.4 % vs. 15.0 %, $p < 0.001$), and be currently unemployed or retired (59.0 % vs. 47.2 %, $p = 0.014$) (Table 1, Table A2, Fig. 1). Finally, the medium- and high-risk groups only differed significantly on vaccination status such that the medium-risk group was more likely to be vaccinated (73.3 % vs. 54.0 %, $p < 0.001$) (Table 1, Table A2, Fig. 1).

3.2. Experiences with COVID-19 infection and severity

Respondents were asked whether they believed they had had one or more cases of COVID-19. Overall, 7.9 % (n = 173) of low-risk (mostly vaccinated social circle), 16.0 % (n = 66) of medium-risk (somewhat vaccinated social circle), and 24.0 % (n = 24) of high-risk respondents (mostly unvaccinated social circle) believed they had been infected at least once (16.1 % difference between low- and high-risk) (Table 2, Fig. 2). There was a statistically significant difference between the three risk groups ($p < 0.001$) (Table A2).

Respondents who said yes to having had a COVID-19 infection were also asked whether they would describe their case as being severe or leading to long-term disability. Of those who believed they had COVID-19, 16.8 % (n = 29) of low-risk respondents, 24.2 % (n = 16) of medium risk respondents, and 25.0 % (n = 6) of high-risk respondents believed their case was severe (8.2 % difference between low- and high-risk) (Table 2, Fig. 2); however, these differences were not large enough to be statistically significant given the number of responses available (Table A2).

Respondents were asked "Approximately how many people do you know in your circle of family, friends, or neighbours who you regularly interact with and who has had a case of COVID-19?". The three risk groups answered significantly different ($p = 0.037$). About one-third (33.2 %, n = 730) of low-risk respondents, 36.9 % (n = 152) of medium-risk respondents, and 44.0 % (n = 44) of high-risk respondents knew at least one person who had had a case of COVID-19 (10.8 % difference between the low- and high-risk groups, $p = 0.025$) (Table 2, Fig. 2, Table A2).

Respondents were also asked "How many of those persons had a severe case of COVID-19 leading to hospitalization, death, or lasting disability?". Twenty-four percent (24.0 %, n = 175) of low-risk, 26.3 % (n = 40) of medium-risk, and 36.4 % (n = 16) of high-risk respondents knew at least one person with a severe case (12.4 % difference between low- and high-risk) (Table 2, Fig. 2); however, again, these differences were not large enough to be statistically significant given the number of responses available (Table A2).

3.3. Beliefs regarding the seriousness of COVID-19

Respondents were asked "How serious of a threat do you think the coronavirus (COVID-19) is to yourself?". About a third (35.7 %, n = 786) of low-risk respondents (mostly vaccinated social circle), 28.2 % (n = 116) of medium-risk respondents (somewhat vaccinated social circle), and 18.0 % (n = 18) of high-risk respondents (mostly unvaccinated social circle) believed COVID-19 was a "Very serious" risk (17.7 % difference between low- and high-risk) (Table 2, Fig. 3). Comparatively, 4.3 % (n = 95) of low-risk, 13.6 % (n = 56) of medium-risk, and 32.0 % (n = 32) of high-risk respondents believed COVID-19 was "Not serious at all" of a risk (27.7 % difference) (Table 2, Fig. 3). The number of those selecting two extreme responses differed significantly across the three risk groups ($p < 0.001$) (Table A2).

Respondents were also asked "How serious of a threat do you think the coronavirus (COVID-19) is to Canadians?". Almost half of low-risk respondents (48.0 %, n = 1,057), 34.7 % (n = 142) of medium-risk respondents, and 22.0 % (n = 22) of high-risk respondents believed COVID-19 was a "Very serious" risk to Canadians (26.0 % difference

Table 2
Survey participant's COVID-19 infection, severity, and beliefs, grouped by risk.

	Low risk* (81.1 % of total, n = 2,200)	Medium risk *(15.2 % of total, n = 412)	High risk * (3.7 % of total, n = 100)	Absolute difference between high risk and low risk
COVID-19 self-infection				
Do you believe that you have personally had one or more cases of COVID-19?				
Yes	173 (7.9 %)	66 (16.0 %)	24 (24.0 %)	16.10 %
No	1,818 (82.6 %)	292 (70.9 %)	71 (71.0 %)	11.60 %
Not sure	209 (9.5 %)	54 (13.1 %)	5 (5.0 %)	4.40 %
Would you describe one or more of your cases of COVID-19 to be either severe or to have lead to long term symptoms or disability?				
Yes	29 (16.8 %)	16 (24.2 %)	6 (25.0 %)	8.20 %
No	130 (75.1 %)	48 (72.7 %)	16 (66.7 %)	8.40 %
Not sure	14 (8.1 %)	2 (3.0 %)	2 (8.3 %)	0.20 %
COVID-19 infection in social network				
Approximately how many people do you know in your circle of family, friends, or neighbours who you regularly interact with and who has had a case of COVID-19?				
None that I am aware of	1,470 (66.8 %)	260 (63.1 %)	56 (56.0 %)	10.80 %
1–2 people	442 (20.1 %)	83 (20.1 %)	22 (22.0 %)	1.90 %
3–4 people	170 (7.7 %)	35 (8.5 %)	16 (16.0 %)	8.30 %
5–6 people	66 (3.0 %)	14 (3.4 %)	3 (3.0 %)	0 %
7–8 people	12 (0.5 %)	4 (1.0 %)	2 (2.0 %)	1.50 %
9–10 people	10 (0.5 %)	3 (0.7 %)	0 (0 %)	0.50 %
More than 10 people	30 (1.4 %)	13 (3.2 %)	1 (1.0 %)	0.40 %
Total know at least one person	730 (33.2 %)	152 (36.9 %)	44 (44.0 %)	10.80 %
How many of those persons had a severe case of COVID-19 leading to hospitalization, death, or lasting disability?				
None that I am aware of	555 (76.0 %)	112 (73.7 %)	28 (63.6 %)	12.40 %
1–2 people	156 (21.4 %)	31 (14.8 %)	13 (29.5 %)	8.10 %
3–4 people	13 (1.8 %)	6 (4.2 %)	3 (6.8 %)	5.00 %
5–6 people	2 (0.3 %)	1 (0.7 %)	0 (0 %)	0.30 %
7–8 people	1 (0.1 %)	0 (0 %)	0 (0 %)	0.10 %
9–10 people	1 (0.1 %)	0 (0 %)	0 (0 %)	0.10 %
More than 10 people	2 (0.3 %)	2 (1.4 %)	0 (0 %)	0.30 %
Total know at least one person	175 (24.0 %)	40 (26.3 %)	16 (36.4 %)	12.40 %
Beliefs about the seriousness of COVID-19				
How serious of a threat do you think the coronavirus (COVID-19) is to yourself?				
Not serious at all	95 (4.3 %)	56 (13.6 %)	32 (32.0 %)	27.70 %
Not very serious	379 (17.2 %)	83 (20.1 %)	17 (17.0 %)	0.20 %
Somewhat serious	940 (42.7 %%)	157 (38.1 %)	33 (33.0 %)	9.70 %
Very serious	786 (35.7 %)	116 (28.2 %)	18 (18.0 %)	17.70 %
How serious of a threat do you think the coronavirus (COVID-19) is to Canadians?				
Not serious at all	40 (1.8 %)	29 (7.1 %)	31 (31.0 %)	29.20 %
Not very serious	208 (9.5 %)	82 (20.0 %)	18 (18.0 %)	8.50 %
Somewhat serious	895 (40.7 %)	156 (38.1 %)	29 (29.0 %)	11.70 %
Very serious	1,057 (48.0 %)	142 (34.7 %)	22 (22.0 %)	26.00 %
Social influence on vaccination status				
Vaccinated	**2,115 (96.1 %)**	**302 (73.3 %)**	**54 (54.0 %)**	**42.10 %**
Everyone or most in my social circle were getting the vaccine				
Yes	388 (18.3 %)	31 (10.3 %)	3 (5.6 %)	12.70 %
No	1,727 (81.7 %)	271 (89.7 %)	51 (94.4 %)	12.70 %
Unvaccinated	**85 (3.9 %)**	**110 26.7 %)**	**46 46.0 %)**	**42.10 %**
I do not know of anyone in my social circle who received the vaccine				
Yes	85 (18.1 %)	17 (15.5 %)	13 (28.3 %)	10.20 %
No	69 (81.2 %)	93 (84.5 %)	33 (71.7 %)	9.50 %

* Low risk: mostly vaccinated social circle; medium risk: somewhat vaccinated social circle; high risk: mostly unvaccinated social circle.

between low- and high-risk) (Table 2, Fig. 3). Additionally, 1.8 % (n = 40) of low-risk, 7.1 % (n = 29) of medium-risk, and 31.0 % (n = 31) of high-risk respondents believed COVID-19 was "Not serious at all" of a risk to Canadians (29.2 % difference, $p < 0.001$) (Table 2, Fig. 3). The number of those selecting these two extreme responses differed significantly across the three risk groups ($p < 0.001$) (Table A2).

3.4. Social network pressure on vaccination

Vaccinated participants were asked to select their reasons for getting vaccinated, including whether social pressure or desire to conform was an influence. Among vaccinated respondents, 18.5 % (n = 388) of the low-risk group (mostly vaccinated social circle), 10.3 % (n = 31) of the medium-risk group (somewhat vaccinated social circle), and 5.6 % (n = 3) of the high-risk group (mostly unvaccinated social circle) selected "Everyone or most in my social circle were getting the vaccine" as a reason for receiving the vaccine (Table 2, Table A2). The low-risk group was significantly more likely to select this as an option than both the medium-risk group (18.3 % vs. 10.3 %, $p < 0.001$) and the high-risk group (18.3 % vs. 5.6 %, $p = 0.016$) (Table A3). There was no significant difference between the medium- and high-risk groups. "Everyone or most in my social circle were getting the vaccine" was the ninth most common reason for receiving the vaccine overall (17.1 %, n = 422) (Table A4), and ten (0.4 %, n = 10) respondents highlighted it as their only reason for being vaccinated.

Unvaccinated respondents were similarly asked to select their reasons for not getting the vaccine and whether social pressure or desire to conform was an influence in remaining unvaccinated. Among unvaccinated respondents, 18.1 % (n = 85) of the low-risk group, 15.1 % (n = 17) of the medium-risk group, and 28.3 % (n = 13) of the high-risk group selected "I do not know of anyone in my social circle who received the vaccine" as a reason for not receiving the vaccine (Table 2, Table A3). The high-risk group was significantly more likely to select this as an option than the low-risk group (28.3 % vs. 18.1 %, $p = 0.001$) (Table A3). The low-risk group was significantly more likely to select this as an option than the medium-risk group (18.1 % vs. 15.5 %, $p < 0.001$). Overall, "I do not know of anyone in my social circle who received the vaccine" was the 11th most common reason for not receiving the vaccine (31.9 %, n = 46) (Appendix 5), and only one respondent selected it as their only reason for remaining unvaccinated.

3.5. Model results

After controlling for multiple factors, the model indicated that participants with a household income of more than $50,000 annually had a

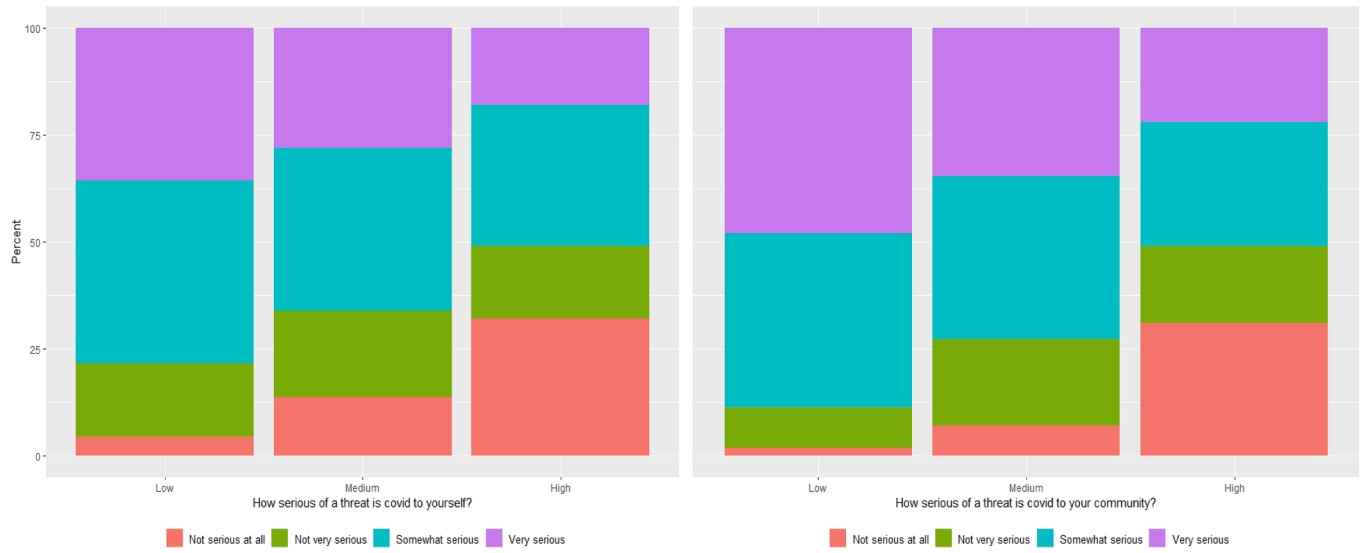

Fig. 2. Perceptions of COVID-19 seriousness.

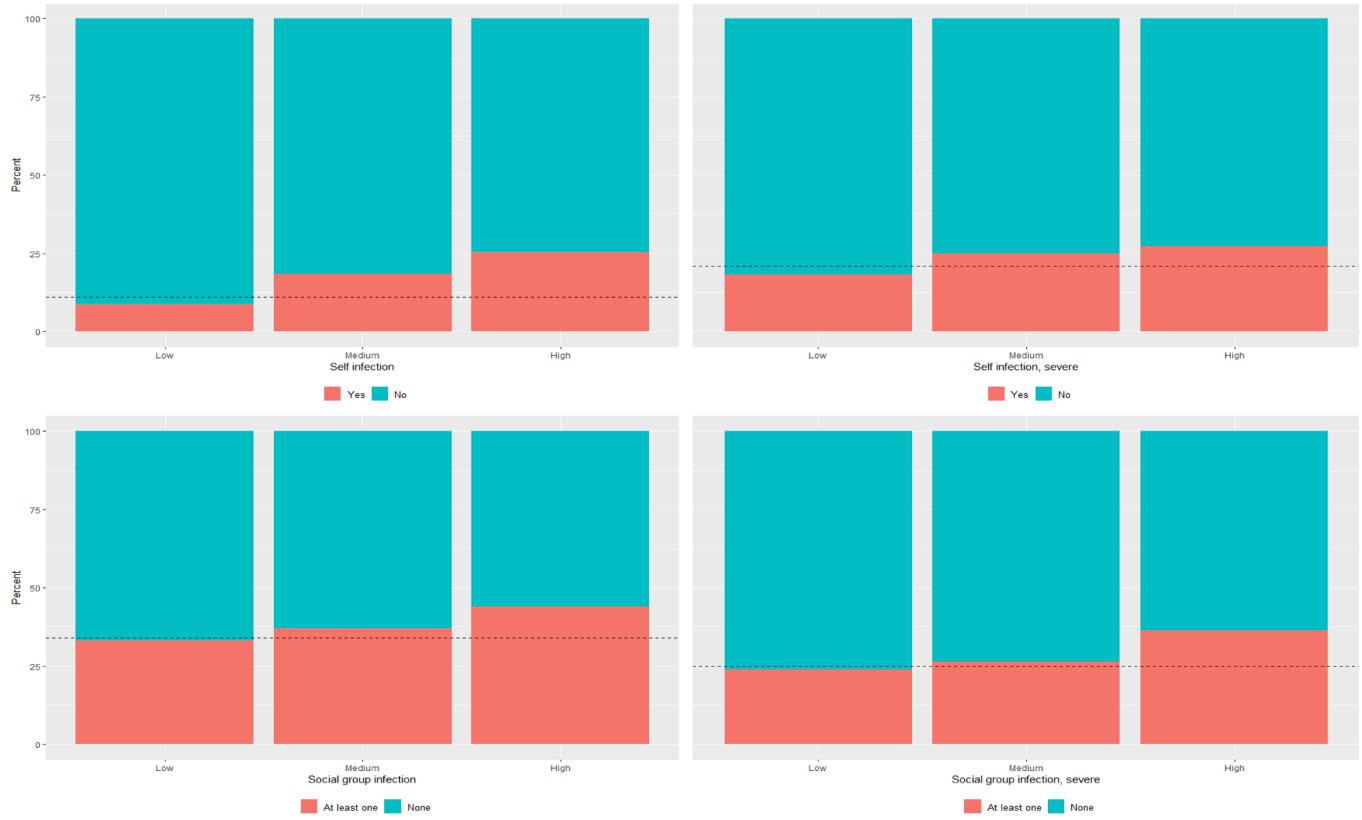

Fig. 3. Percentages across risk groups of who experienced at least one COVID-19 infection.

significantly increased odds of being in a higher risk group compared to those making under $50,000 (Table 3, Figure A2). Participants who experienced severe COVID-19 symptoms also had an increased odds of being in a higher risk group compared to those who did not (Table 3, Figure A3). Last, participants who reported the threat of COVID-19 to others was either "somewhat serious", "not very serious", or "not serious at all" had significantly increased odds of being in a higher risk group as compared to those who said it was "very serious"; the odds were highest for those who reported "not serious at all" (Table 3, Figure A4).

3.6. Comparison of chi-square and regression analyses

The results of the chi-square tests and the ordinal logistic regression model differed in several ways. The chi-square analysis showed significance between several sociodemographic, including personal vaccination status, identifying as white, age, and employment status; however, the regression model showed income over $50,000 as the only demographic factor showing an increased odds of being in a high-risk group. Both analyses confirmed significant differences between risk groups in their response to questions regarding their perceived threat of

Table 3
The likelihood of being in a higher risk group, based on commonality of vaccinations within social network.

Characteristic	Odds Ratio	95 % Confidence Interval	
Vaccination Status (*Ref: Vaccinated*)			
Not Vaccinated	2.12	0.88	5.08
Ethnicity *(Ref: White)*			
Non-White	1.63	0.76	3.49
Age *(Ref: 70 +)*			
18–39	3.35	0.52	35.20
40–49	4.30	0.62	47.21
50–59	3.35	0.52	34.72
60–69	1.17	0.14	13.21
Education Level *(Ref: High-school or less)*			
College-educated	0.63	0.32	1.25
Income *(Ref: <50 k)*			
>50 k	**2.04***	1.04	4.04
Rural Status *(Ref: Rural)*			
Urban	1.23	0.52	2.80
Citizenship Status *(Ref: Canadian Citizen)*			
Permanent Resident/Non-Citizen	1.12	0.41	2.90
Current Work Status *(Ref: Not working)*			
Working	0.78	0.35	1.73
Severe Covid-19 Symptoms – Social Circle *(Ref: 1 or more)*			
None	0.95	0.51	1.79
Severe Covid-19 Symptoms – Self *(Ref: No)*			
Yes	**2.26***	1.03	4.95
Threat to self *(Ref: Very serious)*			
Somewhat serious	0.61	0.23	1.59
Not very serious	0.45	0.12	1.61
Not serious at all	1.47	0.34	6.18
Threat to others *(Ref: Very serious)*			
Somewhat serious	**2.70***	1.12	6.77
Not very serious	**4.30***	1.14	16.73
Not serious at all	**14.45****	2.44	90.63

P-value: <0.05 '*', <0.01'**', <0.001'***'.

COVID-19 to the self and others as well as the number of those who had personally experienced severe COVID symptoms. Of these, the perceived threat to others was the strongest factor distinguishing the risk groups.

4. Discussion

We surveyed 2,712 residents of Canada in November and December 2021 about how common vaccinations were in respondents' social networks. Analysis using two different approaches pointed to questions regarding the seriousness of COVID-19 to themselves, rather than perceived seriousness to others, as most predictive of their social network risk group (i.e., how many in their social networks were vaccinated). While several sociodemographic variables also appeared to be significant, deeper analysis using an ordinal logistic regression model demonstrated that having an income of over $50,000 per year and having experienced severe COVID-19 symptoms were also strongly associated with risk group.

Risk perception was most strongly associated with being in a social circle of predominately unvaccinated individuals. This finding has also been demonstrated in other recent studies. A scoping review published in 2021 found that perceived self-risk of contracting COVID-19, lesser fear of COVID-19, and believing COVID-19 was not serious were associated with being vaccine hesitant [20]. One survey conducted in February and June 2020 found that risk perception was associated with acceptance of the vaccine, and during the lockdown, where risk was perceived to be the highest, vaccine hesitancy decreased [21]. A longitudinal study conducted in winter 2020, spring 2021, and summer 2021 similarly found that perception of higher risk and severity of COVID-19 earlier in the pandemic led to increased vaccination later [22]. The inverse was found to be true in another survey conducted in 2021, where those with lower risk perception were more likely to be vaccine hesitant [23]. These findings make sense; those who believe COVID-19 posed more of a threat would likely be more selective in their social network, or associate with those who were also more cautious, whereas those who did not believe COVID-19 posed a threat would be more likely to associate those who had similar feelings. Our findings add to the body of evidence of social network works generally align in their perceptions.

Although the perception of seriousness of COVID-19 was low among individual respondents in the high-risk group (i.e., largely unvaccinated), there were also significantly more respondents in this group who experienced more severe COVID-19 infections. These findings are intuitive given the demonstrated efficacy and effectiveness of COVID-19 vaccines. For example, hospitalizations and severe outcomes in Ontario were higher among unvaccinated persons. Similarly, across Canada, most hospitalizations and deaths related to COVID-19 were among unvaccinated persons [24,25]. In the UK, the risk of severe outcomes due to COVID-19 infection reduced significantly after receiving a booster [26], which were only just made available when the present study was conducted. Our findings suggest that vaccines were effective in the real world at reducing severe COVID-19 infections as the high-risk group had the largest proportion of unvaccinated respondents (46.0 %).

Interestingly, our study found that those with higher incomes were more likely to be in the high-risk group. This is contrary to the typical narrative that healthcare, and subsequently vaccines are more accessible

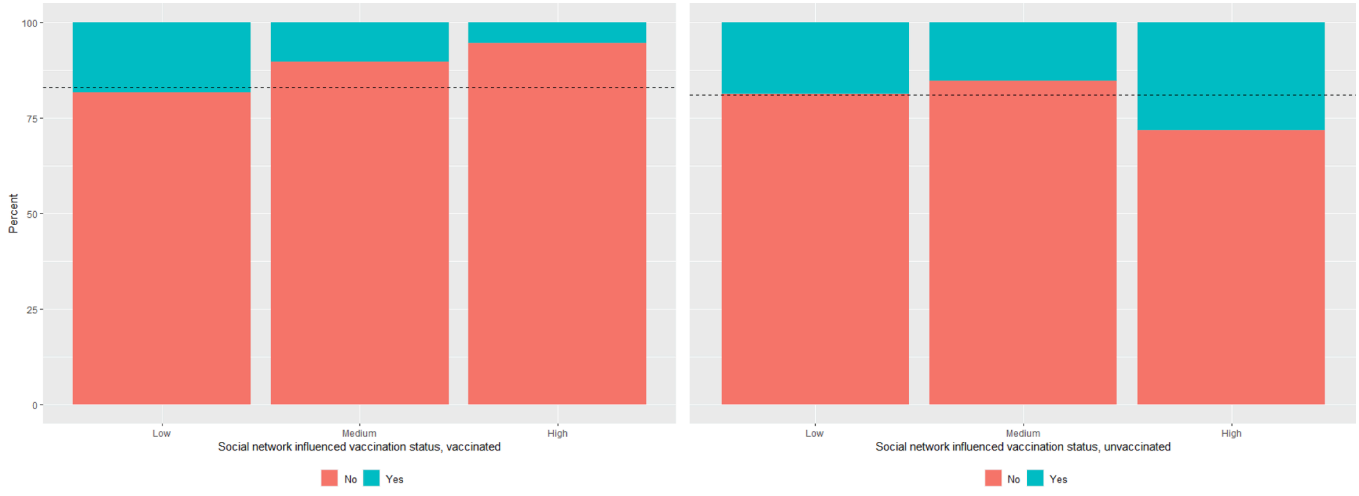

Fig. A1. Social network influence.

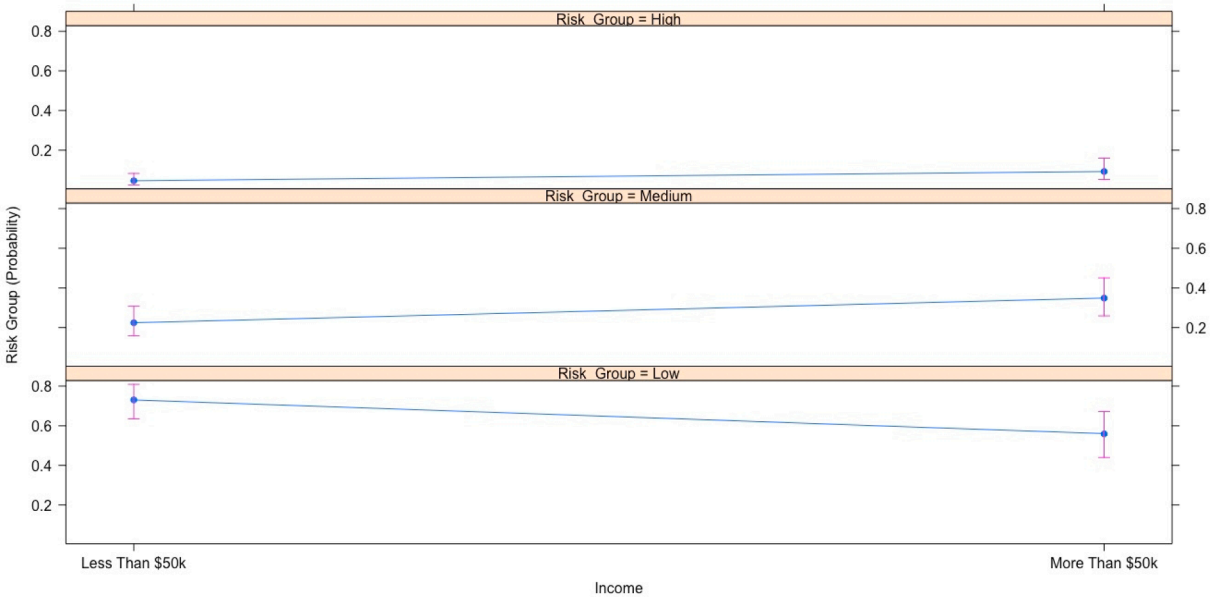

Fig. A2. Probability of Risk Group by Income Level.

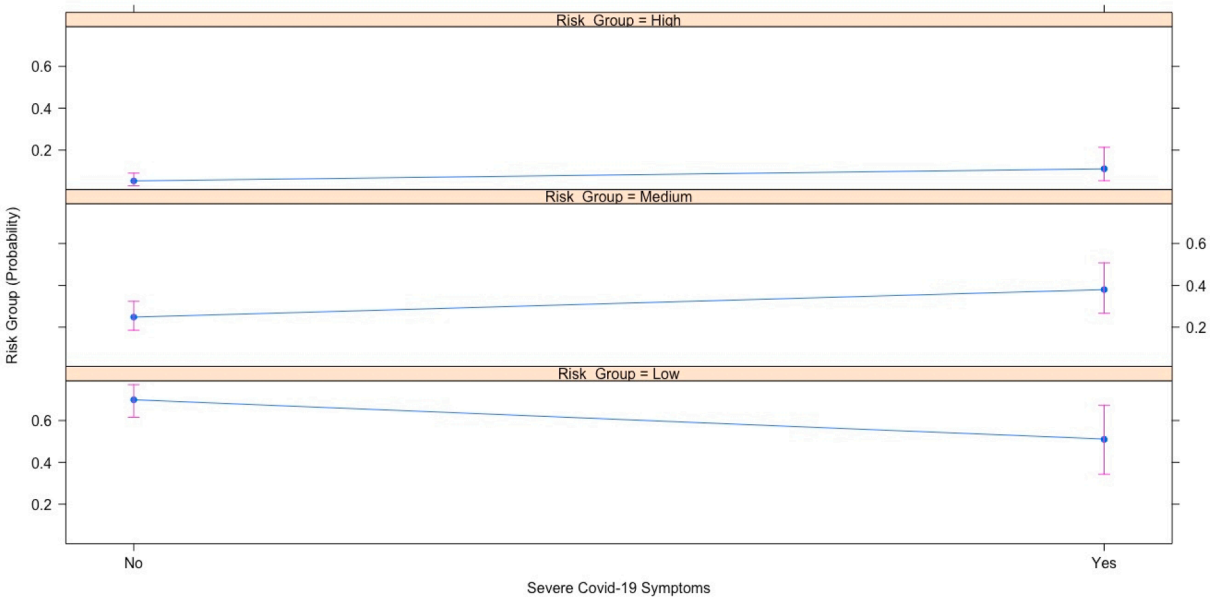

Fig. A3. Probability of Risk Group by Severity of COVID-19 symptoms.

to those with higher incomes. However, recent studies have also shown vaccine hesitancy among clusters of high-income earners. One prominent study from 2015 found that wealthy children were more likely to be exempt from mandatory school vaccines for personal reasons [27]. This finding was replicated in 2021, where school districts with more markers of poverty were more likely to be fully immunized and districts with fewer markers of poverty had more exemptions for personal reasons [28]. In the context of COVID-19, vaccine hesitancy and abstinence has been described as a "peculiar privilege", particularly in high-income countries [29]. These findings are counter-intuitive, as there is lower uptake in low income households [30]; however, many of these reports use data from early in the pandemic, when vaccination was still relatively new, whereas our survey was conducted later and after vaccine mandates had been implemented. Vaccine abstinence, therefore, may be a privilege as the only higher income people able to remain unvaccinated were those who were able to avoid mandates or were able to get an exemption.

There were several differences between the model and chi-squared tests, demonstrating that some results may be sensitive to the type of analytical approach used, showing the presence of confounding, and underscoring the need for most sophisticated modelling techniques when surveying on complex topics like these. While it is also possible that having larger samples sizes could have brought some of the sociodemographic factors measured over the threshold into statistical significance, our results regarding risk perceptions were robust regardless of the smaller sample size.

There are several policy implications from this work. First, our study points to the potential of social network interventions as a public health tool. Social network interventions work by leveraging platforms like social media, friend groups, or word of mouth to change or maintain specific health behaviours [31]. A scoping review from 2019 found that, though social network interventions were not effective for all health

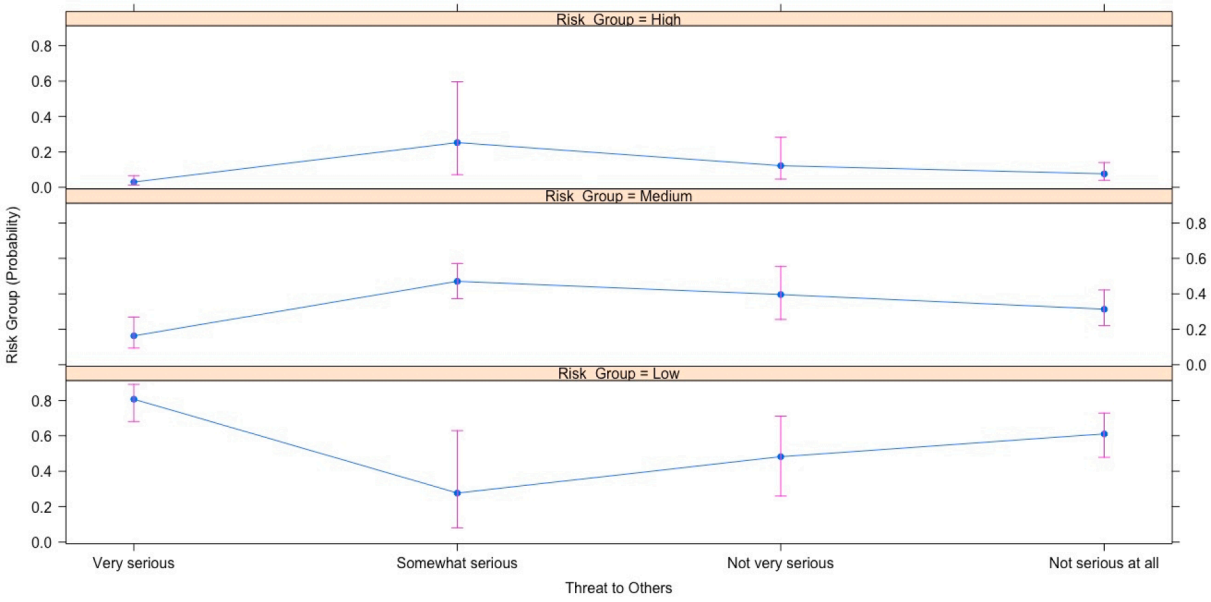

Fig. A4. Probability of Risk Group by Self-Perceived Threat of COVID-19 to Others.

Table A2
Chi-squared tests.

	Overall	Low vs. medium	Medium vs. high	Low vs. high
Sociodemographic factors				
Vaccination status	**p < 0.001**	**p < 0.001**	**p < 0.001**	**p < 0.001**
Gender	p = 0.223	p = 0.620	p = 0.189	p = 0.090
Ethnicity	**p = 0.023**	p = 0.051	p = 0.343	**p = 0.034**
Age	**p < 0.001**	**p < 0.001**	p = 0.128	**p < 0.001**
Education	**p = 0.047**	**p < 0.001**	p = 0.946	p = 0.256
Income	p = 0.243	p = 0.606	p = 0.095	p = 0.121
Rurality	**p = 0.002**	**p < 0.001**	p = 0.459	p = 0.330
Immigrant status	p = 0.408	p = 0.215	p = 0.364	p = 0.691
Marital status	p = 0.859	p = 0.911	p = 0.653	p = 0.584
Current employment	**p = 0.002**	**p = 0.005**	p = 0.370	**p = 0.014**
COVID-19 infection				
Social circle covid	**p = 0.037**	p = 0.144	p = 0.190	**p = 0.025**
Social circle covid, severe	p = 0.167	p = 0.540	p = 0.194	p = 0.064
Self covid	**p < 0.001**	**p < 0.001**	p = 0.138	**p < 0.001**
Self covid severe	p = 0.391	p = 0.255	p = 0.833	p = 0.315
Seriousness of COVID-19				
Threat to self (very vs. not at all)	**p < 0.001**	**p < 0.001**	**p < 0.001**	**p < 0.001**
Threat to others (very vs. not at all)	**p < 0.001**	**p < 0.001**	**p < 0.001**	**p < 0.001**
Influence of social network				
Vaccinated, social influence	**p < 0.001**	**p < 0.001**	p = 0.278	**p = 0.016**
Unvaccinated, social influence	**p < 0.001**	**p < 0.001**	p = 0.064	**p = 0.001**

Table A3
Reasons for receiving the vaccine.

Accessibility	
1. There was a walk-in/mobile vaccination site close to me	271
2. I was offered the vaccine at my place of employment	84
3. I was offered the vaccine at my doctor's office/hospital	64
4. I was offered the vaccine with entry to bar/pub/restaurant/sporting game or facility	28
Social Factors	
5. Everyone or most in my social circle were getting the vaccine	422
6. I wanted to protect myself, my family, and friends	1480
7. A medical professional that I trusted recommended getting the vaccine	1377
8. My work mandated it	41
9. Increased insurance premium from work if I did not get the vaccine	135
10. Someone in my household got COVID-19	17
11. Someone in my work got COVID-19	40
12. My province introduced a vaccine passport system for accessing non-essential or discretionary activities	77
13. My province offered a financial incentive for getting vaccinated	406
14. Someone I know who is not in my household (family/friends/acquaintance) got COVID-19	49
Beliefs, values, and experiences	
15. I trust the scientists/experts who created the vaccine	193
16. I understand that they did not cut corners for vaccine development but rather conducted all steps concurrently	1229
17. I know that mRNA technology has been studied for other illnesses (Ebola, MERS, HIV)	613
18. I understand how the different COVID-19 vaccines work	723
19. I want an end to these restrictions	604
20. It was approved by the FDA	1061
21. It was mandated by my work	629
22. A chance at a million-dollar lottery or other incentive for vaccinated participants	128
Marketing Factors	
23. I saw it on social media	56
24. I heard it on the radio	136
25. I saw it on a billboard	131
26. TV ads	30
27. Internet ads	199
28. Other	104

outcomes, they did have a significant effect on sexual health outcomes, smoking cessation, alcohol misuse, and overall wellbeing [31]. Second, it may be possible to use this information on individual risk perception — which may be more readily available (perhaps gathered via social media) — to identify specific communities at risk or even to anticipate

Table A4
Reasons for not receiving the vaccine.

Accessibility (n = 8)	
1. I cannot get time off of work	1
2. I do not have access to transport to allow me to get to a vaccination appointment	1
3. I do not know how or have been unable to get an appointment	2
4. The nearest vaccination location is too far away	2
5. I am too busy and simply don't have time	2
Social Factors (n = 101)	
6. I do not know of anyone in my social circle who received the vaccine	46
7. Taking this vaccine is against my religious/personal/political beliefs or values	14
8. I have already had COVID-19 and have natural immunity	21
9. Someone in my household already had COVID-19	10
10. Someone in my work got COVID-19	4
11. Someone in my social circle not in my household (friends/family/acquaintance) already had COVID-19	2
12. A trusted medical professional told me to not get vaccinated	8
13. If so, whom (e.g., family doctor, specialist, nurse, etc)?_____	4
Beliefs, values, and experiences (n = 1,214)	
14. I am afraid of needles	20
15. I do not trust vaccines in general (not just the COVID-19 vaccine)	19
16. They made the vaccine too fast	144
17. I don't trust the medical system	119
18. I don't trust the government	138
19. I am worried about the vaccine altering my DNA	67
20. I do not want to be a guinea pig	146
21. I already had COVID-19	18
22. I got the first dose and had a bad reaction	0
23. I have a medical exception from my physician	10
24. The risk of side effects outweighs the risk of having COVID-19	126
25. Vaccines go against natural/alternative medicine	43
26. This has been blown out of proportion	96
27. I am worried about the vaccine effects on my fertility	39
28. Taking this vaccine is against my religious/personal beliefs or values	49
29. I am opposed to the government forcing us to get vaccinated	152
30. I never get sick except for when I get vaccinated	28
Marketing Factors (n = 201)	
31. Information keeps changing, it's hard to know what to believe	124
32. I don't know what's in the vaccine and do not want it in my body	12
33. I don't understand how the vaccines work	5
34. I saw information on the internet or in the news which made me not want the vaccine	25
35. Other	35
36. Please specify_____	

specific hotspots needing improved health system readiness, supports, and communication. Third, given our findings regarding income in late-2021 versus those from other surveys conducted early in 2021 [32], our study underscores possible unintended consequences that populations with limited resources are more heavily impacted when authorities resort to more coercive measures like workplace mandates, leaving those with more resources (and presumably more influence) less affected.

There were several limitations to this study. One limitation is that there were significantly more low-risk respondents than both medium- and high-risk respondents (2,200 vs. 412 vs. 100). Therefore, some of the significant differences identified between groups may have been due, in part, to the difference in population sizes and the lack of responses from the smaller groups. Particularly, the non-white ethnicity group was limited, so the findings of this study may be difficult to generalize across diverse populations. Additionally, the study population was gathered by convenience sampling. There are many Canadians that do not use this survey platform, may not have access to the internet, or may not understand English or French well, and wealthier people may be less motivated to participate in this survey platform to earn points.

5. Conclusion

The results of this survey demonstrate that respondents' perception of the seriousness of COVID-19 to themselves, and especially to others, was predictive of the predominate vaccination status of those in their social circles. Unsurprisingly, those from social circles with lower vaccination coverage also more often reported experiencing severe COVID-19 symptoms. By the time the survey was conducted in late-2021 (immediately following widespread vaccine mandates), our study also found that individuals who associated with predominately unvaccinated social groups also tended to have higher incomes. These findings may have important implications for pandemic preparedness, policy approaches, health system readiness, and health communication messaging, and may point to the potential of social network interventions as a promising public health tool.

CRediT authorship contribution statement

Ally Memedovich: Data curation, Formal analysis, Investigation, Visualization, Writing – original draft. **Taylor Orr:** Formal analysis, Methodology, Investigation, Visualization, Writing – original draft. **Aidan Hollis:** Conceptualization, Writing – review & editing. **Charleen Salmon:** Conceptualization, Data curation, Funding acquisition, Writing – review & editing. **Jia Hu:** Conceptualization, Writing – review & editing. **Kate Zinszer:** Conceptualization, Writing – review & editing. **Tyler Williamson:** Conceptualization, Writing – review & editing. **Reed F. Beall:** Conceptualization, Data curation, Investigation, Funding acquisition, Methodology, Supervision, Project administration, Resources, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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We are grateful to Dr. Peter Loewen at the University of Toronto for his feedback and ideas while designing our survey, particularly the questions surrounding the seriousness of COVID-19 and social networks.

Competing interests

The authors declare they have no competing or conflicting interests.

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Role of funding source

None

Appendix 1. . Full survey

COVID-19 VACCINE SURVEY

SOCIODEMOGRAPHIC VARIABLES

1. What is your age? **TERMINATE IF < 16**.
2. What is your citizenship status?
- Canadian-born citizen.
- Naturalized citizen.
- Permanent resident.
- Work permit.
- Visitor.
- Other.

Please specify:_____.

3. What gender do you identify as?
- Male.
- Female.
- Other (Trans, non-binary, two-spirit, gender queer, etc).
- Prefer not to say.
4. What is your postal code? (Please only use upper case letters e.g., A0A 0A0)_____.
- Prefer not to say (TERMINATE).
5. What is your marital status?
- Single.
- Married.
- Common-law.
- Separated.
- Divorced.
- Widowed.
- Prefer not to say.
6. Including yourself, how many people live in your household?_____(RANGE 1–20).

6b. **IF Q6 > 1 OR IF Q1 < 18: [IF Q1 < 18: "**Including yourself, how**" ELSE: "**How**"]** many in your household are under the age of 18?_____(If answered with at least 1, they will have follow-up questions in the COVID-19 vaccinations in children section).

7. What ethnicity do you identify as? (SELECT ONE).
- Arab.
- Biracial/Multiracial.
- Black or African Canadian.
- White/Caucasian.
- Chinese.
- Filipino.
- First Nations/Inuit/Metis.
- Japanese.
- Korean.
- Pacific Islander (e.g., Oceania like Guam, Fiji, Palau, Samoa, etc).
- Hispanic/Latinx.
- South Asian (e.g., Vietnamese, Cambodian, Laotian, Thai, etc).
- West Asian (e.g., Iranian, Afghan, etc.).
- Prefer not to say.
8. What is the highest level of educational you've attained?
- Some junior high.
- Junior high.
- Some high school.
- High school diploma.
- Some technical/trade/vocational college.
- Technical/trade/vocational college diploma.
- Some post-secondary university.
- Undergraduate university degree.
- Graduate degree (MSc, PhD).
- Professional degree (e.g., MD, DDS/DMD, JD/LLB, DVM, etc).
- Multiple graduate degrees.
- Prefer not to say.
9. What is your annual household income?

- Less than $20,000.
- $20,000-$29,999.
- $30,000-$39, 999.
- $40,000-$49, 999.
- $50,000-$59, 999.
- $60,000-$69, 999.
- $70,000-$79, 999.
- $80,000-$89, 999.
- $90,000-$99, 999.
- $100,000-$109, 999.
- $110,000-$119, 999.
- $120,000-$149, 999.
- $150,000-$199, 999.
- $200,000-$249, 999.
- $250,000-$299, 999.
- $300,000-$349, 999.
- $350,000 or more.
- Prefer not to say.

ATTITUDES ABOUT THE COVID-19 PANDEMIC

10. How serious of a threat do you think the coronavirus (COVID-19) is to yourself?
    - Very serious
    - Somewhat serious
    - Not very serious
    - Not serious at all
11. How serious of a threat do you think the coronavirus (COVID-19) is to Canadians?
    - Very serious
    - Somewhat serious
    - Not very serious
    - Not serious at all

OCCUPATIONAL COVID-19 RISK ASSESSMENT QUESTIONS.

12. Are you currently working?
    - Yes.
    - No.
    - Retired.
    - Prefer not to say.

ASK IF Q12 = YES:

13. Would you categorize your occupation as frontline/essential/public-facing work?
    - Yes.
    - No.
14. **[If you answered yes to Q13 answer Q14]** Which category would your occupation best fall under?
    - Healthcare workers (Acute care ICU/ED physician, nurse, respiratory therapist, paramedics, OT/PT, aides, assistants, other).
    - Long-term care/Nursing homes.
    - Essential non-healthcare workers (e.g., sanitation and waste management, housekeeping).
    - Sales and services (e.g., grocery store, retail worker).
    - Manufacturing (e.g., meatpacking plant, food manufacturing plant).
    - Dentist and dental-related occupation
    - Pharmacist and pharmacy-related occupation
    - Other public-facing occupation

Please specify:_____.

NATURAL COVID-19 INFECTION

15. Approximately how many times have you been tested for COVID-19?
    - None.
    - 1–3 times.
    - 4–6 times.
    - 7–9 times.
    - 10–12 times.

- 13–15 times.
- More than 15 times.

16. [if answered "more than 15 times"] Are you required to be routinely tested for COVID-19?
    - Yes, by my employer or as part of my professional activities.
    - Yes, in order to access non-essential or recreational services or travel.
    - No, but I get tested often to protect myself or others around me.
    - I would rather not answer.
    - Other.

    Please specify:_____.

17. Do you believe that you have personally had one or more cases of COVID-19?
    - Yes.
    - No.
    - Not sure.
18. **[If you answered yes to Q17]** How many times have you been diagnosed with COVID-19 for a separate episode of illness that was diagnosed by a healthcare professional or a positive test result for an active COVID-19 infection?
    - Never.
    - Once.
    - Twice.
    - Three times.
    - More than 3 times.
19. **[if you answered yes to Q17]** Would you describe one or more of your cases of COVID-19 to be either severe or to have lead to long term symptoms or disability?
    - Yes.
    - No.
    - Not sure.
20. **[If you answered yes to Q17]** Were there any occasions in which you believed that you experienced an active case of COVID-19, but it was never officially diagnosed by a healthcare professional or a positive test result for an active COVID-19 infection for any reason?
    - Yes.
    - No.
    - Prefer not to say.
21. **[if you answer yes to Q20]** What were contributing factors for why you did not receive a test or diagnosis from a healthcare professional (check all that apply)?
    - Testing was unavailable at that time.
    - Booking a test was too complicated or expensive.
    - Stigma of having COVID-19 or being tested for COVID-19.
    - Fear of implications of a positive result.
    - Fear of missing work.
    - Fear of having quarantine restrictions imposed by public health authorities.
    - Inconvenience.
    - Lack of trust in testing quality or administration
    - Other. Please specify_____.

NATURAL COVID-19 INFECTIONS IN YOUR SOCIAL CIRCLE.

22. Approximately how many people do you know in your circle of family, friends, or neighbours who you regularly interact with and who has had a case of COVID-19?
    - None
    - 1–2 people
    - 3–4 people
    - 5–6 people
    - 7–8 people
    - 9–10 people
    - More than 10 people
23. **[If not "none" to Q22]** How many of those persons had a severe case of COVID-19 leading to hospitalization, death, or lasting disability?
    - None
    - 1–2 people
    - 3–4 people
    - 5–6 people
    - 7–8 people
    - 9–10 people
    - More than 10 people
24. Have you or anyone you know had a case of COVID-19, even though they are fully vaccinated?
    - Yes, many

- Yes, a few
- None
- Not that I am aware of

COVID-19 VACCINATIONS IN YOUR SOCIAL CIRCLE.

25. How many adults do you know in your circle of friends or neighbours who have been or plan to be vaccinated against COVID-19?
- All
- Most
- Some
- A few
- None
- Not sure

26. **[IF Q25 = All, AUTOCODE Q26 AS None AND SKIP]** How many adults do you know in your circle of family or neighbours who do not plan to be vaccinated against COVID-19 for any reason, even though they are eligible and vaccines are available to them?
- All
- Most
- Some
- A few
- None
- Not sure

27. **[if answered 26 as all, most, some, or a few]** What are the most common reasons that you have heard from this person or persons in your circle of family or neighbours as to why they do not plan to be vaccinated? (check all that apply) **RANDOMIZE FIRST 6.**
- Lack of time or understanding to easily access the vaccines.
- Fear or distrust of the health system.
- Social pressures in their social circles.
- Values or political statements related to personal freedoms.
- Health concerns related to the vaccines themselves such as severe side effects.
- Skepticism of the seriousness of COVID-19 or of the reality of COVID-19.
- I do not know their reasons.
- Other. Please specify_____.

COVID-19 VACCINATIONS IN YOUR HOUSEHOLD.

IF NO OTHER ADULTS IN HOUSEHOLD ((Q1 > 17 and Q6 minus Q6b < 2) OR (Q1 < 18 and Q6 > Q6b)), SKIP TO Q31.

28. How many adults in your household have been vaccinated against COVID-19?
- All.
- Most.
- Some.
- A few.
- None.
- Not sure.

29. **[IF Q28 = All, AUTOCODE Q29 AS None AND SKIP]** How many adults in your household do not plan to be vaccinated against COVID-19 for any reason even though they are eligible and vaccines are available to them?
- All.
- Most.
- Some.
- A few.
- None.
- Not sure.

30. **[if answered 29 as all, most, some, or a few]** What are the most common reasons that you have heard from this adult or adults in your household as to why they do not plan to be vaccinated? (check all that apply) **RANDOMIZE FIRST 6.**
- Lack of time or understanding to easily access the vaccines.
- Fear or distrust of the health system.
- Social pressures in their social circles.
- Values or political statements related to personal freedoms.
- Health concerns related to the vaccines themselves such as severe side effects.
- Skepticism of the seriousness of COVID-19 or of the reality of COVID-19.
- I do not know their reasons.
- Other. Please specify_____.

COVID-19 VACCINATIONS IN CHILDREN.

31. **[If 6b > 0]** How old are the children in your household (check all that apply)?

- Between 12 and 17 years of age.
- 11 or younger.

32. **[If yes to 11 or younger]** Would you recommend the COVID-19 vaccine for your child currently (or once approved for those 11 and under)?
- Yes.
- No.
- Not sure.

33. **[If yes to 11 or younger]** Have your talked with your child or children about getting a vaccination against COVID-19?
- Yes.
- No.
- I do not know.

34. **[If yes to 11 or younger]** Has your child expressed any major concerns about getting a COVID vaccine to you?
- Yes.
- No.
- I do not know.

35. **[If yes to 34]** What are their most common concerns about being vaccinated? (check all that apply) **RANDOMIZE FIRST 5**.
- Fear of needles.
- Fear or distrust of the health system.
- Social pressures in their social circles.
- Health concerns related to the vaccines themselves such as severe side effects.
- Skepticism of the seriousness of COVID-19 or of the reality of COVID-19.
- I do not know their reasons.
- Other. Please specify_____.

35b**. [if yes to 32]** If you would consent to vaccinating your child under-11 years, what would be the best way for your child to receive that vaccine? (check all that apply).

- Through our family doctor or pediatrician
- Through a walk-in vaccination clinic
- Through a pharmacy as a walk-in
- Through our pharmacy by appointment
- Through their school
- Through our church
- Through our church youth program
- Through vaccination clinic by appointment
- Through an after-school program or organized sports team
- Vaccine clinics set up at community events during holidays or weekends
- Other. Please specify_____

COVID-19 VACCINATIONS AND YOU.

36. Have you received at least 1 COVID-19 vaccine?
- Yes.
- No.

[If no to Q36 go directly to Q66 Barriers and Facilitators Section].

37. **[If yes to Q36]** Were you prioritized to get the vaccine early (defined as earlier than someone of your cohort/similar characteristics)?
- Yes.
- No.

38. **[If yes to Q37]** If you were prioritized for an early vaccine, which category best describes why you were prioritized?
- Age (senior).
- Frontline healthcare worker.
- Living in an assisted-living facility.
- Underlying health condition
- Pregnancy.
- Other_____.

39. **[If answered (Underlying health condition) to Q38]** Do you have any co-morbidities listed below? (Select all that apply).
- Diabetes
- Heart conditions
- Respiratory conditions
- Immunocompromised
- BMI $>$ 40 or higher
- Not applicable
- Other

If other, please explain_____.

40. Are you fully vaccinated against COVID-19 (e.g., 2 doses in a 2-dose schedule or 1 dose in a 1-dose schedule)?
- Yes.
- No.

41. **[If yes to Q36]**: When did you receive your 1st COVID-19 vaccine (mm/dd/yyyy)? **[EARLIEST POSSIBLE DATE = DEC. 1, 2020]**.
42. **[If yes to Q36]** If you did receive your 1st COVID-19 vaccine, which vaccine did you receive?
- Pfizer-BioNTech.
- Moderna.
- AstraZeneca.
- Janssen (Johnson & Johnson).
- I don't know which manufacturer.
- Other.

Please specify:_____.
NOTE: If answered (Janssen/Johnson & Johnson or I don't know) in Q42 then do not need to answer Q46-Q53.

43. **[If answered (Janssen/Johnson & Johnson), (Pfizer), (Moderna), (AstraZeneca) or don't know to Q42]** If you did receive your 1st COVID-19 vaccine, where did you receive the vaccine?
- Mass vaccination site.
- Pharmacist.
- Family doctor.
- Place of employment.
- Hospital/Emergency Department.
- Mobile pop-up vaccination site.
- Community centre.
- Outside of Canada.

Please specify:_____.

- Other. Please specify:_____.

44. **[If answered Q41]** Did you have any side effects from your first shot of the COVID-19 vaccine?
- Yes.
- No.

45. **[If yes to Q44]** What were the side effects that you experienced from your first shot? (select all that apply) (RANDOMIZE ALL EXCEPT OTHER).
- Redness, warmth, swelling, bruising, itching, or feeling sore where you had the needle
- Feeling tired or unwell
- A headache
- Fever or chills
- Feeling sick to your stomach (nausea), vomiting (throwing up), or loose stool (diarrhea)
- Swollen lymph nodes
- A cough
- Other

Please specify:_____.

46. Did you receive your 2nd dose of your vaccine?
- Yes.
- No.
- Other.

Please specify:_____.

47. **[If yes to Q46, skip]** If you have not received your 2nd dose, are you scheduled to receive it?
- Yes.
- No.
- Other.

Please specify:_____.

48. **[If yes to Q47]** When is your 2nd COVID-19 vaccine scheduled (mm/ dd/yyyy)?
49. **[If yes to Q46]** When did you receive your 2nd COVID-19 vaccine (mm/ dd/yyyy)?
50. **[If yes to Q46]** If you did receive your 2nd COVID-19 vaccine, which vaccine did you receive?
- Pfizer-BioNTech.
- Moderna.

- AstraZeneca.
- I don't know which manufacturer.
- Other.

Please specify:_____.

51. **[If answered (Pfizer), (Moderna), or (AstraZeneca) or don't know to Q50]** If you did receive your 2nd COVID-19 vaccine, where did you receive the vaccine?
- Mass vaccination site.
- Pharmacist.
- Family doctor.
- Place of employment.
- Hospital/Emergency Department.
- Mobile pop-up vaccination site.
- Community centre.
- Outside of Canada.

Please specify:_____.

- Other.

Please specify:_____.

52. **[If yes to Q46]** Did you have any side effects from your second shot of the COVID-19 vaccine?
- Yes.
- No.

53. **[If yes to Q52]** What were the side effects that you experienced from your second shot? (select all that apply) (RANDOMIZE ALL EXCEPT OTHER).
- Redness, warmth, swelling, bruising, itching, or feeling sore where you had the needle
- Feeling tired or unwell
- A headache
- Fever or chills
- Feeling sick to your stomach (nausea), vomiting (throwing up), or loose stool (diarrhea)
- Swollen lymph nodes
- A cough
- Other

Please specify:_____.

54. **[Do not ask if Q46 = No/Other]** Did you receive a 3rd dose of vaccine against COVID-19 or a booster dose for single vaccine schedule (such as the Janssen/Johnson & Johnson vaccine)?
- Yes.
- No.
- Other.

Please specify:_____.

55. **[Do not ask if Q46 = No/Other or Q54 = Yes.]** If you have not received your 3rd/booster dose, are you scheduled to receive it?
- Yes.
- No.
- Other.

Please specify:_____.

56. **[If yes to Q55]** When is your 3rd/booster COVID-19 vaccine scheduled (mm/dd/yyyy)?
57. **[If yes to Q54]** When did you receive your 3rd/booster COVID-19 vaccine (mm/dd/yyyy)?

Q57b. **[If yes to Q54]** If you did receive your 3rd/booster COVID-19 vaccine, which vaccine did you receive?

- Pfizer-BioNTech.
- Moderna.
- AstraZeneca.
- I don't know which manufacturer.
- Other.

Please specify:_____.

58. **[If answered (Pfizer), (Moderna), or (AstraZeneca) or don't know to Q57b]** If you did receive your 3rd/booster COVID-19 vaccine, where did you receive the vaccine?
    - Mass vaccination site.
    - Pharmacist.
    - Family doctor.
    - Place of employment.
    - Hospital/Emergency Department.
    - Mobile pop-up vaccination site.
    - Community centre.
    - Outside of Canada.

    Please specify:_____.

    - Other.

    Please specify:_____.

59. **[If yes to Q54]** Did you have any side effects from your third/booster shot of the COVID-19 vaccine?
    - Yes.
    - No.
60. **[If yes to Q59]** What were the side effects that you experienced from your third/booster shot? (select all that apply) (RANDOMIZE ALL EXCEPT OTHER).
    - Redness, warmth, swelling, bruising, itching, or feeling sore where you had the needle
    - Feeling tired or unwell
    - A headache
    - Fever or chills
    - Feeling sick to your stomach (nausea), vomiting (throwing up), or loose stool (diarrhea)
    - Swollen lymph nodes
    - A cough
    - Other

    Please specify:_____.

61. If you received the COVID-19 vaccine early, did you have any special access to getting the vaccines? (such as a pharmacist friend, used VaxHunters on Twitter, Reddit, etc).
    - Yes.
    - If yes, please specify:_____.
    - No.
62. When did you first hear about the vaccine? (mm/yyyy) **[EARLIEST POSSIBLE DATE = DEC. 2020]**.
63. How did you first hear about the vaccine?
    - News.
    - Internet.
    - Trusted healthcare professional.
    - Friends.
    - Family.
    - Other.
    - Please specify:_____.
64. When did you first become aware of the vaccine being available to you? (mm/yyyy) **[EARLIEST POSSIBLE DATE = DEC. 2020]**.
65. If you have an official record of your COVID-19 vaccination(s) and are willing to provide a picture of each record so that we can verify the dates and types of vaccine received entered in the previous questions, please upload them now. As the main purpose is to verify vaccination dates, please feel free to avoid any personal information in your snapshot like your name or date of birth.

This is entirely optional, and you will be able to continue with the survey regardless of whether you choose to share any images. **NOTE: Optional, allow for up to 3 image files**.

BARRIERS AND FACILITATORS (Questions to be done after COVID-19 Vaccination questions section).

[ANDREW, IF YOU CAN MAKE THE GRID YOU TALKED ABOUT SO PARTICIPANTS CAN ANSWER ABOUT REASONS BETWEEN SHOTS, THAT WOULD BE IDEAL].

Below you will see reasons that may have led to your decision to either receive or refrain from receiving vaccination against COVID-19. Please select the most applicable to your experience.

66. **FOR Q66/67 RANDOMIZE OPTIONS WITHIN EACH GROUP, AND ORDER OF GROUPS. GROUP TITLES (E.G. "ACCESSIBILITY") SHOULD BE SELECTABLE. [If yes to Q36]** Which of the following factors helped you decide to get the COVID-19 vaccine? (Select all that apply).
    - Accessibility
    - There was a walk-in/mobile vaccination site close to me
    - I was offered the vaccine at my place of employment

- I was offered the vaccine at my doctor's office/hospital
- I was offered the vaccine with entry to bar/pub/restaurant/sporting game or facility
- Social Factors
- Everyone or most in my social circle were getting the vaccine
- I wanted to protect myself, my family, and friends
- A medical professional that I trusted recommended getting the vaccine
- My work mandated it
- Increased insurance premium from work if I did not get the vaccine
- Someone in my household got COVID-19
- Someone in my work got COVID-19
- My province introduced a vaccine passport system for accessing non-essential or discretionary activities
- My province offered a financial incentive for getting vaccinated
- Someone I know who is not in my household (family/friends/acquaintance) got COVID-19
- Beliefs, values, and experiences
- I trust the scientists/experts who created the vaccine
- I understand that they did not cut corners for vaccine development but rather conducted all steps concurrently
- I know that mRNA technology has been studied for other illnesses (Ebola, MERS, HIV)
- I understand how the different COVID-19 vaccines work
- I want an end to these restrictions
- It was approved by the FDA
- It was mandated by my work
- A chance at a million-dollar lottery or other incentive for vaccinated participants
- Marketing Factors
- I saw it on social media
- I heard it on the radio
- I saw it on a billboard
- TV ads
- Internet ads
- Other

Please specify:_____.

67. **[If no to Q36]** Which of the following factors helped you decide to not get the COVID-19 vaccine? (Select all that apply).
- Accessibility
- I cannot get time off of work
- I do not have access to transport to allow me to get to a vaccination appointment
- I do not know how or have been unable to get an appointment
- The nearest vaccination location is too far away
- I am too busy and simply don't have time
- Social Factors
- I do not know of anyone in my social circle who received the vaccine
- Taking this vaccine is against my religious/personal/political beliefs or values
- I have already had COVID-19 and have natural immunity
- Someone in my household already had COVID-19
- Someone in my work got COVID-19
- Someone in my social circle not in my household (friends/family/ acquaintance) already had COVID-19
- A trusted medical professional told me to not get vaccinated
- If so, whom (e.g., family doctor, specialist, nurse, etc)?_____
- Beliefs, values, and experiences
- I am afraid of needles
- I do not trust vaccines in general (not just the COVID-19 vaccine)
- They made the vaccine too fast
- I don't trust the medical system
- I don't trust the government
- I am worried about the vaccine altering my DNA
- I do not want to be a guinea pig
- I already had COVID-19
- I got the first dose and had a bad reaction
- I have a medical exception from my physician
- The risk of side effects outweighs the risk of having COVID-19
- Vaccines go against natural/alternative medicine
- This has been blown out of proportion
- I am worried about the vaccine effects on my fertility
- Taking this vaccine is against my religious/personal beliefs or values
- I am opposed to the government forcing us to get vaccinated
- I never get sick except for when I get vaccinated

- Marketing Factors
- Information keeps changing, it's hard to know what to believe
- I don't know what's in the vaccine and do not want it in my body
- I don't understand how the vaccines work
- I saw information on the internet or in the news which made me not want the vaccine
- Other

Please specify_____.

68. **IF YES TO Q36:** Did any other factors not stated help you decide to get partially or fully vaccinated against COVID-19? Please explain.

Yes (please specify:).

No.
Don't know.

69. **IF NO TO Q36:** Did any other factors not stated help you decide not to get partially or fully vaccinated against COVID-19 vaccine? Please explain.

Yes (please specify:).

No.
Don't know.

QUESTIONS ABOUT VACCINE PRIORITIZATION

70. Do you agree with how COVID vaccinations were prioritized to certain groups when supply was limited?
    - Yes
    - No
    - Not sure or no opinions
    - Other
    - Please specify_____
71. Do you have alternative ideas you would like to share on how COVID vaccinations access should have been organized when supply was limited?

Yes.

No.
Don't know.
This is the end of the questionnaire. Thank you for taking the time to fill out this survey.
See Fig. A1., Fig. A2, Fig. A3, Fig. A4.
See Table A2, Table A3, Table A4.

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