Vaccine: X 8 (2021) 100091

Contents lists available at ScienceDirect

Vaccine: X

journal homepage: www.elsevier.com/locate/jvacx

# Demographic, psychological, and experiential correlates of SARS-CoV-2 vaccination intentions in a sample of Canadian families

Christine L. Lackner [a,*], Charles H. Wang [b]

[a] Psychology Department, Mount St. Vincent University, 166 Bedford Highway, Halifax, Nova Scotia B3M2J6, Canada
[b] Performance and Analytics, Nova Scotia Health Authority (Central Zone), Charter Place Offices Suite 404, 1465 Brenton Street, Halifax, Nova Scotia B3J3T4, Canada

ARTICLE INFO

*Article history:*
Received 11 November 2020
Received in revised form 10 March 2021
Accepted 18 March 2021
Available online 22 March 2021

*Keywords:*
SARS-CoV-2 vaccination
COVID-19
Coronavirus
Vaccine intention
Omission bias

ABSTRACT

The COVID-19 pandemic has been ongoing for close to a year, with second waves occurring presently and many viewing vaccine uptake as the most likely way to curb successive waves and promote herd immunity. Reaching herd immunity status likely necessitates that children, as well as their parents, receive a vaccine targeting SARS-CoV-2. In this exploratory study, we investigated the demographic, experiential, and psychological factors associated with the anticipated likelihood and speed of having children receive a SARS-CoV-2 vaccine in a sample of 455 Canadian families (858 children; parents' mean age = 38.2 ± 6.82 years). Using linear mixed-effects and proportional odds logistic regression models, we demonstrated that older parental age, living in the Prairies (relative to Central Canada), more complete child vaccination history, and a greater tendency to prioritise the risks of the disease relative to the risks of side effects (i.e. lower omission bias) were associated with higher likelihoods of intention to vaccinate participants' children, with trend-level associations with lower perceived danger of the vaccine and higher psychological avoidance of the pandemic. Faster speed of intended vaccination was predicted by a similar constellation of variables with an additional predictor of a child in the family having a COVID-19 related health risk being associated with slower intended speed. Results are discussed concerning public health knowledge mobilisation and the unique Canadian health landscape.


## 1. Introduction

As of March 2021, four vaccines have been approved by Health Canada for the novel coronavirus (SARS-CoV-2, the virus); however, widespread distribution has not occurred [1]. This approval represents a significant first step towards mitigating the future effects of the COVID-19 (the disease) pandemic; however, enough people need to be willing to receive the vaccine, and to do so in a timely manner, to achieve herd immunity status, as natural exposure may be insufficient to reach this level of protection [2]. While the proportion of vaccinated individuals needed to achieve herd immunity status varies by disease, projected estimates for COVID-19 range between 56% and 82% [3–5], and some believe these proportions are impossible to estimate [2]. Furthermore, 19.2% of the Canadian population is aged younger than 18 years [6], which likely necessitates that children be vaccinated to achieve these values. Refusal rates in other segments of the population are high (e.g. only 30.8% of Canadians aged 18–64 years without a chronic medical condition were vaccinated against influenza in the 2018–2019 season [7]), and we might expect similar refusal rates presently [8].

Vaccine hesitancy and anti-vaccine convictions pose a significant public health challenge globally [9]. Even in Canada, where vaccines are free to administer and relatively easy to access, many parents refuse to completely or partially vaccinate their children—both for regularly scheduled vaccines (e.g. measles, mumps, and rubella [MMR]; pertussis) and seasonal vaccines (e.g. influenza). Canada has failed to meet its goal of 95% vaccine coverage (comprising all regularly scheduled vaccines recommended by Health Canada prior to adolescence) in accordance with the World Health Organization [10,11] and ranks 28th out of 29 affluent countries for vaccine coverage rates [12]. Therefore, studying intentions to vaccinate against SARS-CoV-2 *in the Canadian context* is vital if Canada wants to promote herd immunity and mitigate the future consequences of the COVID-19 pandemic.

In addition to the notion that children will need to be vaccinated against COVID-19 to reach herd immunity status within both the larger community and subpopulations with which they regularly interact (e.g. childcare and school peers), it is important to study vaccination intentions *in the family context* for two reasons:

* Corresponding author.
*E-mail addresses:* christine.lackner@msvu.ca (C.L. Lackner), charles.wang@nshealth.ca (C.H. Wang).

https://doi.org/10.1016/j.jvacx.2021.100091
2590-1362/

(1) parents are the health decision-makers for their children; and (2) children, relative to adults, are less likely to be COVID-19 symptomatic and in turn, less likely to fully isolate [13], which may increase the likelihood that they will transmit the disease to others (although some believe that children are not major transmission vectors [14]). Thus, understanding parental intentions to vaccinate themselves and their children for SARS-CoV-2 is essential. Families are a pivotal piece of the public health landscape and previous vaccination campaigns targeted at children have made major impacts on disease transmission [15]. In this exploratory study, we examined what demographic, experiential, and psychological factors predict Canadian parents' intentions to have their family vaccinated.

### 1.1. Demographic predictors

There are numerous demographic predictors of vaccination intentions and behaviours, for one's children. Concerning demographic predictors of routine child vaccinations, parents or guardians of higher socio-economic status (SES) or who live in more privileged neighbourhoods are more likely to vaccinate their child(ren) against MMR than are their counterparts [16]. Increased family size is negatively correlated with likelihood of having one's child(ren) immunized against pertussis [17–19], and vaccine completeness (DTP, polio, and MMR) at 19-months-old [19] (however, [20] found a family size effect in the opposite direction). Parents of a non-minority vs. minority background are more likely to have their child(ren) vaccinated against pertussis, polio, and MMR [19]. Furthermore, vaccine uptake is not uniform across all regions of a country. For instance, those in Western USA are more likely to refuse or delay their children's routine vaccinations than those in other census areas [21]. Regional differences have also been found in pertussis and MMR uptake in Italy [17], HPV uptake in the USA [22], and MMR and pertussis vaccination in Canada [23].

Concerning child vaccination against seasonal influenza or other viruses, parents of higher SES [24], living in more affluent or urban neighbourhoods [25,26], more advanced age [24], and from non-minority backgrounds [27] are more likely to intend to or actually vaccinate their children for seasonal influenza and/or H1N1 than are their counterparts.

We explored the demographic predictors of likelihood and speed of having children receive a SARS-CoV-2 vaccination to determine if previous relationships involving child vaccination hold in the novel public health context of COVID-19 or if they are washed out by psychological and experiential predictors that may be specific to COVID-19.

### 1.2. Psychological and experiential predictors

Vaccine uptake is not uniform across populations; there are individual difference variables to be considered, including, but not limited to, the demographic characteristics described earlier. In addition to demographics, we explored the psychological and experiential predictors of intentions to vaccinate against SARS-CoV-2—both those that are specific (e.g. knowing someone with the disease) and non-specific (e.g. levels of trait anxiety) to COVID-19.

First, we examined previous experience with vaccination: the completeness of vaccine history and the experience of vaccine adverse events (VAEs) as potential predictors of both the speed and likelihood of having children vaccinated. Individuals who regularly vaccinated against influenza (vs. not) were more likely to be vaccinated against H1N1 during the 2009 epidemic [28–31]. Mothers who decline (vs. accept) influenza vaccination during pregnancy are less likely to have their children fully vaccinated [32]. Parental vaccine history is associated with MMR vaccine uptake [33]. Therefore, those with complete vaccination schedules may be more likely to have their children receive the SARS-CoV-2 vaccine than those with incomplete schedules.

Child vaccination history is predicted by parental attitudes towards vaccines and the experience of, or worries about, VAE [34]. Early experiences with vaccines can have enduring influences on subsequent vaccinations. Parents who have personal experience with or knowledge of others with VAEs have lower confidence ratings in the safety, health benefits, and effectiveness of vaccination [35], and they have higher levels of vaccine hesitancy than those with less experience or knowledge [36]. Exposure to vignettes involving VAEs decreases participants' intentions to get vaccinated against a hypothetical disease [37]. Thus, we asked parents about their own, and their children's, experiences with VAEs (if any). Additionally, attitudes towards vaccinations generally were assessed, including their perceived dangers, powerlessness, and trust in authorities regarding vaccines—which all influence vaccination intentions [20,38,39].

We also asked participants about whether they and their children had a primary care physician. Having a strong, trusting relationship with a primary healthcare provider is associated with increased confidence in vaccines [35]. Doctor's recommendations for vaccination were associated with increased H1N1 vaccine uptake [31]. We wanted to know whether the same pattern would hold true for SARS-CoV-2 vaccination intentions.

Experiential variables such as vaccine history, VAEs, and access to care cannot likely be separated from individuals' psychology and their thinking about vaccination. Additional psychological variables may also influence opinions about vaccination. First, arguably, the closer the disease 'hits home' the greater the likelihood of taking action to protect oneself and one's family. For instance, compared to their counterparts, young women with a family history of gynaecological cancers are more likely to get the HPV vaccine [40], and children with a family history of immigration from a highly tuberculosis endemic country are more likely to be vaccinated for tuberculosis [41]. Qualitative reports suggest that individuals with a family history of autism (vs. not) are less likely to have their children vaccinated against MMR [42], a vaccine that has been falsely indicted for increasing risk of autism. People who believe that they had a low risk of H1N1 infection were not likely to get vaccinated against H1N1; however, they believed that their attitudes would change if a member of their social circle contracted the illness [43]. In other words, the socially closer the perceived threat, the greater the tendency to vaccinate.

Social distance is one component of a greater construct known as psychological distance, which influences the probability of perceiving and reacting to disease threats [44]. Therefore, we investigated how many (if any) people the responding parent knows who have been diagnosed with COVID-19, their relationship closeness, and their health outcome. The threat of COVID-19 may seem greater for those individuals with high numbers of contacts diagnosed and/or knowledge of those with serious COVID-19-related outcomes (e.g. death of a close contact leading to decreased psychological distance from COVID-19). A Malaysian study confirmed this hypothesis. Knowing a friend, neighbour, or colleague infected with COVID-19 was associated with greater intention to vaccinate against SARS-CoV-2 [45]; although we do not know if this relationship holds when making vaccination decisions for one's children, or in the Canadian context where vaccines are freely available. Relatedly, the perceived risk of acquiring the disease impacts vaccination decisions [46], including decisions around oneself receiving the SARS-CoV-2 vaccine [45,47,48] and likely impacts how psychologically distant one feels from COVID-19. To our knowledge, no one has investigated how distal COVID-19 threat (e.g. risk to community and the world) impacts SARS-CoV-2 vaccination intentions in the family context.

Perhaps related to previous experience with VAEs, omission bias—or having a perceived greater risk of harm from being vaccinated (i.e. side effects) relative to the perceived risk of not being vaccinated (i.e. riskiness of the disease)—leads to a tendency to prefer inactive options (i.e. not being vaccinated, [49]). Thus, we examined parental levels of the omission bias.

We additionally examined the influence of the pandemic on parents' psychological well-being, hypothesising that those who were most negatively affected by the pandemic would be those who were more likely to vaccinate their children as compared to their less affected counterparts. Furthermore, levels of state (relatively temporary) and trait (relatively enduring) anxiety may additionally correlate with intentions to vaccinate as mothers high in trait anxiety are *less likely* to have completely vaccinated their children than mothers low in anxiety [50]. Healthcare workers who believed the H1N1 vaccine was unsafe were higher in state anxiety than those who felt it was safe [51]. However, mothers with mild anxiety symptoms are *more likely* to receive the influenza vaccine during pregnancy than women without such anxiety symptoms [52]. These discordant results may be attributable to making healthcare decisions for oneself versus one's children, measures of state versus trait anxiety, and/or the nature of the vaccine and disease in question. Levels of state anxiety may be elevated in the current pandemic context [53–55] as parents report stressors related to relationships, health, safety, work, and finances [56]—and this increased stress may be associated with increased *or* decreased intentions to vaccinate. These lines of research suggest that it is prudent to examine associations between state and trait anxiety and intentions to vaccinate children.

Relative to previous research, we expect the pattern of those receiving vaccines to shift somewhat considering the current pandemic. Previous research revealed that vaccine uptake is not uniform across vaccines (e.g. rates of regularly scheduled immunisations and seasonal influenza vaccination are not equivalent, and intentions to vaccinate against H1N1 were higher than intentions to vaccinate against seasonal flu [21,57]), and that parental attitudes differ across vaccines (e.g. the high degree of concern over the varicella vaccine in [21]). We cannot entirely look to existing vaccine literature to predict vaccination intentions during the current COVID-19 crisis; therefore, while exploratory in nature, this study makes a valuable contribution to our understanding of which Canadian families are likely to have their children vaccinated and how quickly.

Thus, our objectives were to determine the demographic, experiential, and psychological predictors of intent to vaccinate children for SARS-CoV-2. We examined predictors of immunisation intentions including demographic variables: parental age, income, education level, health status, and family size/composition. Additionally, we examined whether the impact of the pandemic on parental mental health, psychological distance from COVID-19, individual differences in anxiety, attitudes towards immunisations, previous experience with VAEs, and access to primary care physicians predict future vaccination intentions for parents and their children. All data were collected using online questionnaires.

## 2. Methods

### 2.1. Procedure

Participants were recruited to participate in 'A study of health behaviours and intentions in the wake of COVID-19' from across Canada using online advertisements and snowball sampling techniques. To avoid biased sampling, we did not include specific reference to vaccinations. A recruitment notice was posted to online classified advertisement websites (Kijiji, the Canadian equivalent to Craigslist in the USA) of major Canadian cities, various Canadian parenting groups on Facebook, and to a variety of academic listserves. Targeted Facebook ads were visible to Canadian parents aged 18–60 years for a two-week period during data collection (15 May to 9 June 2020). The recruitment notices contained a link to SimpleSurvey$^{TM}$—where participants read an informed consent letter and indicated their willingness to participate. Questionnaire completion took approximately 30 min. Both the informed consent letter and the thank-you message contained links to mental health and COVID-19 resources. Ten $50 gift cards were raffled-off to randomly selected participants after data collection. All aspects of the study were approved by the Mount Saint Vincent University Research Ethics Board (File 2019–197), abiding by the principles of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.

### 2.2. Participants

A total of 673 participants clicked on the survey link. Forty-one participants did not advance past the consent form and 45 participants did not advance past the eligibility survey, requiring them to indicate that they were a Canadian parent of (a) child(ren) aged $\leq$ 18 years. Furthermore, 132 participants failed to complete at least 80% of the survey measures and were therefore excluded from analyses. A total of 455 parents responded to 80–100% of our measures and were therefore retained ($N$ = 858 children). Given that participants dropped out at varying time points throughout the survey (many before demographics were completed), we cannot systematically compare those that were retained for analysis versus those who were excluded. Demographic characteristics of the final sample and other descriptive statistics are presented in Table 1 and Table S1 in Supplemental Material.

## 3. Materials

Details of each questionnaire comprising the predictor variables are presented in Supplementary Materials and described briefly here. We asked the responding parent to describe the family composition, income level, province of residence, and educational level, and subsequently calculated a measure of socio-economic status. We asked parents about their access to primary healthcare providers, their risk factors for COVID-19, and if they had a presumed or positive COVID-19 diagnosis [58]. We asked about parental and child past vaccination history, VAEs, and attitudes towards vaccines generally [39]. We assessed the strength of the omission bias [49] regarding a potential SARS-CoV-2 vaccine. We assessed how psychologically close to COVID-19 participants felt by asking about COVID-19 diagnoses and outcomes in their social circles. We assessed the impact of the pandemic on participants' well-being [59] and administered the State-Trait Anxiety Inventory [60].

### 3.1. Outcome variables

#### 3.1.1. SARS-CoV-2 vaccination intentions

Participants were asked to report, on a scale from 1 to 100, how likely they would be to receive a vaccination and how likely they would be to have their children vaccinated against SARS-CoV-2 in the event that a successful vaccine is developed and approved by Health Canada. They were also asked how quickly they would get themselves and each of their children vaccinated ranging from 1 (*as soon as the vaccine is available in my area*) to 5 (*I would not get them vaccinated for SARS-CoV-2*). They responded to these likelihood and speed questions for each of their children.

**Table 1**
Participants' demographic and descriptive statistics.

| Variable | n (%) | Mean | SD | Possible range |
|---|---|---|---|---|
| Parents' age | | 38.2 | 6.82 | ≥18 |
| Parents' sex | | | | |
| Female | 418 (91.9) | | | |
| Male | 33 (7.3) | | | |
| Relationship to child(ren)[1] | | | | |
| Biological mother/father | 801 (93.5) | | | |
| Legal guardian or adoptive parent | 29 (3.4) | | | |
| Stepmother/father | 21 (2.5) | | | |
| Foster parent | 3 (0.3) | | | |
| Grandmother/father | 2 (0.2) | | | |
| Region of residence | | | | |
| Central | 187 (41.1) | | | |
| Atlantic | 177 (38.8) | | | |
| Prairies | 57 (12.5) | | | |
| Western | 33 (7.3) | | | |
| Marital status | | | | |
| Married or cohabiting | 404 (88.8) | | | |
| Single | 51 (11.2) | | | |
| Number of children | | 1.89 | 0.83 | 1–6 |
| Birth order | | | | |
| First born (or only child) | 455 (53.0) | | | |
| Second born | 299 (34.8) | | | |
| Third born | 81 (9.4) | | | |
| Fourth, fifth and sixth born | 23 (2.7) | | | |
| Socio-economic status (z-scored) | | -0.008 | 0.80 | −2.98–1.39[2] |
| Health variables[3] | | | | |
| Proportion of family members with a doctor | | 0.94 | 0.18 | 0–1 |
| Children's number of COVID-19 health risks | | 0.19 | 0.44 | 0–3[2] |
| Children's past vaccine completeness | | 6.38 | 1.71 | 2–8 |
| Children's previous vaccine adverse event | | | | |
| No | 782 (91.2) | | | |
| Yes | 75 (8.8) | | | |
| Parents' past vaccine completeness | | 6.0 | 1.32 | 2–8 |
| Parents' previous vaccine adverse event | | | | |
| No | 403 (88.6) | | | |
| Yes | 46 (10.1) | | | |
| Parents' number of COVID-19 health risks | | 0.93 | 1.15 | 0–8[2] |
| Attitudes towards vaccines | | | | |
| Perceived danger | | 21.48 | 11.84 | 8–56 |
| Powerless | | 8.21 | 4.41 | 3–21 |
| Trust in authority | | 7.87 | 2.98 | 2–12 |
| Omission bias | | −3.56 | 10.18 | −49–23 |
| COVID-19 risk perceptions | | | | |
| Proximal COVID-19 risk | | 6.18 | 2.03 | 1–10 |
| Distal COVID-19 risk | | 7.79 | 1.94 | 1–10 |
| Psychological distance | | | | |
| COVID-19 relationship score | | 2.55 | 8.10 | 0–150[2] |
| COVID-19 outcome score | | 1.83 | 5.02 | 0–60[2] |
| Impact of COVID-19 pandemic | | | | |
| Intrusion | | 17.17 | 5.74 | 8–32 |
| Avoidance | | 18.04 | 4.83 | 8–32 |
| Arousal | | 12.47 | 4.42 | 6–24 |
| Anxiety | | | | |
| State | | 43.48 | 12.61 | 20–80 |
| Trait | | 42.17 | 9.70 | 20–80 |
| Outcome variables | | | | |
| Average child vaccination likelihood | | 76.83 | 33.32 | 1–100 |
| Average child vaccination speed[4] | | 2.46 | 1.39 | 1–5 |

Notes:
[1] Relationship could differ across children. For instance, the responding parent may be a biological parent to one child and a foster parent to another. Therefore, these statistics are presented at the child level (total $N$ = 857).
[2] Indicates observed range, as $z$-scores or health conditions could theoretically take any value.
[3] Averaged at the family level for descriptive purposes.
[4] Higher values indicate a slower intended speed.

### 3.2. Data analysis

All data were processed and analysed using the statistical package R [61]. To model the likelihood of parents intending to have their child(ren) vaccinated, considering that children in the same family are not independent, we utilised two ways of removing the effects of the natural dependencies among the observations within families. The first was to average vaccination likelihoods and average each child-level variable within a family and then model the average likelihood as a linear function of the averaged child-level predictors and the parent-level predictors, using an ordinary least square (OLS) regression.

The second way was to apply a multi-level mixed-effects (MLM) model [62] that specifically tackles the nested relations between

the children and family and between the family and geographic regions. Just like parents tend to have similar vaccination intentions for their children, families of the same geographic region may have similar intentions to vaccinate. A MLM with random intercepts was used to account for the effects of children nested within family and families nested within the same geographic region. The lme4 method [63] was used to run a MLM with random intercepts.

Multicollinearity among the IVs in the linear and linear mixed-effects models was addressed using a variance inflation factor (VIF) analysis. VIF greater than 5 indicates significant multicollinearity and the corresponding variable may need to be removed from the models. All variables in the linear model had a VIF of <3.81 and therefore multicollinearity was not a significant problem. For the multi-level mixed model with random intercepts, the 'baby' group (aged < 24 months) had a marginally high VIF at 5.5; however, we retained this variable to avoid losing data for this group of children and the families to which they belong.

To analyse the speed of SARS-CoV-2 vaccination, a categorical variable, a proportional odds logistic regression (polr) model for ordinal logistic regression [64] was applied. A polr model estimates slope coefficients, which, when exponentiated, represent the odds ratio for a one unit change in the predictor being associated with an increase or decrease in the odds that the outcome variable is in higher categories relative to all other lower categories. For instance, an odds ratio of 0.96 on parental age predicting vaccine speed means that for a one-unit (year) increase in parental age, we expect the odds that the vaccination speed to be 'waiting a couple of weeks or longer' relative to 'vaccinating right away' is 0.96 times as much before the one-year change (i.e. the odds are reduced by 4% for every one-year increase in parental age), given all other variables are held constant. As with vaccination likelihood, vaccination speeds are not independent from each other in the same family. Therefore, we used averaged vaccination speed within families as the outcome variable and the predictor variables pertaining to children within the same family were averaged. To account for potential clustering effects with the same geographic region, we applied Cumulative Link Mixed Models (clmm) implemented in the 'ordinal' package [65] to conduct an ordinal regression with random intercepts for region.

## 4. Results

### 4.1. SARS-CoV-2 vaccination likelihood

The results of the linear regression model are shown in Table 2. The model captured 64% of the variation in the outcome variable: average likelihood of vaccination. Participants in the Prairies (relative to the Central provinces) reported a higher (8.3 points) likelihood of having their children vaccinated. No other regional differences were significant. Older parental age was associated with increased likelihood. At the child level, vaccine history was a significant independent predictor of vaccination likelihood—children who had higher vaccine completeness showed higher likelihoods. At the family level, lower omission bias was a significant predictor of increased child vaccination likelihood, with trend-level associations with lower perceived vaccine danger and higher levels of avoidance.

Under the multiple-level linear mixed-effects model, where the interdependence between the observations for the children in the same families and the families in the same geographic regions were considered, the results also showed increased parental age, more complete parent and child vaccination history, lower perceived danger, and lower omission bias were significant for predicting increased child vaccine likelihood (Table 3). Under this nested model, trust in authority and avoidance showed trend-level predictions in the same direction as the non-nested model. An additional trend-level predictor of child age emerged, with parents reporting higher average vaccine likelihoods for adolescent children relative to babies and other young children.

### 4.2. SARS-CoV-2 vaccination speed

Table 4 presents the results of polr model predicting speed of SARS-CoV-2 vaccination in children. Living in the Prairies (relative to Central Canada, lower perceived danger, higher trust in authority, lower omission bias, and higher levels of avoidance were associated with faster intended speed of child vaccination. Older parental was a trend-level predictor of faster vaccination speed. Having a child in the family with one COVID-19 health risk predicted slower intended speed.

The above polr model used the average vaccination speed and the averaged predictor variables pertaining to children to remove the non-independence between the children in the same family. To further account for potential clustering effects at the regional level, a Cumulative Link Mixed Model (clmm) containing both fixed and random effects (random intercept for regions) in ordinal regression was applied (Table 5). The results of this model were highly similar to the polr model in Table 4. This is consistent with the estimated between-group variance for the region variable as the random intercept is only 0.02 and the intraclass correlation coefficient (ICC) is 0.007. Decreased perceived danger of vaccines, increased trust in authority, lower omission bias, and increased avoidance were associated with faster intended vaccination speed. Older parental age and children's more complete vaccination history were marginally significant predictors. Having a child in the family with one COVID-19 health risk predicted slower intended speed.

## 5. Discussion

Now that four COVID-19 vaccines have been successfully developed, vaccination of children will be required to achieve herd immunity in a timely manner and it is prudent to know the characteristics of those families who intend and do not intend to get their children vaccinated and how quickly this vaccination will occur. Most studies to date only focused on vaccination likelihood, not speed. As Canada has an especially low rate of vaccine uptake among developed countries, and has a publicly funded healthcare system, existing documented associations may not apply in the Canadian context. In the present exploratory study, we examined the demographic, experiential, and psychological predictors of having one's children vaccinated.

Demographically, our results mirrored those of previous vaccine research. Parental age was positively associated with likelihood and marginally associated with speed, similar to results of Taha and colleagues [43] regarding H1N1 vaccination intentions; Kumar and colleagues [66] regarding H1N1 vaccine uptake; and Wu and colleagues [67] and Chen and colleagues [24] regarding child influenza vaccine uptake. Somewhat surprisingly, SES did not emerge as a robust predictor of likelihood or speed. This discrepancy of findings may be attributable to several factors including the publicly funded nature of Canada's healthcare system (families would not have to pay out of pocket for the vaccine and therefore finances are not a barrier to access), the novel context that COVID-19 has created, and the demographic characteristics of our sample (Supplementary Table 1). We are unsure of the precise reason for the increased likelihood and speed of vaccine uptake among families residing in the Prairies; however, we suspect that this may have to do with political attitude differences

**Table 2**
Linear regression model of the within-family average likelihood of having children vaccinated.

| | Estimate | SE | t | Pr (>\|t\|) |
|---|---|---|---|---|
| Intercept | 26.63 | 16.68 | 1.60 | 0.11 |
| Demographics | | | | |
| Parents' sex – male (female as ref grp) | −0.28 | 4.18 | 0.07 | 0.95 |
| Parents' age | 0.45 | 0.22 | 2.09 | 0.04* |
| Family size | −0.71 | 1.20 | 0.59 | 0.56 |
| Socio-economic status | 0.14 | 1.53 | 0.09 | 0.93 |
| Children's average age – baby as ref grp | | | | |
| Preschool | −2.82 | 3.31 | 0.85 | 0.39 |
| Child | −1.53 | 3.51 | 0.44 | 0.66 |
| Adolescent | −3.24 | 5.11 | 0.63 | 0.53 |
| Region of residence – Central as ref grp | | | | |
| Atlantic | 3.26 | 2.40 | 1.36 | 0.18 |
| Prairies | 8.29 | 3.42 | 2.42 | 0.02* |
| Western | 4.00 | 4.16 | 0.96 | 0.34 |
| Health variables | | | | |
| Proportion of family members with a doctor | −1.56 | 6.41 | 0.24 | 0.81 |
| Children's average 1 COVID-19 health risk (ref grp = 0 risks) | −4.66 | 3.98 | 1.17 | 0.24 |
| Children's average $\geq$ 2 COVID-19 health risks (ref grp = 0 risks) | 4.07 | 6.68 | 0.61 | 0.54 |
| Children's average past vaccine completeness | 2.19 | 1.11 | 1.98 | 0.05* |
| Children's previous VAE (ref grp = no VAEs) | 1.05 | 3.22 | 0.33 | 0.74 |
| Parents' past vaccine completeness | 2.22 | 1.38 | 1.60 | 0.11 |
| Parents' previous VAE (ref grp = no VAEs) | −2.69 | 3.81 | 0.71 | 0.48 |
| Parents' number of COVID-19 health risks (continuous) | −0.08 | 1.01 | 0.08 | 0.93 |
| Attitudes towards vaccines | | | | |
| Perceived danger | −0.29 | 0.15 | 1.91 | 0.06· |
| Powerless | 0.15 | 0.33 | 0.47 | 0.64 |
| Trust in authority | 0.79 | 0.53 | 1.49 | 0.14 |
| Omission bias | 1.76 | 0.19 | 9.47 | <0.001*** |
| COVID-19 risk perceptions | | | | |
| Proximal COVID-19 risk | −0.81 | 1.45 | 0.56 | 0.58 |
| Distal COVID-19 risk | 1.19 | 1.64 | 0.73 | 0.47 |
| Psychological distance | | | | |
| COVID-19 relationship score | 0.03 | 0.17 | 0.17 | 0.87 |
| COVID-19 outcome score | −0.01 | 0.28 | 0.02 | 0.98 |
| Impact of COVID-19 pandemic event | | | | |
| Intrusion | −0.10 | 0.34 | 0.28 | 0.78 |
| Avoidance | 0.53 | 0.29 | 1.81 | 0.07· |
| Arousal | −0.34 | 0.46 | 0.75 | 0.45 |
| Anxiety | | | | |
| State | 0.07 | 0.12 | 0.56 | 0.58 |
| Trait | 0.14 | 0.14 | 0.98 | 0.33 |

Notes: (1) Ref grp = reference group. All categorical variables must be compared against a reference group as indicated in the table. (2) VAE = vaccine adverse event. (3) SE = standard error. (4) Negative scores indicate higher omission bias; thus, lower omission bias is associated with increased likelihood of having one's child vaccinated. ·p < 0.1, *p < 0.05, **$p$ < 0.01, ***$p$ < 0.001.

[68] which are associated with attitudes towards vaccination [69], and/or a desire to fully 're-open' the Prairie provinces, which have been especially impacted in the current pandemic (e.g. collapsing oil prices and aerospace manufacturing, [70]). For some, hopes of economic recovery hinge upon the successful creation of a vaccine [71]; thus, hopes for economic recovery in the Prairies may hinge strongly on vaccine uptake. Future research should explore these possibilities.

Experientially, our results also mirrored that of previous vaccine research. Child previous vaccine history was associated with increased likelihood consistent with the results of previous research on H1N1 [28–31], seasonal influenza [32], and MMR [33] vaccination. Yet, the previous experience of VAEs did not decrease either the intended speed or likelihood of vaccination in accordance with prior results [36] (only approximately 9% of our child sample reported VAEs). The proportion of family members with a family doctor was also not associated. This is somewhat surprising given that strong relationships with primary healthcare providers have been associated with confidence in vaccines generally [35] and doctor recommendations are associated with H1N1 vaccine uptake [31]. However, we did not ask participants to provide detailed information on their relationships with their doctors, just whether or not they had one. It could be that simply having a doctor is not enough to promote SARS-CoV-2 child vaccination intentions; rather, the doctor–patient relationship must be strong. Furthermore, as the vaccine was unavailable at the time of the study, participants may not have discussed the possibility of a vaccine with their doctor.

Several psychologically relevant variables were associated with vaccine likelihood and speed, including attitudes towards vaccines generally. Dovetailing with previous research, those who perceived greater danger in vaccines and those with reduced levels of trust in authority relating to vaccines indicated a slower intended speed of vaccine uptake. Interestingly, feelings of powerlessness surrounding vaccination did not correlate with intended speed or likelihood of vaccinating one's children. Powerlessness similarly did not correlate with vaccination intentions in Jolley and Douglas [39], perhaps because vaccination is largely a choice in both Canada and the United Kingdom (where Jolley and colleagues' participants resided). Participants who preferred to accept the risks of not being vaccinated against SARS-CoV-2 (e.g. increased risk of getting COVID-19) relative to the risks of being vaccinated (e.g. side effects) scored high on omission bias. Individuals high in omission bias were less likely to intend to have their child(ren) vaccinated and intended to delay vaccination for a longer period of time. This is consistent with Hamilton-West [49] who found that students high on omission bias were unlikely to receive the MMR vaccine following an outbreak of mumps on a UK university campus.

**Table 3**
Multilevel mixed-effects regression model with random intercepts predicting likelihood of having individual children vaccinated.

| | Estimate | SE | t | Pr (>\|t\|) |
|---|---|---|---|---|
| Intercept | 34.00 | 15.95 | 2.1 | 0.03* |
| Demographics | | | | |
| Parents' sex – Male (female as ref grp) | −0.19 | 4.12 | < 0.01 | 0.96 |
| Parents' age | 0.39 | 0.17 | 2.3 | 0.02* |
| Family size | −1.18 | 1.12 | 1.1 | 0.29 |
| Socio-economic status | −0.40 | 1.47 | 0.3 | 0.79 |
| Child age – baby as ref grp | | | | |
| Preschool | −0.18 | 0.18 | 0.9 | 0.36 |
| Child | 0.14 | 0.87 | 0.2 | 0.87 |
| Adolescent | 1.17 | 0.61 | 1.9 | 0.07· |
| Health variables | | | | |
| Proportion of family members with a doctor | −2.83 | 6.34 | 0.4 | 0.66 |
| Child has 1 COVID-19 health risk (ref grp = 0 risks) | 0.08 | 0.22 | 0.4 | 0.71 |
| Child has ≥ 2 COVID-19 health risks (ref grp = 0 risks) | 0.54 | 2.17 | 0.3 | 0.8 |
| Children's past vaccine completeness | 0.69 | 0.29 | 2.4 | 0.02* |
| Children's previous VAE (ref grp = no VAEs) | -0.84 | 1.56 | 0.5 | 0.59 |
| Parents' past vaccine completeness | 3.64 | 1.04 | 3.5 | < 0.001*** |
| Parents' previous VAE (ref grp = no VAEs) | −0.45 | 3.61 | 0.1 | 0.9 |
| Parents' number of COVID-19 health risks (continuous) | 0.13 | 0.96 | 0.1 | 0.9 |
| Attitudes towards vaccines | | | | |
| Perceived danger | −0.31 | 0.15 | 2.1 | 0.04* |
| Powerless | 0.25 | 0.32 | 0.8 | 0.43 |
| Trust in authority | 0.95 | 0.52 | 1.8 | 0.07· |
| Omission bias | 1.81 | 0.18 | 10.1 | < 0.001*** |
| COVID-19 risk perceptions | | | | |
| Proximal COVID-19 risk | −1.23 | 1.39 | 0.9 | 0.38 |
| Distal COVID-19 risk | 1.27 | 1.6 | 0.8 | 0.43 |
| Psychological distance | | | | |
| COVID-19 relationship score | 0.02 | 0.17 | 0.1 | 0.93 |
| COVID-19 outcome score | < 0.01 | 0.28 | < 0.01 | 0.98 |
| Impact of Event | | | | |
| Intrusion | −0.1 | 0.34 | 0.3 | 0.77 |
| Avoidance | 0.49 | 0.29 | 1.7 | 0.09· |
| Arousal | −0.20 | 0.45 | −0.4 | 0.66 |
| Anxiety | | | | |
| State | 0.04 | 0.12 | 0.3 | 0.76 |
| Trait | 0.14 | 0.14 | 1.0 | 0.33 |
| Random effects | | | | |
| $\delta^2$ (within-group, i.e. residual, variance): 0.05 | | | | |
| $\tau^2$ (between-group variance): | | | | |
| Regions: 6.61 | | | | |
| Family:Regions: 360.95 | | | | |
| Child order: Family:Regions: 45.07 | | | | |
| ICC (intraclass correlation coefficient): | | | | |
| Regions: 0.02 | | | | |
| Family:Regions: 0.88 | | | | |
| Child order: Family:Regions: 0.11 | | | | |
| Marginal $R^2$/Conditional $R^2$: 0.61/1.0 | | | | |

Notes: (1) Ref grp = reference group. All categorical variables must be compared against a reference group as indicated in the table. (2) VAE = vaccine adverse event. (3) SE = standard error. (4) Negative scores indicate higher omission bias, so here, lower omission bias is associated with increased likelihood of having child vaccinated. Marginal $R^2$ = proportion of variance explained by the fixed effects in the model. Conditional $R^2$ = proportion of variance explained by the fixed and random effects combined in the model. ·p < 0.1, *p < 0.05, **p < 0.01, ***p < 0.001.

Psychological variables related to the ongoing pandemic were also associated with vaccine likelihood and speed. Levels of perceived distal and proximal COVID-19 risk were not predictive of increased vaccine likelihood and speed. These results are somewhat surprising given that two existing COVID-19 vaccine intentions studies found increased intention with increased perceived COVID-19 risk [45,47]; although, as with previous discordant results, this may be attributable to differences in decision-making processes for oneself and one's children, as well as differences in samples. Wong and colleagues used a Malaysian sample and Reiter and colleagues an American sample. American versus Canadian samples may differ in perceived levels of risk as cases have been substantially lower in Canada versus the United States [72]. Infection rates do not explain the differences between Canadian and Malaysian samples in this regard; therefore, these national differences warrant further investigation. Both America [73] and Malaysia [74] do not have universal access to healthcare, and vaccination likelihoods are probably related to this important variable.

The impact of the COVID-19 pandemic on parents, specifically on their tendency to avoid thoughts, negative emotions, or information about the pandemic, was marginally related to an increased likelihood of having their children vaccinated, and significantly related to intending to vaccinate them more quickly, whereas levels of intrusion and arousal were not related. To our knowledge, no existing study has addressed these three measures in association with vaccination intentions in any pandemic context (e.g. SARS, MERS etc); thus, we have little to compare our results to. However, it seems reasonable to conclude that high levels of avoidance—one symptom of post-traumatic stress disorder [75]—may be associated with an increased desire to take action to potentially protect one's family from COVID-19. Subsequent to the initiation of this study, the Impact of Event Scale with Modifications for

**Table 4**
Proportional odds logistic regression model predicting average within-family speed of having children vaccinated.

| | Estimate | SE | z | Pr (>\|z\|) |
|---|---|---|---|---|
| Demographics | | | | |
| Parent sex – Male (female as ref grp) | −0.18 | 0.44 | −0.41 | 0.68 |
| Parent age | −0.04 | 0.02 | −1.84 | 0.07 · |
| Family size | −0.05 | 0.12 | −0.43 | 0.67 |
| Socio-economic status | 0.15 | 0.14 | 1.06 | 0.29 |
| Average child age – baby as ref grp | | | | |
| Preschool | −0.09 | 0.33 | −0.27 | 0.78 |
| Child | −0.26 | 0.35 | −0.75 | 0.45 |
| Adolescent | 0.03 | 0.50 | 0.05 | 0.96 |
| Region of residence – Central as ref grp | | | | |
| Atlantic | −0.36 | 0.23 | −1.53 | 0.13 |
| Prairies | −0.82 | 0.34 | −2.39 | 0.02* |
| Western | −0.26 | 0.40 | −0.64 | 0.52 |
| Health variables | | | | |
| Proportion of family members with a doctor | −0.82 | 0.56 | −1.45 | 0.15 |
| A child has 1 COVID-19 health risk (ref grp = 0 risks) | 0.76 | 0.38 | 2.01 | 0.04* |
| Child(ren) has ≥ 2 COVID-19 health risks (ref grp = 0 risks) | −0.93 | 0.64 | −1.46 | 0.15 |
| Children's average past vaccine completeness | −0.16 | 0.11 | −1.54 | 0.12 |
| Children's previous VAE (ref grp = no VAEs) | −0.19 | 0.32 | −0.60 | 0.55 |
| Parents' past vaccine completeness | −0.12 | 0.13 | −0.90 | 0.37 |
| Parents' previous VAE (ref grp = no VAEs) | −0.10 | 0.37 | −0.27 | 0.79 |
| Parents' number of COVID-19 health risks (continuous) | 0.05 | 0.10 | 0.55 | 0.58 |
| Attitudes towards vaccines | | | | |
| Perceived danger | 0.05 | 0.02 | 3.15 | <0.001** |
| Powerless | 0.00 | 0.03 | 0.07 | 0.95 |
| Trust in authority | −0.12 | 0.05 | −2.43 | 0.02* |
| Omission bias | −0.16 | 0.02 | −7.86 | <0.001 |
| COVID-19 risk perceptions | | | | |
| Proximal COVID-19 risk | −0.02 | 0.14 | −0.11 | 0.91 |
| Distal COVID-19 risk | −0.16 | 0.16 | −1.05 | 0.30 |
| Psychological distance | | | | |
| COVID-19 relationship score | 0.01 | 0.02 | 0.54 | 0.59 |
| COVID-19 outcome score | −0.01 | 0.02 | −0.27 | 0.79 |
| Impact of COVID-19 pandemic event | | | | |
| Intrusion | 0.04 | 0.04 | 1.19 | 0.23 |
| Avoidance | −0.06 | 0.03 | −2.20 | 0.03* |
| Arousal | −0.01 | 0.04 | −0.23 | 0.82 |
| Anxiety | | | | |
| State | 0.00 | 0.01 | −0.28 | 0.78 |
| Trait | −0.01 | 0.01 | −0.73 | 0.47 |
| Intercept (cut points): | | | | |
| As soon as the vaccine is available in my area\|A couple of weeks: −7.01*** | | | | |
| A couple of weeks\|A couple of months: −5.85*** | | | | |
| A couple of months\|A year or more: −4.27** | | | | |
| A year or more\|Never: −1.40 | | | | |

Notes: (1) Ref grp = reference group. All categorical variables must be compared against a reference group as indicated in the table. (2) VAE = vaccine adverse event. (3) SE = standard error. (4) Negative scores indicate higher omission bias, (5) faster immunisation intentions are represented by lower scores on our Likert-scale measure, so a negative estimate between parental age and speed, for example, indicates a faster intended speed with increasing parental age. ·p < 0.1, *p < 0.05, **$p$ < 0.01, ***$p$ < 0.001.

COVID-19 has been developed and validated [76]; thus, future research should include this modified scale.

Levels of anxiety were not linked with vaccination likelihood and speed in the present study. Mohammed and colleagues [52] found that mothers with mild anxiety symptoms were more likely to receive the influenza and pertussis vaccine during pregnancy than their counterparts with no or high levels of anxiety symptoms. This suggests that future research should look for curvilinear relationships between anxiety and intentions to vaccinate.

Surprisingly, psychological distance from COVID-19, here measured as the number of contacts with a positive COVID-19 diagnosis, their relationship closeness, and their health outcomes was not related to likelihood or speed. This is contrary to Taha and colleagues [43], who found that participants believed their attitudes towards the H1N1 vaccine would become more positive if a member of their social circle contracted the illness. These discordant findings may be attributable to the nature of the pandemic. H1N1 was not as widespread as COVID-19, and many more people know someone who has been diagnosed with the disease, likely washing out some of the variability in this measure.

## 6. Conclusions

Overall, various demographic, experiential, and psychological predictors were related to the intended speed and likelihood of having one's children vaccinated against SARS-CoV-2, some in ways that replicated past research on vaccination intentions, and some in surprising and novel ways. It is important that public health workers recognise the uniqueness in the Canadian context and the uniqueness of the family context in predicting speed and likelihood of vaccination. Understanding families' current intentions to vaccinate for SARS-CoV-2 will allow policymakers and public health officials to develop targeted messaging campaigns to those with the greatest degree of vaccine hesitancy [77,78]. Careful planning for widespread COVID-19 vaccination should begin now [79] so that evidence-based public health information can be disseminated in a targeted manner, engaging communities in the process (see campaigns from Immunize Canada, as an example). This is vital research given the current prevalence of the anti-vaccination movement and how parents are promoting said movement.

**Table 5**
Cumulative Linked mixed-effects regression model with random intercepts predicting within-family average speed of having children vaccinated.

| | Estimate | SE | z | Pr(>\|z\|) |
|---|---|---|---|---|
| Demographics | | | | |
| Parents' sex – Male (female as ref grp) | −0.15 | 0.43 | −0.36 | 0.72 |
| Parents' age | −0.04 | 0.02 | −1.75 | 0.08 |
| Family size | −0.06 | 0.12 | −0.54 | 0.59 |
| Socio-economic status | 0.16 | 0.14 | 1.13 | 0.26 |
| Average child age – baby as ref grp | | | | |
| Preschool | −0.08 | 0.33 | −0.26 | 0.80 |
| Child | −0.28 | 0.35 | −0.81 | 0.42 |
| Adolescent | −0.02 | 0.50 | −0.05 | 0.96 |
| Health variables | | | | |
| Proportion of family members with a doctor | −0.74 | 0.56 | −1.32 | 0.19 |
| Child has 1 COVID-19 health risk (ref grp = 0 risks) | 0.80 | 0.38 | 2.12 | 0.03* |
| Child(ren) has $\geq$ 2 COVID-19 health risks (ref grp = 0 risks) | −0.87 | 0.63 | −1.38 | 0.17 |
| Children's average past vaccine completeness | −0.18 | 0.11 | −1.68 | 0.09 |
| Children's previous VAE (ref grp = no VAEs) | −0.21 | 0.32 | −0.64 | 0.52 |
| Parents' past vaccine completeness | −0.12 | 0.13 | −0.94 | 0.35 |
| Parents' previous VAE (ref grp = no VAEs) | −0.18 | 0.37 | −0.48 | 0.63 |
| Parents' number of COVID-19 health risks (continuous) | 0.05 | 0.10 | 0.53 | 0.60 |
| Attitudes towards vaccines | | | | |
| Perceived danger | 0.05 | 0.01 | 3.04 | <0.001 |
| Powerless | 0.00 | 0.03 | 0.10 | 0.92 |
| Trust in authority | −0.12 | 0.05 | −2.42 | 0.02* |
| Omission bias | −0.16 | 0.02 | −7.97 | <0.001*** |
| COVID-19 risk perceptions | | | | |
| Proximal COVID-19 risk | 0.00 | 0.14 | −0.03 | 0.98 |
| Distal COVID-19 risk | −0.13 | 0.16 | −0.86 | 0.39 |
| Psychological distance | | | | |
| COVID-19 relationship score | 0.01 | 0.02 | 0.59 | 0.55 |
| COVID-19 outcome score | −0.01 | 0.02 | −0.26 | 0.80 |
| Impact of Event | | | | |
| Intrusion | 0.04 | 0.04 | 1.08 | 0.28 |
| Avoidance | −0.06 | 0.03 | −2.09 | 0.04* |
| Arousal | −0.01 | 0.04 | −0.18 | 0.86 |
| Anxiety | | | | |
| State | 0.00 | 0.01 | −0.14 | 0.89 |
| Trait | −0.01 | 0.01 | −0.86 | 0.39 |
| Intercepts (cut points) | | | | |
| As soon as the vaccine is available in my area\|A couple of weeks | −6.60 | 1.68 | −3.92 | <0.001*** |
| A couple of weeks\|A couple of months | −5.45 | 1.68 | −3.25 | <0.001*** |
| A couple of months\|A year or more | −3.89 | 1.66 | −2.34 | 0.02* |
| A year or more\|Never | −1.02 | 1.65 | −0.62 | 0.54 |
| Random effects | | | | |
| $\tau^2$ (between-group variance): 0.02 | | | | |
| ICC (intraclass correlation coefficient): | | | | |
| Regions: 0.007 | | | | |
| Marginal $R^2$/ Conditional $R^2$: 0.635/0.637 | | | | |

Notes: (1) Ref grp = reference group. All categorical variables must be compared against a reference group as indicated in the table. (2) VAE = vaccine adverse event. (3) SE = standard error. (4) Negative scores indicate higher omission bias, so here, lower omission bias is associated with increased speed of having child vaccinated. Marginal $R^2$ = proportion of variance explained by the fixed effects in the model. Conditional $R^2$ = proportion of variance explained by the fixed and random effects combined in the model.
$p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Furthermore, we recognise that the intention-behaviour gap can sometimes be large; however, in at least one study, intentions to vaccinate against the seasonal flu and actual behaviour were substantially correlated [80]. Thus, we expect some degree of continuity in the attitudes that parents are currently reporting. We plan to follow-up with these participants to determine the predictors of COVID-19 vaccine uptake including exposure to pro- and anti-vaccination information. Future research should include larger samples to increase the power required for multi-level modelling designs; strive for better demographic representativeness; and include questions about political, religious, and other personal beliefs to further elucidate regional differences in uptake.

## 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.

## Acknowledgements

C.L.L. thanks Megan Scanlan, Mount Saint Vincent University, for her help as a research assistant throughout the project and Dave Malyk for his editorial advice. C.H.W. thanks Dr. Edward Susko, Department of Mathematics and Statistics, Dalhousie University, for insightful discussions on the statistical models for the analyses.

## Authors' contributions

C.L.L. was responsible for acquiring funds, the study design, data collection, some data analysis, and drafting the manuscript. C.H.W. was responsible for the statistical modelling and reviewing drafts of the manuscript. Both authors have approved the final article.

## Funding

This study was supported by two internal Mount Saint Vincent University grant awards to C.L.L.—a Rapid Response COVID-19

grant and an Aid to Scholarly Publications Grant. The funding body did not have a role in the study design, data collection, analysis, interpretation, writing, or decision to submit the manuscript.

## Data statement

The data are not publicly available as all data are confidential.

## 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.

## Ethics statement

Ethical clearance was obtained from the Mount Saint Vincent University Research Ethics Board (File 2019-197), according to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans. All participants provided informed consent.

## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jvacx.2021.100091.

## References

[1] Government of Canada. COVID-19 vaccines; 2020. https://www.canada.ca/en/health-canada/services/drugs-health-products/covid19-industry/drugs-vaccines-treatments/vaccines.html [accessed March 10, 2021].
[2] Altmann DM, Douek DC, Boyton RJ. What policy makers need to know about COVID-19 protective immunity. Lancet 2020;395:1527–9. https://doi.org/10.1016/S0140-6736(20)30985-5.
[3] Kwok KO, Lai F, Wei WI, Wong SYS, Tang JWT. Herd immunity – estimating the level required to halt the COVID-19 epidemics in affected countries. J Infect 2020;80:e32–3. https://doi.org/10.1016/j.jinf.2020.03.027.
[4] Sanche S, Lin YT, Xu C, Romero-Severson E, Hengartner N, Ke R. High contagiousness and rapid spread of Severe Acute Respiratory Syndrome Coronavirus 2. Emerg Infect Dis 2020;26:1470–7. https://doi.org/10.3201/eid2607.200282.
[5] Thunstrom L, Ashworth M, Finnoff D, Newbold SC. Hesitancy towards a COVID-19 vaccine and prospects for herd immunity. Preprint; 2020. https://doi.org/10.2139/ssrn.3593098.
[6] Statistics Canada. Population estimates on July 1st, 2019 by age and sex [Table]; 2019.
[7] Public Health Agency of Canada. Vaccine uptake in Canadian adults 2019; 2019.
[8] Frank K (Statistics Canada), Rubab A (Statistics Canada). Canadians' willingness to get a COVID-19 vaccine when one becomes available: What role does trust play? 2020.
[9] Dubé E, Laberge C, Guay M, Bramadat P, Roy R, Bettinger J. Vaccine hesitancy: an overview. Hum Vaccines Immunother 2013;9:1763–73. https://doi.org/10.4161/hv.24657.
[10] Statistics Canada. Vaccine uptake in Canadian children: Highlights from childhood National Immunization Coverage Survey; 2016.
[11] Government of Canada. Vaccination Coverage Goals and Vaccine Preventable Disease Reduction Targets by 2025; n.d. https://www.canada.ca/en/public-health/services/immunization-vaccine-priorities/national-immunization-strategy/vaccination-coverage-goals-vaccine-preventable-diseases-reduction-targets-2025.html [accessed January 7, 2021].
[12] Scheifele DW, Halperin SA, Bettinger JA. Childhood immunization rates in Canada are too low: UNICEF. Paediatr Child Heal 2014;19:237–8. https://doi.org/10.1093/pch/19.5.237.
[13] Dong Y, Mo X, Hu Y, Qi X, Jiang F, Jiang Z, et al. Epidemiological characteristics of 2143 pediatric patients with 2019 Coronavirus Disease in China. Pediatrics; 2020 [in press]. p. e20200702. https://doi.org/10.1542/peds.2020-0702.
[14] Lee B, Raszka WV. COVID-19 transmission and children: the child is not to blame. Pediatrics 2020;146. https://doi.org/10.1542/peds.2020-004879.
[15] Gay N, Ramsay M, Cohen B, Hesketh L, Morgan-Capner P, Brown D, et al. The epidemiology of measles in England and Wales since the 1994 vaccination campaign. Commun Dis Rep CDR Rev 1997;7:R17–21.
[16] Friederichs V, Cameron JC, Robertson C. Impact of adverse publicity on MMR vaccine uptake: a population based analysis of vaccine uptake records for one million children, born 1987–2004. Arch Dis Child 2006;91:465–8. https://doi.org/10.1136/adc.2005.085944.
[17] Impicciatore P, Bosetti C, Schiavio S, Pandolfini C, Bonati M. Mothers as active partners in the prevention of childhood diseases: Maternal factors related to immunization status of preschool children in Italy. Prev Med (Baltim) 2000;31:49–55. https://doi.org/10.1006/pmed.2000.0677.
[18] Li J, Taylor B. Childhood immunisation and family size. Health Trends 1993;25:16–9.
[19] Trauth JM, Zimmarman RK, Musa D, Mainzer H, Nutini JF. Do beliefs of inner-city parents about disease and vaccine risks affect immunization?. J Natl Med Assoc 2002;94:820–32.
[20] Casiday R, Cresswell T, Wilson D, Panter-Brick C. A survey of UK parental attitudes to the MMR vaccine and trust in medical authority. Vaccine 2006;24:177–84. https://doi.org/10.1016/j.vaccine.2005.07.063.
[21] Gust DA, Darling N, Kennedy A, Schwartz B. Parents with doubts about vaccines: which vaccines and reasons why. Pediatrics 2008;122:718–25. https://doi.org/10.1542/peds.2007-0538.
[22] Walker TY, Elam-Evans LD, Williams CL, Fredua B, Yankey D, Markowitz LE, et al. Trends in human papillomavirus (HPV) vaccination initiation among adolescents aged 13–17 by metropolitan statistical area (MSA) status, National Immunization Survey-Teen, 2013–2017. Hum Vaccines Immunother 2020;16:554–61. https://doi.org/10.1080/21645515.2019.1671765.
[23] Gilbert NL, Gilmour H, Wilson SE, Cantin L. Determinants of non-vaccination and incomplete vaccination in Canadian toddlers. Hum Vaccines Immunother 2017;13:1447–53. https://doi.org/10.1080/21645515.2016.1277847.
[24] Chen CH, Chiu PJ, Chih YC, Yeh GL. Determinants of influenza vaccination among young Taiwanese children. Vaccine 2015;33:1993–8. https://doi.org/10.1016/j.vaccine.2015.01.032.
[25] Jung M, Lin L, Viswanath K. Associations between health communication behaviors, neighborhood social capital, vaccine knowledge, and parents' H1N1 vaccination of their children. Vaccine 2013;31:4860–6. https://doi.org/10.1016/j.vaccine.2013.07.068.
[26] Green HK, Andrews N, Letley L, Sunderland A, White J, Pebody R. Phased introduction of a universal childhood influenza vaccination programme in England: Population-level factors predicting variation in national uptake during the first year, 2013/14. Vaccine 2015;33:2620–8. https://doi.org/10.1016/j.vaccine.2015.03.049.
[27] Cheung S, Wang HL, Mascola L, El Amin AN, Pannaraj PS. Parental perceptions and predictors of consent for school-located influenza vaccination in urban elementary school children in the United States. Influenza Other Respi Viruses 2015;9:255–62. https://doi.org/10.1111/irv.12332.
[28] Galarce EM, Minsky S, Viswanath K. Socioeconomic status, demographics, beliefs and A(H1N1) vaccine uptake in the United States. Vaccine 2011;29:5284–9. https://doi.org/10.1016/j.vaccine.2011.05.014.
[29] Kaboli F, Astrakianakis G, Li G, Guzman J, Naus M, Donovan T. Influenza Vaccination and intention to receive the pandemic H1N1 influenza vaccine among healthcare workers of British Columbia, Canada: a cross-sectional study. Infect Control Hosp Epidemiol 2010;31:1017–24. https://doi.org/10.1086/655465.
[30] Maltezou HC, Dedoukou X, Patrinos S, Maragos A, Poufta S, Gargalianos P, et al. Determinants of intention to get vaccinated against novel (pandemic) influenza A H1N1 among health-care workers in a nationwide survey. J Infect 2010;61:252–8. https://doi.org/10.1016/j.jinf.2010.06.004.
[31] Ramsey MA, Marczinski CA. College students' perceptions of H1N1 flu risk and attitudes toward vaccination. Vaccine 2011;29:7599–601. https://doi.org/10.1016/j.vaccine.2011.07.130.
[32] Fuchs EL. Self-reported prenatal influenza vaccination and early childhood vaccine series completion. Prev Med (Baltim) 2016;88:8–12. https://doi.org/10.1016/j.ypmed.2016.03.012.
[33] Flynn M, Ogden J. Predicting uptake of MMR vaccination: a prospective questionnaire study. Br J Gen Pract 2004;54:526–30.
[34] Betsch C, Bödeker B, Schmid P, Wichmann O. How baby's first shot determines the development of maternal attitudes towards vaccination. Vaccine 2018;36:3018–26. https://doi.org/10.1016/j.vaccine.2018.04.023.
[35] Nowak GJ, Cacciatore MA. Parents' confidence in recommended childhood vaccinations: extending the assessment, expanding the context. Hum Vaccines Immunother 2017;13:687–700. https://doi.org/10.1080/21645515.2016.1236881.
[36] Chung Y, Schamel J, Fisher A, Frew PM. Influences on immunization decision-making among US parents of young children. Matern Child Health J 2017;21:2178–87. https://doi.org/10.1007/s10995-017-2336-6.
[37] Haase N, Schmid P, Betsch C. Impact of disease risk on the narrative bias in vaccination risk perceptions. Psychol Heal 2020;35:346–65. https://doi.org/10.1080/08870446.2019.1630561.
[38] Duchsherer A, Jason M, Platt CA, Majdik ZP. Immunized against science: Narrative community building among vaccine refusing/hesitant parents. Publ Underst Sci 2020;29:419–35. https://doi.org/10.1177/0963662520921537.
[39] Jolley D, Douglas KM. The effects of anti-vaccine conspiracy theories on vaccination intentions. PLoS ONE 2014;9:e89177. https://doi.org/10.1371/journal.pone.0089177.
[40] Hsu YY, Fetzer SJ, Hsu KF, Chang YY, Huang CP, Chou CY. Intention to obtain human papillomavirus vaccination among taiwanese undergraduate women. Sex Transm Dis 2009;36:686–92. https://doi.org/10.1097/OLQ.0b013e3181ad28d3.
[41] Guthmann JP, Chauvin P, Le Strat Y, Soler M, Fonteneau L, Lévy-Bruhl D. Family history of immigration from a tuberculosis endemic country and low family income are associated with a higher BCG vaccination coverage in Ile-de-France

region, France. Vaccine 2013;31:5666–71. https://doi.org/10.1016/j.vaccine.2013.09.059.
[42] Fairhead J, Leach M. Childhood vaccination: public engagement with science and delivery. Econ Soc Res Counc UK 2004:1–15.
[43] Taha SA, Matheson K, Anisman H. The 2009 H1N1 influenza pandemic: The role of threat, coping, and media trust on vaccination intentions in Canada. J Health Commun 2013;18:278–90. https://doi.org/10.1080/10810730.2012.727960.
[44] White AE, Johnson KA, Kwan VSY. Four ways to infect me: Spatial, temporal, social, and probability distance influence evaluations of disease threat. Soc Cogn 2014;32:239–55. https://doi.org/10.1521/soco.2014.32.3.239.
[45] Wong LP, Alias H, Wong PF, Lee HY, AbuBakar S. The use of the health belief model to assess predictors of intent to receive the COVID-19 vaccine and willingness to pay. Hum Vaccines Immunother 2020;16:2204–14. https://doi.org/10.1080/21645515.2020.1790279.
[46] Brewer NT, Chapman GB, Gibbons FX, Gerrard M, McCaul KD, Weinstein ND. Meta-analysis of the relationship between risk perception and health behavior: the example of vaccination. Heal Psychol 2007;26:136–45. https://doi.org/10.1037/0278-6133.26.2.136.
[47] Reiter PL, Pennell ML, Katz ML. Acceptability of a COVID-19 vaccine among adults in the United States: how many people would get vaccinated?. Vaccine 2020;38:6500–7. https://doi.org/10.1016/j.vaccine.2020.08.043.
[48] Harapan H, Wagner AL, Yufika A, Winardi W, Anwar S, Gan AK, et al. Acceptance of a COVID-19 vaccine in Southeast Asia: a cross-sectional study in Indonesia. Front Publ Heal 2020;8:1–8. https://doi.org/10.3389/fpubh.2020.00381.
[49] Hamilton-West K. Factors influencing MMR vaccination decisions following a mumps outbreak on a university campus. Vaccine 2006;24:5183–91. https://doi.org/10.1016/j.vaccine.2006.03.084.
[50] Ozkaya E, Eker HH, Aycan N, Samanci N. Impact of maternal anxiety level on the childhood vaccination coverage. Eur J Pediatr 2010;169:1397–401. https://doi.org/10.1007/s00431-010-1247-y.
[51] Savas E, Tanriverdi D. Knowledge, attitudes and anxiety towards influenza A/H1N1 vaccination of healthcare workers in Turkey. BMC Infect Dis 2010;10:281. https://doi.org/10.1186/1471-2334-10-281.
[52] Mohammed H, Roberts CT, Grzeskowiak LE, Giles L, Leemaqz S, Dalton J, et al. Psychosocial determinants of pertussis and influenza vaccine uptake in pregnant women: a prospective study. Vaccine 2020;38:3358–68. https://doi.org/10.1016/j.vaccine.2020.02.020.
[53] Huang Y, Zhao N. Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based cross-sectional survey. Psychiatry Res; 2020;112954:advance online publication. https://doi.org/10.1016/j.psychres.2020.112954.
[54] Rodríguez-Rey R, Garrido-Hernansaiz H, Collado S. Psychological impact and associated factors during the initial stage of the Coronavirus (COVID-19) pandemic among the general population in Spain. Front Psychol 2020;11. https://doi.org/10.3389/fpsyg.2020.01540.
[55] Spinelli M, Lionetti F, Pastore M, Fasolo M. Parents' stress and children's psychological problems in families facing the COVID-19 outbreak in Italy. Front Psychol 2020;11:1713. https://doi.org/10.3389/fpsyg.2020.01713.
[56] Brown SM, Doom JR, Lechuga-Pena S, Watamura SE, Koppels T. Stress and parenting during the global COVID-19 pandemic. Child Abuse Negl; 2020 [online preprint].
[57] Makarovs K, Achterberg P. Contextualizing educational differences in "vaccination uptake": a thirty nation survey. Soc Sci Med 2017;188:1–10. https://doi.org/10.1016/j.socscimed.2017.06.039.
[58] Santistevan A, Bliss-Moreau E, Williams LA. Socioemotional correlates of the SARS-CoV-2 Pandemic; 2020.
[59] Horowitz MJ, Wilner N, Alvarez W. Impact of Event Scale (IES): a measure of subjective distress. Psychosom Med 1979;41:209–18.
[60] Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs GA. State-trait anxiety inventory: instrument and scoring key. Mind Garden, Inc.; 1977.
[61] R core team. R: A language and environment for statistical computing; 2019. Vienna, Austria. https://www.R-project.org/.
[62] Gelman A, Hill J. Data analysis using regression and multilevel/hierarchical models. Camabridge, England: Cambridge University Press; 2006.
[63] Bates D, Machler M, Bolker BM, Walker SC. Fitting linear mixed-effects models using lme4. J Stat Softw 2015;67(1):1–48.
[64] McCullagh P. Regression models for ordinal data. J R Stat Soc Ser B 1980;42:109–42. https://doi.org/10.1111/j.2517-6161.1980.tb01109.x.
[65] Christensen RHB. Package 'ordinal' 2019. cran.r-project.org/web/packages/ordinal/ordinal.pdf.
[66] Kumar S, Crouse Quinn S, Kim KH, Musa D, Hilyard KM, Freimuth VS. The social ecological model as a framework for the determinants of 2009 H1N1 vaccine uptake in the US. Health Educ Behav 2012;39:229–43. https://doi.org/10.1177/1090198111415105.The.
[67] Wu AMS, Lau JTF, Ling MaY, Cheng KM, Lau MMC. A longitudinal study using parental cognitions based on the theory of planned behavior to predict childhood influenza vaccination. J Infect Publ Health 2020;13:970–9. https://doi.org/10.1016/j.jiph.2020.04.009.
[68] Henderson A. Why regions matter: sub-state polities in comparative perspective. Reg Fed Stud 2010;20:439–45. https://doi.org/10.1080/13597566.2010.523619.
[69] Baumgaertner B, Carlisle JE, Justwan F. The influence of political ideology and trust on willingness to vaccinate. PLoS ONE 2018;13:1–13. https://doi.org/10.1371/journal.pone.0191728.
[70] The Conference Board of Canada. Uneven recovery – Provincial outlook – August 2020; 2020.
[71] Fidler DP. Vaccine nationalism's politics. Science 2020;369:749. https://doi.org/10.1126/science.abe2275.
[72] Google Statistics. Coronavirus (COVID-19) statistics data; 2020. https://www.google.com/search?kgmid=/g/11j2cc_qll&hl=en-CA&q=Coronavirus&kgs=d35fb7adf36cc7e5&shndl=0&source=sh/x/kp/osrp&entrypoint=sh/x/kp/osrp#wptab=s:H4sIAAAAAAAAAONgVuLVT9c3NMwySk6OL8zJecTozS3w8sc9YSmnSWtOXmO04eIKzsgvd80rySypFNLjYoOyVLgEpVB1ajBI8XOhC [accessed October 14, 2020].
[73] Tanne JH. US needs universal access to health care, American College of Physicians says. BMJ Br Med J 2007;335:1228. https://doi.org/10.1136/bmj.39423.499560.DB.
[74] Quek DKL. The Malaysian health care system: A review. Intensive Work Heal Syst Transit; 2014. https://www.researchgate.net/publication/237409933.
[75] Creamer M, Bell R, Failla S. Psychometric properties of the Impact of Event Scale – Revised. Behav Res Ther 2003;41:1489–96. https://doi.org/10.1016/j.brat.2003.07.010.
[76] Vanaken L, Scheveneels S, Belmans E, Hermans D. Validation of the Impact of Event Scale with modifications for COVID-19. Front Psychiatry 2020;11:1–8. https://doi.org/10.3389/fpsyt.2020.00738.
[77] Böhm R, Meier NW, Groß M, Korn L, Betsch C. The willingness to vaccinate increases when vaccination protects others who have low responsibility for not being vaccinated. J Behav Med 2019;42:381–91. https://doi.org/10.1007/s10865-018-9985-9.
[78] Logan J, Nederhoff D, Koch B, Griffith B, Wolfson J, Awan FA, et al. 'What have you HEARD about the HERD?' Does education about local influenza vaccination coverage and herd immunity affect willingness to vaccinate?. Vaccine 2018;36:4118–25. https://doi.org/10.1016/j.vaccine.2018.05.037.
[79] Schaffer Deroo S, Pudalov NJ, Fu LY. Planning for a COVID-19 vaccination program. J Am Med Assoc 2020;323:2458–9. https://doi.org/10.1001/jama.2020.8711.
[80] Lehmann BA, Ruiter RAC, Chapman G, Kok G. The intention to get vaccinated against influenza and actual vaccination uptake of Dutch healthcare personnel. Vaccine 2014;32:6986–91. https://doi.org/10.1016/j.vaccine.2014.10.034.