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COVID-19 vaccine confidence, concerns, and uptake in children aged 5 and older in Calgary, Alberta: a longitudinal cohort study

Emily J. Doucette BSc[1], Leah Ricketson BSc, MSc[1], Tarannum Tarannum PharmD, MPH[1], Isabella Alatorre BHSc[1], Joslyn Gray BSc[1], Cora Constantinescu MD, MSc[1], Susan Kuhn MD, MSc[1,2], Jessica K. E. Dunn MD[1], James D. Kellner MD, MSc[1,2]

[1]Department of Pediatrics, Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada;
[2]Alberta Children's Hospital Research Institute, University of Calgary, Calgary, Alberta, Canada

Correspondence: James D. Kellner, Department of Pediatrics, Alberta Children's Hospital, 28 Oki Drive NW, Calgary, Alberta, T3B 6A8, Canada. Telephone: 403-955-7813, E-mail Jim.Kellner@albertahealthservices.ca

ABSTRACT

Objectives: Beginning early in the pandemic, there was a worldwide effort to develop effective vaccines against the SARS-CoV-2 virus. Before and after the approval and implementation of vaccines, there were concerns about their need as well as their safety and rapid development. We explored child demographic characteristics and parental concerns to identify factors associated with the decision to vaccinate.

Methods: A cohort of 1035 children from Calgary was assembled in 2020 to participate in 5 visits every 6 months for survey completion and blood sampling for SARS-CoV-2 antibodies. Visits 1 to 2 occurred before approval of vaccines for children; Visits 3 to 5 occurred after vaccine approval for different age groups. We described vaccine concerns and utilized logistic regression to examine factors associated with the decision to vaccinate in children ≥5 years of age.

Results: Children ≥12 years of age, of non-white or non-black ethnicity, and who had received previous influenza vaccines had higher odds of being vaccinated against SARS-CoV-2. Children with previous SARS-CoV-2 infection had lower odds of being vaccinated. The most common concerns in early 2021 were about vaccine safety. By summer 2022, the most common concern was a belief that vaccines were not necessary. Through the study 88% of children were vaccinated.

Conclusions: Age, ethnicity, previous infections, and vaccine attitudes were associated with parental decision to vaccinate against SARS-CoV-2. For children who remained unvaccinated, parents continued to have safety concerns and questioned the necessity of the vaccine. Complacency about the need for vaccination may be more challenging to address and overcome than concerns about safety alone.

Keywords: COVID-19; Pediatrics; Vaccine concerns; Vaccine confidence; Vaccine uptake.

Early in the COVID-19 pandemic children were not considered to have frequent or severe disease or to significantly contribute to SARS-CoV-2 virus transmission (1,2). However, during the periods of Delta and Omicron variant infections starting in 2021, increases in the diagnosis and hospitalization of children with COVID-19 disease highlighted the importance of infections in children and their role in transmission (3), although they presented with milder disease overall than adults (4).

Decisions made by parents and guardians whether to vaccinate their children have been a public health concern long before the COVID-19 pandemic. In Alberta, COVID-19 mRNA vaccines were recommended for children and adolescents aged 12 to 17 years, 5 to 11 years, and 6 months to 4 years in May 2021, November 2021 and July 2022, respectively (5,6). Currently, COVID-19 vaccines are strongly recommended but not mandatory in Alberta (7).

Despite approval and availability of COVID-19 vaccines for children and considerable data on efficacy and safety, the novelty of COVID-19 vaccines and their rapid development, perception of lower disease risk, and mistrust of governments and

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health authorities led to ongoing concerns for some individuals (8). Decisions by parents to vaccinate children are complex with perspectives ranging from complete acceptance of vaccination to strong refusal due to the potential risk of severe side effects or doubts regarding vaccine benefits, safety, and effectiveness (9–11). Previous studies exploring vaccine acceptability have found parental sociodemographic factors (e.g., ethnicity or median income) and child characteristics (e.g., underlying health conditions) have a significant role in determining the intention to vaccinate against COVID-19 (9,12–14).

Although the intention to vaccinate children is well studied, few studies have described the outcome of vaccination after parental intentions were stated. Understanding factors that may have influenced parental decisions is important to inform public health decisions and improve vaccine uptake in the future. The objective of this study was to evaluate demographic factors and concerns that influenced parental intentions to vaccinate children over the age of 5 years against COVID-19 in Alberta, and follow-up on each child's vaccination status once COVID-19 vaccines were available.

METHODS

Enrollment and data collection

The Alberta Childhood COVID-19 Cohort (AB3C) Study is a longitudinal serosurveillance study conducted at the Alberta Children's Hospital in Calgary. In 2020, infants, children, and youth under 18 years from Calgary and surrounding areas, with or without prior SARS-CoV-2 infections, were recruited to complete up to five in-person visits for venous blood collection approximately every 6 months over 2 years (July 2020 to September 2022). At enrollment, all participants were under 18 years of age. The target study sample was 1000 children, including 200 with confirmed or probable prior SARS-CoV-2 infections, and 800 children without prior infections. Age and gender matching of participants with prior infections to those without infections was planned. Informed consent was obtained for all participants. An electronic survey was completed with every visit (15). The surveys included questions about adherence to non-pharmaceutical public health measures, as well as intention to vaccinate following the development and approval of COVID-19 vaccines. The surveys were most often completed by parents or caregivers, but were completed by children when willing and old enough to comprehend the study.

Immunization and infection records were obtained from the provincial health authority databases. Figure 1 shows the timepoints for COVID-19 vaccine availability in Alberta relative to the study timeline. By the final visit, vaccines were available for anyone older than 6 months. Since a vaccine for children under 5 years of age was not available until July 2022, this age group was excluded as the final study visits took place in August and September 2022 before many in this youngest age group were vaccinated. The STROBE checklist for reporting a cohort study was performed (16).

Data analysis

Demographic and clinical factors included age, sex at birth, ethnicity, Indigenous status, median household income, body mass index (BMI), pre-existing health conditions (asthma, immunosuppressive disorders, and other health conditions), previous influenza and pertussis vaccinations, and SARS-CoV-2 infection prior to enrollment and between study visits. The BMI measure was stratified into groups at lower risk (BMI <30 kg/m^2) and higher-risk (BMI of ≥30 kg/m^2) of SARS-CoV-2 infection complications (17). Median household income estimates for 2021 were obtained from Statistics Canada based on home postal code (18). Missing data was excluded from analyses. Data from participants who withdrew during the study was included until date of withdrawal. Differences in factors between vaccinated and unvaccinated participants were assessed using the Chi-square test or Mann–Whitney test and considered significant if $P < 0.05$.

A multivariable analysis was conducted using backwards elimination logistic regression to explore factors associated with the decision to vaccinate by the end of the study. The model was adjusted for age group (5 to 11 years and ≥12 years), Indigenous status, ethnicity (White, Black/Black Mixed-race, and Asian/Mixed-Race/Other), presence of health conditions (no health conditions, asthma, immuno-suppression, and other health conditions), prior COVID-19 infection, and decision to vaccinate against influenza. Possible interaction between age and previous COVID-19 infection was evaluated. Pertussis vaccination

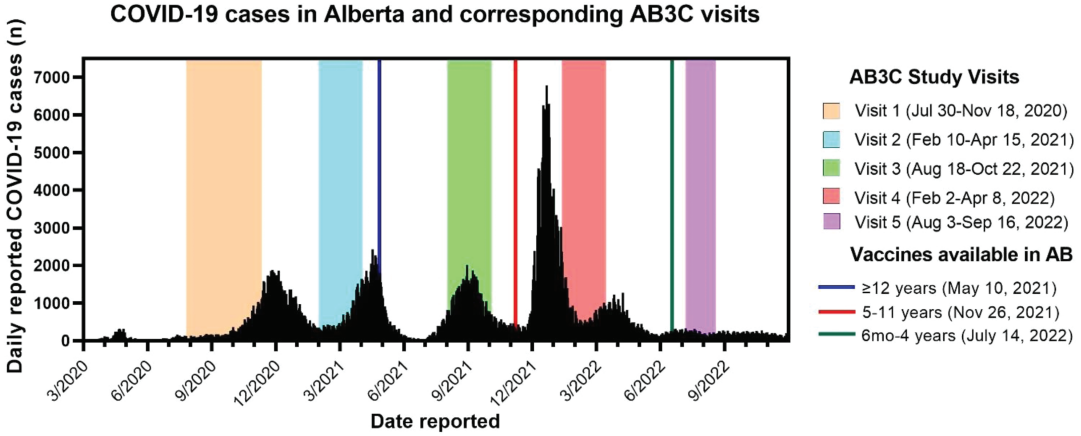


Figure 1. Study visits overview timeline

status was not included due to collinearity with influenza vaccination status. BMI was excluded due to a very small number of children with higher-risk BMI. Data was cleaned and analyzed using STATA (19). Figures were generated using GraphPad Prism 9.2.0 (20).

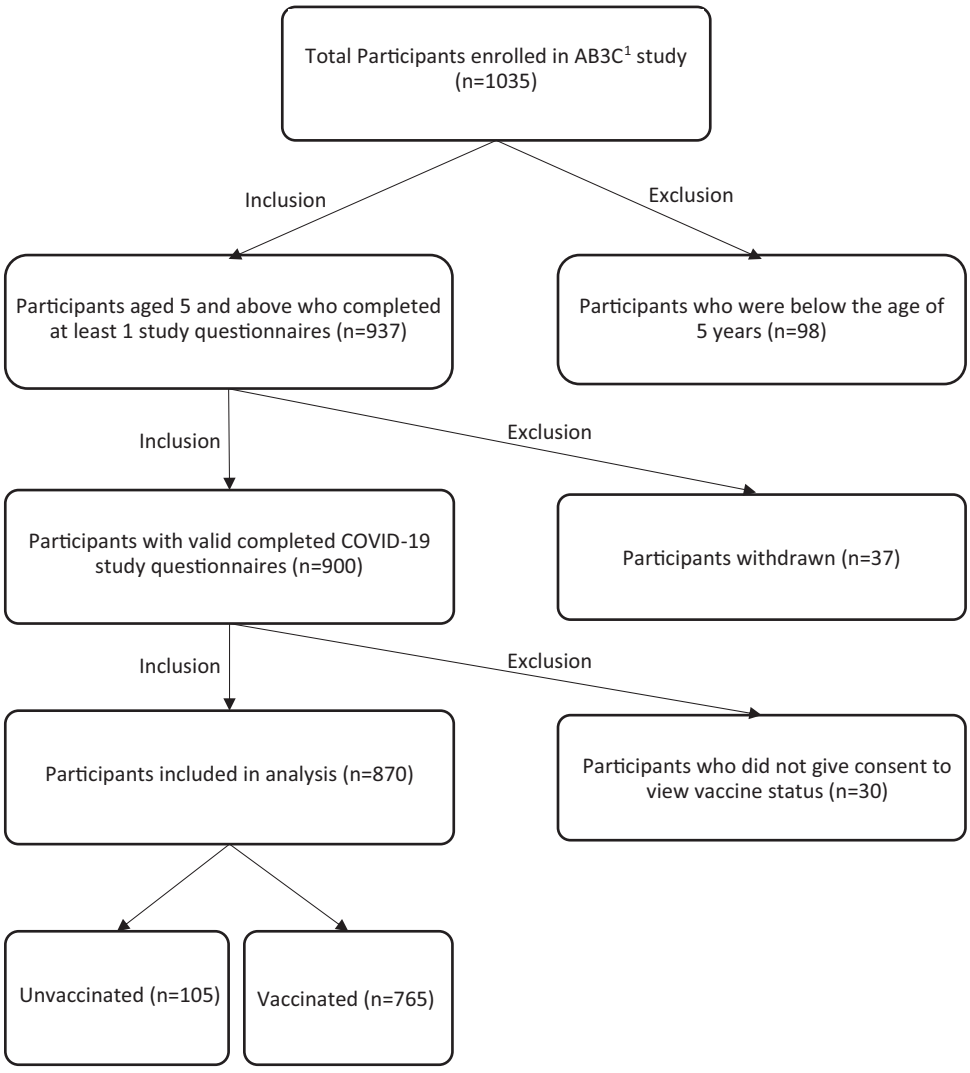
Although odds ratios generated from logistic regression will have higher values than risk ratios (for outcomes with high prevalence) they do provide information on whether the direction of association is positive or negative, and the comparative magnitude of association between factors within a model. Concerns regarding COVID-19 vaccines were stratified based on vaccination status at the end of the study. The proportion of parents with concerns about COVID-19 vaccines before they were available were compared by final vaccination status of children at the end of study (vaccinated or unvaccinated) using a two-sample test of proportions and reported with the difference in proportions and 95% confidence interval for the difference. Descriptive analysis was used to explore the variance of vaccine concerns across Visit 2, 3, and 4 among those who remained unvaccinated at the end of the study. The proportions of respondents reporting each concern at Visit 4 were compared to the proportion reporting the concern at Visit 2 using a two-sample test of proportions and p-values are indicated. In the case of questions not asked at Visit 2, Visit 3 and 4 were compared.

Ethics approval

This study received approval from the University of Calgary Conjoint Health Research Ethics Board (REB20-0480).

RESULTS

A total of 1035 participants were enrolled. After excluding children under 5 years (n = 98), participants who did not consent to vaccine records being accessed (n = 30), and withdrawals and those lost to follow up (n = 37), 870 children remained (Figure 2). By the end of the study, 105 (12.1%) of these children were unvaccinated and 765 (87.9%) were vaccinated. Vaccinated and unvaccinated participants had a similar distribution of sex at birth, Indigenous



1. AB3C: Alberta Childhood COVID-19 Cohort research study

Figure 2. Sample selection for analysis

Table 1. Demographic factors of study sample stratified by COVID-19 vaccination status at the end of the study

Demographic factors	Total (N = 870)	Unvaccinated (N = 105)		Vaccinated (N = 765)		P-value*
	n (%)	n	% (95% CI)	n	% (95% CI)	
Age group at end of study						<0.001
5 to 11 years	393 (45.2)	78	74.3 (65.1 to 81.7)	315	41.2 (37.7 to 44.7)	
≥12 years	477 (54.8)	27	25.7 (18.3 to 34.9)	450	58.8 (55.3 to 62.3)	
Sex at birth						0.603
Male	435 (50.0)	50	47.6 (38.2 to 57.1)	385	50.3 (46.8 to 53.9)	
Female	435 (50.0)	55	52.4 (42.8 to 53.9)	380	49.7 (46.1 to 53.2)	
Ethnicity[†]						<0.001
White	776 (89.5)	93	90.3 (82.9 to 94.0)	683	89.4 (87.0 to 91.4)	
Black	11 (1.3)	6	5.8 (2.6 to 12.4)	5	0.7 (0.27 to 1.6)	
Asian/Mixed/Other	80 (9.2)	4	3.9 (1.5 to 9.9)	76	9.9 (8.0 to 12.3)	
Indigenous status[‡]						0.630
Yes	43 (5.0)	6	5.8 (2.6 to 12.4)	37	4.9 (3.5 to 6.6)	
No	821 (95.0)	97	94.2 (87.6 to 97.4)	724	95.1 (93.2 to 96.3)	
Body mass index (BMI)[§]						0.720
BMI ≥ 30 kg/m^2	1 (0.1)	0	0 (0.0 to 3.8)	1	0.1 (0.0 to 0.8)	
BMI<30 kg/m^2	827 (99.9)	94	100 (96.1 to 100)	733	99.9 (99.2 to 100)	
Health conditions[**]						0.927
Asthma	104 (12.0)	12	11.4 (6.6 to 19.2)	92	12.0 (9.8 to 14.5)	
Immunosuppressed	15 (1.7)	1	0.9 (0.0 to 6.5)	14	1.8 (1.1 to 3.1)	
Other	41 (4.7)	5	4.8 (2.0 to 10.9)	36	4.7 (3.4 to 6.5)	
None	710 (81.6)	87	82.9 (74.4 to 88.9)	623	81.4 (78.5 to 84.0)	
COVID-19 infection prior to receiving first dose of vaccine[††]						<0.001
No infection	706 (81.1)	53	50.5 (41.1 to 59.8)	653	85.4 (82.6 to 87.8)	
Infected	164 (18.9)	52	49.5 (40.2 to 58.9)	112	14.6 (12.2 to 17.2)	
Influenza immunization						<0.001
Never had an influenza vaccine in the past	130 (14.9)	44	41.9 (32.8 to 51.5)	86	11.2 (9.2 to 13.7)	
Had one influenza vaccine in the past	56 (6.4)	12	11.4 (6.1 to 19.1)	44	5.8 (4.3 to 7.6)	
Had more than one influenza vaccine in the past	684 (78.6)	49	46.7 (37.3 to 56.2)	635	83.0 (80.2 to 85.5)	
D-TaP and/or Tdap immunization[‡‡]						<0.001
Unvaccinated	24 (2.8)	23	21.9 (15.0 to 30.8)	1	0.1 (0.0 to 0.9)	
Incomplete course of immunization	83 (9.5)	21	24.7 (13.4 to 28.7)	62	8.1 (6.3 to 10.3)	
Complete course of immunization	763 (87.7)	61	53.3 (48.5 to 67.1)	702	91.9 (89.7 to 93.7)	
Household median income (CAD)[§§]						0.019
<100,000	188 (21.9)	31	29.5 (21.6 to 38.9)	157	20.8 (18.1 to 23.9)	
100,000 to <150,000	467 (54.4)	46	43.8 (34.6 to 53.4)	421	55.8 (53.3 to 59.3)	
150,000 to <200,000	134 (15.6)	14	13.3 (8.0 to 21.3)	120	15.9 (13.5 to 18.7)	
≥200,000	70 (8.1)	14	13.3 (8.0 to 21.3)	56	7.4 (5.7 to 9.5)	

*Chi-square test was used to estimate the P-value.
[†]Some participants did not respond to this question [(n = 2) for the unvaccinated group and (n = 1) for the vaccinated group].
[‡]Some participants did not respond to this question [(n = 2) for the unvaccinated group and (n = 4) for the vaccinated group].
[§]Some participants did not respond to the questions needed to measure BMI [(n = 11) for the unvaccinated group and (n = 31) for the vaccinated group].
**For other self-reported health conditions refer to Supplementary Table 1.
[††]Of those unvaccinated, this variable considers infection at any point in the study as infected, regardless of their unvaccinated status.
[‡‡]For pertussis-containing vaccines, participants were considered to have a complete course if they received all-doses recommended for their age at the end of the study (5 doses for 5 to 11 years, 5 or 6 doses for 12 to 14 years, and 6 doses for 15+ years).
[§§]Median income data was not available for 11 participants who live in small postal code areas (≤250 persons or <40 households)

status, high risk BMI, and health conditions (Table 1). Differences between the vaccinated and unvaccinated groups were seen in ethnicity, age, vaccine history, and past COVID-19 infection.

The median age of participants was 12 years (IQR: 9 to 15). Unvaccinated participants had a median age of 9 years (IQR: 7 to 12), compared with vaccinated participants with a median age of 13 years (IQR: 10 to 16) (P < 0.001). Among included participants, 50.2% (n = 437) reported a COVID-19 infection before or during the study period and 3.6% (n = 31) reported a COVID-19 re-infection.

In the multivariable model, Indigenous status, median household income, and health conditions were not associated with the decision to vaccinate and were removed from the final model. The final model was adjusted for, ethnicity, influenza vaccine history, age and COVID-19 past infection status as well as interaction between age and past COVID-19 infection. There was a strong association between the decision to vaccinate against COVID-19 with those who previously vaccinated their child against influenza with two or more doses, and with those who reported ethnicity that was non-White or non-Black (Table 2). Overall, compared to previously uninfected 5 to 11 year old children, 12+ year old children and adolescents were more likely to be vaccinated and those with previous COVID-19 infections were less likely to be vaccinated. With inclusion of the interaction term, these opposite associations were negated for those who were 12+ years old.

Of children whose parents stated at Visit 2 that they intended to have their child vaccinated, 95.6% (n = 624) were vaccinated by end of the study, compared with 34.8% (n = 8) of those who did not intend to have their child vaccinated and 68.6% (n = 118) who were unsure.

A higher proportion of survey respondents whose children remained unvaccinated at the end of the study reported concerns about the vaccine compared to those whose children were vaccinated (Table 3). In addition, the most common concerns expressed by respondents whose children remained unvaccinated changed between Visits 2, 3, and 4 (Table 4).

DISCUSSION

This longitudinal study in Alberta, Canada, identified demographic and clinical factors and parental concerns associated with the likelihood of children ≥5 years of age receiving a COVID-19 vaccine. Over 95% of parents who, before vaccines were available, stated their intention to vaccinate their child did so, despite expressing concerns about the vaccines.

Table 2. Multivariable analysis of factors associated with odds of vaccinating children

Factor	Odds ratio	95% CI	P-value
Age group modified by COVID-19 infection prior to receiving first dose of vaccine			
5 to 11 years no past infection	Reference		
5 to 11 years with past infection	0.09	0.05 to 0.18	<0.001
12+ years no past infection	3.4	1.8 to 6.5	<0.001
12+ years with past infection	1.0	0.4 to 2.4	0.986
Ethnicity			
White	Reference		
Black	0.3	0.1 to 1.4	0.126
Asian/mixed/other	6.8	2.0 to 23.3	0.003
History of influenza vaccine			
Never received influenza vaccine	Reference		
Vaccinated for influenza—1 dose in past	2.5	1.1 to 6.1	0.036
Vaccinated for influenza 2+ doses in past	10.2	5.8 to 18.1	<0.001

Table 3. Vaccine concerns selected at Visit 2 (prior to the COVID-19 vaccine being approved for individuals <18 years old) by COVID-19 vaccination status at the end of the study[†]

	Vaccinated (N = 742)[‡] n (%)	Unvaccinated (N = 95)[‡] n (%)	Test of proportions percentage point difference (95% CI)
Don't think vaccine is necessary for my child	49 (6.6)	27 (28.4)	21.8 (19.4 to 37.4)***
Not sure the vaccine works	81 (10.9)	21 (22.1)	11.2 (0.03 to 19.8)**
Worried about vaccine side effects (safety)	362 (48.8)	70 (73.7)	24.9 (15.3 to 34.4)***
Believe vaccines were developed too quickly	129 (17.4)	46 (48.4)	31.0 (20.6 to 41.4)***
Concerned that not enough people have received the vaccine yet to feel comfortable having my child vaccinated	183 (24.7)	54 (56.8)	32.1 (21.7 to 42.6)***
Worried that important information about the vaccines has not been made public	90 (12.1)	35 (36.8)	24.7 (14.7 to 34.7)***
No concerns at all	196 (26.4)	8 (8.4)	−18.0 (−24.4 to −11.6)***

*P < 0.05,
**P < 0.01,
***P < 0.001.
[†]Participant were able to select all concerns that applied to them.
[‡]Participants who left all parts of the questions blank or selected prefer not to answer were excluded from this analysis, n = 10 unvaccinated, n = 23 vaccinated

Table 4. Reported concerns at Visits 2, 3, and 4 from respondents of participants who remained unvaccinated at the end of the study[†]

	Selected concerns at Visit 2 (N = 95) n (%)	Selected concerns at Visit 3 (N = 99) n (%)	Selected concerns at Visit 4 (N = 85) n (%)	Test of proportions percentage point difference V2 vs. V4 (95% CI)
Don't think vaccine is necessary for my child	27 (28.4)	33 (33.3)	45 (52.9)	24.4 (10.4 to 38.4)***
Don't think vaccine is necessary since the child had a COVID-19 infection already	Question not asked at this visit	15 (15.2)	35 (41.2)	26.0 (13.4 to 38.6)***,‡
Not sure the vaccine works	21 (22.1)	12 (12.1)	19 (22.4)	0.3 (−11.9 to 12.5)
Worried about vaccine side effects (safety)	70 (73.7)	57 (57.6)	44 (51.8)	−21.9 (−35.7 to −8.1)**
Believe vaccines were developed too quickly	46 (48.4)	25 (25.3)	21 (24.7)	−23.7 (−37.3 to −10.1)**
Concerned that not enough people have received the vaccine yet to feel comfortable having my child vaccinated	54 (56.8)	33 (33.3)	21 (24.7)	−32.1 (−45.6 to −18.6)***
Lack of vaccine research for my child's age group	Question not asked at this visit	60 (60.6)	29 (34.1)	−26.5 (−40.4 to −12.6)***,‡
Worried that important information about the vaccines has not been made public	35 (36.8)	28 (28.3)	25 (29.4)	−7.4 (−21.1 to 6.3)

*P < 0.05,
**P < 0.01,
***P < 0.001.
[†]Some participants indicated they prefer not to answer or left all options blank. They were not included in this analysis (at Visit 2, n = 10 unvaccinated and n = 23 vaccinated; at Visit 3, n = 6 unvaccinated and n = 21 vaccinated; at Visit 4, n = 10 unvaccinated n = 0 vaccinated). At Visit 4, 52 participants did not complete the questionnaire, n = 10 unvaccinated, n = 42 vaccinated.
[‡]Compared proportions of V4 to V3 for questions not asked at V2

Reassuringly, over two-thirds of parents who were unsure did eventually choose to vaccinate, suggesting that efforts to increase knowledge and trust may have improved vaccine acceptance. However, just over one-third of parents who initially stated their intention to not vaccinate their children did have them vaccinated. Overall, parents who vaccinated their children were less likely to express any of the elicited concerns, the trend in concerns of parents of children who were not vaccinated was variable with some increasing, some decreasing, and some not changing. Parents were not asked whether any specific concerns were more influential in the decision to have their child vaccinated or not.

Older children and adolescents with no past infection were more likely to be vaccinated than younger children, despite vaccine having been available for at least 8 months for both age groups by the end of the study. The initial national recommendation for the use of COVID-19 vaccines in 5 to 11 year olds was 'discretionary' (and later updated to a 'strong' recommendation) (21). This may have negatively influenced vaccine uptake. In Alberta, the uptake of COVID-19 vaccines was highest in the first 3 months of availability for all age groups, including 5- to 11-year-olds, followed by rapid levelling off (22). However, the implementation of COVID-19 vaccine for 5- to 11-year-olds started just before the first Omicron wave, when the number of SARS-CoV-2 infections, especially in young children, rose rapidly. Despite recommendations that all eligible persons be vaccinated even after a SARS-CoV-2 infection, previous infection was an independent variable associated with lower likelihood of vaccination in the multivariable model. These findings are consistent with a survey of children 9 to 18 years in the UK which found decreased vaccination acceptance in students with history of COVID-19 infection (23).

Ethnicity has been found to be an influencing factor towards vaccine uptake (9,12,24), although some report insignificant results (13). While Black or non-White participants were more likely to be vaccinated, the small number of Black and other non-White participants limits the interpretation of these findings. Participants who had ever previously received an influenza vaccine were more likely to receive a COVID-19 vaccine, suggesting general acceptance towards vaccines. These findings align with other studies, endorsing influenza vaccine acceptance as a strong predictor of COVID-19 vaccine acceptance (13,25,26). This correlation between influenza vaccine uptake and COVID-19 vaccine acceptance may be leveraged in future public health messaging for the public and healthcare providers.

In 2019, the World Health Organization declared vaccine hesitancy to be one of the top ten threats to public health (27), and this was further amplified during the pandemic. The current study identified that hesitancy related to vaccine confidence (e.g., safety, rapid development) was less frequent by the end of the study, while hesitancy related to complacency (e.g., vaccination considered unnecessary), was more frequently by the end of the study. Based on the current findings and other reports (12,28–31), vaccine confidence concerns may be more amenable to information-based education campaigns, whereby parents can feel better informed and have more confidence in vaccines efficacy (32). However, complacency may need to be addressed by interventions rooted in behavioural change methodology, which would identify determinants for vaccine uptake motivation and inform the design of tailored campaigns of persuasion (33). Similarly, education about the benefits of hybrid immunity from both COVID-19 infection and vaccination being superior to immunity from only infection or vaccination may also improve vaccine confidence and reduce complacency (34).

A strength of this study was the longitudinal approach following children over a 2-year period with a high level of retention, before and after the introduction of COVID-19 vaccines for children. Previous studies in Canada have focused mainly on adults (35) and most studies in children globally have focused on cross-sectional questionnaires exploring parental demographic factors that may influence the likelihood of accepting COVID-19 vaccinations for their children, without follow-up to determine actual vaccine uptake (9,10,12,13,25,31,36–38).

Convenience sampling methods through social media were used to recruit participants at a time of high public interest in the COVID-19 pandemic, and participants may have been more vaccine confident than the general population. This is evidenced by higher rates of vaccination in the study population compared to the province of Alberta, particularly for 5- to 11-year-olds (22). In addition, there was limited participation from families with lower incomes. The sample size limited detailed exploration about whether ethnicity, BMI, and socio-economic status influenced the uptake of COVID-19 vaccine in children. Despite the high rate of vaccination by the final visit, parents of both immunized and unimmunized participants expressed various concerns about receiving the vaccine throughout the study.

CONCLUSION

Public health efforts to provide access to accurate information and vaccination are important. Age, ethnicity, previous infections, and vaccine attitudes all influence parental decision to vaccinate. Our findings suggest that concerns about vaccine safety were addressed over time for some parents of children ≥5 years of age, leading to the vaccination of most participants. However, parents of unvaccinated children ≥5 years of age continued to have safety concerns and questioned the necessity of the vaccine. This complacency towards vaccinating may be more challenging to address and overcome than concerns about safety alone (33). As hybrid immunity has been shown to provide the highest level of protection over just infection-acquired immunity or just vaccine-acquired immunity (34), public health messaging should focus on behaviour change methodology and informing the public of the benefits of vaccination even in those with prior infections.

SUPPLEMENTARY DATA

Supplementary data are available at *Paediatrics & Child Health* Online.

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POTENTIAL CONFLICT OF INTEREST

James D. Kellner has been an investigator on projects funded by GlaxoSmithKline, Merck, Moderna, and Pfizer, outside the submitted work. All funds have been paid to his institution, and he has not received any personal payments. He has been an unpaid Data Safety Monitoring Board Member for a COVID-19 vaccine clinical trial. He has been an unpaid member of the Canadian COVID-19 Immunity Task Force (Leadership Group member, Field Studies Working Party Co-Chair and Pediatric Network Lead), and of the Alberta Advisory Committee on Immunizations. Cora Constantinescu has been an investigator on projects funded by GlaxoSmithKline, Merck, and Pfizer. She has also contributed to continuing medical education initiatives (by producing and delivering vaccine related education materials) supported by pharmaceutical companies such as bioMerieux, Moderna, and Pfizer. All funds, including any honoraria have been paid to her institution (University of Calgary), and she has not received any personal payments. She has held an unpaid executive position for the organization 19 to Zero. Jessica K. E. Dunn has been an investigator on projects funded by GlaxoSmithKline, Merck, Moderna, and Pfizer, outside the submitted work. All funds have been paid to her institution, and she has not received any personal payments. All other authors have no conflicts to declare.

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