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Factors associated with childhood non-vaccination against COVID-19 in Canada: A national survey analysis

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ABSTRACT

Background: COVID-19 vaccination efforts are critical in mitigating the impact of the virus, but despite proven safety and efficacy, vaccination rates among children in Canada are lower than in adults, prompting a need to explore determinants of childhood COVID-19 non-vaccination to improve uptake.

Method: This study analyzed data from the Canadian COVID-19 Immunization Coverage Survey 2022. Using multivariable logistic regression, it examined the association between COVID-19 non-vaccination among children aged 5–17 and factors such as parental sociodemographic characteristics, vaccine knowledge, attitudes, and beliefs (KAB), and vaccination history.

Results: The analysis revealed that negative KAB towards vaccines, reflected in higher KAB composite scores, significantly increased the likelihood of non-vaccination. Additionally, factors such as lower household incomes, rural residence, employment in sectors not at risk for vaccine-preventable diseases, and younger parental age were associated with higher non-vaccination. The study also highlighted ethnic disparities in vaccination odds and found that children with incomplete routine vaccinations or inconsistent flu vaccination histories were more likely to be unvaccinated against COVID-19. Surprisingly, children of parents who consistently received flu vaccinations were more likely to be unvaccinated against COVID-19. Furthermore, parental education levels showed a complex relationship with children's COVID-19 vaccination status, indicating nuanced influences on vaccination decisions.

Conclusion: The findings offer vital insights into the factors influencing COVID-19 vaccination uptake among children in Canada, suggesting avenues for targeted strategies to improve vaccine coverage.

1. Introduction

As COVID-19 continues to challenge global public health, vaccination initiatives play a pivotal role in preventing serious complications such as severe symptoms, hospitalizations, deaths, and in reducing viral transmission. Canada has authorized Pfizer-BioNTech's COVID-19 vaccine for children and adolescents, extending its use to those aged 12–15 years old in May 2021, and 5–11 years old in November 2021 [1]. Moderna's vaccine was approved for those aged 12 years old and older in August 2021, and for ages 6–11 years old in March 2022. As of June 2023, both the Pfizer and Moderna mRNA vaccines have been authorized for children as young as 6 months. Booster doses have also been authorized for children aged 5 years old and older. The National Advisory Committee on Immunization (NACI) recommends that children who are 6 months to 17 years old be offered a primary series of an mRNA COVID-19 vaccine if they have no contraindications to the vaccine [2]. The Canadian Paediatric Society (CPS) also advocates for the vaccination of this segment of the population [3].

Although clinical trials and real-world data affirm the safety and efficacy of COVID-19 vaccines for children [4–7], the vaccination rates in Canada for children aged 5 to 17 years old are much lower than for those of the adult population. As of June 2023, only 50.0 % of children aged 5–11 years old and 82.9 % of those aged 12–17 years old had received at least one dose of a COVID-19 vaccine, compared to vaccination rates above 85 % for adults aged 18–49 years old and above 90 % for adults aged 50 years old and older [8]. While children typically exhibit milder cases and have a better prognosis than adults, they can still be at risk of severe illness and long-term health consequences from COVID-19 [9–11], making it important that they are vaccinated as well. Parents play a critical role in deciding whether their children should receive vaccines, including those for COVID-19. As such, understanding the factors associated with parental decision-making regarding COVID-

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19 non-vaccination for their children is crucial.

An Ontario qualitative study pinpointed factors like the novelty of COVID-19 vaccines, the evidence supporting their use, politicization of vaccine guidance, social pressure, and balancing individual versus collective benefits as essential for parental decisions to vaccinate their children [12]. A Montreal-based study revealed that social inequalities in childhood COVID-19 vaccine acceptance and uptake have emerged, affecting lower-income households, racialized groups, and immigrants [13]. Similarly, in the United States, higher trust in scientists and in the COVID-19 vaccine development and approval process were positively associated with parental COVID-19 vaccination [14,15]. Disparities in vaccine acceptance and uptake are also observed, particularly among racial and ethnic minority or socioeconomically disadvantaged populations [16,17].

Many existing studies, while insightful, focus on specific subpopulations, vaccination intentions, or examine contexts beyond Canada. To bridge these gaps, this study aims to investigate the determinants associated with childhood COVID-19 non-vaccination, including parental perceptions of COVID-19 vaccine safety and effectiveness, and sociodemographic factors. By identifying and addressing these factors, public health officials can devise targeted strategies to enhance childhood vaccine acceptance and uptake in Canada.

2. Methodology

2.1. Study design and data source

This study leverages data from the 2022 Childhood COVID-19 Immunization Coverage Survey (CCICS), an annual survey implemented by the Public Health Agency of Canada in 2022, that collects information on the proportion of children in Canada who have received a COVID-19 vaccine and/or a seasonal influenza vaccine during the 2021–2022 influenza season (September to March) from all Canadian provinces and territories. The survey also explores the knowledge, attitudes, and beliefs (KAB) of parents or guardians regarding these vaccines, investigates vaccination barriers, and assesses intentions for future vaccinations. The survey targets parents or guardians of children younger than 18 years of age in all Canadian provinces and territories. Data collection for this survey occurred between April 20, 2022, and July 21, 2022 and 10,536 Canadian parents/guardians aged 18 years or older were recruited and surveyed from a general population sample by random digit dialling (RDD). Data was collected using a multimodal approach, including online and phone surveys, to obtain a nationally representative sample. Survey results were weighted by region, child's age group, and child's sex at birth. Bootstrap weights were also applied. Recruitment ensured quotas were reached for key sub-populations which are parents of children aged 0–4, 5–11, and 12–17 years, parents from different provinces and territories, and an even distribution of male and female children, to ensure statistical relevance and representativeness. The response rate for the survey was 26.1 %. More information on survey methodology can be found elsewhere [18].

2.2. Participants

For this analysis, the study population consisted of parents/guardians of children aged 5–17 years, as they were eligible for COVID-19 vaccination at the time of data collection. Children aged 0–4 years were not eligible for COVID-19 vaccines when data collection started and thus were excluded from this study. The total number of participants included in the analysis was 7802.

2.3. Variables and Measurements

Outcome Variable: The primary outcome variable for this study was the child's COVID-19 vaccination status, represented as a binary variable. Participants were asked the question, "Has your child ever received at least one dose of a COVID-19 vaccine that has been approved in Canada?" The response options included "Yes," "No," "Don't know," and "Prefer not to answer." Participants who provided non-response answers ("Don't know" and "Prefer not to answer") were excluded, and the "Yes" and "No" responses were utilized to determine the child's vaccination status.

Predictor Variables: Predictor variables were chosen based on factors identified in the literature as being related to the outcome or factors that the authors believed could potentially be associated with the outcome [15–17,19–23]. Respondents were asked about their child's and their own sociodemographic characteristics and immunization histories, as well as some health factors for their child and their own knowledge, attitudes, and beliefs about vaccination. The following variables were included as sociodemographic predictors: region of residence, child's and parent's age group, parent's sex at birth, parent's level of education, parent's ethnicity, parental employment sector, parent's urban/rural status, and household income. Due to smaller sample sizes, data from the three territories (Nunavut, Yukon, Northwest Territories) were combined into one category for the region of residence, as were other and mixed ethnicities and Indigenous people from outside Canada for the ethnicity of the parent.

Additional predictor variables encompassing health-related factors and immunization history included the presence of a chronic medical condition for the child, the child's routine vaccination history, the parent's COVID-19 vaccination status, and the flu vaccination history of both the child and the parent.

General, COVID-19, and flu vaccine KABs were assessed using nine survey questions (Table 2). Responses are measured on a 5-point scale (strongly agree to strongly disagree) and then were grouped into three categories for the simple logistic regression analyses: strongly or somewhat disagree, strongly or somewhat agree, and don't know. To reduce collinearity, simplify interpretability, and promote a more parsimonious model that can help prevent overfitting, a composite score representing the average score (strongly agree = 1, somewhat agree = 2, don't know = 3, somewhat disagree = 4, strongly disagree = 5) across the nine vaccine KAB statements was created and used in the multiple regression model. A higher composite score indicated more negative attitudes or beliefs towards vaccination. "Don't know" responses were coded as 3, reflecting a more neutral position. The authors acknowledge that this coding method might not distinguish between respondents who genuinely lack knowledge or an opinion on the topic and those who feel neutral about it. However, the small number of "Don't know" responses suggests that the potential information loss would be minimal.

Covariates: To account for differences in vaccination rollout plans and eligibility across provinces and territories, region of residence and the child's age group were included as covariates. Consequently, any observed associations between vaccination status and control variables should be interpreted with caution, as potential confounding due to differences in provincial vaccine eligibility might be present.

2.4. Statistical analysis

To examine the study sample, descriptive statistics were employed. This involved calculating frequencies and percentages for categorical predictor variables, and the mean, median, and standard deviation (SD) for the KAB composite score. Weighted proportions with their 95 % confidence intervals (CI) were also estimated using the modified Wilson method for the confidence limits.

The association between childhood non-vaccination against COVID-19 and the predictor variables (including individual KAB items and the composite score) was initially assessed using simple logistic regression, with each predictor analyzed for its individual relationship with the dependent variable. The final multivariable logistic regression model included all predictor variables, except for the individual KAB item predictors, to avoid multicollinearity. This approach allowed us to control for the potential confounding effects of these predictor variables on the outcome of childhood non-vaccination against COVID-19, thereby providing a more comprehensive understanding of the association. For validity in the logistic regression model, a minimum cell count of 30 was required in each group. Both adjusted (aOR) and unadjusted odds ratios (OR) with 95 % confidence intervals (Cis) were reported. Linearity for the KAB composite score, which was treated as a quasi-continuous variable, was assessed by visually inspecting the scatter plot between this predictor variable and the logit values of the outcome variable.

For multiple logistic regression models, the REG procedure's variance inflation factor (VIF) option was employed to assess multicollinearity since SAS's LOGISTIC and SURVEYLOGISTIC procedures lack multicollinearity diagnostics. All VIFs remained under 5. Nonetheless, the REG procedure doesn't consider complex design elements. Consequently, multicollinearity was further evaluated by conducting chi-square associations among all predictor variables (data not shown). Despite associations between most predictor variables, the models did not exhibit signs of severe multicollinearity such as inflated standard errors.

In the simple logistic regression models, responses labeled 'prefer not to answer' or 'don't know' were excluded for each predictor variable, except for the 9 individual KAB predictors. For these 9 predictors, only the responses labeled 'prefer not to answer' were excluded. In contrast, for the multiple logistic regression model, responses labeled 'prefer not to answer' or 'don't know' across all predictor variables were treated as missing data. These were excluded through listwise deletion, which affected 16.7 % of the data, resulting in a final sample of 6,501 respondents. The excluded participants due to missing data and those in the final analytical sample were compared on key demographic variables using the Rao-Scott likelihood ratio chi-square test to discern potential generalizability challenges.

Survey weights were applied to enhance the representativeness of estimates. To accommodate the complex survey design, standard errors and confidence intervals of weighted proportions and odds ratios were estimated using bootstrap resampling (500 samples). Data analysis was conducted with SAS Enterprise Guide 7.1.

3. Results

3.1. Sample characteristics

The characteristics of the 7802 participants in this study are detailed in Table 1. Among the respondents, 48.4 % were parents of children aged 5–11 years, and 51.6 % were parents of children aged 12 to 17 years. The majority of respondents were aged 40–49 years (54.6 %), were assigned female sex at birth (59.8 %), resided in urban settings (82.6 %), self-reported as White (76.1 %), and had attained at least a Bachelor's degree (56.3 %). Furthermore, 58.2 % were not working (either in a paid or volunteer position) in sectors associated with a higher risk of vaccine-preventable diseases [24]. About 34.6 % of respondents reported a household income equal to or exceeding $150,000. In terms of the children's COVID-19 vaccination status, 82.0 % had received at least one dose of an approved vaccine in Canada, 17.0 % remained unvaccinated, and 1 % of respondents were either unsure or preferred not to disclose this information.

3.2. Vaccine Knowledge, Attitude, and Beliefs (KAB)

The vaccine KAB composite score had a mean of 2.0, a median of 1.7, a standard deviation of 1.1, and a range between 1 and 5. Simple logistic regression models revealed that for all KABs, disagreeing with a statement was significantly associated with non-vaccination compared to agreeing with it (Table 2). The strongest association with non-vaccination was found for those who disagreed with the statement "My child needs to be vaccinated against COVID-19 even after infection" (OR 47.01; 95 % CI: 46.34–47.69). Additionally, in multivariable

Table 1
Characteristics of the study population.

Variable	n[a]	Unweighted %	Weighted % (95 % CI)[b]
COVID-19 vaccination status of child			
Vaccinated	6398	82.0	81.3 (80.4–82.1)
Unvaccinated	1325	17.0	18.7 (17.9–19.6)
Age group of parent			
18–29	39	0.5	0.5 (0.3–0.7)
30–39	1394	17.9	18.6 (17.8–19.5)
40–49	4263	54.6	56.0 (54.9–57.1)
50+	2005	25.7	24.9 (23.9–25.8)
Age group of child			
5–11	3779	48.4	53.9 (52.8–55.1)
12–17	4023	51.6	46.1 (44.9–47.2)
Education of parent			
Below high school diploma	105	1.4	1.1 (0.9–1.4)
High school diploma	632	8.1	7.6 (7.0–8.2)
Post-secondary education below bachelor's (including trade school)	2569	32.9	32.9 (31.9–34.0)
Bachelor's or above	4395	56.3	58.4 (57.3–59.5)
Biological sex of parent			
Male	3085	39.5	39.7 (38.7–40.8)
Female	4666	59.8	60.3 (59.2–61.3)
Employment sector of parent			
Sectors at risk of vaccine-preventable diseases[c]	3023	38.8	39.4 (38.3–40.6)
Sectors not at risk	4540	58.2	60.6 (59.4–61.7)
Province of residence			
Alberta	981	12.6	13.4 (12.6–14.2)
British Columbia	1042	13.4	12.1 (11.4–12.9)
Manitoba	299	3.8	4.2 (3.8–4.7)
New Brunswick	288	3.7	1.9 (1.6–2.3)
Newfoundland and Labrador	305	3.9	1.2 (1.0–1.5)
Nova Scotia	306	3.9	2.3 (2.0–2.7)
Ontario	2334	29.9	38.1 (36.8–39.3)
Prince Edward Island	287	3.7	0.4 (0.3–0.6)
Quebec	1416	18.2	22.1 (21.1–23.1)
Saskatchewan	298	3.8	3.7 (3.3–4.2)
Territories	246	3.2	0.5 (0.3–0.6)
Urban/Rural status			
Urban	6441	82.6	86.2 (85.4–87.0)
Rural	1292	16.6	13.8 (13.0–14.6)
Household income			
0–$39,999	490	6.3	6.7 (6.1–7.3)
$40,000–$59,999	549	7.0	7.5 (6.9–8.1)
$60,000–$79,999	648	8.3	8.8 (8.2–9.5)
$80,000–$99,999	872	11.2	12.2 (11.4–12.9)
$100,000–$149,999	1846	23.7	26.4 (25.3–27.4)
$150,000 or more	2698	34.6	38.5 (37.3–39.6)
Ethnicity of parent			
Black	202	2.6	2.9 (2.5–3.3)
East/Southeast Asian	365	4.7	4.6 (4.2–5.1)
South Asian	231	3.0	3.4 (3.0–3.9)
Latin American	121	1.6	1.8 (1.5–2.1)
Middle Eastern and North African	171	2.2	2.5 (2.2–2.9)
Indigenous	121	1.6	1.0 (0.8–1.2)
White	5936	76.1	78.8 (77.9–79.7)
Other/Mixed ethnicity/Indigenous from outside Canada	355	4.6	5.0 (4.5–5.5)
COVID-19 vaccination status of parent			
0–2 doses	2615	33.5	33.3 (32.3–34.4)

(*continued on next page*)

Table 1 (*continued*)

Variable	n[a]	Unweighted %	Weighted % (95 % CI)[b]
3 + doses	5112	65.5	66.7 (65.6–67.7)
Influenza vaccination of parent			
Every flu season	1839	23.6	22.7 (21.8–23.7)
Most flu seasons	1490	19.1	19.0 (18.2–19.9)
Some flu seasons	2185	28.0	28.4 (27.4–29.4)
Never	2236	28.7	29.8 (28.8–30.9)
Influenza vaccination of child			
Every flu season	1736	22.3	21.6 (20.7–22.6)
Most flu seasons	1202	15.4	15.2 (14.4–16.1)
Some flu seasons	1583	20.3	20.0 (19.1–20.9)
Never	3178	40.7	43.2 (42.1–44.3)
Routine vaccination of child			
All routine vaccinations for age	7227	92.6	93.5 (93.0–94.1)
Only some	325	4.2	4.3 (3.9–4.8)
None	168	2.2	2.2 (1.9–2.5)
Chronic medical condition of child			
Yes	1082	13.9	13.7 (13.0–14.5)
No	6611	84.7	86.3 (85.5–87.0)
Average Score of Vaccine Attitudes			
Mean	2.0	–	2.1 (2.1–2.1)
Median	1.7	–	1.7 (1.7–1.7)
Minimum	1.0	–	–
Maximum	5.0	–	–
Standard deviation	1.1	–	–

Note: n values are unweighted.
[a] n = 7802 however columns may not add up to it due to missing data.
[b] n = 7723 after excluding missing values for the dependent variable.
[c] The sectors mentioned in the survey were based on the Canadian Immunization Guide.

logistic regression, higher vaccine KAB composite score, indicating more negative attitudes or beliefs towards vaccination, was also associated with higher non-vaccination (aOR 4.41; 95 % CI: 4.38–4.45).

3.3. *Associated sociodemographic and vaccination history factors with Non-Vaccination*

In the multivariable regression analysis, after adjusting for covariates, non-vaccination was independently and significantly associated with all predictor variables in the model. Table 3 presents the unadjusted and adjusted odds ratios (aORs) and 95 % confidence intervals for each predictor.

Respondents aged 49 or younger were more likely to report non-vaccination for their child than older respondents, with aORs ranging from 1.22 (95 % CI: 1.19–1.24) to 1.89 (95 % CI: 1.85–1.93). Those with lower household income had higher non-vaccination compared to households earning $150,000 or more, with aORs ranging from 1.12 (95 % CI: 1.10–1.15) to 1.66 (95 % CI: 1.62–1.71).

Other factors associated with higher non-vaccination included parents self-identifying as Black (aOR 1.16; 95 % CI: 1.12–1.20), Middle Eastern and North African (aOR 1.65; 95 % CI: 1.60–1.70), or mixed/other ethnicities (aOR 1.35; 95 % CI: 1.31–1.39) compared to White; having a high school degree (aOR 1.12; 95 % CI: 1.08–1.16) compared to a Bachelor's degree or higher; living in rural settings (aOR 1.36; 95 % CI: 1.33–1.38) compared to urban areas; and not working in sectors associated with a higher risk of vaccine-preventable diseases (aOR 1.09; 95 % CI: 1.07–1.10) compared to working in one.

In contrast, factors associated with lower non-vaccination included being a female respondent (aOR 0.79; 95 % CI: 0.78–0.80) compared to a male respondent; a parent self-identifying as East/Southeast Asian

Table 2
Association between certain parental vaccination knowledge, attitude, and beliefs and non-vaccination against COVID-19 in children.

Knowledge, Attitude, and Beliefs	% in Agreement (95 % CI)[a,b]	% Unvaccinated Among Agreed (95 % CI)[a]	OR (95 % CI)[a,b,c]	p-value
Vaccines are safe in general	91.4 (90.8–92.0)	14.4 (13.6–15.2)	11.75 (11.64–11.86)	<0.0001
Vaccines are effective in general	92.2 (91.6–92.8)	14.8 (14.0–15.6)	12.15 (12.03–12.27)	<0.0001
COVID-19 vaccines are safe	77.2 (76.3–78.1)	6.4 (5.8–7.0)	32.69 (32.33–33.06)	<0.0001
COVID-19 vaccines are effective	74.1 (73.1–75.1)	5.4 (4.8–6.0)	29.32 (28.98–29.67)	<0.0001
Additional COVID-19 doses are important to continue to protect myself from the virus	61.4 (60.3–62.5)	3.5 (3.0–4.1)	28.05 (27.68–28.43)	<0.0001
Vaccination is a safer way to build immunity against COVID-19 than getting infected	69.6 (68.6–70.7)	5.1 (4.5–5.7)	26.43 (26.10–26.76)	<0.0001
In general, the flu vaccine is safe	85.0 (84.2–85.8)	13.3 (12.5–14.2)	8.98 (8.88–9.08)	<0.0001
In general, the flu vaccine is effective	71.3 (70.3–72.3)	10.3 (9.5–11.1)	6.62 (6.53–6.70)	<0.0001
My child needs to be vaccinated against COVID-19 even after infection	63.1 (62.0–64.2)	2.5 (2.1–2.9)	47.01 (46.34–47.69)	<0.0001

[a] Percentages and odds ratios are weighted.
[b] n = 7723 after excluding missing values for the dependent variable and may vary in the simple logistic regression analysis due to missing values for each independent variable.
[c] Disagreement with statement vs Agreement (reference group).

(aOR 0.50; 95 % CI: 0.48–0.53), South Asian (aOR 0.82; 95 % CI: 0.79–0.85), or Latin American (aOR 0.86; 95 % CI: 0.81–0.91) compared to White; possessing less than a high school diploma (aOR 0.62; 95 % CI: 0.59–0.65) or a postsecondary degree below Bachelor's (aOR 0.90; 95 % CI: 0.89–0.91) compared to a Bachelor's degree or higher; and having a child without a chronic medical condition (aOR 0.96; 95 % CI: 0.94–0.99) compared to those with such a condition.

Regarding factors related to immunization records prior to the COVID-19 pandemic, children who received only some of the recommended routine vaccinations for their age (aOR 1.18; 95 % CI: 1.15–1.22) or none (aOR 1.60; 95 % CI: 1.53–1.68) were more likely to be unvaccinated compared to those who received all. Additionally, children who received the flu vaccine most flu seasons (aOR 1.18; 95 % CI: 1.14–1.23), some flu seasons (aOR 1.98; 95 % CI: 1.92–2.05), or never (aOR 2.21; 95 % CI: 2.14–2.28) were more likely to report non-vaccination compared to those who received it every flu season. In contrast to the child's vaccination history, parents who received the flu vaccine less often prior to the pandemic were less likely to report non-vaccination for their child than parents who received it every flu season, with aORs ranging from 0.52 (95 % CI: 0.50–0.53) to 0.85 (95 % CI:

Table 3
Multivariable logistic regression of factors associated with non-vaccination against COVID-19 in children.

Variable	% Unvaccinated (95 % CI)[a,b]	n[c]	Unadjusted OR (95 % CI)[a,c]	Adjusted OR (95 % CI)[a,c,d]
Age group of parent				
18–29	43.2 (28.6–59.0)	30	6.25 (5.98–6.53)*	1.75 (1.59–1.92)*
30–39	31.7 (29.3–34.2)	1185	3.82 (3.76–3.88)*	1.89 (1.85–1.93)*
40–49	17.2 (16.1–18.4)	3607	1.71 (1.69–1.73)*	1.22 (1.19–1.24)*
50+	10.8 (9.6–12.3)	1679	Reference	Reference
Age group of child				
5–11	26.0 (24.7–27.5)	3183	3.11 (3.07–3.15)*	10.34 (10.22–10.48)*
12–17	10.2 (9.3–11.2)	3318	Reference	Reference
Education of parent				
Below high school diploma	28.9 (21.0–38.3)	78	2.52 (2.43–2.62)*	0.62 (0.59–0.65)*
High school diploma	22.6 (19.5–26.1)	496	1.81 (1.79–1.84)*	1.12 (1.08–1.16)*
Post-secondary education below bachelor's (including trade school)	25.4 (23.7–27.1)	2107	2.11 (2.09–2.13)*	0.90 (0.89–0.91)*
Bachelor's or above	13.9 (12.9–14.9)	3820	Reference	Reference
Biological sex of parent respondent				
Male	21.2 (19.8–22.7)	2587	Reference	Reference
Female	16.6 (15.6–17.7)	3914	0.74 (0.73–0.74)*	0.79 (0.78–0.80)*
Employment sector of parent				
Sectors at risk of vaccine-preventable diseases[e]	15.5 (14.2–16.8)	2642	Reference	Reference
Sectors not at risk	19.7 (18.5–20.8)	3859	1.34 (1.33–1.35)*	1.09 (1.07–1.10)*
Province of residence				
Alberta	25.3 (22.6–28.1)	841	1.41 (1.36–1.47)*	1.35 (1.33–1.38)*
British Columbia	20.3 (17.9–22.8)	870	1.06 (1.02–1.10)*	1.53 (1.50–1.56)*
Manitoba	14.4 (10.8–18.8)	242	0.70 (0.66–0.74)*	0.59 (0.52–0.67)*
New Brunswick	17.2 (13.2–22.0)	235	0.86 (0.79–0.94)*	0.54 (0.51–0.58)*
Newfoundland and Labrador	6.9 (4.5–10.3)	251	0.31 (0.29–0.33)*	0.41 (0.39–0.44)*
Nova Scotia	10.0 (7.1–13.9)	264	0.46 (0.43–0.50)*	0.30 (0.30–0.31)*
Ontario	19.4 (17.8–21.0)	1871	Reference	Reference
Prince Edward Island	11.9 (8.6–16.2)	244	0.56 (0.52–0.61)*	0.62 (0.60–0.64)*
Quebec	15.7 (13.9–17.7)	1229	0.78 (0.75–0.81)*	0.65 (0.64–0.66)*
Saskatchewan	18.7 (14.6–23.5)	251	0.96 (0.92–1.00)	0.49 (0.47–0.52)*
Territories	12.0 (8.5–16.7)	203	0.57 (0.48–0.67)*	1.35 (1.11–1.64)*

Table 3 (*continued*)

Variable	% Unvaccinated (95 % CI)[a,b]	n[c]	Unadjusted OR (95 % CI)[a,c]	Adjusted OR (95 % CI)[a,c,d]
Urban/Rural status				
Urban	16.9 (16.0–17.9)	5447	Reference	Reference
Rural	28.3 (25.9–30.8)	1054	1.93 (1.91–1.95)*	1.36 (1.33–1.38)*
Household income				
0–$39,999	26.6 (22.9–30.7)	402	2.26 (2.22–2.30)*	1.66 (1.62–1.71)*
$40,000–$59,999	18.6 (15.6–22.1)	489	1.42 (1.39–1.46)*	1.14 (1.10–1.17)*
$60,000–$79,999	25.7 (22.5–29.2)	581	2.15 (2.11–2.19)*	1.48 (1.45–1.51)*
$80,000–$99,999	17.5 (15.1–20.2)	797	1.32 (1.30–1.34)*	1.12 (1.10–1.15)*
$100,000–$149,999	19.9 (18.1–21.8)	1692	1.55 (1.53–1.56)*	1.20 (1.18–1.22)*
$150,000 or more	13.8 (12.6–15.2)	2540	Reference	Reference
Ethnicity of parent				
Black	23.4 (18.0–29.7)	169	1.44 (1.41–1.47)*	1.16 (1.12–1.20)*
East/Southeast Asian	7.9 (5.6–11.2)	291	0.41 (0.39–0.42)*	0.50 (0.48–0.53)*
South Asian	11.9 (8.3–16.8)	171	0.64 (0.63–0.65)*	0.82 (0.79–0.85)*
Latin American	15.0 (9.8–22.5)	100	0.83 (0.81–0.86)*	0.86 (0.81–0.91)*
Middle Eastern and North African	23.9 (18.1–30.8)	144	1.48 (1.44–1.52)*	1.65 (1.60–1.70)*
Indigenous	26.9 (19.7–35.4)	98	1.73 (1.63–1.84)*	1.03 (0.94–1.12)
White	17.5 (16.6–18.5)	5235	Reference	Reference
Other/Mixed ethnicity/ Indigenous from outside Canada	25.5 (21.3–30.4)	293	1.62 (1.59–1.65)*	1.35 (1.31–1.39)*
COVID-19 vaccination status of parent				
0–2 doses	48.6 (46.7–50.5)	2023	27.77 (27.44–28.11)*	6.55 (6.44–6.66)*
3 + doses	3.3 (2.8–3.8)	4478	Reference	Reference
Influenza vaccination of parent				
Every flu season	5.0 (4.1–6.1)	1627	Reference	Reference
Most flu seasons	9.4 (8.0–11.0)	1301	1.96 (1.93–2.00)*	0.85 (0.82–0.87)*
Some flu seasons	19.3 (17.7–21.0)	1819	4.51 (4.45–4.57)*	0.52 (0.50–0.53)*
Never	34.1 (32.1–36.1)	1754	9.77 (9.61–9.93)*	0.61 (0.59–0.62)*
Influenza vaccination of child				
Every flu season	4.9 (4.0–6.0)	1523	Reference	Reference
Most flu seasons	8.6 (7.2–10.3)	1068	1.82 (1.78–1.87)*	1.18 (1.14–1.23)*
Some flu seasons	15.0 (13.3–16.9)	1347	3.42 (3.37–3.48)*	1.98 (1.92–2.05)*
Never	30.8 (29.2–32.5)	2563	8.62 (8.45–8.80)*	2.21 (2.14–2.28)*
Routine vaccination of child				
All routine vaccinations for age	16.4 (15.5–17.2)	6152	Reference	Reference

(*continued on next page*)

Table 3 (*continued*)

Variable	% Unvaccinated (95 % CI)[a,b]	n[c]	Unadjusted OR (95 % CI)[a,c]	Adjusted OR (95 % CI)[a,c,d]
Only some	44.8 (39.4–50.3)	232	4.14 (4.09–4.19)*	1.18 (1.15–1.22)*
None	55.3 (47.5–62.8)	117	6.31 (6.17–6.44)*	1.60 (1.53–1.68)*
Chronic medical condition of child				
Yes	16.7 (14.6–19.1)	908	Reference	Reference
No	18.7 (17.8–19.7)	5593	1.15 (1.13–1.16)*	0.96 (0.94–0.99)*
Average Score of Vaccine Attitudes	–	–	5.63 (5.59–5.67)*	4.41 (4.38–4.45)*

Note: n values are unweighted.
[a] Percentages and odds ratios are weighted.
[b] n = 7723 after excluding missing values for the dependent variable.
[c] Missing data for all independent variables were also excluded in the simple and multiple regression models. n values are shown for the multiple regression model with a sample size of 6501.
[d] Adjusted for all the other variables present in this column.
[e] The sectors mentioned in the survey were based on the Canadian Immunization Guide.
[*] Statistically significant ($p < 0.05$).

0.82–0.87). Concerning COVID-19 immunization history, parents who received 0–2 doses of a COVID-19 vaccine were also significantly more likely to report non-vaccination for their child (aOR 6.55; 95 % CI: 6.44–6.66) compared to those who received 3 doses or more.

4. Discussion

This study provides insight into factors linked to non-vaccination against COVID-19 among Canadian children aged 5–17. By examining the interplay of sociodemographic factors, vaccine knowledge, attitudes, beliefs, and vaccination history, we can better tailor interventions and communication approaches to enhance COVID-19 vaccination uptake in this demographic.

We found that elevated vaccine KAB composite scores among parents, signifying more opposing attitudes or beliefs about vaccination, correlated with COVID-19 non-vaccination among their 5–17 yr. old children. This underscores the necessity of rectifying misunderstandings and bolstering public comprehension of COVID-19 vaccines' benefits and safety, especially for parents who might hold misconceptions or reservations about vaccinating their child. Our findings echo previous studies that established the considerable influence of vaccine knowledge, attitudes, and beliefs on vaccination decision-making [15–17,19–23]. Our study highlights the need for evidence-based interventions and educational campaigns to foster trust and improve COVID-19 vaccine acceptance.

The observation that parents with lower household incomes were more likely to report non-vaccination for their children aligns with prior research conclusions [13,15,17,20,23,25,26]. It's plausible that despite the free availability of the COVID-19 vaccine, families with lower incomes may encounter additional barriers to access. These barriers could include limited transportation options, inability to secure time off work for appointments, medical mistrust, or inadequate healthcare infrastructure in their communities [27–29]. These are potential considerations that warrant further focused study to fully elucidate their impact on COVID-19 vaccination odds among lower-income families. To improve vaccination odds among these populations, certain initiatives could be beneficial. These could include providing transportation assistance and implementing targeted educational campaigns or community-based initiatives to foster trust and promote COVID-19 vaccine acceptance [29].

In line with the international literature, our analysis revealed significant associations between non-vaccination and various other sociodemographic factors, such as younger age of the parent [15,20]. Our analysis aligns with some studies [30–32] and diverges from others [14,21] in finding a significant independent association between rurality and increased childhood COVID-19 non-vaccination. These findings suggest that tailored interventions and messaging could be vital to effectively address the unique concerns and needs of these specific subpopulations. For rural communities, this could involve engaging trusted local figures to disseminate accurate vaccine information, promote health literacy, and serve as vaccine ambassadors. Leveraging social media platforms, local media, and influential celebrities can further facilitate the circulation of accurate vaccine information and recount positive vaccination encounters [29,30]. Additionally, rural communities may require additional support, such as COVID-19 mobile vaccination clinics to overcome access barriers and improve vaccine uptake. This is especially pertinent in the Canadian context, given the country's immense geographic expanse and diverse population densities. The discrepancies observed between our findings and those from studies conducted in other countries may stem from several factors inherent to the unique context of each study. These factors could include differences in healthcare systems, cultural and societal factors, or variations in study design and data collection methods.

Our study also highlights the importance of considering ethnic and cultural factors in addressing COVID-19 non-vaccination. The observed variations in non-vaccination odds across different ethnic groups may reflect diverse cultural beliefs, historical experiences, or trust in healthcare systems, as suggested by studies on vaccine hesitancy in minority populations [33–39]. This could underscore the need for culturally sensitive approaches to COVID-19 vaccine promotion, such as working with community leaders, using culturally appropriate messaging, and addressing systemic inequities that contribute to mistrust in healthcare systems.

The relationship between the child's vaccination history and non-vaccination against COVID-19 offers valuable insights for future interventions. Our study found that children who received only some or none of the recommended routine vaccinations for their age, as well as those who received the flu vaccine less consistently, were more likely to report non-vaccination against COVID-19. These findings align with previous research showing that children's prior vaccination experiences can influence parental decision-making for subsequent vaccinations [15,20,22], but they differ from a study that found no significant association between a parent's willingness to allow their children to receive the COVID-19 vaccine and the child's routine vaccination status [40]. These results may underscore the importance of promoting routine immunization and building trust in vaccination programs overall, as it may have a ripple effect on the uptake of new vaccines, such as those for COVID-19.

A seemingly paradoxical finding from our investigation was the association between parents' flu vaccination history and their children's COVID-19 vaccination. Interestingly, parents who were less frequently vaccinated against the flu before the pandemic reported lower non-vaccination for their children compared to those who received the flu vaccine every season. While initially surprising, this finding actually aligns with behavioral science research indicating that decision-making processes can differ significantly depending on whether parents are deciding for themselves or for someone else [41]. This phenomenon can be attributed to the shift in perspective that occurs when individuals switch roles from being a patient to a decision-maker for another individual, which has been found to result in more survival-maximizing decisions, such as accepting medical interventions, including vaccinations [42]. This shift may be driven by the greater emotional engagement and responsibility parents feel when making health decisions for their children, pushing them towards maximizing their children's survival chances, even when they have not acted similarly regarding their own health. It is also important to acknowledge that public perception of disease severity and vaccine efficacy differ significantly between influenza, which is known for its variable yearly vaccine efficacy and more severe impact on children, and COVID-19, generally milder in children but more severe in older adults. These differences likely influence parental choices regarding vaccination. Nevertheless, this intriguing finding underscores the complexity of parental decision-making processes and their potential implications on public health strategies. Further research is needed to confirm the exact mechanism contributing to this discrepancy for childhood COVID-19 vaccination and to develop targeted interventions that effectively promote vaccination for both parents and their children.

Furthermore, our study revealed a nuanced relationship between parents' education levels and COVID-19 non-vaccination. Compared to individuals holding a bachelor's degree or higher, we observed lower childhood non-vaccination odds in parents with education levels below a high school diploma or with a postsecondary degree below a bachelor's, while those with a high school degree exhibited higher non-vaccination odds. This finding suggests that the influence of education on childhood COVID-19 vaccination decisions may be more nuanced than previously assumed, suggesting the possibility of effect modification or interaction by one or more third variables. Prior global research has either associated higher educational attainment with increased vaccination odds or intent [15,17,20,23], or found no association between educational attainment and vaccination odds or intent [14,20–22]. The lower non-vaccination odds observed among respondents with higher educational attainment, such as post-secondary degrees or above, may be due to the significant association between years of education and health literacy [43]. Parents with a more basic education level, such as those with only a high school degree, may have a limited understanding of complex health concepts, potentially making them less able to understand and follow healthcare providers' recommendations [44], which in turn might lead to lower vaccination odds among their children. Our study cannot explain why children of parents with less than a high school education had higher vaccination odds compared to those with a bachelor's degree or higher. This unexpected finding highlights the need for further investigation to gain a deeper understanding of the factors driving the observed associations between parental education levels and childhood COVID-19 non-vaccination.

Among individual KABs, the strongest association with non-vaccination was observed in respondents who disagreed with the statement 'My child needs to be vaccinated against COVID-19 even after infection.' This aligns with prior research indicating a decreased willingness to vaccinate post-COVID-19 recovery [45]. Despite evidence

Table 4
Differences in demographic variables between the excluded and analytic samples.

		Analytical Sample (n = 6501)			Sample with Missing Data			
Key Demographic Variables		n	Unweighted %	Weighted % (95 % CI)	n	Unweighted %	Weighted% (95 % CI)	Rao-Scott Likelihood Ratio Chi-Square Test
Sex	Male	2587	39.8	39.9 (38.7–41.1)	498	39.8	39.6 (36.9–42.3)	**p = 0.008**
	Female	3914	60.2	60.1 (58.9–61.3)	752	60.2	60.4 (57.7–63.1)	
Age	18–29	30	0.5	0.5 (0.3–0.7)	9	0.7	0.60 (0.30–1.2)	**p <.0001**
	30–39	1185	18.2	18.9 (18.0–19.9)	209	17.4	17.3 (15.2–19.5)	
	40–49	3607	55.5	56.1 (54.9–57.3)	656	54.7	55.0 (52.2–57.8)	
	50+	1679	25.8	24.5 (23.4–25.5)	326	27.2	27.2 (24.7–29.7)	
Education	Less than high school	78	1.2	1.0 (0.8–1.3)	27	2.1	1.6 (1.0–2.5)	**p <.0001**
	High school or equivalent	496	7.6	7.2 (6.6–7.8)	136	11.3	10.0 (8.4–11.8)	
	Postsecondary below Bachelor's	2107	32.4	32.1 (31.0–33.2)	462	38.5	38.2 (35.4–40.9)	
	Bachelor's or above	3820	58.8	59.7 (58.5–60.9)	575	47.9	50.2 (47.4–53.1)	
Household income	Under $40,000	402	6.2	6.1 (5.6–6.7)	88	14.6	14.0 (11.5–17.0)	**p <.0001**
	$40,000-$59,999	489	7.5	7.3 (6.7–7.9)	60	10.0	10.0 (7.8–12.6)	
	$60,000-$79,999	581	8.9	8.6 (8.0–9.3)	67	11.1	11.7 (9.4–14.5)	
	$80,000-$99,999	797	12.3	12.2 (11.4–13.0)	75	12.5	11.1 (8.9–13.9)	
	$100,000-$149,999	1692	26.0	26.3 (25.3–27.4)	154	25.6	26.4 (23.0–30.1)	
	$150,000 and above	2540	39.1	39.4 (38.3–40.6)	158	26.3	26.8 (23.4–30.5)	
Ethnicity	Black	169	2.6	2.8 (2.5–3.3)	33	3.3	3.5 (2.5–4.8)	**p <.0001**
	East/Southeast Asian	291	4.5	4.2 (3.8–4.8)	74	7.4	7.0 (5.6–8.7)	
	South Asian	171	2.6	3.0 (2.6–3.4)	60	6.0	6.7 (5.3–8.4)	
	Latin American	100	1.5	1.7 (1.4–2.0)	21	1.6	2.3 (1.6–3.5)	
	Middle Eastern and North African	144	2.2	2.4 (2.1–2.8)	27	2.1	2.9 (2.0–4.1)	
	Indigenous	98	1.5	0.9 (0.7–1.2)	23	1.8	1.2 (0.7–2.1)	
	White	5235	80.5	80.2 (79.2–81.1)	701	70.0	69.7 (66.8–72.5)	
	Other/Mixed ethnicity/ Indigenous from outside Canada	293	4.5	4.8 (4.3–5.3)	62	6.2	6.7 (5.3–8.4)	

Note: n values are unweighted.

showing that hybrid immunity—resulting from both infection and vaccination—substantially lowers the risk of severe reinfection compared to immunity from previous infection alone [46,47], only 63 % of our respondents acknowledged the importance of vaccination post-infection. By March 2023, a significant portion of the Canadian population had experienced COVID-19 infection [48]. Given that both natural immunity and initial vaccine-induced immunity wane over time, and considering the emergence of variants with greater immune evasion [49,50], it is imperative for public health messages to highlight the benefits of further vaccination in previously infected individuals.

Our study is not without certain limitations. First, the survey's cross-sectional nature precludes establishing causality between the assessed factors and non-vaccination, as it only captures a snapshot of the situation at a specific point in time. Second, relying on self-reported data may result in recall bias or social desirability bias, as respondents might inadvertently misremember or deliberately misreport experiences and actions to cast themselves in a better light. Third, a substantial segment of our sample was omitted from the multivariable regression analysis due to incomplete data. Demographic variable differences—such as parental age, education, ethnicity, and income—emerged when contrasting the excluded sample with the analytic one (Table 4). Consequently, this could restrict our findings' generalizability to the larger population, as excluded participants may exhibit distinct characteristics or vaccination behaviors. Notwithstanding these limitations, our investigation provides invaluable insights into factors correlated with non-vaccination among children aged 5–17 years in Canada as this study still offers several advantages. Its random selection of participants mitigates selection bias and the large, weighted sample size facilitates precise estimates, yielding robust, statistically significant results. Moreover, the survey's nationwide scope across Canada encapsulates diverse socioeconomic, cultural, and geographical backgrounds, reducing regional bias.

5. Conclusion

To conclude, this study unveils crucial insights regarding factors linked to COVID-19 non-vaccination among Canadian children aged 5–17. Our discoveries highlight the pressing need for tailored interventions and strategic communication to address COVID-19 vaccine knowledge, attitudes, beliefs, and sociodemographic factors. This may involve a multifaceted approach of evidence-based educational campaigns, culturally sensitive messaging, and equitable access to COVID-19 vaccines, particularly for financially disadvantaged families and rural populations.

Additional research is necessary to delve into the intricate nature of parents' decision-making processes concerning COVID-19 vaccinations for themselves and their child, as well as to comprehend the role of education levels in these choices. Ultimately, this study lays the groundwork for devising targeted approaches to increase COVID-19 vaccine uptake to better safeguard the health of the children and their communities.

Ethics approval

The Childhood COVID-19 Immunization Coverage Survey had been approved by the Public Health Agency of Canada Research Ethics Board. The survey was completed on a voluntary basis, and data are kept confidential.

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CRediT authorship contribution statement

David Guan: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Sailly Dave:** Conceptualization, Data curation, Validation, Writing – review & editing, Supervision. **Marwa Ebrahim:** Conceptualization, Supervision, Writing – review & editing. **Julie A. Laroche:** Supervision, Writing – review & editing.

Declaration of competing interest

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

Data availability

The authors do not have permission to share data.

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