



# Socioeconomic status differences in parental immunization attitudes and child immunization in Canada: Findings from the 2013 Childhood National Immunization Coverage Survey (CNICS)



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## ARTICLE INFO

### Keywords:

Child vaccinations  
Social determinants of health  
Vaccine hesitancy  
Vaccine refusal  
Health inequalities  
Child health  
Canada

## ABSTRACT

Childhood vaccination efforts in Canada have been negatively impacted by parents' vaccine hesitancy based on their knowledge, attitudes, and beliefs (KAB) about vaccinations. Less understood is the extent to which child vaccination receipt and KAB vary by parents' socioeconomic status (SES). Analyzing different age groups of children and vaccinations, we examine the extent to which (a) family SES (parent education, household income) is a determinant of Canadian parents' vaccination KAB and child vaccination receipt, and (b) whether SES is indirectly associated with receipt via KAB. In 2017, we analyzed 2013 Childhood National Immunization Coverage Survey (CNICS) data. We estimated models for parental KAB and child vaccination receipt for measles, mumps, and rubella (MMR) at age 2 ( $n = 3620$ ); diphtheria, pertussis, and tetanus (DPT) at age 7 ( $n = 3465$ ); and human papillomavirus (HPV) at ages 12–14 ( $n = 5213$  females). SES is inconsistently associated with KAB and vaccine receipt across the three age groups. SES differences in KAB mostly center on vaccine-specific side effect and safety concerns, with lower education and income levels associated with higher odds of being concerned. Non-receipt of minimum age-specific vaccination dosages was associated with concerns about vaccine effectiveness (DPT, HPV) and side effects (MMR, HPV) and lower perceived importance of immunizing a child (MMR, HPV). KAB mediation was mostly limited to SES patterns in MMR. We discuss the implications of these findings for designing general and population-specific vaccination education strategies and future studies of KAB and undervaccination.

## 1. Introduction

Ensuring adequate vaccination coverage remains a continued challenge in Canada and other high-income countries. A major factor underlining this challenge is parents' vaccine hesitancy (Dubé et al., 2015)—which may be patterned by parental socioeconomic status (SES). Through providing access to flexible, yet unequally distributed resources, like knowledge, money, and beneficial social connections, SES differentially shapes parents' choices and capacities to engage in health-promoting practices, including vaccinations for their children (Carpiano et al., 2008; Polonijo and Carpiano, 2013). The present study investigates the extent to which SES patterns may exist in Canadian parents' vaccination-related knowledge, attitudes, and beliefs (KAB)

and child vaccination receipt, across different age-specific vaccinations.

Canadian evidence indicates parents' vaccine hesitancy and child vaccination receipt are associated with their KAB—specifically, negative perceptions regarding the utility of vaccinations; lower trust of vaccination information; greater concerns about safety, effectiveness, and potential side effects; and lower perceived importance of vaccinations (Dubé et al., 2016; MacDonald et al., 2014; Gilbert et al., 2016).

Qualitative research on vaccine-hesitant US mothers found side effect, safety, and efficacy concerns can cluster with intensive parenting beliefs common among higher SES parents (Reich, 2014, 2016). Research in Canada corroborates these findings, with higher parental education associated with lower odds of daughters receiving the HPV vaccine in British Columbia (Ogilvie et al., 2010) and national (Gilbert

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<https://doi.org/10.1016/j.ypmed.2019.03.033>

Received 4 July 2018; Received in revised form 11 March 2019; Accepted 17 March 2019

Available online 20 March 2019

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**Table 1**

Weighted descriptive statistics of vaccination-specific up-to-date status; knowledge, attitude, and belief (KAB); and socioeconomic status variables for each age-specific vaccination subsample—2013 Childhood National Immunization Coverage Survey (CNICS), Canada.

Age 2 (n = 3620)	%	Age 7 (n = 3465)	%	Ages 12–14 (n = 5213 females)	%
Not received ≥ 1 dose for...		Not received ≥ 5 doses for...		Not received ≥ 1 dose for...	
Measles	7.0	Diphtheria	26.1	HPV	29.1
Mumps	7.3	Tetanus	26.5		
Rubella	7.4	Pertussis	26.8		
Knowledge, attitudes, and beliefs					
Lack of vaccine confidence, weighted mean (SE)	4.0 (0.03)	Lack of vaccine confidence, weighted mean (SE)	4.0 (0.03)	Lack of vaccine confidence, weighted mean (SE)	4.0 (0.03)
Concern about potential side effects	2.17 (0.03)	Concern about potential side effects	2.2 (0.03)	Concern about potential side effects	2.1 (0.02)
Strongly disagree	14.7	Strongly disagree	16.2	Strongly disagree	13.8
Somewhat disagree	18.2	Somewhat disagree	15.5	Somewhat disagree	15.0
Somewhat agree	36.0	Somewhat agree	36.5	Somewhat agree	38.1
Strongly agree	31.1	Strongly agree	31.8	Strongly agree	33.0
Importance to immunize your child against MMR, weighted mean (SE)	4.1 (0.04)	Importance to immunize your child against DTP, weighted mean (SE)	4.2 (0.04)	Importance to immunize your child against VPD, weighted mean (SE)	18.6 (0.03)
Safety concerns about MMR vaccination, weighted mean (SE)	2.2 (0.03)	Safety concerns about DTP vaccination, weighted mean (SE)	2.2 (0.03)	Safety concerns regarding vaccinations, weighted mean (SE)	2.2 (0.02)
Not concerned	36.2	Not concerned	38.2		
Somewhat concerned	23.8	Somewhat concerned	21.3		
Concerned	19.5	Concerned	20.0		
Very concerned	20.5	Very concerned	20.5		
Socioeconomic status					
Education		Education		Education	
Secondary or less	20.2	Secondary or less	21.0	Secondary or less	28.1
Post-secondary	36.8	Post-secondary	36.2	Post-secondary	42.6
University graduate	43.0	University graduate	42.8	University graduate	29.3
Household income		Household income		Household income	
C\$0–19,999	6.5	C\$0–19,999	7.4	C\$0–19,999	7.0
C\$20,000–39,999	12.6	C\$20,000–39,999	11.7	C\$20,000–39,999	15.6
C\$40,000–59,999	14.0	C\$40,000–59,999	13.4	C\$40,000–59,999	14.7
C\$60,000–79,999	16.6	C\$60,000–79,999	14.6	C\$60,000–79,999	13.9
C\$80,000–99,999	14.6	C\$80,000–99,999	14.0	C\$80,000–99,999	13.6
C\$100,000–119,999	10.0	C\$100,000–119,999	10.6	C\$100,000–119,999	10.7
≥ C\$120,000	25.6	≥ C\$120,000	28.3	≥ C\$120,000	24.5

SE = standard error; MMR = measles, mumps, rubella; DTP = diphtheria, tetanus, pertussis; HPV = human papillomavirus; VPD = vaccine-preventable diseases.

et al., 2016) samples. Nevertheless, school-level vaccination coverage rates for Vancouver area Kindergarteners were substantially lower in some of the most affluent and disadvantaged public health catchment areas—suggesting the presence of vaccine hesitancy as well as knowledge and access mechanisms (especially for the latter) (Carpiano and Bettinger, 2016). Despite this prior work, the extent of Canadian SES disparities in vaccination KAB and receipt of childhood age-specific vaccinations remains unclear, as does the extent to which SES disparities in parental KAB may contribute to disparities in vaccination receipt.

Given these concerns, we analyze Canadian national data to investigate three research issues regarding receipt of specific vaccinations for three age groups: (1) measles, mumps, and rubella (MMR) at age 2; (2) diphtheria, pertussis, and tetanus (DTP) at age 7; and (3) human papillomavirus (HPV) at ages 12–14 for females. First, we examine the extent to which family SES is associated with parents' KAB regarding vaccines for their children and adolescents. As studies indicate that higher SES is positively associated with vaccine hesitancy, we hypothesize higher SES parents will be more likely to report:

- lower confidence about vaccines in general (i.e., regarding effectiveness, safety, and health importance)
- greater concern about potential side effects of vaccines in general
- greater vaccine-specific safety concerns, and
- lower perceived importance of vaccinating one's child against a specific vaccine-preventable disease (VPD).

Second, we examine SES disparities in vaccination-specific receipt; hypothesizing that the likelihood of a child receiving at least the

minimum, age-specific doses will be lowest among both the highest and lowest SES groups. Third, we determine the extent to which SES may be indirectly associated with vaccination receipt via parents' vaccination KAB—testing the general hypothesis that parental KAB constitute important pathways through which SES shapes vaccination disparities.

## 2. Methods

### 2.1. Data and study samples

During 2016–17, we analyzed the 2013 Childhood National Immunization Coverage Survey (CNICS), which constitutes the most recent available national immunization coverage data among Canadian children ages 2, 7, 12–14 (girls only), and 17 as of March 1, 2013 (total n = 24,853). This cross-sectional survey is conducted biennially by Statistics Canada for the Public Health Agency of Canada. Sampling details are reported extensively elsewhere (Statistics Canada, 2015). Participants were selected by random sampling with stratification by province or territory, using a sampling frame estimated to cover 96% of Canadian children (Pantel, 2010). For these three age-groups, response rates ranged from 60.4% (girls ages 12–14) to 63.5% (age 2).

CNICS collected information from the parent/guardian (hereafter “parent”) about the selected child's immunizations, the parent's KAB, and child and parent demographics. Parents were asked if their child had ever received any immunization. Those responding “no” (overall, only 2.7%, 1.1%, and 1.0% respectively among the 2, 7, and 12–14 year old subsamples) were asked for the reasons why the child had not been vaccinated, but not asked KAB questions. Parents responding “yes” were asked if they had an immunization record available for their child.

**Table 2**

Weighted descriptive statistics of sociodemographic confounder variables for each age-specific subsample—2013 Childhood National Immunization Coverage Survey (CNICS), Canada.

	%		
	Age 2 (n = 3620)	Age 7 (n = 3465)	Ages 12–14 (n = 5213 females)
<b>Healthcare provider access</b>			
Seen provider in last year, vaccination discussed	38.1	21.4	29.2
Seen provider in last year, no/don't know vaccination			
Discussion	50.0	55.3	51.7
Did not see provider in last year	11.9	23.3	19.1
<b>Child demographics</b>			
Female gender	48.1	46.7	N/A
Child born outside Canada	3.3	8.8	12.0
<b>Responding primary caregiver demographics</b>			
Age, mean (SE)	33.3 (0.1)	38.0 (0.1)	42.5 (0.1)
Born outside Canada	29.2	32.3	27.9
<b>Marital status</b>			
Married/common-law	87.5	83.6	74.0
Widowed/separated/divorced	4.4	9.8	17.8
Single/never married	8.1	6.6	8.2
<b>Province/territories</b>			
Alberta	12.2	12.2	11.5
British Columbia	10.7	11.5	11.8
Manitoba	3.1	3.8	3.8
New Brunswick	1.9	2.0	2.2
Newfoundland and Labrador	1.1	1.4	1.5
Nova Scotia	1.8	2.4	2.6
Ontario	38.0	40.1	41.0
Prince Edward Island	0.3	0.4	0.4
Quebec	27.8	22.4	21.6
Saskatchewan	2.7	3.4	3.1
Territories	0.3	0.4	0.4

SE = standard error.

All parents reporting no children with an available record were included in CNICS' coverage assessment component. Data were obtained primarily from parent-held records (parental report was not accepted), with information collected by antigen, not vaccine. To confirm immunization history, survey staff asked parents for permission to contact healthcare providers who immunized the child, or healthcare facilities where the child was immunized. However, despite 90% of parents providing agreement by phone, immunization data from healthcare providers and settings was obtained for only 33.1% of participants due to < 50% of parents returning their signed consent form, and some healthcare providers or facilities that either could not be reached or did not respond.

Our analysis focuses on three immunization- and age-specific subsamples: MMR at age 2 (n = 3620), DPT at age 7 (n = 3465), and HPV at ages 12–14 (n = 5213 females). Each subsample is comprised of cases with non-missing data on all study variables. Missingness ranged from 3.7% (age 2/MMR) to 10.4% (girls age 12–14/HPV).

## 2.2. Measures

Table 1 presents coding for the vaccination receipt, KAB, and SES variables.

### 2.2.1. Child vaccination receipt

Vaccination receipt was determined from the reported doses for any specific vaccination, the child's age, and the National Advisory Committee on Immunization (NACI) published schedule. MMR and DPT receipt are based on specific antigens, which resulted in three measures each for MMR at age 2 (MMR) and DPT at age 7. As with prior CNICS analyses (Gilbert et al., 2017), we used this approach because of the potential for directional misclassification due to missing doses, illegible dose information, or missing dates in parent-held immunization

records. Overall, we determined that an immunization record was more likely to be missing information on previously administered doses than have an immunization erroneously recorded. This error would have been additive if we had constructed a composite variable that attempted to identify those fully or partially vaccinated across multiple antigens, and led to misclassifying a larger number of children on the outcome variables.

From this protocol, MMR, DPT, and HPV receipt are binary measures assessing whether the child has *not received* (coded 1 vs. has received = 0) each of the following antigen-specific doses for her/his age group: (by age 2) at least one dose of measles, mumps, and rubella antigen (3 separate variables); (by age 7) at least five doses of diphtheria, pertussis, and tetanus antigen (3 separate variables); and (by ages 12–14 [girls only]) at least one dose of HPV vaccine (one variable).

### 2.2.2. Parental knowledge, attitudes, and beliefs (KAB)

We utilized measures assessing general and vaccine-specific KABs. In creating our multi-item KAB variables described below, we truncated response scales to ensure adequate cell sizes. Nevertheless, all truncated variables correlated highly ( $r > 0.90$ ) with analogous variables using the full scale.

Our two general KAB variables are:

1. *Lack of vaccine confidence* is a three-item index assessing the extent to which the parent agreed that: “In general, childhood vaccines are...” (a) safe, (b) effective, and (c) important for your child's health. Each item utilized a four-point response scale (from strongly agree = 1 to strongly disagree = 4), which we summed and truncated at values of 7 or higher.
2. *Potential side effect concerns* uses a single item—“In general, you are concerned about the potential side effects from vaccines”—also coded on the abovementioned four-point scale.

**Table 3**

Subsample-specific adjusted estimates for parents' vaccination-related knowledge, attitude, and belief (KAB) variables regressed on socioeconomic status and sociodemographic variables—2013 Childhood National Immunization Coverage Survey (CNICS), Canada.

Age 2 subsample (n = 3620)	1. Lack of vaccine confidence				2. Side effect concerns (referent = strongly agree)				3. Unimportance	4. MMR vaccine safety concerns (referent = not concerned)			
	B (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)	B (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)	B (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)
Education													
Secondary or less	0.16 (−0.03, 0.35)	0.57 (0.39, 0.85)	0.74 (0.45, 1.21)	0.85 (0.51, 1.42)	0.00 (−0.21, 0.22)	0.92 (0.59, 1.44)	1.62 (1.04, 2.51)	1.52 (0.94, 2.47)					
Post-secondary	0.24 (0.09, 0.38)	0.67 (0.50, 0.92)	0.64 (0.44, 0.94)	0.67 (0.45, 0.99)	0.11 (−0.07, 0.28)	1.15 (0.84, 1.58)	1.36 (0.96, 1.93)	2.06 (1.43, 2.98)					
University graduate	Referent	Referent	Referent	Referent	Referent	Referent	Referent	Referent					
Household income													
C\$0–19,999	−0.23 (−0.54, 0.07)	0.95 (0.47, 1.92)	0.72 (0.30, 1.70)	0.67 (0.25, 1.75)	0.26 (−0.14, 0.66)	0.77 (0.35, 1.67)	1.22 (0.50, 2.95)	1.93 (0.88, 4.23)					
C\$20,000–39,999	0.02 (−0.23, 0.27)	1.19 (0.72, 1.95)	0.43 (0.22, 0.84)	0.90 (0.48, 1.70)	0.12 (−0.17, 0.41)	0.87 (0.51, 1.49)	1.89 (1.05, 3.41)	1.72 (0.94, 3.14)					
C\$40,000–59,999	0.08 (−0.13, 0.29)	0.95 (0.61, 1.46)	0.65 (0.38, 1.09)	0.60 (0.32, 1.11)	0.33 (0.07, 0.60)	1.18 (0.72, 1.93)	1.66 (0.97, 2.83)	1.32 (0.77, 2.26)					
C\$60,000–79,999	−0.00 (−0.18, 0.18)	0.90 (0.60, 1.35)	0.65 (0.39, 1.09)	0.52 (0.30, 0.92)	0.26 (0.00, 0.51)	1.19 (0.78, 1.82)	1.70 (1.02, 2.83)	1.32 (0.81, 2.15)					
C\$80,000–99,999	0.08 (−0.13, 0.29)	0.99 (0.65, 1.51)	0.74 (0.45, 1.22)	0.52 (0.29, 0.92)	0.01 (−0.22, 0.25)	1.20 (0.78, 1.86)	1.70 (1.00, 2.86)	1.39 (0.85, 2.26)					
C\$100,000–119,999	0.09 (−0.14, 0.32)	0.69 (0.46, 1.06)	0.49 (0.29, 0.81)	0.42 (0.23, 0.76)	0.13 (−0.13, 0.40)	1.19 (0.75, 1.90)	2.25 (1.30, 3.90)	1.70 (0.97, 2.98)					
≥ C\$120,000	Referent	Referent	Referent	Referent	Referent	Referent	Referent	Referent					
Age 7 subsample (n = 3465)	1. Lack of vaccine confidence				2. Side effect concerns (referent = strongly agree)				3. Unimportance immunizing against DPT	4. DPT vaccine safety concerns (referent = not concerned)			
	B (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)	B (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)	B (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)
Education													
Secondary or less	−0.03 (−0.23, 0.16)	0.69 (0.47, 1.03)	0.73 (0.44, 1.21)	1.03 (0.64, 1.66)	0.09 (−0.12, 0.30)	1.26 (0.83, 1.91)	1.42 (0.89, 2.25)	1.46 (0.88, 2.42)					
Post-secondary	−0.06 (−0.21, 0.09)	0.72 (0.53, 0.97)	0.60 (0.40, 0.88)	0.87 (0.59, 1.30)	0.15 (−0.02, 0.32)	1.15 (0.82, 1.61)	1.61 (1.13, 2.28)	1.50 (1.03, 2.18)					
University graduate	Referent	Referent	Referent	Referent	Referent	Referent	Referent	Referent					
Household income													
C\$0–19,999	−0.02 (−0.33, 0.30)	0.94 (0.48, 1.83)	0.71 (0.31, 1.65)	0.95 (0.44, 2.05)	0.08 (−0.27, 0.43)	1.18 (0.56, 2.47)	2.45 (1.18, 5.07)	2.11 (0.97, 4.59)					
C\$20,000–39,999	−0.05 (−0.32, 0.22)	0.79 (0.48, 1.83)	0.38 (0.18, 0.81)	0.93 (0.47, 1.84)	−0.06 (−0.37, 0.25)	0.72 (0.36, 1.44)	2.05 (1.09, 3.83)	1.67 (0.84, 3.34)					
C\$40,000–59,999	−0.00 (−0.24, 0.23)	0.71 (0.44, 1.14)	0.55 (0.30, 0.99)	0.48 (0.26, 0.87)	−0.17 (−0.45, 0.10)	1.40 (0.80, 2.43)	1.52 (0.83, 2.80)	2.42 (1.32, 4.41)					
C\$60,000–79,999	0.11 (−0.11, 0.33)	1.04 (0.69, 1.58)	0.60 (0.34, 1.06)	1.01 (0.58, 1.75)	−0.15 (−0.39, 0.10)	1.01 (0.61, 1.68)	1.40 (0.84, 2.33)	1.74 (1.04, 2.92)					
C\$80,000–99,999	0.10 (−0.11, 0.32)	1.11 (0.73, 1.69)	0.71 (0.44, 1.14)	1.02 (0.59, 1.75)	−0.23 (−0.45, −0.02)	1.25 (0.80, 1.95)	1.49 (0.89, 2.49)	1.58 (0.96, 2.61)					
C\$100,000–119,999	−0.12 (−0.33, 0.09)	1.37 (0.87, 2.13)	1.27 (0.77, 2.11)	1.09 (0.63, 1.89)	−0.19 (−0.43, 0.04)	1.05 (0.66, 1.66)	1.14 (0.65, 2.01)	1.15 (0.66, 1.99)					
≥ C\$120,000	Referent	Referent	Referent	Referent	Referent	Referent	Referent	Referent					
Girls, ages 12–14 subsample (n = 5213)	1. Lack of vaccine confidence				2. Side effect concerns (referent = strongly agree)				3. Unimportance of immunizing child		4. Concern about vaccine safety		
	B (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)	B (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)	B (95% CI)	cOR (95% CI)	B (95% CI)	cOR (95% CI)	cOR (95% CI)
Education													
Secondary or less	0.03 (−0.11, 0.18)	0.90 (0.66, 1.23)	0.66 (0.45, 0.99)	1.00 (0.66, 1.52)	−0.36 (−0.91, 0.20)	0.08 (−0.04, 0.21)							
Post-secondary	0.07 (−0.06, 0.20)	0.80 (0.62, 1.04)	0.66 (0.48, 0.93)	0.96 (0.66, 1.38)	−0.04 (−0.54, 0.44)	0.07 (−0.04, 0.17)							

(continued on next page)

Table 3 (continued)

Girls, ages 12–14 subsample (n = 5213)	1. Lack of vaccine confidence	2. Side effect concerns (referent = strongly agree)			3. Unimportance of immunizing child	4. Concern about vaccine safety
		Somewhat agree	Somewhat disagree	Strongly disagree		
	B (95% CI)	cOR (95% CI)	cOR (95% CI)	cOR (95% CI)	B (95% CI)	B (95% CI)
University graduate	Referent	Referent	Referent	Referent	Referent	Referent
Household income						
C\$0–19,999	–0.16 (–0.42, 0.10)	1.28 (0.74, 2.21)	1.08 (0.53, 2.20)	1.17 (0.55, 2.47)	0.14 (–0.91, 1.20)	0.30 (0.09, 0.51)
C\$20,000–39,999	0.02 (–0.18, 0.22)	1.04 (0.69, 1.55)	1.07 (0.64, 1.78)	0.73 (0.41, 1.28)	–0.13 (–0.88, 0.62)	0.31 (0.15, 0.48)
C\$40,000–59,999	–0.02 (–0.21, 0.16)	0.96 (0.66, 1.40)	1.11 (0.68, 1.80)	0.96 (0.58, 1.60)	–0.18 (–0.91, 0.55)	0.17 (0.01, 0.33)
C\$60,000–79,999	0.05 (–0.12, 0.23)	1.20 (0.83, 1.72)	1.23 (0.78, 1.94)	1.00 (0.60, 1.68)	–0.09 (–0.75, 0.58)	0.15 (–0.01, 0.30)
C\$80,000–99,999	0.15 (–0.02, 0.33)	0.82 (0.58, 1.15)	0.85 (0.55, 1.33)	0.83 (0.51, 1.36)	0.75 (0.16, 1.35)	0.07 (–0.06, 0.21)
C\$100,000–119,999	–0.06 (–0.24, 0.12)	1.18 (0.79, 1.76)	1.13 (0.68, 1.90)	1.15 (0.71, 1.88)	–0.42 (–1.10, 0.27)	0.07 (–0.09, 0.22)
≥ C\$120,000	Referent	Referent	Referent	Referent	Referent	Referent

B = unstandardized slope coefficient; SE = standard error; cOR = conditional odds ratio; CI = confidence interval; MMR = measles, mumps, rubella; DPT = diphtheria, pertussis, and tetanus; HPV = human papillomavirus. All models control for variables listed in this table and Table 2; Models for ages 12–14 also control for child age.

Our two vaccine-specific KAB variables are as follows:

1. *Importance of vaccinating* against specific vaccine-preventable diseases was assessed for MMR and DPT, but not HPV. Parents were asked how important they thought it was to immunize their child against each of 27 different VPDs (using the four-point response scale of very important = 1 to not important at all = 4). For the age 2/MMR subsample, *importance of vaccinating against MMR* was a composite item of the summed responses to the aforementioned importance items for measles, mumps, and rubella. Likewise, for the age 7/DPT subsample, *importance of vaccinating against DPT* was a composite scale computed from responses to three items regarding diphtheria, pertussis, and tetanus. For both scales, values of 7 or higher were truncated at 7 to ensure adequate cell size. For the girls ages 12–14/HPV subsample, because there was no HPV-analogous item, we constructed a summative score index of responses to all 27 abovementioned importance items, with the scale truncated at 25.
2. *Vaccine-specific safety concerns* were assessed with a single item each for the age 2/MMR and age 7/DPT subsamples and a composite item for the girls ages 12–14/HPV subsample. For the age 2/MMR and age 7/DPT subsamples, respondents' concern regarding the respective safety of the MMR and DPT vaccines was assessed using a four-point response scale ranging from not concerned at all (referent) to very concerned. Because no specific item existed for the HPV vaccine, we created a general vaccine safety concern composite measure that was the mean of responses to all nine vaccine-specific safety concern items, with higher scores indicating greater concern.

Supplementary analyses indicated these KAB items were not substantially correlated such that simultaneous inclusion in models would not introduce multicollinearity.

### 2.2.3. Socioeconomic status variables

SES was assessed with two categorical variables: parent's education and family income. CNICS imputes missing income values using the nearest-neighbor method.

### 2.2.4. Control variables

We also control for healthcare access in last year and if the provider

discussed child immunizations with the caregiver, and several child- and parent-specific demographic factors (Table 2 reports coding and descriptive statistics).

### 2.3. Analyses

We analyzed our data in Stata 13, utilizing the svyset module to obtain accurate estimates and standard errors, respectively, from CNICS' sampling weights and 1000 bootstrap weights. To test our hypotheses regarding SES and KAB, we estimated linear and multinomial logistic regression models that regressed each KAB variable on SES and control variables.

We tested for SES disparities in vaccination receipt using binary logistic regression models that regressed receipt of a vaccination antigen on (a) SES and (b) SES and KAB variables—in both cases, adjusting for all control variables. To determine if SES was indirectly associated with vaccination receipt via KAB, we assessed whether, in the aforementioned models, (a) SES was associated with KAB variables (path a) and (b) KAB was associated with receipt, net of the influence of SES (path b).

For linear, binary and multinomial logistic model results, we respectively report unstandardized slope coefficients (B), odds ratios (OR), and conditional odds ratios (cOR), and 95% confidence intervals (CIs). Conditional odds ratios can be interpreted as the odds of being in a category of interest versus the baseline, conditional on not being in another category (Statalist, 2014).

## 3. Results

### 3.1. Descriptive statistics

Table 1 reports weighted descriptive statistics for the key study variables. Approximately 7% of 2-year-olds did not receive any dose of a measles, mumps, or rubella-containing antigen, compared to 26% of 7-year-olds with < 5 DPT-related antigens and 29.1% of girls ages 12–14 with zero HPV vaccine doses. For KAB variables, response distributions were similar across subsamples.

**Table 4**  
Adjusted odds ratios (95% confidence intervals) for child not having received antigen-specific immunizations at select ages—2013 Childhood National Immunization Coverage Survey (CNICS), Canada.

	Child has not received by...					
	Age 2 (n = 3620), 1 dose of...			Age 7 (n = 3465), ≥5 doses of...		
	Measles	Mumps	Rubella	Diphtheria	Pertussis	Tetanus
Education						
Secondary or less	1.78 (1.02, 3.10)	1.67 (0.97, 2.89)	1.69 (0.98, 2.92)	1.45 (1.00, 2.09)	1.39 (0.96, 1.99)	1.40 (0.97, 2.02)
Post-secondary	0.98 (0.60, 1.58)	0.89 (0.56, 1.41)	0.89 (0.56, 1.42)	1.55 (1.14, 2.10)	1.50 (1.11, 2.03)	1.53 (1.13, 2.07)
University graduate	Referent	Referent	Referent	Referent	Referent	Referent
Household income						
C\$0–19,999	0.97 (0.39, 2.41)	1.09 (0.46, 2.57)	1.07 (0.45, 2.53)	0.88 (0.50, 1.53)	0.91 (0.52, 1.58)	0.87 (0.50, 1.53)
C\$20,000–39,999	1.10 (0.55, 2.22)	1.09 (0.55, 2.18)	1.08 (0.54, 2.15)	0.94 (0.57, 1.57)	1.01 (0.61, 1.67)	0.96 (0.58, 1.59)
C\$40,000–59,999	1.57 (0.79, 3.13)	1.59 (0.82, 3.11)	1.57 (0.81, 3.06)	0.82 (0.53, 1.27)	0.83 (0.54, 1.28)	0.81 (0.52, 1.24)
C\$60,000–79,999	1.08 (0.56, 2.08)	1.03 (0.54, 1.99)	1.02 (0.53, 1.97)	0.82 (0.54, 1.25)	0.83 (0.55, 1.26)	0.83 (0.55, 1.25)
C\$80,000–99,999	0.48 (0.23, 0.98)	0.49 (0.24, 0.98)	0.48 (0.24, 0.97)	0.93 (0.61, 1.41)	0.91 (0.60, 1.37)	0.91 (0.60, 1.37)
C\$100,000–119,999	1.36 (0.68, 2.73)	1.32 (0.66, 2.61)	1.30 (0.65, 2.59)	0.41 (0.26, 0.65)	0.42 (0.27, 0.66)	0.41 (0.26, 0.65)
≥ C\$120,000	Referent	Referent	Referent	Referent	Referent	Referent
KAB variables						
1. Lack of vaccine confidence	1.19 (1.00, 1.42)	1.18 (0.99, 1.40)	1.18 (0.99, 1.40)	1.23 (1.10, 1.37)	1.24 (1.11, 1.39)	1.23 (1.10, 1.37)
2. Concern about potential side effects						
Strongly agree	Referent	Referent	Referent	Referent	Referent	Referent
Somewhat agree	0.65 (0.39, 1.09)	0.59 (0.35, 0.98)	0.59 (0.36, 0.98)	0.82 (0.61, 1.12)	0.83 (0.61, 1.13)	0.83 (0.61, 1.13)
Somewhat disagree	0.45 (0.23, 0.90)	0.42 (0.22, 0.83)	0.42 (0.22, 0.82)	1.13 (0.74, 1.74)	1.12 (0.73, 1.71)	1.12 (0.73, 1.72)
Strongly disagree	0.45 (0.24, 0.85)	0.44 (0.23, 0.84)	0.44 (0.23, 0.83)	1.12 (0.72, 1.75)	1.17 (0.76, 1.83)	1.15 (0.75, 1.78)
3. Unimportance immunizing against MMR/DPT	1.19 (1.03, 1.38)	1.19 (1.03, 1.38)	1.19 (1.03, 1.38)	1.09 (0.99, 1.20)	1.07 (0.98, 1.18)	1.08 (0.98, 1.19)
4. Safety concerns regarding MMR/DPT vaccination						
Not concerned	Referent	Referent	Referent	Referent	Referent	Referent
Somewhat concerned	0.95 (0.54, 1.70)	0.95 (0.54, 1.69)	0.95 (0.53, 1.68)	0.85 (0.57, 1.26)	0.84 (0.56, 1.26)	0.85 (0.57, 1.27)
Concerned	0.66 (0.37, 1.19)	0.78 (0.44, 1.38)	0.78 (0.44, 1.37)	1.02 (0.69, 1.51)	1.01 (0.69, 1.49)	1.01 (0.69, 1.49)
Very concerned	1.19 (0.67, 2.10)	1.13 (0.64, 2.00)	1.12 (0.63, 1.99)	1.32 (0.89, 1.98)	1.29 (0.87, 1.92)	1.32 (0.88, 1.96)

Child has not received ≥ 1 dose of HPV vaccine by ages 12–14 (n = 5213 females)

Education	
Secondary or less	1.04 (0.77, 1.41)
Post-secondary	1.00 (0.76, 1.31)
University graduate	Referent
Household income	
C\$0–19,999	1.02 (0.61, 1.71)
C\$20,000–39,999	1.06 (0.69, 1.61)
C\$40,000–59,999	1.50 (1.03, 2.19)
C\$60,000–79,999	1.34 (0.93, 1.93)
C\$80,000–99,999	1.07 (0.75, 1.53)
C\$100,000–119,999	1.10 (0.75, 1.63)
≥ C\$120,000	Referent
KAB variables	

(continued on next page)

Table 4 (continued)

	Child has not received $\geq 1$ dose of HPV vaccine by ages 12–14 ( <i>n</i> = 5213 females)
1. Lack of vaccine confidence	1.15 (1.05, 1.27)
2. Concern about potential side effects	
Strongly agree	Referent
Somewhat agree	0.72 (0.56, 0.92)
Somewhat disagree	0.62 (0.43, 0.89)
Strongly disagree	0.45 (0.30, 0.68)
3. Unimportance to immunize child against VPD	1.04 (1.01, 1.06)
4. Safety concerns regarding vaccinations	1.09 (0.96, 1.23)

KAB = Knowledge, Attitudes, and Beliefs; MMR = measles, mumps, rubella; DPT = diphtheria, pertussis, and tetanus; HPV = human papillomavirus. Items 3 and 4 respectively refer to MMR and DPT for MMR and DPT models. All models control for variables listed in this table and Table 2; Models for ages 12–14 also control for child age.

### 3.2. SES differences in KAB

Table 3 reports SES associations with KAB variables.

*Age 2/MMR Subsample:* Parents with some post-secondary education (versus university degrees) had higher (a) lack of confidence in vaccine effectiveness ( $B = 0.24$ ); (b) odds of strongly agreeing about concern for vaccine side effects (cORs for all other responses versus strongly agree = 0.64–0.67); and (c) odds of being very (versus not) concerned about MMR vaccine safety (cOR = 2.06). Similarly, parents with  $\leq$ secondary school education had (a) 75% higher odds of strongly (versus somewhat) agreeing about vaccine side effect concerns (percentage derived from inverse of cOR for somewhat agree = 0.57), and (b) 62% higher odds of reporting being concerned (versus not concerned) about MMR vaccine safety.

Parents in middle class income categories (versus  $\geq$ C\$120,000) had higher (a) odds of strongly agreeing (vs. somewhat or strongly disagreeing) with having vaccine side effect concerns (C\$60,000–119,999; cORs = 0.42–0.52), (b) unimportance of immunizing against MMR (C\$40,000–79,999; Bs = 0.26–0.33), and (c) odds of being concerned about MMR vaccine safety (all but one category between C\$20,000–C\$119,999, cORs = 1.70–2.25).

*Age 7/DPT Subsample:* Similar to the above, parents with a post-secondary education had higher odds of (a) strongly agreeing about concern for vaccine side effects (cORs for somewhat agree and somewhat disagree versus strongly agree = 0.72–0.60) and (b) being concerned (61%) or very concerned (50%) about DPT vaccine safety.

For income, parents in categories spanning C\$20,000–59,999 were more likely to strongly agree about side effect concerns. Also, parents in the two lowest categories (spanning C\$0–39,999) had approximately 2–2.5 times higher odds of being concerned (versus not concerned) about DPT vaccine safety, while those in more middle income brackets (spanning C\$40,000–79,999) had approximately 1.75–2.4 times higher odds of being either concerned or very concerned.

*Girls ages 12–14/HPV Subsample:* Lower educational attainment was associated with strongly agreeing about side effect concerns; though only the estimates for somewhat disagree (versus strongly agree) had CIs not inclusive of 1. Parents with incomes < C\$60,000 reported greater vaccine safety concerns (Bs = 0.17–0.30).

#### 3.2.1. SES disparities in vaccination receipt

Across the three subsamples, SES disparities in vaccination receipt (controlling for all confounders except KAB; not shown in tables) were mostly among the age 2/MMR and age 7/DPT subgroups. Estimates for which CIs did not include 1.0 were generally limited to education, not income, hence we focus mainly on education estimates, due to their

consistent patterns, versus income-specific findings limited to only one category for a particular outcome.

*Age 2/MMR Subsample:* Children of parents with  $\leq$ secondary school education (versus completing university) had higher odds of non-receipt of minimum doses: ORs ranging from 1.74 (mumps antigen) to 1.82 (measles antigen).

*Age 7/DPT Subsample:* Parents with  $\leq$ secondary school education (versus university degree) had 43% (tetanus antigen) and 47% (diphtheria antigen) higher odds of their child not receiving the minimal dosage (with the OR for pertussis being of similar magnitude, but CIs including 1.0). For parents with some post-secondary education, ORs for all three antigens ranged from 1.51 (pertussis) to 1.56 (diphtheria).

*Girls ages 12–14/HPV Subsample:* The only SES difference not including 1.0 was for income level C\$40,000–59,999 (OR = 1.46).

#### 3.2.2. SES-adjusted KAB Patterns in Vaccination Status

Table 4 reports SES- and KAB-specific adjusted odds ratios for a child not having received specified vaccination doses.

*Age 2/MMR Subsample:* The odds of a child not receiving at least one dose of a measles-containing vaccine by age 2 were (a) approximately 125–130% higher among parents who strongly agreed (vs., the respective categories of strongly disagreed and disagreed) regarding concern about vaccine side effects and (b) 19% higher for each unit increase in parental belief that MMR vaccination was unimportant.

*Age 7/DPT Subsample:* Only increased lack of confidence in vaccines was associated with (approximately 24%) higher odds of a child not receiving at least five doses of DPT vaccines by age 7.

*Girls ages 12–14/HPV Subsample:* Girls' non-receipt of at least one dose of HPV by ages 12–14 was associated with parents' (a) higher lack of vaccine confidence in general (15% higher odds per each unit increase); (b) strongly agreeing they had concerns about potential vaccine side effects (i.e. 39–122% higher odds of non-receipt, based on inverse of ORs ranging from 0.72 [for somewhat agree vs. strongly agree] to 0.45 [strongly disagree vs. strongly agree]); and (c) more strongly endorsing the unimportance of vaccinating against VPDs (OR = 1.04).

#### 3.2.3. Mediation

Lastly, we assessed the presence of mediation by a KAB variable for any pathways where estimates for SES  $\rightarrow$  KAB (path a, Table 3) and KAB  $\rightarrow$  vaccination status, net of SES (path b, Table 4) had CIs not including 0 (for linear models) or 1 (for non-linear models). Table 5 summarizes associations from Tables 3 and 4 to identify potential mediation using these criteria.

The age 2/MMR subsample offers the greatest evidence for KAB contributing to SES disparities in vaccination—via vaccine side effect

**Table 5**  
Summary of observed associations between Socioeconomic Status (SES); Knowledge, Attitudes, and Beliefs (KAB); and Non-Receipt of Minimum Immunization Dose variables.

Age 2/MMR subsample SES→	KAB mediators→	Non-receipt of ≥ 1 doses		
		Measles	Mumps	Rubella
Education: Post-secondary (+)	1. Lack of vaccine confidence	(1)	(1)	(1)
Education: Secondary or less (-) Post-secondary (-)	2. Concern about potential side effects Somewhat agree (vs. strongly agree)	(1)	(-)	(-)
Education: Post-secondary (-) Household income: \$20,000–39,999 (-) \$100,000–119,999 (-)	Somewhat disagree (vs. strongly agree)	(-)	(-)	(-)
Education: Post-secondary (-) Household income: \$60,000–79,999 (-) \$80,000–99,999 (-) \$100,000–119,999 (-)	Strongly disagree (vs. strongly agree)	(-)	(-)	(-)
Household income: \$40,000–59,999 (+) \$60,000–79,999 (+)	3. Unimportance immunizing against MMR	(+)	(+)	(+)
Education: Secondary or less (+) Household income: \$20,000–39,999 (+) \$60,000–79,999 (+) \$80,000–99,999 (+) \$100,000–119,999 (+)	4. Safety concerns regarding MMR vaccine Somewhat (vs. not) concerned Concerned (vs. not concerned)	(1) (1)	(1) (1)	(1) (1)
Education: Post-secondary (+)	Very (vs. not) concerned	(1)	(1)	(1)

  

Age 7/DPT subsample SES→	KAB mediators→	Non-receipt of ≥ 5 doses		
		Diphtheria	Pertussis	Tetanus
Education: Post-secondary (-)	1. Lack of vaccine confidence	(+)	(+)	(+)
Education: Post-secondary (-) Household income: \$20,000–39,999 (-) \$40,000–59,999 (-)	2. Concern about potential side effects Somewhat agree (vs. strongly agree) Somewhat disagree (vs. strongly agree)	(1) (1)	(1) (1)	(1) (1)
Household income: \$40,000–59,999 (-)	Strongly disagree (vs. strongly agree)	(1)	(1)	(1)
Household income: C\$80,000–99,999 (-)	3. Unimportance immunizing against DPT	(1)	(1)	(1)
Education: Post-secondary (+) Household income: \$0–19,999 (+) \$20,000–39,999 (+)	4. Safety concerns regarding DPT vaccine Somewhat (vs. not) concerned Concerned (vs. not concerned)	(1) (1)	(1) (1)	(1) (1)
Education: Post-secondary (+) Household income: \$40,000–59,999 (-) \$60,000–79,999 (+)	Very (vs. not) concerned	(1)	(1)	(1)

  

Girls ages 12–14/HPV subsample SES→	KAB mediators→	non-receipt of ≥ 1 dose of HPV vaccine	
	1. Lack of vaccine confidence		(+)
	2. Concern about potential side effects Somewhat agree (vs. strongly agree) Somewhat disagree (vs. strongly agree)		(-)  (-)

(continued on next page)

Table 5 (continued)

Girls ages 12–14/HPV subsample	KAB mediators→	non-receipt of $\geq 1$ dose of HPV vaccine
SES→		
Education:		
Secondary or less (–)		
Post-secondary (–)		
Household income:	Strongly disagree (vs. strongly agree)	(–)
C\$80,000–99,999 (+)	3. Unimportance immunizing against VPD	(+)
Household income:	4. Safety concerns regarding vaccinations	(1)
\$0–19,999 (+)		
\$20,000–39,999 (+)		
\$40,000–59,999 (+)		

Note: MMR = measles, mumps, rubella; DPT = diphtheria, pertussis, and tetanus; HPV = human papillomavirus; VPD = vaccine preventable disease. Referent category for education = university graduate; for household income = C\$120,000 or more. The symbols (+) and (–) respectively indicate positive and negative associations between either (a) an SES variable and KAB variable or (b) a KAB variable and vaccination receipt variable. All such notation indicates an association where the 95% confidence interval (CI) did not include 0 (for a linear model) or 1 (for a non-linear model). For example, for the Age 2/MMR subsample, post-secondary education (vs. university graduate) is positively associated with lack of vaccine confidence. The symbol “(1)” indicates a KAB→vaccination receipt association had a 95% CI that included 1. Empty cells for the “SES→” column indicate that the 95% CI for the observed SES→KAB association included either 0 for a linear model or 1 for a non-linear model.

concerns and perceived unimportance of immunizing against MMR. Post-secondary education (versus university degree) was indirectly associated with higher odds of a child not receiving at least one dose of measles-containing vaccines via the KAB pathway of strong agreement (versus somewhat agree, somewhat disagree, and strongly disagree) about vaccine side effect concerns. Similarly, the three income categories spanning C\$60,000–119,999 (each versus  $\geq$  C\$120,000) were associated with greater side effect concerns, which, in turn, was associated with higher odds of not receiving the minimum dosage. Furthermore, the two income levels that include C\$40,000–79,999 were associated with higher odds of this outcome via greater belief in the unimportance of vaccinating against MMR.

For the *age 7/DPT subsample*, little evidence of KAB mediation existed. For the *girls ages 12–14/HPV subsample*, the limited evidence of mediation was  $\leq$  secondary and post-secondary education (versus completing a university degree) being associated with one category of concern for vaccine side effects (strongly agree, versus somewhat disagree), which was, in turn, associated with higher odds of non-receipt of one dose. Hence, evidence for mediation is mostly limited to the age 2/MMR subsample.

#### 4. Discussion

Analyzing data for three age groups of Canadian children in 2013, we examined (a) the extent of SES patterning in parents' vaccination KAB and their child's vaccination receipt and (b) whether SES may be indirectly associated with vaccination receipt via KAB. Our findings indicate important group-specific nuances.

##### 4.1. SES→KAB

Partially corroborating our hypotheses, SES differences in KAB mostly center on parental concerns about potential vaccine side effects and safety concerns (with doubt regarding effectiveness and apathy about their importance being generally limited to the age 2/MMR subsample). These SES→KAB patterns were most consistent among parents in the age 2/MMR and age 7/DPT subsamples, with more negatively-oriented KAB found among parents with post-secondary (non-university graduate) education levels and (mostly) lower-to-upper middle class incomes.

For the *girls ages 12–14/HPV subsample*, SES patterns in KAB were mostly limited to greater concerns among disadvantaged and middle-class households regarding vaccine safety, with education associated only with one of three levels of concern about vaccine side effects.

Given the extent of misinformation spread regarding MMR vaccine safety and its (well refuted) link to autism, it is perhaps unsurprising that the most KAB associations were found for parents of two-year-olds, an age when MMR vaccine receipt is discussed and scheduled. Similar findings among the age 7/DPT subsample parents likely also reflect prior (i.e. when their children were younger) and current exposure to such increased misinformation.

##### 4.2. SES→vaccination

Contrary to our hypothesis, SES disparities in vaccination receipt were mostly limited to education (not income)—and mainly among the age 2/MMR and age 7/DPT subgroups—with lower education (i.e., less than a university degree) being associated with higher odds of not receiving the minimum age-specific dosage. Prior studies observed lower coverage rates among low- and high-SES groups; however, these studies were ecologic (community-level) (Carpiano and Bettinger, 2016; Sugerman et al., 2010).

For HPV, our null findings contrast with prior Canadian studies. Ogilvie et al. (2010) observed higher parental education associated with lower odds of British Columbia girls receiving the HPV vaccine. However, their findings were based on a sample of age 6 girls and included different covariates than in our models. Gilbert et al.'s (2016) analyses of 2013 CNICS data only found university education associated with parent's reported *refusal* of HPV vaccination. Also, the general lack of income-HPV vaccine dose associations observed in our study may reflect the HPV vaccine being predominantly administered in all provinces and territories free of charge via publicly-funded, school-based programs, thereby limiting access and financial constraints to its receipt (Shapiro et al., 2017; Dubé et al., 2019).

##### 4.3. SES→KAB→vaccination

Support for our KAB mediation hypothesis is mostly limited to our *age 2/MMR subsample*: vaccine side effect concerns mediating lower (vs. university) education and upper-middle class-level (versus higher) income level disparities in MMR vaccination receipt. Despite this limited evidence, our findings corroborate reported associations between KAB and (measles and HPV) vaccination non-receipt in Canada—notably negative perceptions regarding the utility of vaccinations; greater concerns about safety, effectiveness, and potential side effects; and lower perceived importance of vaccinations (Dubé et al., 2016; MacDonald et al., 2014; Gilbert et al., 2016).

#### 4.4. Limitations

Several study limitations deserve mention. First, CNICS' cross-sectional design limits causal conclusions. Though a prospective design is favorable for establishing time ordering, such national data are presently unavailable. Second, these findings, based on 2013 data, may not reflect current patterns. Third, due to CNICS' design, our analysis excluded the few parents who refused all child vaccinations. However, it included vaccine hesitant parents, who may be more likely to be convinced by vaccination education strategies (Leask et al., 2012).

#### 5. Conclusions

Child undervaccination in Canada remains a pressing public health challenge. While additional individual- and community/school-level investigations of KAB and VPD risk are necessary, our study contributes to the complex issue of vaccine hesitancy by offering several insights for future research and clinical and public health communication efforts. First, given the inconsistent findings across the three subsamples, age- and vaccination-specific communication strategies may be useful for parents. Second, the observed KAB-vaccination receipt associations suggest the need for *targeted approaches* where SES disparities exist, alongside *universal approaches* where no SES disparities are observed. Third, vaccination side-effect concerns, whether patterned by SES, are inconsistently associated with receipt. Hence, for some age groups and specific vaccines, parents' concerns may not translate into barriers to vaccination.

#### Conflicts of interests

The authors have no potential conflicts of interest to disclose.

#### Financial disclosure

No financial disclosures were reported by the authors of this paper.

#### Acknowledgments

The authors are grateful to all 2013 CNICS participants. CNICS was developed jointly by the Special Survey Division, Statistics Canada, and the Centre for Immunization and Respiratory Infectious Diseases, Public Health Agency of Canada. Special thanks to Jennifer Pennock, Public Health Agency of Canada, for reviewing the manuscript prior to submission and peer-review; and the staff of the British Columbia Inter-University Research Data Centre.

#### Funding

CNICS was funded by the Public Health Agency of Canada (PHAC). RMC received contract funding from PHAC to conduct the analysis and contribute to this manuscript when he was affiliated with the University of British Columbia. This contract supported ANP's contributions to this study.

#### Contributors

RMC led the study, conducted the analysis, and led the write-up of the findings. ANP contributed to the analyses. All authors contributed to the interpretation of results and contributed to the final manuscript. All authors approved the final manuscript.

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