

Pertussis Vaccination in Canadian Pregnant Women, 2018–2019



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ABSTRACT

Objective: This study was undertaken to measure the uptake of pertussis vaccination during pregnancy in Canada and to identify sociodemographic factors associated with non-vaccination.

Methods: A total of 5091 biological mothers of children born between September 2, 2018, and March 1, 2019, were interviewed about pertussis vaccination during their pregnancy.

Results: Among 4607 mothers who recalled whether they had been vaccinated for pertussis, 43% had been vaccinated and 57% had not. The main reason given by mothers for not having been vaccinated was not being aware that pertussis vaccination was recommended. Factors independently associated with non-vaccination were being born outside Canada, lower household income, living in a province or territory where pertussis vaccination was not provided free of charge, having had previous live births, and having received maternity care from a midwife.

Conclusion: Advice from the maternity care provider is an important driver of pertussis vaccination during pregnancy.

RÉSUMÉ

Objectif : Cette étude a été entreprise pour mesurer la vaccination contre la coqueluche pendant la grossesse au Canada et pour identifier les facteurs sociodémographiques associés à la non-vaccination.

Keywords: pertussis; vaccination; socioeconomic factors; pregnancy; Canada

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Méthodologie : Les mères biologiques de 5 091 enfants nés du 2 septembre 2018 au 1^{er} mars 2019 ont été interviewées au sujet de leur vaccination contre la coqueluche pendant leur grossesse.

Résultats : Des 4 607 mères qui se souvenaient si elles avaient été vaccinées contre la coqueluche, 43% l'avaient été et 57% ne l'avaient pas été. La principale raison donnée par les mères de ne pas s'être fait vacciner étaient qu'elles ne savaient pas que c'était recommandé. Les facteurs indépendamment associés à la non-vaccination étaient : être née à l'extérieur du Canada, avoir un revenu du ménage plus faible, vivre dans une province ou un territoire où le vaccin n'était pas offert gratuitement, avoir eu d'autres naissances vivantes auparavant et avoir reçu son suivi de grossesse d'une sage-femme.

Conclusion : Les conseils du professionnel de la santé qui fait le suivi de grossesse influencent grandement la vaccination pendant la grossesse.

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INTRODUCTION

Despite widespread vaccination, pertussis remains endemic in Canada,^{1,2} with incidence rates highest for infants aged <1 year: 72.5 per 100 000 population from 2013 to 2017. The 4 pertussis-related deaths reported in Canada during this period occurred in infants aged <6 months.²

Vaccination with the tetanus, diphtheria, and acellular pertussis (Tdap) vaccine during pregnancy induces the production of antibodies that are transferred through the placenta to the foetus and persist in infants up to 2–4

months of age.^{3,4} Maternal vaccination with Tdap has been shown to significantly reduce the incidence of pertussis in infants' first 2 months of life,^{5–7} with administration of the vaccine during the third trimester of pregnancy being significantly more effective than vaccination during the second trimester.⁷ Tdap vaccination during the second or third trimester of pregnancy is not associated with any adverse pregnancy or birth outcomes.⁸

For these reasons, the National Advisory Committee on Immunization recommended in February 2018 that Tdap be administered in every pregnancy in Canada, ideally between 27 and 32 weeks of gestation.⁹ In March 2018, the Society of Obstetricians and Gynaecologists of Canada issued a new clinical practice guideline on immunization in pregnancy that included a recommendation that every pregnant woman be offered Tdap, ideally between 21 and 32 weeks.¹⁰ As of November 2019, all provinces and territories except for Ontario and British Columbia had implemented programs to provide pertussis vaccination free of charge to pregnant women. Uptake of this newly recommended vaccination has yet to be analyzed for Canadian mothers.

Because maternal vaccination for pertussis is relatively new, pregnant women and even health care providers may not be aware of it. In the United Kingdom in 2017–2018 (i.e., 5 years after the implementation of maternal vaccination against pertussis), there were still women declining vaccination because they feared it might harm their unborn child, and some maternity care providers were reluctant to discuss maternal vaccination with their patients.¹¹

This study was undertaken to measure the uptake of pertussis vaccination during pregnancy in Canada and to identify sociodemographic factors associated with nonvaccination.

METHODS

The Survey on Vaccination during Pregnancy was conducted for the first time as part of the 2019 Childhood National Immunization Coverage Survey. The survey collected information about prenatal care; pertussis and influenza vaccination during pregnancy; knowledge, attitudes, and beliefs regarding vaccination; and sociodemographic factors. A detailed description of survey methods and the questionnaire are available elsewhere.¹²

A sample of babies born between September 2, 2018, and March 1, 2019, was selected randomly from the list of children for whom the Canadian Child Benefit was

claimed, which was estimated to include 96% of Canadian children in 2018.

Data were collected from December 2, 2019, to March 6, 2020 (i.e., 9–18 months after the selected child was born). The biological mothers of these children were contacted and invited to participate in the survey, provided they had lived in Canada for most of their pregnancy. Household income was provided from administrative data sources and was imputed when missing using the nearest neighbour method (0.1% of records).¹³

For the purpose of assessing survey results, provinces and territories were grouped based on whether they were offering Tdap free of charge to pregnant women as of August 2018 (the month before new mothers were eligible for inclusion in the survey). The Northwest Territories, Nunavut, Saskatchewan, Québec, New Brunswick, and Prince Edward Island were all offering the Tdap vaccine free of charge to pregnant women at this time, whereas Yukon, British Columbia, Alberta, Manitoba, Ontario, Nova Scotia, and Newfoundland and Labrador were not.

Ethics and Privacy

This survey was conducted by Statistics Canada as part of its mandate to “collect, compile, analyze, abstract, and publish statistical information relating to the commercial, industrial, financial, social, economic, and general activities and conditions of the people of Canada” and was not therefore considered health research. The survey was completed on a voluntary basis, and data were kept confidential.

Data Analysis

Frequencies and percentages for all categorical variables were computed to describe the study sample. Weighted proportions with their 95% confidence intervals were also estimated using the modified Wilson method for the confidence limits. The association between sociodemographic factors and nonvaccination was measured using simple and multiple logistic regression models from which odds ratios and associated 95% confidence intervals were calculated. Although being advised to get vaccinated for pertussis was strongly associated with the mother being vaccinated in the simple regression model, this variable was not included in multiple regression because it was deemed to be an intermediate step in causal pathways between other factors and nonvaccination. Finally, because the variable describing the availability of Tdap vaccination free of charge was derived from the province or territory of care, these variables could not be included together in a model. Therefore, only the former was included, because it

was deemed to be more informative given the objective of the study.

With the exception of the unweighted rates in the sample description shown in Table 1, all rates and odds ratios described in this study were weighted using survey weights

provided by Statistics Canada to ensure that estimates were representative of the population. To account for the complex survey design, standard errors and confidence intervals of weighted rates and odds ratios were estimated with the bootstrap technique.¹⁴ Statistical analysis was performed using SAS version 9.4.

Table 1. Sample characteristics (n = 5091)

Variable	Unweighted, no (%) ^a	Weighted, % (95% CI)
Mother's country of birth		
Canada	3852 (75.7)	67.3 (65.4–69.2)
Other	1233 (24.2)	32.5 (30.6–34.5)
Mother's age at childbirth, y		
15–27	1178 (23.1)	22.4 (20.8–24.2)
28–31	1525 (30.0)	26.9 (25.2–28.7)
32–34	1142 (22.4)	22.5 (20.8–24.3)
35–52	1195 (23.5)	26.8 (25.0–28.7)
Mother's education		
Secondary or less	1266 (24.9)	26.0 (24.3–27.8)
Postsecondary	1467 (28.8)	28.9 (27.1–30.8)
University graduate	2335 (45.9)	44.4 (42.5–46.4)
Household income, CAD\$		
\$0–\$49 999	984 (19.3)	24.5 (22.9–26.2)
\$50 000–\$89 999	1366 (26.8)	28.0 (26.3–29.8)
\$90 000–\$129 999	1185 (23.3)	21.4 (19.9–22.9)
\$130 000 or more	1556 (30.6)	26.1 (24.6–27.5)
Number of past live births		
0	2208 (43.4)	42.5 (40.6–44.5)
1	1861 (36.6)	35.6 (33.7–37.5)
≥2	1019 (20.0)	21.9 (20.3–23.7)
Duration of pregnancy, wk		
<32	72 (1.4)	1.5 (1.0–2.2)
32–36	371 (7.3)	8.2 (7.1–9.5)
≥37	4624 (90.8)	89.7 (88.2–90.9)
Primary maternity care provider during pregnancy^b		
Obstetrician/gynaecologist	2957 (58.1)	62.3 (60.4–64.1)
General practitioner (family doctor)	1472 (28.9)	22.7 (21.2–24.2)
Midwife	442 (8.7)	12.3 (11.0–13.6)
Nurse	116 (2.3)	1.2 (0.9–1.6)
Other or no maternity care	101 (2.0)	1.5 (1.1–2.1)
Primary maternity care provider advised getting pertussis vaccine during pregnancy		
Yes	2775 (54.5)	49.2 (47.1–51.3)
No	1696 (33.3)	37.4 (35.4–39.4)
No maternity care (question not asked)	15 (0.3)	0.2 (0.1–0.5)
Vaccinated for pertussis during pregnancy		
Yes	2347 (46.1)	39.1 (37.2–41.0)
No	2260 (44.4)	50.8 (48.8–52.8)
Don't know	484 (9.5)	10.1 (8.9–11.4)

^aColumns may not add to the total sample size due to missing data.

^bMay or may not be the professional who attended the child's birth.

RESULTS

Of 9096 child/mother pairs selected from the sampling frame, 5091 completed the survey, yielding a response rate of 58.9% after removing out of scope cases. Respondent characteristics are described in Table 1. Of the mothers who participated in the survey, 39% reported having been vaccinated against pertussis during their pregnancy, 51% had not been vaccinated, and 10% did not know. Among women who recalled whether they had been vaccinated, the percentages of vaccinated and nonvaccinated mothers were 43% and 57%, respectively.

Nearly all mothers (99%) had received maternity care during their pregnancy, mostly from obstetrician/gynaecologists (62%). There were no significant differences among women who had received maternity care from obstetrician/gynaecologists, family doctors, nurses, or midwives with respect to advice to get vaccinated for pertussis during pregnancy (Table 2). More women were advised to get vaccinated in provinces or territories where Tdap was provided free of charge to pregnant women (68%) than in provinces and territories where vaccination was not funded (52%).

The main reasons given by mothers for nonvaccination were not being aware that pertussis vaccination was recommended during pregnancy (60%), not wanting to be vaccinated during pregnancy (16%), and the vaccine not being offered by their maternity care provider (11%) (Table 3).

The rate of nonvaccination was significantly higher in provinces and territories where the vaccine was not offered

free of charge (61%) than in those where it was publicly funded (46%). Other factors significantly associated with nonvaccination in simple logistic regression analyses were being born outside of Canada; lower education; lower household income; having had previous pregnancies; having had previous live births; having received maternity care from an obstetrician/gynaecologist or a midwife or having no professional care at all (compared with a family doctor); and not having been advised to get the vaccine (Table 4).

In multiple regressions, factors independently associated with nonvaccination were being born outside of Canada; household income between CAD \$50 000 and \$89 999 (compared with CAD >\$130 000); having received maternity care in a province or territory where the vaccine was not offered free of charge; having 1 or more past live births; and having received maternity care from a midwife.

DISCUSSION

Less than half of mothers had been vaccinated against pertussis during their pregnancy. Higher coverage rates have been reported in other countries with pertussis vaccination during pregnancy: 54% in the United States in 2018¹⁵; 56% in England in 2014–2015¹⁶; and 69% in Flanders (Belgium) in 2016.¹⁷ It is important to note that these measurements were taken a number of years after the vaccine was first recommended in each of these countries.

In contrast, this survey was conducted the year after the issuance of new guidelines for vaccination during pregnancy in 2018, and some provinces and territories were

Table 2. Association between maternal care provider and lack of advice to get vaccinated for pertussis during pregnancy

Variable	No.	Mothers not advised to get vaccinated for pertussis during pregnancy	
		% (95% CI)	Unadjusted OR (95% CI)
Primary maternity care provider^a			
Obstetrician/gynaecologist	2644	42.8 (40.0–45.7)	1.04 (0.84–1.28)
General practitioner (family doctor)	1299	41.9 (37.9–46.0)	Reference
Midwife	351	45.7 (39.2–52.4)	1.17 (0.85–1.61)
Nurse	101	34.8 (20.4–52.7) ^b	0.74 (0.32–1.70) ^b
Tdap during pregnancy^c			
Free of charge	1777	31.5 (28.3–35.0)	Reference
Not free of charge	2618	47.9 (45.1–50.7)	2.00 (1.65–2.41)

Note: Counts (no.) are unweighted; percentages and ORs are weighted.

^aMay or may not be the professional who attended the child’s birth. Mothers who received maternity care from an “other” professional or no maternal care at all were excluded from this analysis.

^bEstimates and CIs are considered to be of marginal quality due to high sampling variability and should be used with caution.

^cVariable derived from the province or territory of care.

OR: odds ratio; Tdap: tetanus, diphtheria, and acellular pertussis.

Table 3. Reasons reported by mothers for not getting vaccinated for pertussis during pregnancy (n = 2258)^a

Reason	Percentage (95% CI)
Not aware it was recommended	59.6 (56.7–62.4)
Did not want to be vaccinated	15.9 (14.0–18.1)
Not confident vaccine would protect baby	3.0 (2.1–4.1) ^b
Could have harmed baby	3.3 (2.5–4.4) ^b
Not offered by health care provider	10.7 (9.1–12.5)

^aRates are weighted; respondents could provide more than 1 answer.

^bEstimates and CIs are considered to be of marginal quality due to high sampling variability and should be used with caution.

not yet providing the vaccine free of charge. It might be expected that coverage rates will increase with time, as more provinces and territories fund the vaccine and the vaccine recommendation becomes more well known.

Being advised by the primary maternity care provider was found to be the main driver of maternal vaccination. Consistent with that observation, being unaware that pertussis vaccination during pregnancy was recommended was the number one reason mothers gave for not being vaccinated. Maternity care provider practice was not investigated in this study. The vaccine being offered free of charge was clearly a determinant of advice from the maternity care provider but is not the sole explanation; one-third of mothers were not advised to get vaccinated in provinces where it was offered free of charge, and half were advised to get vaccinated in provinces and territories where the vaccine was not free. Of note, less than 1% of unvaccinated mothers mentioned the cost of the vaccine as the reason for nonvaccination.

Socioeconomic inequalities observed in this study are consistent with observations from other countries. In the United States, in univariate analyses, vaccination rates varied with ethnicity and were lower in women with lower education, single women, those unemployed, those with public (vs. private) insurance, and those below the poverty line. Coverage was significantly lower in women who had only been advised to get the vaccine than in those who had been offered vaccination by a health care provider, and was even lower in those who had received no recommendation.¹⁵ In England, coverage decreased with increasing deprivation.¹⁶ Similarly, in Ireland, vaccine uptake decreased with decreasing socioeconomic status.¹⁸ In Belgium, it varied between income categories with no clear dose-response trend.¹⁷

Lower vaccination rates in adults born outside of Canada is consistent with what was observed in the Canadian Community Health Survey in 2011–2014, where seasonal influenza vaccination coverage was significantly lower for immigrants than for Canadian-born respondents.¹⁹ It is also consistent with the 2006 Maternity Experiences Survey that found a lower uptake of some maternal health interventions, such as attending prenatal classes and taking folic acid, in immigrant women.²⁰

Although the risk of nonvaccination varied depending on the primary maternal providers, and mothers followed by midwives were more likely not to get vaccinated, it is important to note that this does not imply a causal relationship. Mothers who decide to seek care from a midwife rather than from a medical doctor or a nurse may be already more reluctant about vaccination.

Multiparous mothers may be less receptive to vaccination advice from health care providers than nulliparous ones, as prior personal experience of raising a healthy baby without having received pertussis vaccination during pregnancy might dampen motivation to accept a new intervention during subsequent pregnancies. Moreover, if the vaccine is not easily accessible, childcare may present barriers to uptake of vaccination even when multiparous mothers are accepting of the recommendation.

This study was able to measure inequalities in uptake, but is not able to fully explain them. Further research to identify the underlying barriers and facilitators of maternal pertussis vaccination are needed.

This study has strengths and limitations. The major strengths were a random selection (making it representative of the population) and a large sample size (more than 5000 mothers, of whom more than 4600 could be included in coverage estimations). Limitations include self-reporting of vaccination, which may have led to recall bias or social desirability bias. There may also have been nonresponse bias, as survey mothers who agreed to participate in the survey may have been different from those who did not. However, this bias would have affected the actual coverage estimates, not the associations observed in the study between maternity care, sociodemographic variables, and nonvaccination.

CONCLUSION

Despite guidelines, half of the mothers surveyed had not been vaccinated for pertussis during their pregnancy.

Table 4. Determinants of pertussis nonvaccination during pregnancy

Variable	No. ^{a,b}	Unvaccinated, % (95% CI)	Odds ratio (95% CI)	
			Unadjusted	Adjusted ^c
Mother's country of birth				
Canada	3531	53.0 (50.5–55.5)	Reference	Reference
Other	1071	63.9 (59.9–67.7)	1.57 (1.29–1.91)	1.43 (1.15–1.79)
Household income, CAD\$				
\$0–\$49 999	874	57.1 (51.8–62.3)	1.37 (1.05–1.78)	1.16 (0.83–1.61)
\$50 000–\$89 999	1231	63.7 (59.7–67.5)	1.80 (1.44–2.25)	1.67 (1.29–2.17)
\$90 000–\$129 999	1065	55.3 (50.9–59.6)	1.27 (1.01–1.60)	1.26 (0.98–1.62)
\$130 000 or more	1437	49.4 (45.7–53.0)	Reference	Reference
Province or territory where maternal care was received (or delivery if no maternal care received)				
Newfoundland and Labrador	377	84.1 (80.0–87.4)	16.86 (11.28–25.21)	
Prince Edward Island	294	23.8 (19.3–29.1)	Reference	
Nova Scotia	422	37.8 (32.8–43.1)	1.94 (1.35–2.80)	
New Brunswick	435	29.0 (24.7–33.7)	1.31 (0.91–1.87)	
Québec	568	51.2 (46.9–55.6)	3.36 (2.41–4.67)	
Ontario	502	59.7 (55.1–64.1)	4.73 (3.35–6.67)	
Manitoba	392	43.0 (37.6–48.5)	2.41 (1.68–3.44)	
Saskatchewan	436	26.0 (21.7–30.8)	1.12 (0.78–1.62)	
Alberta	538	62.1 (57.6–66.4)	5.24 (3.75–7.31)	
British Columbia	474	74.4 (70.1–78.4)	9.30 (6.48–13.34)	
Yukon, Northwest Territories, and Nunavut	169	29.9 (32.4–55.2)	1.36 (0.64–2.89)	
Tdap during pregnancy (based on province of care)^d				
Free at each pregnancy	1833	45.7 (42.3–49.3)	Reference	Reference
Not free at each pregnancy	2774	61.3 (58.6–63.8)	1.88 (1.57–2.25)	1.78 (1.47–2.16)
No. of past live births				
0	2038	49.4 (46.2–52.6)	Reference	Reference
1	1662	59.1 (55.4–62.6)	1.48 (1.22–1.79)	1.56 (1.27–1.92)
≥2	906	66.8 (62.2–71.0)	2.06 (1.62–2.61)	2.14 (1.65–2.77)
Primary maternity care provider during pregnancy^{e,f}				
Obstetrician/gynaecologist	2714	55.8 (53.0–58.6)	1.24 (1.01–1.52)	1.15 (0.92–1.43)
General practitioner (family doctor)	1318	50.5 (46.4–54.5)	Reference	
Midwife	385	70.4 (64.2–76.0)	2.34 (1.68–3.26)	2.21 (1.56–3.14)
Nurse	97	47.9 (32.1–64.1) ^e	0.90 (0.44–1.87) ^g	0.84 (0.40–1.80) ^g
Other/no maternal care	91	72.4 (57.2–83.7) ^g	2.57 (1.24–5.33) ^g	2.43 (1.12–5.30) ^g
Primary maternity care provider advised getting pertussis vaccine during pregnancy^e				
Yes	2657	21.7 (19.3–24.3)	Reference	
No	1617	95.3 (93.7–96.5)	73.27 (51.40–104.46)	

Note: Only mothers who reported having been vaccinated (n = 2347) or not having been vaccinated (n = 2260) for pertussis during their pregnancy are included in this analysis. Those who did not know if they had been vaccinated are excluded. Only variables significantly associated with nonvaccination are shown in the table.

^aThe n values are unweighted. Percentages and odds ratios are weighted.

^b“Not stated” categories are not shown, but were nevertheless included in the simple and multiple regression models, except for “mother’s place of birth” (n = 5) and “number of past live births” (n = 1), the small sizes of which caused a problem of nonconvergence in the multiple regression model. The final multiple regression model includes 2344 vaccinated mothers and 2257 unvaccinated mothers (total 4601).

^cOdds ratios are adjusted for all variables shown in the table, plus mothers’ indigenous identity, age at childbirth, education, marital status, urban or rural area of residence, and duration of pregnancy.

^dThe “Tdap during pregnancy” variable is derived from the province or territory of care. Therefore, the latter was excluded from the multiple regression analysis.

^e“Maternity care provider” and “advice to get vaccinated” were not included together in a multiple regression because advice is an intermediate step in the causal pathway between provider and vaccination.

^fMay or may not be the professional who attended the child’s birth.

^gEstimates and CIs are considered to be of marginal quality due to high sampling variability and should be used with caution.

Tdap: tetanus, diphtheria, and acellular pertussis.

Advice from the maternity care provider is an important driver of pertussis vaccination during pregnancy.

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REFERENCES

- Smith T, Rotondo J, Desai S, et al. Pertussis surveillance in Canada: trends to 2012. *Can Commun Dis Rep* 2014;40:21–30.
- Public Health Agency of Canada. Vaccine preventable disease: surveillance report to December 31, 2017. Ottawa: Public Health Agency of Canada; 2020.
- Vilajeliu A, Ferrer L, Munrós J, et al. Pertussis vaccination during pregnancy: antibody persistence in infants. *Vaccine* 2016;34:3719–22.
- Halperin SA, Langley JM, Ye L, et al. A randomized controlled trial of the safety and immunogenicity of tetanus, diphtheria, and acellular pertussis vaccine immunization during pregnancy and subsequent infant immune response. *Clin Infect Dis* 2018;67:1063–71.
- Dabrera G, Amirthalingam G, Andrews N, et al. A case-control study to estimate the effectiveness of maternal pertussis vaccination in protecting newborn infants in England and Wales, 2012–2013. *Clin Infect Dis* 2015;60:333–7.
- Skoff TH, Blain AE, Watt J, et al. Impact of the US maternal tetanus, diphtheria, and acellular pertussis vaccination program on preventing pertussis in infants <2 months of age: a case-control evaluation. *Clin Infect Dis* 2017;65:1977–83.
- Winter K, Nickell S, Powell M, et al. Effectiveness of prenatal versus postpartum tetanus, diphtheria, and acellular pertussis vaccination in preventing infant pertussis. *Clin Infect Dis* 2017;64:3–8.
- McMillan M, Clarke M, Parrella A, et al. Safety of tetanus, diphtheria, and pertussis vaccination during pregnancy: a systematic review. *Obstet Gynecol* 2017;129:560–73.
- Update on immunization in pregnancy with tetanus toxoid, reduced diphtheria toxoid and reduced acellular pertussis (Tdap) vaccine. an Advisory Committee Statement (ACS) - National Advisory Committee on Immunization (NACI). Available at: <https://www.canada.ca/en/public-health/services/publications/healthy-living/update-immunization-pregnancy-tdap-vaccine.html>. Accessed March 7, 2022.
- Castillo E, Poliquin V. SOGC Clinical Practice Guideline no. 357 - immunization in pregnancy. *J Obstet Gynaecol Can* 2018;40:478–89.
- Wilcox CR, Calvert A, Metz J, et al. Determinants of influenza and pertussis vaccination uptake in pregnancy: a multicenter questionnaire study of pregnant women and healthcare professionals. *Pediatr Infect Dis J* 2019;38:625–30.
- Statistics Canada. Childhood national immunization coverage survey; 2020. Available at: <https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=1257279>. Accessed March 7, 2022.
- Estimation with nearest neighbour imputation at Statistics Canada. Proceedings of the Survey Research Methods Section, American Statistical Association 1999:131–138. Available at: http://www.asasrms.org/Proceedings/papers/1999_019.pdf. Accessed March 7, 2022.
- Rust KF, Rao JNK. Variance estimation for complex surveys using replication techniques. *Stat Methods Med Res* 1996;5:283–310.
- Kahn KE, Black CL, Ding H, et al. Influenza and Tdap vaccination coverage among pregnant women - United States, April 2018. *MMWR Morb Mortal Wkly Rep* 2018;67:1055–9.
- Byrne L, Ward C, White JM, et al. Predictors of coverage of the national maternal pertussis and infant rotavirus vaccination programmes in England. *Vaccine* 2018;146:197–206.
- Maertens K, Braeckman T, Blaizot S, et al. Coverage of recommended vaccines during pregnancy in Flanders, Belgium. Fairly good but can we do better? *Vaccine* 2018;36:2687–93.
- Quattrocchi A, Mereckienė J, Fitzgerald M, et al. Determinants of influenza and pertussis vaccine uptake in pregnant women in Ireland: a cross-sectional survey in 2017/18 influenza season. *Vaccine* 2019;37:6390–6.
- Roy M, Sherrard L, Dubé È, et al. Determinants of non-vaccination against seasonal influenza. *Health Rep* 2018;29:12–22.
- Kingston D, Heaman M, Chalmers B, et al. Comparison of maternity experiences of Canadian-born and recent and non-recent immigrant women: findings from the Canadian Maternity Experiences Survey. *J Obstet Gynaecol Can* 2011;33:1105–15.