

Vaccination of Pregnant Women to Improve Vaccination Coverage in Canada: A Review

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Building the capacity to improve vaccine acceptance and uptake

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Table of Contents

Introduction.....	4
Recommended Vaccines during Pregnancy	4
Immunization Programs for Pregnant Women in Canada	5
Vaccination during Pregnancy: Coverage, Barriers, and Facilitators	10
Determinants of Women’s Attitudes during Pregnancy.....	12
Determinants of Attitudes of Health Care Providers.....	13
Strategies to Increase Vaccine Acceptance and Coverage in Pregnant Women.....	13
The P3 Model: Impacting Factors and Levels of Influence	15
Use of Information Sstems to Improve Vaccination Programs during Pregnancy	18
Use of Other Interactive and Online Tools to Improve Vaccination Programs during Pregnancy	19
Conclusion.....	21
Bibliography.....	22
Appendix.....	26

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Introduction

While several vaccines for pregnant women are currently under development, such as the cytomegalovirus (CMV) and group B streptococcal (GBS) vaccines for maternal immunization, certain vaccines are already in use today in the most countries to vaccinate pregnant women, and in turn, also protecting their infants, such as the influenza and pertussis vaccines. The goal of these immunization programs is to protect not only pregnant women but also their infants, who receive maternal antibodies via placental transfer or through breast milk (Maertens et al. 2018; Omer 2017; Faucette et al. 2015). Vaccination during pregnancy, according to Moniz and Beigi (Bednarczyk et al. 2018), allows for the full immunization of infants from birth (Omer 2017). However, vaccination coverage in most high-income countries remains below the target levels set for recommended vaccines during pregnancy (Maertens et al. 2018; Dubé et al. 2019). Although infants can be vaccinated after birth, many vaccines have a minimum age requirement (Omer 2017). In Canada, no routine vaccination is planned at birth (Government of Canada 2019). However, it is recommended that pregnant women get vaccinated to protect themselves and their unborn babies against infections that can cause birth defects, premature birth, miscarriage or death (Public Health Agency of Canada n.d.). These recommendations were updated in February 2018 (National Advisory Committee on Immunization 2018). As a result, immunization with the combined tetanus toxoid, reduced diphtheria toxoid and reduced acellular pertussis (Tdap) vaccine is now available to all women during each of their pregnancy (Public Health Agency of Canada n.d.), regardless of their history of Tdap vaccination. According to the National Advisory Committee on Immunization (NACI), this routine maternal immunization with Tdap during pregnancy, compared with previous recommendations to immunize only during outbreaks, will provide more robust and complete protection against pertussis in infants. This review will focus on recommended vaccines during pregnancy, vaccination coverage, barriers and facilitators to vaccine acceptance, and strategies to increase vaccination coverage and acceptance among pregnant women in Canada. All references selected for this review are presented in the appended tables.

Recommended Vaccines during Pregnancy

Newborns and infants are at a high risk of infection with vaccine-preventable diseases because they rely on maternal antibodies for protection before receiving their first vaccine doses (Bolotin et al. 2019). In most high-income countries such as Canada, infant vaccinations are not completed until 6 months of age, and this inability to vaccinate and prevent infections in newborns and infants results in an immunodeficiency (Omer 2017). For example, the highest overall incidence rate of pertussis in Canada between 2011 and 2015 (64.5 cases per 100,000 people) was reported in infants less than one year of age (Public Health Agency of Canada 2017). This vulnerable age group, too young to be vaccinated, can be protected through maternal vaccination.

Vaccination during pregnancy has garnered considerable interest lately, and there are many articles in scientific journals that address this issue in Canada. Studies either question the lack of information on the safety of vaccination during pregnancy, or reveal the conflicting views of health care providers, both of which can reduce the acceptance of vaccines by pregnant women (Bettinger, Greyson, and Money 2016; Dubé et al. 2019). These contradictory attitudes toward vaccination explain why there is such hesitation and doubt among pregnant women, and even among some health care professionals. Epidemiological studies have confirmed that vaccines are safe and effective, but the key challenge now is to convince pregnant women of these findings, especially when expectant mothers are often told to avoid medications during pregnancy. Pregnant women are often confused by normative recommendations for vaccination during pregnancy and frustrated by contradictions among health care providers, as was observed in a study on pandemic influenza vaccines (Bettinger, Greyson, and Money 2016). In view of these facts, it is important to identify effective strategies to increase vaccine uptake in pregnant women in Canada. These strategies are largely dependent on the recommendations of maternity care providers, but this issue will be discussed later in this review (Dubé et al. 2019). Vaccination during pregnancy is an effective approach to reducing the risk of morbidity and mortality from vaccine-preventable diseases (Omer 2017). For example, a study conducted between October 14, 2015, and October 24, 2017, in Australia, Canada, the Czech Republic, Finland, Italy and Spain concluded that vaccination against tetanus, diphtheria and pertussis during pregnancy resulted in “high levels of pertussis antibodies in cord blood, was well tolerated and had an acceptable safety profile” (Perrett et al. 2020, 2096). These results support the recommendation of giving this vaccine during pregnancy to prevent pertussis in early infancy. In addition, after examining the potential interference of vaccine-specific maternal antibodies with infant responses to primary vaccination, Wilcox and Jones (2020) showed that vaccine-specific secretory immunoglobulin A (IgA) is present in the milk of women who were vaccinated during pregnancy. Therefore, breastfed infants can be provided with additional protection by altering the composition of breastmilk.

Immunization Programs for Pregnant Women in Canada

Two types of vaccines can be given during pregnancy. The first type are the inactivated vaccines, which contain whole or parts of killed infectious agents. An example of this type is the influenza vaccine (Table 1). The second type are the live attenuated vaccines, which contain bacteria or viruses that have been weakened. Examples of this type are the varicella vaccine and the measles, mumps and rubella (MMR) vaccine (Table 2). Live vaccines are generally contraindicated during pregnancy, and the best time for women of childbearing age to receive these vaccines is before pregnancy. Most inactivated vaccines, on the other hand, are considered safe during pregnancy.

Table 1. Summary of Recommendations for Immunization in Pregnancy: Inactivated Vaccines

Vaccine	Use in Pregnancy	Comments
Cholera and travellers' diarrhea	Use if indicated if risk of severe disease is high	<ul style="list-style-type: none"> No data on use during pregnancy
Meningococcus quadrivalent conjugate, Meningococcus B	Recommended for those with health conditions predisposing to meningococcal disease; travel to a high-risk area; post-exposure prophylaxis; during an outbreak	<ul style="list-style-type: none"> No data on use during pregnancy
Pertussis: (given as Tetanus- diphtheria- acellular pertussis - Tdap)	Recommended in every pregnancy, irrespective of immunization history	<ul style="list-style-type: none"> No evidence of risk to fetus or pregnancy Recommended between 27 and 32 weeks of gestation Immunization between 13 and 26 weeks of gestation may be considered in certain circumstances Should be given at least 4 weeks before delivery but may be given at any time up to delivery if not given earlier
Japanese encephalitis	Use if indicated (for high-risk situations)	<ul style="list-style-type: none"> No data on safety or efficacy during pregnancy
Influenza (inactivated)	Recommended in every pregnancy	<ul style="list-style-type: none"> Can be used safely during pregnancy
Haemophilus influenzae b (Hib)	Recommended for those with health conditions predisposing to severe Hib disease	<ul style="list-style-type: none"> No data on use during pregnancy
Hepatitis A	Use if indicated	<ul style="list-style-type: none"> No data on safety or efficacy during pregnancy Should be considered in pregnancy when potential benefits outweigh risks such as for post-exposure prophylaxis or for travel to high-risk endemic areas
Hepatitis B	Recommended for seronegative pregnant women at high risk of exposure to hepatitis B	<ul style="list-style-type: none"> Can be used safely during pregnancy
Polio (inactivated)	Use if indicated	<ul style="list-style-type: none"> Limited data on use during pregnancy
Pneumococcal polysaccharide (Pneu-P-23)	Recommended for those with health conditions predisposing to invasive pneumococcal disease	<ul style="list-style-type: none"> Limited data on use during pregnancy
Rabies	Use if indicated for post-exposure prophylaxis Delay pre-exposure immunization unless there is increased risk of exposure during pregnancy	<ul style="list-style-type: none"> Limited data on use during pregnancy

Vaccine	Use in Pregnancy	Comments
Typhoid (inactivated)	Use if indicated	<ul style="list-style-type: none"> No data on use during pregnancy
Pneumococcal conjugate 13-valent (Pneu-C-13)	Recommended for those with immunocompromising conditions predisposing to invasive pneumococcal disease	<ul style="list-style-type: none"> No data on use during pregnancy
Human papillomavirus (HPV)	Currently not recommended	<ul style="list-style-type: none"> Limited data on use during pregnancy
Herpes zoster (recombinant)	Currently not recommended	<ul style="list-style-type: none"> No data on use during pregnancy Unlikely to be used in pregnancy, given age indication (≥ 50 yrs)

*Source: Canadian Immunization Guide

Table 2. Summary of Recommendations for Immunization in Pregnancy: Live Attenuated Vaccines

Vaccine	Use in Pregnancy	Comments
Bacille Calmette-Guérin	Contraindicated	<ul style="list-style-type: none"> No studies on use in pregnancy No harmful effects on the fetus observed
Yellow fever	Generally contraindicated	<ul style="list-style-type: none"> Immunization only if travel to area with high risk of transmission is unavoidable and high level of mosquito protection is not feasible Seroconversion rates lower during pregnancy; post-immunization serology recommended Limited data on fetal safety Inadvertent immunization not a reason for pregnancy termination
Influenza (live attenuated)	Contraindicated	<ul style="list-style-type: none"> No data on use during pregnancy Live attenuated influenza vaccine has a similar or lower efficacy than inactivated influenza vaccine in adults In adults; inactivated influenza vaccine is preferred if there is a chronic health condition

Vaccine	Use in Pregnancy	Comments
Measles-mumps-rubella	Generally contraindicated	<ul style="list-style-type: none"> Immunize rubella-susceptible women immediately post-partum No known fetal effects; theoretical risk May be indicated in pregnancy if non-immune in outbreak situation Inadvertent immunization not a reason for pregnancy termination
Typhoid (oral)	Contraindicated	<ul style="list-style-type: none"> In individuals requiring protection, inactivated typhoid vaccine should be used
Varicella	Contraindicated	<ul style="list-style-type: none"> Immunize varicella-susceptible women immediately post-partum No known fetal effects; theoretical risk Inadvertent immunization not a reason for pregnancy termination
Smallpox (live replicating)	Generally contraindicated Consider in high-risk situation such as post-exposure	<ul style="list-style-type: none"> May cause fetal infection Close contacts who are vaccinated should be isolated from pregnant women and from newborns until scab falls off
Herpes zoster (live)	Contraindicated	<ul style="list-style-type: none"> Unlikely to be used in pregnancy, given age indication (≥ 50 yrs)

*Source: Canadian Immunization Guide

Under certain conditions and upon the recommendation of a health care provider, pregnant women can choose to be vaccinated with a live attenuated vaccine. This may be possible during an outbreak (when the risk of infection is high), or because of travel to an endemic country. In addition, immunization with the Tdap combined vaccine is now recommended for women during each pregnancy and is available in the public vaccination programs of most Canadian provinces and territories, except for British Columbia and Ontario (Table 3). Because of uncertainties regarding the safety of vaccinating pregnant women during mass vaccination campaigns, the Global Advisory Committee on Vaccine Safety (GACVS) examined data from intervention and non-intervention studies, as well as from spontaneous reporting systems, on the safety of several inactivated (viral or bacterial), toxoid or live attenuated vaccines (World Health Organization 2013). The GACVS review concluded that vaccination with inactivated or toxoid vaccines showed no evidence of adverse pregnancy outcomes. Therefore, pregnant women can receive these vaccines if medically indicated. Consequently, the vaccines that may be recommended during pregnancy in Canada are hepatitis B, tetanus, diphtheria, pertussis, polio, meningitis, and pneumococcus, as well as certain vaccines to be taken prior to international travel (Public Health Agency of Canada n.d.). Since influenza is more likely to cause serious illness in pregnant women, it is recommended that all women be vaccinated against influenza (flu) during pregnancy, especially during the flu season (November

to April). Giving an inactivated influenza vaccine reduces the risk of complications from influenza during pregnancy and after the birth of the baby. In Quebec, it is recommended to vaccinate pregnant women in their 2nd and 3rd trimesters.

Table 3. Summary of Publicly Funded Tdap Vaccination Programs for Pregnant Women by Canadian Province and Territory*

Province or Territory	Use of Tdap Vaccine	Date of Introduction of Program	Health professionals authorized to administer immunizing agents
British Columbia	For each pregnancy	November 2020	Family physician , Midwives, Specialty Prenatal Care Service Providers and Community-Based Pharmacists
Alberta	One booster dose in adulthood and for each pregnancy	January 2019	Family physician, pharmacist
Saskatchewan	One booster dose in adulthood and for each pregnancy	October 2017	Family physician, midwife, nurse, pharmacist
Manitoba	One booster dose in adulthood and for each pregnancy	—	—
Ontario	One booster dose in adulthood	—	—
Quebec	For each pregnancy	May 2018	Family physician, midwife, nurse, licensed practical nurse
New Brunswick	One booster dose in adulthood and for each pregnancy	March 2018	Family physician, midwife, nurse, pharmacist
Nova Scotia	One booster dose in adulthood and for each pregnancy	August 2018	Family physician, midwife, nurse
Prince Edward Island	Every 10 years and for each pregnancy	Unknown	Family physician, midwife, nurse
Newfoundland and Labrador	Every 10 years and for each pregnancy	January 2019	Pharmacist
Yukon	One booster dose in adulthood and for each pregnancy	Unknown	Pharmacist
Northwest Territories	Every 10 years and for each pregnancy	April 2018	Pharmacist, community health nurse
Nunavut	One booster dose in adulthood and for each pregnancy	May 2018	Pharmacist, community health nurse

*Sources: Public Health Agency of Canada, provincial and territorial health care system websites

Even though women can be vaccinated during pregnancy, they should ideally make sure that they have received all the recommended vaccines before pregnancy. To this end, health care professionals play a crucial role in updating the vaccination records of women of childbearing age and providing them with information on

recommended vaccines. For example, certain lesser-used vaccines would not be given to breastfeeding women because an infection can be transmitted to the baby through breast milk. These include the yellow fever vaccine and the BCG (Bacille Calmette-Guérin) vaccine against tuberculosis. On the other hand, all common vaccines currently given to breastfeeding mothers in Canada are safe and do not harm their breastfed babies (World Health Organization 2013). Breastfeeding women should get the flu shot during flu season to reduce the risk of contracting the virus, which can be passed on to their babies. This is especially important for babies that are less than six months old because they cannot get the flu shot at that age. To reduce their baby's risk of catching the flu, mothers should get their flu shot even if they have stopped breastfeeding.

Vaccination during Pregnancy: Coverage, Barriers, and Facilitators

In Canada, influenza vaccination coverage during pregnancy remains suboptimal and well below the 80% target (Dubé et al. 2019). For example, a retrospective study conducted in Ontario from November 2009 to April 2010 with a cohort of all women who gave birth to a live or stillborn infant in Ontario hospitals showed that only 42.6% of women (24,134 out of 56,654) received one or both types of seasonal H1N1 vaccine (Liu et al. 2012). In Nova Scotia, H1N1 vaccination coverage in 2009 was estimated at 64% among pregnant women (Strang and English 2010). In Quebec, 49.4% (9,622 out of 19,490) of pregnant women residing in Montreal were vaccinated against pandemic influenza A (H1N1) from October 22, 2009 to April 8, 2010, based on an analysis of individual vaccination records from census, survey and administrative sources (Brien et al. 2012). Furthermore, most pregnant women are not always immunized with the Tdap combined vaccine before the birth of their child, all the more so given that some provinces in Canada still do not have public vaccination programs during pregnancy (Government of Canada 2016). It is therefore clear from these examples that, regardless of the study period or Canadian province, vaccination coverage of pregnant women in Canada is sub-optimal, as is the case in other countries that have vaccination programs during pregnancy (Dubé et al. 2019; Maertens et al. 2018; Bettinger, Greyson, and Money 2016). We now turn to the identification of factors that may prevent or motivate vaccination during pregnancy. This can shed light on the concerns that pregnant women and health care providers may have. It can also help determine strategies for improving vaccination coverage in Canada.

In a review of 64 studies by MacDougall and Halperin (2016), the influenza vaccine was the most frequently evaluated, with 11 studies focusing on the 2009 H1N1 pandemic. In line with new recommendations, 10 studies explored factors associated with the use of Tdap vaccine during pregnancy. However, the authors did not identify any studies that assessed factors associated with the acceptance of tetanus toxoid during pregnancy. Poliquin, Greyson, and Castillo (2019) searched four selected Canadian journals to find studies on factors that facilitate or prevent vaccination during pregnancy in Canada. A total of 17 studies met the inclusion criteria, and most of them dealt with seasonal and pandemic influenza vaccines. Facilitators and barriers were examined at the patient and health care provider level. In both groups, knowledge was an important factor in the acceptance of vaccination during pregnancy (Table 4).

Table 3. Barriers and Facilitators of Vaccination during Pregnancy in Canada

Level	Barriers	Facilitators
Patient-level: demographic characteristics	<ul style="list-style-type: none"> Lower maternal income Younger maternal age Literacy and/or language issues Lower education No babies in the home No medical comorbidities 	<ul style="list-style-type: none"> Higher maternal income Older maternal age No literacy and or language challenges Higher formal education Another child <24 months old at home Presence of medical comorbidities
Patient-level: knowledge/attitudes	<ul style="list-style-type: none"> Less concern over disease severity Intention not to be vaccinated, or unsure Lower knowledge about vaccination Lower knowledge about influenza Safety concerns about vaccination Feeling of not enough information 	<ul style="list-style-type: none"> Concern over disease severity Intention to be vaccinated Knowledge of benefits of vaccination Knowledge of influenza Less concern over vaccine safety Feeling of having sufficient information
Patient-level: care experience	<ul style="list-style-type: none"> Fewer early prenatal visits Prenatal care by obstetrician or midwife No recollection of physician recommendation 	<ul style="list-style-type: none"> More early prenatal visits Prenatal care by family doctor Physician recommendation to be vaccinated
Provider-level	<ul style="list-style-type: none"> Specialty: Obstetrics and gynaecology or midwifery Lower vaccine knowledge Care setting: private specialty practice Less positive attitude towards influenza vaccine Not getting influenza vaccine 	<ul style="list-style-type: none"> Specialty: Family practice Higher vaccine knowledge Care setting: academic centre or family practice Positive attitude towards influenza vaccine Personal receipt of influenza vaccine

*Source: Poliquin, Greyson, and Castillo (2019)

Given that most studies dealt with H1N1 and the use of the Tdap vaccine (MacDougall and Halperin 2016; Poliquin, Greyson, and Castillo 2019), we will closely examine the factors that determine the attitudes of pregnant women and preventive health care providers. As will be discussed in more detail below, these attitudes toward vaccination during pregnancy are influenced by some of the same factors in the two groups.

Determinants of Women’s Attitudes during Pregnancy

According to Moniz and Beigi and their concept based on the Health Belief Model, “key determinants of maternal influenza vaccination include perceived vulnerability to influenza disease, perceived benefits that outweigh costs of vaccination, vaccination-related normative beliefs and prior behaviours, and self-efficacy” (Moniz and Beigi 2014, 2565). They go on to say that “the effects of these determinants can be modified by perceived regret about vaccination behaviours and by cues to action regarding vaccine-related decisions in pregnancy.” Research into how immigrant mothers gather information and make vaccination decisions for seasonal and pandemic flu during pregnancy was conducted through 23 semi-structured qualitative interviews with women from Bhutanese refugee, South Asian and Chinese communities in Edmonton, Alberta (Kowal, Jardine, and Bubela 2015). The three major findings were that the women received immunization information passively, had universal trust in vaccines, and remembered almost nothing about the H1N1 vaccination campaign. In Belgium, Flemish postpartum women were visited in their homes to have them participate in a vaccination coverage survey based on the Expanded Program on Immunization (EPI). The goal was to estimate pertussis and influenza vaccine coverage during pregnancy in 2016 and to determine predictors of non-vaccination (Maertens et al. 2018). Among women who were fully informed about the risks associated with the diseases, as well as maternal vaccination costs and recommendations, 12.4% and 23.9% had still not been vaccinated against pertussis and influenza, respectively. In several studies, the ineffectiveness of health care providers to communicate and disseminate recommendations was considered a barrier to vaccination during the 2009 H1N1 pandemic, as were other factors identified by pregnant women, such as limited access to vaccination services and high vaccine or administration costs (MacDougall and Halperin 2016). Lefebvre et al. (2019), in a study of post-partum women in the Loire-Atlantique region of western France, determined the acceptance rate for pertussis vaccination to be 77%. Acceptance was higher in women who were younger, had higher knowledge scores, were informed about pertussis, had previously received a flu vaccination, and had never refused being vaccinated.

In order to assess how and why attitudes become more favourable toward vaccines or vaccination over time, and which sources are particularly influential in the vaccination process, a longitudinal study was conducted in Germany on 351 women (Betsch et al. 2018). The cross-sectional control groups consisted of 204, 215 and 173 women, respectively. The results showed that during pregnancy, mothers viewed their previous vaccination experiences positively. However, their attitudes became much more negative after the first vaccination experience with their child. According to the authors of this study, the changes were closely related to increased risk perception and vaccination concerns, which had a negative impact on women’s attitudes toward vaccination. On the other hand, increased knowledge about vaccination over time had a positive influence on attitude. Nevertheless, the behaviour of health professionals can even influence the vaccination decisions of those pregnant women who have in-depth knowledge about maternal vaccination. Given that non-integration of vaccination into basic prenatal care and lack of recommendations from health care providers are also known barriers to vaccination (Dubé et al. 2019), vaccine recommendations and clear messages about fetal safety by health professionals may be the main motivating factors for pregnant women (Poliquin, Greyson, and Castillo 2019).

Determinants of Attitudes of Health Care Providers

According to MacDougall and Halperin, “barriers identified that affect health care providers’ provision of vaccines during pregnancy were similar to those that affected pregnant women” (MacDougall and Halperin 2016, 858). These included misperceptions and concerns about disease risk, vaccine safety and effectiveness, as well as the need for vaccination during pregnancy. In addition, inadequate knowledge and the lack of continued training of obstetric care providers were often cited as barriers to implementing recommendations for maternal vaccination. On the other hand, factors that facilitated the vaccination process included a generally positive attitude toward vaccination, concerns about the severity of influenza, confidence in vaccine safety and efficacy, and the importance given to primary care and preventive medicine. Recommendations from the principal care provider are therefore critical to improving vaccination, as observed for maternal influenza vaccination in Australia (Regan et al. 2016), but this depends on several factors. One such factor is the incorporation of vaccination training into the education of health professionals. For example, semi-structured interviews with 23 Australian midwives revealed that they sometimes found it difficult to deal with recommending vaccination within a woman-centred setting. Most of the midwives considered their vaccination training to be inadequate and a barrier to giving effective information on vaccination, as were other workplace issues, such as time pressure (Frawley et al. 2020). In contrast, among health professionals in France, “belief that inactivated vaccines are obstetrically safe, regular practice of influenza vaccination in pregnant women, pertussis cocooning strategy, and never prescribing preventive homeopathy for influenza” (Lefebvre et al. 2019, 583) were factors associated with acceptance of pertussis vaccination during pregnancy. As noted by MacDougall and Halperin (2016), there are significant economic barriers to immunization during pregnancy, and those identified by health care providers included: “workload, lack of staff and suitable practice setting, reimbursement of obstetrical care providers for the cost of ordering the vaccine and maintaining its supply, vaccination status tracking, and compliance with reporting” (MacDougall and Halperin 2016, 860).

Strategies to Increase Vaccine Acceptance and Coverage in Pregnant Women

Immunization of pregnant women has become a recognized strategy to combat neonatal infection. Scheduled vaccination against common infections during pregnancy, such as hepatitis B, pertussis and Haemophilus influenzae protects infants during that critical period of vulnerability before their immunization a few months to several years after birth (Faucette et al. 2015). One strategy to increase vaccination coverage and acceptance in pregnant women is based on recommendations from maternity care providers to increase influenza vaccination rates (Dubé et al. 2019). This is a reiteration of an idea suggested earlier. Increasing vaccination coverage can reduce the high risk of influenza complications in pregnant women and infants (Jordan et al. 2015). Researchers in England conducted a systematic literature review of studies dealing with vaccination against pertussis and influenza in pregnant women (Bisset and Paterson 2018). Most of the selected studies were carried out in the US and focused on strategies to increase influenza vaccination during pregnancy. But the authors found a lack of high-quality evidence for strategies in high-income countries to increase pertussis and influenza vaccination coverage during pregnancy. Nevertheless, the components of vaccination during pregnancy must be properly and scientifically documented to develop better recommendations. For example, in the initial evaluation of a network of researchers formed to assess influenza vaccine effectiveness during pregnancy, study sites in Australia, Canada, Israel and the United States identified a retrospective cohort of pregnant women aged 18 to

50 years whose pregnancies overlapped with local influenza seasons from 2010 to 2016 (Naleway et al. 2019). In addition to addressing the key question about influenza vaccination effectiveness, the network's data will help fill other important knowledge gaps, such as understanding the incidence, clinical course and severity of influenza-related hospitalizations during pregnancy. Based on the evidence collected, another group of researchers proposed that clinicians should provide pregnant women with information pamphlets about influenza and a verbalized statement about the benefits of maternal vaccination for newborns (Wong, Lok, and Tarrant 2016). In another review, after systematically searching 3542 published articles, six studies, three of which were randomized controlled trials, were selected for analysis (Mohammed et al. 2019). The data obtained showed that strategies for increasing uptake rates focused on health care providers, pregnant women, and improving access to vaccines. For health care providers, interventions included reminders, training, feedback, and standing orders. For pregnant women interventions focused solely on education. Previous studies had demonstrated the effectiveness of using a "best-practice alert" in provider-based interventions. When implemented in the medical record system, the reminder system also proved to be successful in alerting health care professionals to offer maternal pertussis vaccination to their pregnant patients in Dallas, Texas (Morgan et al. 2015). Of 10,201 women who were offered the Tdap vaccine during prenatal care, 9,879 (96.8%) accepted after implementation of the best-practice alert. This rate was compared to a 48% (5,064 out of 10,600) postpartum Tdap vaccination rate in the year prior to the introduction of the alert. For studies focusing on pregnant women, educational interventions did not significantly improve pertussis vaccination during pregnancy, although some studies have shown a positive effect (Mohammed et al. 2019). Interventions that focus solely on educating pregnant women about the benefits of vaccines may not be an effective strategy, according to Mohammed and colleagues (2019), but this depends on the content of the educational message (Moniz et al. 2013). As for interventions to improve access to pertussis vaccination, the review by Mohammed et al. (2019) found no studies that focused solely on this subject during pregnancy. According to the authors, the best available evidence indicates that to improve maternal pertussis vaccination, health professionals should inform all pregnant women of its importance, midwives ought to participate in maternal immunization programs at prenatal clinics, reminder systems must be used so that health care providers can target non-immunized pregnant women, and maternal pertussis immunization needs to be incorporated into standard prenatal care.

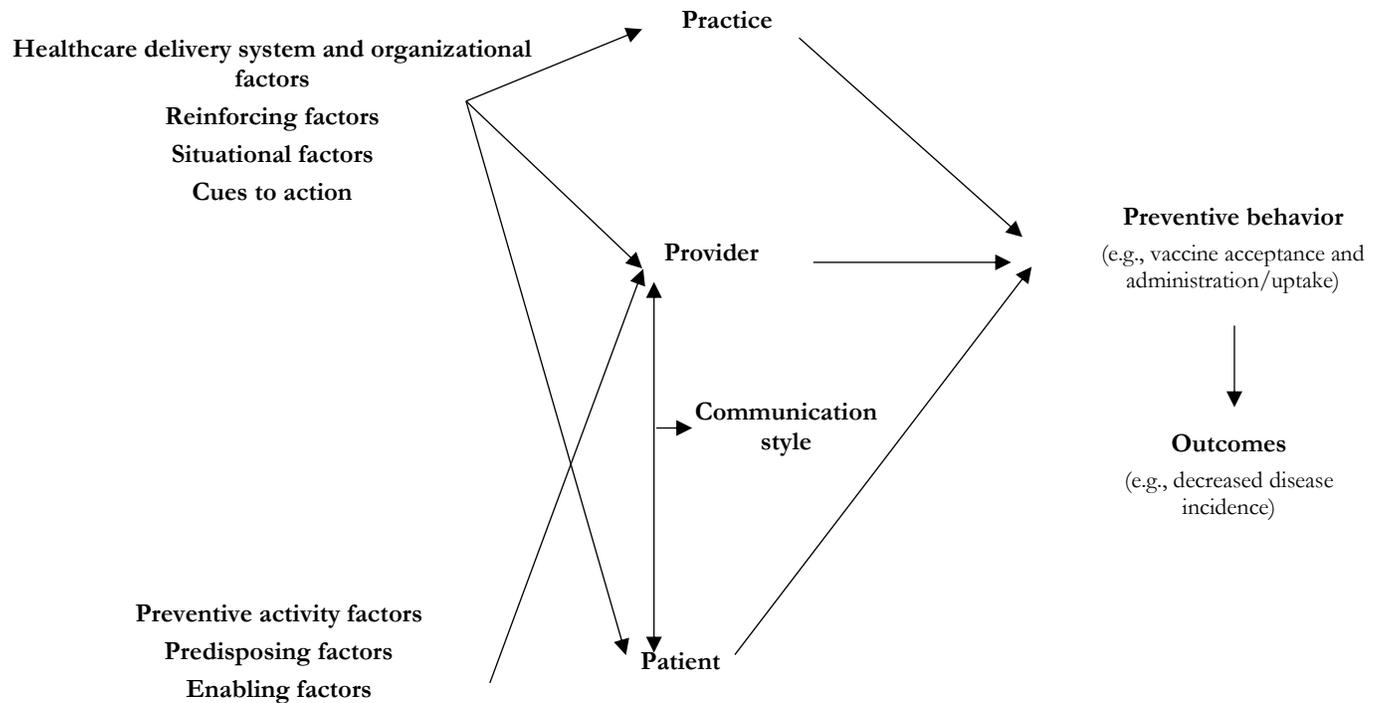
In general, three potential spheres in which to intervene can help providers understand how to increase coverage where vaccination is available and affordable (Brewer et al. 2017): the thoughts and feelings that motivate people to be vaccinated, the social processes that influence vaccination decisions, and behaviour changes that facilitate vaccination directly, regardless of what people think and feel (e.g., vaccine obligations). To examine interventions from the viewpoint of these psychological propositions - thoughts and feelings, social processes, and direct behaviour change - a research team synthesized existing evidence on the effectiveness of interventions to improve maternal influenza vaccination (Ellingson et al. 2019). According to them, these interventions are by far the most abundant and effectively documented. Using Brewer et al.'s (2017) categorization of thoughts and feelings, namely, how people perceive disease (risk perception), how they view vaccine effectiveness and safety (confidence), and what motivates them to be vaccinated (motivation), Ellingson and colleagues (2019) examined interventions aimed at influencing thoughts and feelings of patients and those of providers. From the analysis of the evidence, the authors identified provider recommendations as the most important predictor of vaccine receipt in pregnant women, but few studies assessed interventions to improve patient-provider dialogue. One such example is an exploratory study in two Australian public hospitals describing midwifery practices (Kaufman et al. 2019). The purpose of the study was to collect qualitative data

from midwives to help develop viable and adequate vaccine communication interventions based on an evidence-based model used by obstetricians in the US. Most midwives who participated in the interviews reported that they had received minimal or no vaccination communication training. Their communication was concentrated more on providing information about vaccines than on persuading women to be vaccinated. The results emphasize that communication tools that are in line with the standards of practice of midwives are needed to help them deal with parents' questions and concerns about maternal vaccines.

The P3 Model: Impacting Factors and Levels of Influence

An interaction between activities at the level of the health care practice, the health care provider and the patient during the clinical encounter can create adequate delivery of immunization services. To analyze these levels, theoretical models have been used, such as the Health Belief Model, Theory of Planned Behavior/Theory of Reasoned Action, Social Ecological Model, Social Cognitive Theory, and the Systems Model of Clinical Preventive Care. However, none of these models fully take into account the interaction between all three levels of the clinical encounter, namely the health care practice, the health care professional and the patient (Bednarczyk et al. 2018). Based on the key elements of many existing theoretical models, Bednarczyk and colleagues (2018) developed the P3 model (Practice, Provider and Patient) for preventive care interventions (Figure 1). According to the authors, the P3 model considers the three levels of the clinical consultation as well as the factors that influence them. The applicability of the P3 model has been demonstrated through two preventive care programs, immunization and colorectal cancer screening (Table 5). This model can be implemented in any preventive care promotion activity and, because of its flexibility, can be adapted to interventions focusing on the vaccination of pregnant women. According to Bednarczyk and collaborators, an example of this flexibility can be seen in: “the increased provision of influenza vaccine in community-based settings [...] where there is still a need for the provider (e.g., the pharmacist) to recommend vaccination and be able to answer patient questions, while also including appropriate practice-level components (e.g. signage indicating that influenza vaccine is available, linkage of the pharmacy to immunization information systems)” (Bednarczyk et al. 2018, 136). An intervention based on this model is currently under way in Australia (Kaufman et al. 2019).

Figure 1. Graphical Representation of P3 (Practice-, Provider, and Patient-Level) Model With Identification of Impacting Factors and the Levels They Act On



*Source: Bednarczyk et al. (2018)

Table 4. Practical Applications of the P3 Model to Interventions Targeted at Improving Immunization and Colorectal Cancer Screening

	Immunization	Colorectal cancer screening
Practice-level	<ul style="list-style-type: none"> ▪ Standing orders (allow for vaccine services to be given even in nursing visit situations) ▪ Immunization champion ▪ Immunization information systems with reminder-recall functionality ▪ Assessment, Feedback, Incentives, eXchange (AFIX) program ▪ Coordination of staff to identify patients in need of vaccination to allow promotion messaging to occur at all stages of the clinical encounter (e.g., at check-in, preliminary intake, clinical examination, and check-out, including scheduling for future immunization visits, as necessary) ▪ Provision of Vaccine Information Statements 	<ul style="list-style-type: none"> ▪ Standing orders for distribution of home fecal immunochemical tests for colorectal cancer screening as part of an effective multicomponent intervention to improve colorectal cancer screening ▪ Prevention (cancer screening) champion ▪ Provision of materials (e.g., screening recommendations) ▪ Coordination of staff to identify patients in need of screening to allow promotion messaging to occur at all stages of the clinical encounter (e.g., at check-in, preliminary intake, clinical examination, and check-out, including scheduling for follow-up contact and visits, as necessary)
Provider-level	<ul style="list-style-type: none"> ▪ EMR or IIS prompts for patients who are in need of vaccination ▪ Standardized communication style (e.g., standard recommendation language and answers to FAQ) for communicating about vaccination services ▪ Training related to changes in vaccination recommendations 	<ul style="list-style-type: none"> ▪ EMR prompts for patients who are in need of screening ▪ Training related to changes in screening recommendations
Patient-level	<ul style="list-style-type: none"> ▪ Education (e.g., pamphlets, magazines, electronic tablets) 	<ul style="list-style-type: none"> ▪ One-on-one education ▪ Small media

*Source: Bednarczyk et al. (2018)

Use of Information Systems to Improve Vaccination Programs during Pregnancy

An interactive text message module (Text4baby) has been implemented in the US to encourage maternal influenza vaccination (Jordan et al. 2015). It is a free national text message service for pregnant women and mothers of infants under one year of age. The service was evaluated by assessing whether a text reminder or tailored education improved influenza vaccination or the intention to be vaccinated later in the flu season, as reported by Text4baby participants. Results showed that a reminder increased the likelihood that mothers will plan to be vaccinated at follow-up, as well as later in the season. Among mothers who did not plan to be vaccinated because of cost, those who received a personalized message about low-cost vaccination were more likely to be vaccinated at follow-up. However, there were limitations to this study, as the amount and type of information that can be collected by text is restricted (Text4baby collects only very brief information) and collecting too much data may discourage participation. Interactive educational interventions that provide targeted information to pregnant women may be useful in Canada to improve vaccination coverage, as seen in a study on pertussis vaccination among pregnant African American women (Kriss et al. 2017). This mobile app that sends automatic text messages has also increased vaccine uptake during pregnancy (Evans, Wallace, and Snider 2012). In a randomized controlled trial that enrolled 1,187 obstetric patients in 5 New York City community clinics, sending text reminders about influenza vaccination was associated with increased influenza immunization, particularly among women who received the messages early in the third trimester (Stockwell et al. 2014). Outside the US, studies of text message reminders have also shown interesting results. The teach back method for providing health information was evaluated in Jamaica and its success was associated with health knowledge, which was closely related to general skills (F. L. Wilson et al. 2012).

In Canada, the CANImmunize app, launched in April 2014 by the Ottawa Hospital Research Institute, is a digital strategy that can address pregnant women's needs for vaccination information. Researchers have proposed focusing on the role of pharmacists in directing those who are hesitant, or those who have questions, to download the app and access evidence-based information on vaccines and vaccine-preventable diseases (Houle et al. 2017). This app is a tool that enables pregnant women to manage their own immunizations. In a study to determine how to adapt the app to newcomers' needs, 92% of participants attending the Ottawa Newcomer Clinic (ONC) owned smartphones, but most were not actively using digital health apps (Paradis et al. 2018). However, the authors of this study pointed out that mobile technology can be a useful tool to assist newcomer families in adhering to provincial and territorial immunization schedules. Having identified the lack of an immunization information system in Nunavut, a group of researchers proposed the development of a set of tools to be used by health care providers. This would comprise of a customized web portal, as well as a mobile app interface for capturing or entering immunization records to be included in a centralized database (Wilson et al. 2017). According to the authors, the development of such a mobile immunization information system in Nunavut must build on the existing CANImmunize platform to reduce the cost and complexity of creating a new system. This information system will then allow for accurate estimates of vaccination coverage and, consequently, increased effectiveness of outbreak response strategies. Since the two previous studies did not target pregnant women, further digital studies are needed to determine the real impact of digital apps such as CANImmunize on pregnant women in Canada.

Information on the Internet, with or without social media components, can also positively influence vaccination coverage in pregnant women. Participants in one study were randomly assigned to one of two versions of a website containing either vaccine information and interactive social media components or vaccine information only, or to a control group receiving routine care (O’Leary et al. 2017). For Tdap vaccination, there were no significant differences between study groups. However, for influenza vaccination, women in the routine care group had a lower rate of vaccine use than those in the groups that visited the websites.

Use of Other Interactive and Online Tools to Improve Vaccination Programs during Pregnancy

One of the recommendations of the second meeting of the WHO Vaccine Safety Net (VSN) held on 4-5 June 2018 in Veyrier-du-Lac, France, was to “obtain website and social media analytics data to gauge the use and effectiveness of website and social media activities and inform communication strategies” (World Health Organization 2019, 17). It was also suggested that materials and training be developed for health professionals to improve their communication with patients. As information becomes more abundant and complex, it becomes more difficult to detect a message in a text (Romer 2015). However, in a hyper-connected and polarized world, our brains not only process visual information faster, but also make us more effective at detecting changes and comparing quantities, sizes, shapes and colours. Choosing an effective method for communicating information on vaccine safety is becoming increasingly necessary. The development of data visualization tools such as graphs, tables, icons, computer graphics and other formats is thus being proposed by the WHO Regional Office for Europe 2019 (WHO Regional Office for Europe 2019). Such an approach can also be applied to vaccination programs for pregnant women in Canada. Health professionals who are authorized to administer immunizing agents can be targeted to improve their ability to communicate complex information in a clear and effective manner. Pregnant women can also be targeted to persuade them to take the appropriate measures prescribed by vaccination programs during pregnancy. Therefore, simple changes in the presentation of data can have a significant impact, whether in terms of improved program performance or increased participation in vaccination by pregnant women.

Three initiatives in the field of communication strategy regarding vaccine safety and vaccination, although aimed at the general public, seem relevant in addressing the information needs of pregnant women and health professionals. These are the Polish initiative, which is centred around communication on vaccine safety, the French initiative, which utilizes intelligently shared electronic vaccination records, and the Brazilian initiative, which focuses on strategies and actions for the promotion of vaccinations. Looking at the initiative in Poland, where the website Szczepienia.info was created in October 2007 and managed by the National Institute of Public Health (2017). The Institute has a 100-year tradition and has been strongly associated with vaccination in Poland since its creation. According to the World Health Organization (2019), the website’s name means “immunization information,” and it provides accurate information to the entire population. In 2017, a project was undertaken to update and improve the website. Updates included new navigation tools, a comprehensive glossary, extensive new information on vaccines, and vaccination recommendations. The redesigned website now includes vaccination schedules, computer graphics, and recordings of short statements by immunization experts. It is also more visually appealing and easier to navigate. It now has more engaging and shareable content and new sections (including in English). The website receives 800 to 1000 questions a year from

patients and health care professionals. The most common topics are mandatory vaccination, freedom of choice in vaccination decisions, and vaccine ingredients. Answers to questions are provided by medical experts. However, challenges remain. They include: trying to obtain external funding to support the website, using social media, continuing collaboration with the Polish Society of Vaccinology, developing collaboration with young doctors, improving the adaptation of language to different audiences (e.g., pregnant women), and communicating better with those who have doubts about vaccines and vaccination. Having reviewed the Polish experience, the French initiative, which focuses on intelligently shared electronic immunization records. The website MesVaccins.net (“MyVaccines”) has been set up for this purpose (Groupe d’études en préventologie n.d.). It is therefore a platform for information, communication and expertise on vaccines and vaccination. So, “the aim of MesVaccins.net is to contribute to large-scale customization, harmonization and validation of vaccine-related information provided to the public, either directly or by health care professionals” (World Health Organization 2019, 42). The rules are drawn up by vaccinology professionals and added within 48 hours, since the MesVaccins.net knowledge base is updated regularly as new recommendations are issued. For example, the 2014 vaccination schedule was included within 48 hours of its publication. However, is there reason enough to personalize, harmonize and validate the information on vaccines provided to pregnant women? This review would have to be expanded to examine whether the French initiative is moving away from communication strategies on vaccine safety and vaccination of pregnant women. It would be interesting to see whether such strategies have been developed in other countries as well. In contrast to the French initiative, the Brazilian Immunization Society began not only to invest in communication with physicians and other health professionals in 2015, but also to provide information on vaccines to the general public. Two campaigns have been undertaken to increase vaccination coverage. The slogan of the first public campaign, “Vaccines Protect Everyone,” included a website for families (www.familia.sbim.org.br), an online encyclopedia on vaccines, and videos of interviews with people affected by serious infections that could have been prevented by vaccination (Sociedade Brasileira de Imunizações (SBIm) n.d.). A second campaign called “Wave Against Cancer” aimed to promote vaccination against HPV infection. It had the effect of increasing positive comments about the HPV vaccine on social media. This created more positive news about the vaccine and an increase in HPV vaccination coverage.

At the end of this review, however, we should point out that although these initiatives had their shortcomings, all three and their respective tools can be viewed through the prism of the Canadian experience of vaccination during pregnancy. While federal, provincial and territorial initiatives already exist in terms of communication strategies for vaccine safety and vaccination in Canada, they do require improvement.

Conclusion

The benefits of vaccination during pregnancy are supported by various findings in this review. To improve the management of maternal immunization programs, there is a need to reconsider the arguments in favour of recommended vaccines during pregnancy, the facilitators and barriers of vaccination during pregnancy, and the strategies to increase vaccine coverage and acceptance in Canada. Depending on the level of adaptation, we can talk about the acceptance, hesitation or refusal of the women concerned, all of which reveal the specific approach to the event. Vaccination during pregnancy therefore calls for a double protection: the protection of the pregnant woman and her unborn baby. This protection requires the development of a relationship of trust between pregnant women and the preventive care system. Although many barriers to the implementation of a maternal vaccination platform have been identified, evidence-based interventions to improve vaccination coverage are limited (MacDougall and Halperin 2016). Nevertheless, according to MacDougall and Halperin (2016), there is a clear link between reminders, training of health professionals and substantial improvements in vaccination coverage. Utilizing digital decision support, while still bearing in mind the effectiveness of the participatory approach and standing orders for vaccination, will help increase vaccination coverage among pregnant women. The interventions that we have identified through the review of the evidence can assist Canadian health professionals, vaccination program decision-makers, and other concerned parties in their efforts to improve vaccination coverage among pregnant women.

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Appendix

Questions leading to this literature review:

1. What initiatives have already been taken in Canada regarding the vaccination of pregnant women?
2. What initiatives have already been taken in other developed countries?
3. Which of these initiatives have been successful or unsuccessful?
4. Which factors facilitate or are barriers to vaccination during pregnancy?

Research

The following databases were researched and referenced: Scopus, Embase, Web of Science, PubMed/Medline, and Cochrane Library. The Google Scholar search engine was used for web searches.

Types of studies included

Inclusion criteria. Studies from:

- original research articles and books in English and French that deal with vaccination coverage, vaccination of pregnant women, immunization or vaccination programs, immunization or vaccination strategies, vaccination and information systems, text messaging reminders, and facilitators or barriers to vaccination during pregnancy;
- grey literature such as review articles, government publications and agency reports, and government or other institutional websites;
- populations of pregnant women;
- developed countries.

Exclusion criteria. Information from:

- editorials and comments in letters to the editor;
- studies regarding vaccination of women who have never conceived;
- animal vaccination studies;
- vaccination studies in underdeveloped countries.

Retrieval of articles and books: The selection and retrieval of articles and books was made by consulting the bibliographical databases selected above. All identified studies were screened in two stages: review of titles and abstracts and review of the full text. For the title and abstract screening, study abstracts were first cross-referenced against the inclusion criteria described above. The full texts of all studies selected for inclusion were then reviewed.

The following references were selected for each of the themes in Table 6 below:

Table 6: Selected References

N°	Author(s) and Year of publication	Origin/ Country of origin	Aims/Purpose	Study population and sample size	Key findings
Recommended Vaccines during Pregnancy					
1	https://doi.org/10.1080/21645515.2019.1619402				
	Bolotin et al. 2019	Canada	Estimate population immunity to measles in the province of Ontario, Canada and to identify groups at higher risk of outbreaks.	1,199 residual sera from patients aged 1–39 years.	Of 1,199 sera, 1035 were above the measles threshold for protection, 70 were equivocal and 94 were negative. The proportion of positive sera was highest for those 1–5 years, with 180/199 positive sera, and lowest for those age 12–19 years, at 158/199.
2	https://doi/full/10.1056/NEJMra1509044				
	Omer 2017	United States of America	Synthesizes the evidence for current maternal immunization recommendations, reviews new developments in this rapidly evolving field, and outlines critical areas for future research that will provide a framework for a comprehensive maternal immunization platform.	Systematic review	Influenza vaccines are efficacious against influenza-like illness and laboratory-confirmed influenza in pregnant women and their infants. ³⁵ Four randomized, controlled trials, conducted in South Africa, Mali, Nepal, and Bangladesh, have evaluated the efficacy of inactivated influenza vaccine administered during pregnancy against laboratory-confirmed maternal and infant infection. In these trials, the efficacy in infants ranged from 30% in Nepal to 63% in Bangladesh.
3	https://doi.org/10.1016/j.vaccine.2019.10.105				
	Perrett et al. 2019	Australia, Canada, Spain, Czech Republic, Finland, Italy, Belgium, India	Assess immunogenicity, transplacental transfer of maternal pertussis antibodies, reactogenicity and safety of a reduced-antigen-content diphtheria-tetanus-three-component acellular pertussis vaccine (Tdap) during pregnancy.	687 pregnant women were vaccinated (Tdap: N = 341 control: N = 346).	-Superiority of the pertussis immune response (maternally transferred pertussis antibodies in cord blood) was demonstrated by the GMC ratios for anti-filamentous hemagglutinin, 20.7 for anti-pertactin and 8.5 for anti-pertussis toxoid. -Tdap vaccination during pregnancy resulted in high levels of pertussis antibodies in cord blood, was well tolerated and had an acceptable safety profile.
4	https://doi.org/10.1016/B978-0-12-814582-1.00004-8				
	Wilcox et al. 2020	United Kingdom	-Discuss the potential interference of maternally-derived vaccine-specific antibody with infant responses to primary vaccination. -Discuss the potential for additional protection to be conferred to the newborn via alteration of breastmilk composition.		

Vaccination Coverage, Barriers and Facilitators during Pregnancy

1	https://doi.org/10.1016/j.jogc.2016.08.004 Bettinger et al. 2016	Canada	Investigate the attitudes and behaviour of pregnant women and new mothers regarding seasonal and pandemic influenza vaccination.	34 women (26 pregnant women and 8 mothers of newborns), with a follow-up survey to assess outcomes at the end of the subsequent influenza season.	-Most women did not consider influenza vaccination to be an important preventative measure to take while pregnant. -Recommendations from maternity care providers and communication about the severity of and susceptibility to influenza for pregnant women would facilitate vaccine uptake.
2	https://doi.org/10.1016/j.jogc.2018.09.007 Dubé et al. 2019	Canada	Assess Canadian maternity care providers' knowledge, attitudes, and practices regarding influenza vaccination in pregnancy.	Physicians, obstetricians-gynaecologists, midwives, pharmacists, and nurses who care for pregnant individuals.	-The main determinants were following official recommendations on influenza vaccination, discussing vaccines with most or all pregnant individuals seen in their practice, and being vaccinated themselves during the previous influenza season. -Enhancing influenza vaccine uptake in pregnancy is largely dependent on maternity care providers' recommendations.
3	https://doi.org/10.1016/j.wombi.2019.02.006 Frawley et al. 2019	Australia	Explore midwives' experiences of discussing maternal and childhood immunisation with women and their partners and their confidence in answering parent's questions.	23 semi-structured interviews with registered Australian midwives working in public and private hospital settings, and in private practice.	The vast majority of midwives described their education on immunisation as inadequate and workplace issues, such as time pressure, were identified as further barriers to effective communication about immunisation.
4	https://doi.org/10.17269/cjph.106.4803 Kowal et al. 2019	Canada	Understand information-gathering and decision-making processes of immigrant mothers for scheduled childhood vaccines, vaccination during pregnancy, seasonal flu and pandemic vaccination.	23 qualitative semi-structured interviews with immigrated mothers from Bhutanese refugee, South Asian and Chinese communities.	1) Participants in all three communities passively received immunization information. 2) Participants demonstrated universal trust in vaccines. 3) Participants' recollection of the H1N1 vaccination campaign was almost nil, demonstrating the lack of reach of public health vaccination campaigns to designated priority groups (pregnant women and children) in Alberta.
5	https://doi.org/10.1016/j.medmal.2019.09.001 Lefebvre et al. 2019	France	Assessed the acceptance of this strategy among French postpartum women and health professionals.	Postpartum women and health professionals (family physicians, obstetricians-gynecologists, midwives, and medical students)	Factors associated with acceptance among women were younger age, higher knowledge, having received advice during pregnancy, being vaccinated against influenza, and having never refused any vaccine; among health professionals, factors associated with acceptance were belief that inactivated vaccines are obstetrically safe, regular practice of influenza vaccination in pregnant women, pertussis cocooning strategy, and never prescribing preventive homeopathy for influenza.

6	https://doi.org/10.1016/j.jogc.2018.05.042				
Poliquin et al. 2019	Canada	Identify barriers and facilitators of vaccination during pregnancy in Canada.	Four relevant Canadian journals were screened to identify all studies that considered barriers and/or facilitators to vaccination during pregnancy, specifically in Canadian settings.	17 studies met inclusion criteria, most with a focus on the seasonal and pandemic influenza vaccines. At both levels, knowledge was an important facilitator of vaccine acceptance during pregnancy. Vaccine endorsement by a prenatal care provider and clear messages of safety for the fetus emerged as key motivators. Few studies addressed system-level barriers or interventions for improving vaccine uptake during pregnancy in the Canadian setting.	
7	https://doi.org/10.1016/j.wombi.2016.01.009				
Regan et al. 2016	Australia	Evaluate trends in seasonal influenza vaccine coverage and identify determinants for vaccination among pregnant women in Western Australia.	Post-partum women who delivered a baby in Western Australia between 2012 and 2014.	Women who reported receiving the majority of their antenatal care from a private obstetrician were significantly more likely to have influenza vaccination recommended to them than those receiving the majority of their care from a public antenatal hospital or general practitioner. In 2014, the most common reason women reported for accepting influenza vaccination was to protect the baby (92.8%) and the most common reason for being unimmunised was lack of a healthcare provider recommendation (48.5%).	
8	https://doi.org/10.1016/j.vaccine.2018.03.033				
Maertens et al. 2018	Belgium	Estimate the coverage of pertussis and influenza vaccination during pregnancy in 2016 and to determine predictors for missing vaccination.	Postpartum women were visited at home for a vaccination coverage survey using an Expanded Program on Immunization (EPI)-based two-stage cluster sampling design.	Surprisingly, among women who were completely informed (i.e., on disease-associated risks, maternal vaccination costs and recommendations), still 12.4% were unvaccinated against pertussis and 23.9% against influenza.	
9	https://doi.org/10.4161/21645515.2014.970901				
Moniz et Beigi 2014	United States of America	Focus on the present state of vaccine acceptance in pregnancy, with attention to currently identified barriers and determinants of vaccine acceptance.	Review	In a conceptual model based on the Health Belief framework, key determinants of maternal influenza vaccination include perceived vulnerability to influenza disease, perceived benefits that outweigh costs of vaccination, vaccination-related normative beliefs and prior behaviors, and self-efficacy. The effects of these determinants can be modified by perceived regret about vaccination behaviors and by cues to action regarding vaccine-related decisions in pregnancy.	
10	https://doi.org/10.1016/j.vaccine.2018.04.023				
Betsch et al. 2018	Germany	Assess how and why attitudes become more pro-vaccine or vaccine-skeptical over time, and which sources are especially	351 women entered the longitudinal analyses, while 204, 215 and 173 women were recruited in the	During pregnancy mothers reported rather positive prior experiences with vaccinations. However, their judgment turned significantly more negative after the first vaccination experience with their child. These changes were	

			influential in this process.	cross-sectional control groups, respectively.	significantly related to increased risk perceptions and concerns about vaccination, which then had a negative impact on the vaccination attitude. In contrast, gaining more vaccine-related knowledge over time positively influenced attitude formation
11	https://doi.org/10.1186/1471-2334-13-362				
	Lim et al. 2013	Canada	Assess rubella seroprevalence among prenatal screening tests performed in Ontario.	459,963 women who underwent 551,160 unique prenatal screening tests for rubella	Rubella immunity remained stable at approximately 90% overall
12	https://doi.org/10.1007/BF03404440				
	Liu et al. 2012	Canada	Evaluate the rate of influenza vaccination in pregnant women during the 2009 H1N1 influenza pandemic and explore predictors associated with receiving vaccination during pregnancy.	Women who gave birth in an Ontario hospital between November 2, 2009 and April 30, 2010.	Among 56,654 women who gave birth in the study period, 42.6% had received influenza vaccination during pregnancy
13	https://doi.org/10.1093/aje/kws154				
	Brien et al. 2012	Canada	Analyze rates of 2009 pandemic A/H1N1 influenza vaccination in Montreal, Quebec	Individual-level vaccination records from a vaccination registry with census, survey, and administrative data.	A total of 9 622 (49.4%) pregnant women residents in Montreal were vaccinated against pandemic A/H1N1 influenza from October 22, 2009, through April 8, 2010
14	https://doi.org/10.1080/21645515.2015.1101524				
	MacDougall and Halperin 2016	Canada	Review the literature related to factors that affect a healthcare provider's recommendation and a woman's willingness to be vaccinated during pregnancy.	Systematic review	Concern about the safety of vaccines given during pregnancy was the most often cited barrier among both the public and healthcare providers. Other barriers included doubt about the effectiveness of the vaccine, lack of knowledge about the burden of disease, and not feeling oneself to be at risk of the infection. Major facilitators for maternal immunization included specific safety information about the vaccine in pregnant women. Systems barriers such as inadequate facilities and staffing, vaccine purchase and storage, and reimbursement for vaccination were also cited
Strategies to Increase Vaccine Acceptance and Coverage in Pregnant Women					
1	https://doi.org/10.1016/j.pmedr.2018.06.009				
	Bednarczyk et al. 2018	United States of America	Describe the development of the P3 (Practice-, Provider-, and Patient-level) Model for preventive care interventions.	Existing theoretical models	-The P3 Model builds on the prior work related to individual-level health behavior models, ecological models, communication strategies, and the Systems Model of Clinical Preventive Care, integrating key components into a comprehensive model for promotion of

					<p>prevention activities.</p> <p>-The P3 Model – including both the conceptual model and key activities or considerations for each component - provides a framework for the design, conduct, and evaluation of studies assessing the effectiveness of prevention promotion efforts.</p>
2	https://doi.org/10.1016/j.vaccine.2018.04.013				
	Bisset et al. 2018	United Kingdom	Identify effective strategies in increasing the uptake of vaccination in pregnancy in high-income countries and to make recommendations for England.	A systematic review	The majority of the papers included were conducted in the USA and looked at strategies to increase influenza vaccination in pregnancy. There is limited high quality evidence for strategies in high-income countries to increase coverage of pertussis and influenza vaccination in pregnancy. A number of strategies have been found to be effective
3	https://doi.org/10.1016/j.amepre.2015.04.029				
	Jordan et al. 2017	United States of America	Examine whether a text-based reminder or tailored education improved self-reported influenza vaccination or intent to be vaccinated later in the influenza season among Text4baby participants.	Nearly one third (28,609/89,792) of enrollees responded to a text asking about their vaccination plans.	A reminder increased the odds of vaccination at follow-up among mothers and of continued intent to be vaccinated later in the season. Among mothers not planning to be vaccinated because of cost, those who received a tailored message about low-cost vaccination had higher odds of vaccination at follow-up. Other tailored messages were not effective.
4	https://doi.org/10.1016/j.vaccine.2017.01.037				
	Kriss et al. 2017	United States of America	Evaluate the effect of two ELM-based vaccine educational interventions on Tdap vaccination among pregnant African American women, a group of women who tend to have lower vaccine uptake compared with other groups.	Pregnant African American women recruited during routine prenatal care visits	-From baseline to follow-up, women's reported intention to receive Tdap during the next pregnancy improved in all three groups. Among unvaccinated women, the most common reason reported for non-vaccination was lack of a recommendation for Tdap by the woman's physician. -Education interventions that provide targeted information for pregnant women in an interactive manner may be useful to improve Tdap vaccination during the perinatal period.
5	https://doi.org/10.1371/journal.pone.0214538				
	Mohammed et al. 2019	Australia	Systematically collect and summarize the available evidence on the effectiveness of interventions used to improve pertussis vaccination uptake in pregnant women.	A systematic review	Six studies were included in the review, of which three were randomized controlled trials (RCTs). Strategies to improve uptake were focused on healthcare providers, pregnant women, or enhancing vaccine access. Healthcare provider interventions included provider reminder, education, feedback and standing orders. Interventions directed at pregnant women focused solely on education.
6	https://doi.org/10.2196/11333				
	Naleway et al. 2019	Australia, Canada,	Estimate influenza vaccine effectiveness (IVE) in	Cohort of pregnant women aged from 18	Identified approximately 2 million women whose pregnancies overlapped with influenza seasons;

		Israel, United States of America	preventing acute respiratory or febrile illness (ARFI) hospitalizations associated with laboratory-confirmed influenza virus infection during pregnancy.	to 50 years whose pregnancies overlapped with local influenza seasons from 2010 to 2016.	550,344 had at least one hospitalization during this time. After restricting to women who were hospitalized for ARFI and tested for influenza, the IVE analytic sample included 1005 women.
7	https://doi.org/10.1016/j.vaccine.2015.11.020				
	Wong et al. 2016	Hong Kong	Review evidence on the effectiveness of interventions to improve influenza vaccination coverage in pregnant women.	A systematic review	Eleven studies were included in the review. There is a lack of effective interventions to increase the influenza vaccination rate in pregnant women.
8	https://doi.org/10.1080/21645515.2015.1070984				
	Faucette et al. 2015	United States of America	Broader success of maternal immunization rely on the integration of advances in basic science in vaccine design and evaluation and carefully planned clinical trials that are inclusive to pregnant women.	A systematic literature search	Better inform the public of disease risks, vaccine safety and benefits, continue to disseminate the newest scientific knowledge on maternal vaccination to physicians and encourage them to recommend to patients in all models of care, foster the universal implementation of vaccination by physicians and integrate public and private infrastructure and resources to provide financial support for vaccination programs.
9	http://dx.doi.org/10.1080/10810730.2011.649157				
	Evans et al. 2012	United States of America	Assess the efficacy of Text4baby messaging campaign.	Pregnant women first presenting for care at the Fairfax County, Virginia Health Department.	-Significant effect of text4baby intervention exposure on increased agreement with the attitude statement. -Observed a significantly higher overall agreement to attitudes against alcohol for those who had attained a high school education or greater -Observed also a significant improvement of attitudes toward alcohol consumption from baseline to follow-up.
10	https://doi.org/10.2105/AJPH.2013.301620				
	Stockwell et al. 2014	United States of America	Evaluate the impact of influenza vaccine text message reminders in a low-income obstetric population	1187 obstetric patients from 5 community-based clinics in New York City	In this low-income obstetric population, text messaging was associated with increased influenza vaccination, especially in those who received messages early in their third trimester.
11	https://doi.org/10.1016/j.pedn.2011.05.004				
	Wilson et al. 2012	United States of America/ Jamaica	Assess maternal health literacy of pregnant women in Jamaica and evaluate their ability to communicate the benefits, risks, and safety of the Bacillus Calmette-Guerin (BCG) and Hepatitis B (hep B) vaccines after using the teach back method	Two community health centers located in Kingston, Jamaica	In terms of oral literacy or the ability to communicate about the vaccines, further analysis of the verbal responses from the teach back showed that all the women gave the correct responses about the safety of BCG and hep B vaccines. Twenty-two (65%) of the women correctly identified the benefits of the BCG vaccine (17 for hep B). Fourteen (41%) of the women correctly identified the risks of the BCG vaccine (15 for hep B).

12	https://doi.org/10.1177/1715163517710959				
	Houle, S. and coll. 2017	Canada	Present CANImmunize Explain how pharmacists can get involved	Pharmacists	Pharmacists can refer patients with hesitancy or questions to download CANImmunize and access evidence-based information on vaccines and the diseases they prevent, as well as their safety and effectiveness
13	https://10.1080/22423982.2017.1358566				
	Wilson et al. 2017	Canada	Identified an opportunity to establish a sustainable solution to provide Nunavut with a functional IIS that would provide substantial benefit to both patients and healthcare providers.	Nunavut local healthcare workers and health officials	Developing an IIS in Nunavut that builds on the existing CANImmunize infrastructure would reduce the cost and complexity of developing a new IIS, and allow Nunavut to benefit from the ongoing efforts to secure data on the CANImmunize platform.
14	https://10.1093/ofid/ofx163.1163				
	O'Leary et al. 2017	United States of America	Test of the efficacy of an online vaccine & social media resource in increasing uptake of Tdap & flu vaccines.	Pregnant women in the third trimester of pregnancy	Web-based vaccination information which is sent to pregnant women, with or without social media components, can positively influence maternal flu vaccine uptake
15	https://10.1097/AOG.0b013e31828642b1				
	Moniz et al. 2013	United States of America	Estimate whether text messages sent to ambulatory pregnant women could improve influenza vaccine uptake.	Obstetric patients at less than 28 weeks of gestation	Text messaging prompts were not effective at increasing influenza vaccination rates among a low-income, urban, ambulatory obstetric population. Ongoing efforts are needed to improve vaccine uptake among pregnant women unsure about or unwilling to receive influenza vaccination.
16	https://10.1097/AOG.0000000000000975				
	Morgan et al. 2015	United States of America	-Evaluate how implementation of a best-practice alert, a reminder of clinical guidelines within the electronic medical record, in combination with the recommended change in immunization timing from postpartum to antepartum, affected tetanus toxoid, reduced diphtheria toxoid and acellular pertussis (Tdap) rates. -Examine the association of vaccination with local pertussis attack rates.	10,201 women who received Tdap during prenatal care	The use of a best-practice alert, in concert with the recommended change in timing of maternal vaccination from postpartum to antepartum, was associated with an increase in the Tdap immunization rate to 97%.

17	https://10.1177/1529100618760521	Brewer et al. 2017	United States of America, Australia -Review the basics of vaccination. -Identify the three main problems facing vaccination, and discuss the role of vaccination activists	A systematic review	The first proposition is that thoughts and feelings can motivate getting vaccinated. The second proposition is that social processes can motivate getting vaccinated. The third proposition is that interventions can facilitate vaccination directly by leveraging, but not trying to change, what people think and feel. These interventions are by far the most plentiful and effective in the literature.
18	https://doi.org/10.1080/21645515.2019.1607131	Kaufman et al. 2019	Australia, United States of America Explore midwives' attitudes and values regarding maternal and childhood vaccination, their perceived role in vaccine advocacy and delivery, and barriers and enablers to implementation of a potential communication intervention.	12 midwives for semi-structured interviews at two Australian tertiary public hospitals (one with antenatal vaccines onsite, one without).	Most reported receiving minimal or no training on vaccine communication. Their communication practices focused primarily on vaccine information provision rather than persuasion, although some midwives shared personal views and actively encouraged vaccination. More vaccine and communication training and resources were requested
19	https://doi.org/10.1080/14760584.2019.1562907	Ellingson et al. 2019	United States of America Synthesize the existing evidence on the effectiveness of interventions to improve maternal influenza vaccine uptake	A systematic review	-Interventions that primarily aim to change vaccine attitudes are generally not effective in isolation. -Despite a provider recommendation being the best predictor of vaccine receipt among pregnant women, few studies have evaluated interventions that focus on improving the provider-patient interaction or the provision of information or communication training to providers from public health officials. -Nudge-based interventions, such as provider prompts and standing orders that build on favorable intentions to vaccinate without attempting to change attitudes about vaccines have demonstrated substantial success in improving uptake. -Most providers list the primary barriers to providing the vaccine to patients as financial. More work is needed to assist providers in overcoming the logistical barriers to providing vaccine to their pregnant patients, such as navigating reimbursements and stocking the vaccine in clinic.