Maternal Influenza Vaccination and the Effect of Provincial Immunization Programs in Canada

by

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Abstract

With evidence suggesting the importance of influenza vaccination of pregnant women, Canadian provinces have started to implement different publicly funded immunization programs to encourage vaccination of pregnant women. Four programs are implemented between 2000 and 2010: Universal Influenza Immunization Campaign (UIIC), the program offering coverage to pregnant women (full-coverage program), the program offering coverage to pregnant women in the third trimester (partial-coverage program) and the program offering no coverage to pregnant women (no-coverage program). This paper examines the effect of these programs on influenza vaccination of pregnant women using linear probability model of micro determinants of vaccination. The results show that both UIIC and full-coverage program raise the vaccination rate of pregnant women by 21% compared to no-coverage program. However, only full-coverage program has a differential effect on pregnant women that is over 10% while partial-coverage program raises the vaccination rate of pregnant women and non-pregnant women both by 6.8%.

List of Abbreviations Used

aNIC	adult National Immunization Coverage
CCHS	Canadian Community Health Survey
CPI	Consumer Price Index
NACI	National Advisory Committee on Immunization
PHAC	Public Health Agency of Canada
SARS	Severe Acute Respiratory Syndrome
UIIC	Universal Influenza Immunization Campaign
WHO	World Health Organization

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Chapter 1

Introduction

Influenza afflicts the world with serious respiratory illness in winter every year. In Canada, influenza on average causes 12,200 hospitalizations and 3,500 deaths annually (NACI 2014). More than enough studies have pointed out pregnant women are at excess risks of influenza-associated morbidity (Lindsay et al. 2006; Dodds et al. 2007; Schanzer et al. 2007). Maternal influenza infection also leads to adverse neonatal outcomes like low birth weight and small for gestational age (McNeil et al. 2011). As one of the few effective ways to circumvent the infection of this contagious disease, influenza vaccine not only shields pregnant women and their infants from adverse impact of influenza-related complications but also allows newborns to inherit the protection against influenza from maternal vaccination (Eick et al. 2010). Effectiveness and efficacy of influenza vaccine on pregnant women have been widely proven (Zaman et al. 2008; Benowitz et al. 2010; Poehling et al. 2011). So far studies have raised little concern about influenza vaccination of pregnant women (NACI 2014). Therefore, influenza vaccine is significantly cost-effective and should be widely delivered.

However, the influenza vaccine coverage among pregnant women is quite low in the early 2000s. The 1990-2002 population-based study in Nova Scotia shows that only 2.6% of all pregnant women and 6.7% of pregnant women with chronic conditions received the vaccine (Dodds et al. 2007). To reduce the gap between the current and social optimal immunization rate of pregnant women, World Health Organization (WHO 2012) recommends treating pregnant women as the highest priority group for influenza vaccination among all the risk groups including young children, the elderly, individuals with chronic conditions and health-care workers. The Canadian National Advisory Committee on Immunization (NACI) recommends pregnant women in any trimester to take vaccine in 2007 and thus begins an on-going wave of nation-wide reform of provincial immunization programs (NACI 2007). Following NACI's recommendations, provinces started to expand publicly funded immunization programs to cover pregnant women, either through Universal Influenza Immunization Campaign (UIIC) or pregnant-women-targeted programs.

To the extent of my knowledge, no empirical study has evaluated the effect of any immunization programs on the vaccination behaviour of pregnant women. To fill this knowledge gap, this paper sets up a linear probability model of individual vaccination decision, uses non-pregnant women as a comparison group and implements the Difference-in-Difference method to estimate the impact of provincial immunization programs on pregnant women. As the immunization programs increase the individual propensity of vaccination by reducing the vaccine costs, I focus on the demand side of individual vaccination and the factors related to individual perceived risks of influenza complications and individual perceived benefits of vaccination. The main risk factor here is pregnancy status. Other important health-related risk factors are age, self-rated health, chronic conditions and smoking status. Socio-economic characteristics like education, labour market status, income, residence location, marital status and whether living with young children are also controlled in the analysis. The micro dataset, the Canadian Community Health Survey (CCHS), collects comprehensive information about Canadian residents including health and socio-economics information and is used in the empirical study. The main focus of the study is to estimate the effect of different types of provincial immunization programs on the vaccination propensity of pregnant women and thus will contribute to the issue of influenza vaccination of pregnant women.

The rest of the paper will be organized as follows. Chapter 2 provides the background information of the issue from two aspects: pregnant women as a priority group for influenza vaccination and influenza vaccine as an effective method to prevent influenza infection for pregnant women. It then summarizes the nation-wide reform of provincial immunization programs in Canada that are designed to encourage pregnant women to immunize. Chapter 3 reviews the past studies for empirically capturing individual vaccination behaviour. Chapter 4 provides a short description of data, and summarizes the vaccination trend of pregnant women in the last decade and the vaccination rate for pregnant and non-pregnant women in every group defined by the health and socio-economic factors. Chapter 5 describes the empirical strategy for the linear probability model. Chapter 6 presents and analyzes the regression results. Chapter 7 concludes.

Chapter 2

Background

2.1 Pregnant Women as a Priority Group for Influenza Vaccination

Pregnant women, regardless of their health status, are particularly vulnerable to influenza. High morbidity and mortality among pregnant women have been reported during influenza pandemics. Healthy pregnant women faced excess death rate during the influenza pandemics in 1918/19 and 1957/58 (Freeman 1959; Harris 1919); they also experienced disproportionally high risk of mortality during the most recent influenza pandemic, the H1N1 in 2009 (Louie et al. 2010; Siston et al. 2010).

Seasonal influenza also imposes a great threat to the health of pregnant women. Healthy pregnant women in the third trimester have higher risks of serious respiratory illness during the normal influenza seasons. Pregnant women with comorbidities are even at higher risks than healthy pregnant women (Dodds et al. 2007). Every year, seasonal influenza places a great burden on the health care system in treating pregnant women with influenza-related illness. The hospital admission rate attributable to influenza infection for healthy Canadian pregnant women is consistently higher than for their non-pregnant peers and is equivalent to the rate of people aged 65 to 69 years (Schanzer et al. 2007). Excess outpatient medical visits of pregnant women of all trimesters have also been reported during influenza seasons compared to influenza-unexposed weeks (Lindsay et al. 2006). An antigenic shift in influenza usually causes an excess rate of outpatient medical visits for acute respiratory disease in pregnant women (Mullooly, Barker, and Nolan 1986).

Influenza complications are not only severe for adult pregnant women, but also affect the fetuses and last long after the birth. Even though the effects of maternal infection on the fetus are still not well understood and the transfer of the virus from pregnant women to fetus is low (Rasmussen, Jamieson, and Bressee 2008), recent research shows that high mortality and morbidity have been observed during perinatal and neonatal periods. Perinatal mortality was higher in infants born to infected women than the comparison group during 2009/H1N1 pandemic (Pierce et al. 2011). Compared to the non-infection cohort, neonates are at high risks of morbidity from the maternal influenza infection (Poehling et al. 2006). Maternal influenza infection also increases the rates of acute respiratory illnesses of neonates (France et al. 2006). They are also more likely to be small for gestational age and have lower birth weight (McNeil et al. 2011).

In addition to the apparent effect from maternal influenza infection at birth, the fetal origins hypothesis suggests the existence of latent adverse effects that can last until adulthood or even for a life time. It cannot be compensated by the extra healthcare that is used to treat the apparent neonatal diseases (Almond and Currie 2011). According to the fetal origins hypothesis, the adverse long-term impact is not restricted to health aspects. The study of long-term maternal infection effect of 1918 influenza pandemic has demonstrated its large negative effects on health and economic outcomes including excess rate of physical disability, lower socioeconomic status and lower income (Almond 2006).

2.2 Safety and Efficacy of Maternal Influenza Vaccination

One way to circumvent the adverse impact of influenza is to vaccinate pregnant women. Inactivated influenza virus vaccine can prevent severe influenza complications for pregnant women and fetuses, but the safety and efficacy of the vaccine should be examined in depth before publicly recommending it to pregnant women. More than 10 studies have demonstrated the lack of an adverse effect of inactivated influenza virus vaccine on maternal health during pregnancy and no harmful effects of maternal influenza vaccination on the fetus have been reported so far (Tamma et al. 2009). Although the data on the influenza vaccine safety in pregnancy is relatively inadequate because of the randomized trials adopted by the studies and consequently the small sample size, there are few reports about the severe side effects on infants (Mak et al. 2008). So far the use of vaccines in pregnant women in Canada and Europe has not raised any concerns (NACI 2014).

In contrast to the lack of evidence on the adverse impact of the influenza vaccine, clinical research provides evidence of efficacy and effectiveness of maternal vaccination. Maternal immunization with the influenza vaccine provides a significant clinical protection for mothers against laboratory-proven influenza and several other respiratory illnesses (Zaman et al. 2008). Infants of mothers who have received the influenza vaccine during pregnancy are almost half as likely to have influenza hospitalizations relative to the comparison groups (Poehling et al. 2011). Infants are less likely to have a small gestational age and more likely to have a higher birth weight, given maternal immunization during the influenza seasons (Steinhoff et al. 2012). Increased antibody titers provided by maternal influenza vaccination are found in infants through 2 to 3 months of age (Eick et al. 2010) and the effect might last for up to 6 months (Zaman et al. 2008).

Maternal influenza vaccination is also cost-effective considering no influenza vaccine is licensed for infants younger than 6 months. The protection that infants inherit from maternal immunization is the only available shield standing between influenza and infants up to 6 months old. The protection brought by the maternal influenza vaccination on the infants is around 90% effective (Benowitz et al. 2010). Moreover, the effectiveness of the influenza vaccine might be underestimated in these clinical studies. Due to the nature of epidemiology, the clinical studies, randomized trials as they are, take limited samples and cannot imitate the real life scenarios where externality is much more prominent in the large scale.

2.3 Current Immunization Programs

Given the growing number of studies presenting the evidence of high complication risks of pregnant women and the proof of the vaccine safety and efficacy, the National Advisory Committee on Immunization (NACI) started to recommend that pregnant women take the influenza vaccine. In 2006, the NACI recognized that pregnant women are capable of transmitting influenza to their newborns and recommended pregnant women in their third trimester be immunized (NACI 2006). In 2007, the NACI for the first time listed healthy pregnant women as "people at high risk of influenza-related complications" along with seniors, people with comorbidities, etc. All pregnant women, regardless of their trimesters, are recommended to take the seasonal influenza vaccine (NACI 2007).

Following the NACI, provinces in Canada started to extend their publicly funded immunization programs to include pregnant women (except Ontario, which has offered the influenza vaccine to pregnant women for free since 2000 under the Universal Influenza Immunization Campaign [Johansen et. al 2004]). Alberta is the first province to include healthy pregnant women on the recommendation list. The immunization program in Alberta synchronized with the NACI recommendations, i.e. in 2006 they started to offer free vaccine to pregnant women in the third trimester and extended the coverage to all pregnant women starting in 2007 (Elaine Sartison, Alberta Health, pers. comm.). Manitoba, New Brunswick, Nova Scotia and Saskatchewan, on the other hand, switched from no coverage to full coverage for pregnant women in 2007 (Kellie Navitka, Manitoba Health, pers. comm.; Patricia Mclean, New Brunswick Health, pers. comm.; Nova Scotia Department of Health and Wellness, pers. comm.; Saskatchewan Ministry of Health 2012). Newfoundland and Labrador adopted the immunization program covering all pregnant women in 2010 (Newfoundland and Labrador Health and Community Services 2009, 2010). British Columbia started to offer free vaccine to pregnant women in the third trimester in 2007 (Fraser Heath 2007). It then proceeded to extend its program to full coverage of all pregnant women in 2014 while Quebec only offers free vaccine to pregnant women in the second/third trimesters since 2010 (British Columbia Ministry of Health 2014; Institut National de Santé Publique du Québec 2009; Santé et Services Sociaux Québec 2010). In Prince Edward Island, the influenza vaccine is offered to all residents including pregnant women with only administration fees charged since 2004. This fee is removed for pregnant women in 2009 and thus they receive the vaccine for free from then on (Zhdanava 2013). The change of provincial immunization programs did not stop with coverage over pregnant women. With the exception of Prince Edward Island, New Brunswick and Quebec, the other seven provinces took a step further and adopted Universal Influenza Immunization Campaign later on (Zhdanava 2013; Newfoundland and Labrador Health and Community Services 2013, 2014; PHAC 2015). The information of provincial immunization programs is summarized in Table 1.[1]

[1] No-coverage program does not necessarily mean that no free vaccine is offered to residents other than pregnant women. Here it only refers to coverage over pregnant women.

Chapter 3

Model

The change in the NACI recommendations and the great variety of provincial immunization programs provide a perfect opportunity to examine how pregnant women react to new health information and to evaluate the effect of provincial immunization programs and the economic incentives of influenza vaccine take-up of pregnant women. An empirical model of vaccine take-up decisions should be established to provide a framework to examine the effect of the NACI recommendations and provincial immunization programs.

There has been some previous work done on the determinants of the vaccine take-up from both medical and economic aspects. Economists started to examine this issue in the late 1990s and managed to identify important socio-economic determinants of influenza vaccination from the demand side. Among the first few economics studies, the study done by Mullahy (1999) demonstrates that labour supply, education level and perceived risks of infection are as important in explaining vaccine take-up decisions as self-perceived health status. Aside from the micro determinants of vaccination, economists have recognized the importance of immunization programs in encouraging vaccination. Studies have utilized the various designs of provincial immunization programs in Canada to investigate the effect. The Canadian Community Health Survey (CCHS) shows a large gap of vaccination rate between Ontario, the UIIC province, and other non-UIIC provinces for all age groups since 2000 (Ward 2014). Zhdanava (2013) demonstrates that aside from age and chronic conditions, the timing of vaccines' delivery and the coverage of provincial immunization programs have significant influence on vaccination behaviour in Canada. However, the 2012 adult National Immunization Coverage (aNIC) survey conducted by the Public Health Agency of Canada (PHAC) shows that residing in the provinces with UIIC program is not associated with a significant higher influenza immunization rate when risk factors are controlled. Recommendations from health care professionals during the clinical visit, on the other hand, turns out to be the most significant predictor of vaccination in their study (PHAC 2012).

A few papers discuss the correlates of vaccine take-up decision for pregnant women from the supply side. A survey conducted in Toronto in 2003/04 indicated that the recommendation of the maternity care provider is an important factor in promoting influenza vaccination among pregnant women (Tong et al. 2008). Healthcare-provider recommendations and pregnant women's concerns about the safety of the influenza vaccine during pregnancy, identified as provider-perceived barriers, are the top two factors that determine the acceptance of the influenza vaccine (McNeil, Halperin, and MacDonald 2009). As some risk factors influence the vaccination behaviour through both demand and supply channels, Maurer (2009) takes the research a step further and manages to unravel the effects of supply side and demand side factors. Since physicians make health advice based on patient's health conditions and thus create the supplier-induced demand for vaccine, Maurer shows that risk factors of complications like age, chronic conditions, and the physician quality are the key supply-side factors affecting vaccination behaviour. Education and general preventive health behavior are the key demand-side factors. Gender and partnership status also appear important for vaccination demand while employment does not.

Due to limited data on the supply-side factors, this paper will focus on the demand side. Individual demand is influenced by the perceived costs and benefits of vaccination. The cost here refers to vaccination cost that is not restricted to the vaccine itself. It also includes the transportation fees, waiting time and the lost income if one has to take time off work to receive the vaccine. The benefits of vaccination are two-fold. The direct benefits refer to the risks and severity of influenza complications that are prevented by the vaccine; the indirect benefits represent the decreased possibilities of passing the disease to close family members. When the perceived benefits are higher than the costs, vaccination behaviour shall be observed.

To account for the possible costs incurred by taking vaccine besides the vaccine itself, following Zhdanava's work (2013), I use the residency location as a proxy for the transportation fees. Urban areas have more health clinics offering the vaccine and thus it is closer and easier for residents to access than for residents living in rural areas. I also use labour market status to control for the work time that one has to give up to get vaccinated and possible foregone work time that one loses if she is infected. Since the labour market status has two opposite impacts on vaccination demand, no clear sign is expected. As for benefits of vaccination, I include health related variables: age, self-rated health and presence of chronic conditions, as the direct benefits one shall receive from the influenza vaccine; demographic variables like marital status, presence of young children in the household are included to control for indirect benefits. Smoking status and education level are also included here to better capture vaccination behaviour. Smoking status describes an individual’s health attitude, especially towards respiratory health issues while education, a proxy for health literacy, determines the attitude towards vaccines in general and how one handles new health information. Since people with tight budget constraints are less likely to pay for vaccines, income should also be included.

Chapter 4

Data and Description Statistics

I use the first seven cycles of the Canadian Health Household Survey (CCHS) master file to conduct the analysis. The CCHS is a cross-sectional survey that collects information related to health status and health care utilization along with social-economic statuses from the population 12 years of age and over living in the ten provinces and the three territories. Statistics Canada and Health Canada launched this project in 2000, collected information every two years for the first three cycles and then switched to annual collection since 2007. As most provincial program changes take place in 2000s, the first seven cycles, Cycle 1.1 (2000-2001), Cycle 2.1 (2003-2004), Cycle 3.1 (2005-2006), 2007, 2008, 2009, 2010, provides a suitable time period to investigate the effect of the provincial immunization programs.

As the studied population here is pregnant women, non-pregnant women of childbearing age serve the purpose of a control group. I keep the observations of women aged 15-49 in ten provinces in each cycle. Since the influenza vaccine is usually delivered from October to December, I further drop the observations with the interview date between October and December to avoid underestimating the vaccine take-up in the group.[2,3] Then, I pool the cross-sectional data from seven cycles together using normalized survey weights.[4] To distinguish which immunization program is in effect when the person makes their vaccination decisions, I regroup the pooled data into 10 flu seasons according to their interview date.[5] However, three of flu seasons are dropped due to too few observations and hence observations in 7 flu seasons 2000/01, 2002/03, 2004/05, 2006/07, 2007/08, 2008/09 and 2009/10 remain in the sample.[6] The total observations used in the regressions are around 62,600.

[2] Respondents who have not taken the vaccine before the interview during the flu season, thus considered as unvaccinated, might get vaccinated later in the same flu season.
[3] Due to the 2009 H1N1 pandemics, Quebec postponed the delivery of the seasonal influenza vaccine until January 2010 and the vaccine delivery finished in April (Institut National de Santé Publique du Québec 2009). Hence, I further drop the observations in Quebec from January 2010 to April 2010.
[4] Weights in each cycle are adjusted to sum up to one to avoid oversampling and under-sampling problems.
[5] The seven cycles start from September 2000 to 2010 December with some gaps in between due t o the biennial collection method adopted in the first three cycles. The 10 flu seasons are 1999/2000, 2000/01, 2001/02, 2002/03, 2003/04, 2004/05, 2006/07, 2007/08, 2008/09, 2009/10.
[6] Fortunately, the change of provincial immunization programs did not happen in the dropped flu seasons 1999/2000, 2001/02, 2003/04.

The dependent variable is *flu vaccination status* in that flu season. Each cycle collects the respondents' answers to "When was your last seasonal flu shot?" given the respondents have taken a flu shot before. If the answer is "less than a year", the respondents will be considered as actively vaccinated in that flu season.

The key independent variable is *pregnancy status* at time of the interview. Pregnancy status during the flu season would be the most appropriate way to capture the influence of pregnancy status on vaccination. However, the survey does not contain pregnancy status during flu seasons or trimester status at the interview date or during flu seasons. *Pregnant status* is 1 when the respondent reports being pregnant at time of the interview. Around 3.6% of all women in the sample are recorded as pregnant.

Another crucial variable is *provincial program*. Under the time frame of this study, five types of programs are observed. Pregnant women can take the vaccine for free under UIIC or full-coverage program; pregnant women in the third trimester are covered by partial-coverage program; Prince Edward Island charging administration fees only to all residents including pregnant women from 2004 to 2009; and there are programs charging full price to pregnant women. Therefore, five program dummy variables are created: *UIIC*, *Full coverage*, *Partial coverage*, *Administration fees*, *No coverage* with *No coverage* as the default group.

Chronic health conditions affect the probability of contracting influenza and the severity of complications, and hence are directly related to perceived risks of influenza complications. I create a dummy variable *self-rated health* from the CCHS multiple-choice question of how well one sees her health. The variable takes the value of 1 indicating good health if the person answers good, very good or excellent; it takes the value of 0 if the person chooses poor or fair. The NACI recognizes a list of chronic conditions putting people under high risks of influenza-related complications. Unfortunately, the CCHS does not collect the information of all the chronic conditions on the list.[7] I construct a dummy variable *chronic condition* with 1 indicating the survey respondent has been diagnosed with at least one chronic condition that is on the list of the

[7] The CCHS provides information of chronic condition asthma, chronic bronchitis, emphysema, chronic obstructive pulmonology disease, diabetes, heart disease and effects of a stroke or cancer. However, chronic conditions anemia, hemoglobinopathy, renal disease, immunodeficiency and immunosuppression are not included, which are on the NACI recommendation list (NACI 2014).

NACI recommendations. Three dummy variables are created from the smoking status variable, *never smoked, former smoker and current smoker* with *never smoked* as the default group. *Age* and *age*^{2} are also included to capture any non-linear relationship between vaccine take-up decision and age.

Some socio-economics variables are chosen from the survey to further control for the risks and benefits of vaccination. Using the derived variable of labour market status from the survey, I create groups of *not in the labour force*, *part-time* and *full-time* with corresponding dummy variables and *full-time* as the default group. Labour market status has mixed effects on vaccine take-up. It is relatively costly for full-time workers to get vaccinated while they are also the group that benefits most from vaccination (Mullahy 1999). I also categorize observations by their education attainment into four groups: *less than secondary*, *secondary*, *some post-secondary* and *post-secondary* with *some post-secondary* as the default group. *Income* is first adjusted using Consumer Price Index (CPI) data from Statistics Canada, using 2000 as the base year, and then adjusted according to household size and then the log of this value is taken.[8] I include a dummy variable *urban residency*, as a proxy for the accessibility of vaccine, which takes the value of 1 if the respondent lives in an urban area. *Marital status* records if the survey respondent is married/has a common-law partner; *presence of young children* measures the risks of passing influenza to vulnerable children, taking the value of 1 if there is at least one child of aged 5 and below in the household.

Figure 1 demonstrates the influenza vaccine take-up trends of pregnant women and non-pregnant women by flu seasons. Non-pregnant women have higher vaccination rates than pregnant women on average. The take-up trends of both groups exhibit a similar pattern. Overall, there is a slight upward trend with both groups experiencing downturns in the 2002/03 and 2009/2010 flu seasons. The downturns can probably be attributed to the Severe Acute Respirator Syndrome (SARS) outbreak in 2002/03 and the H1N1 influenza pandemics in 2009/10. Pregnant women seem to be more sensitive to the outbreak and pandemics. Their vaccine take-up rate decreases more than non-pregnant women's during 2002/03 and 2009/10. Other than those two flu seasons, the vaccine take-up rate of pregnant women is slowly catching up with non-pregnant women's and it

[8] Household equivalent income=inflation adjusted income/square root of household size.

surpasses non-pregnant women in flu seasons 2008/09 to reach 30%. Figure 2 shows the vaccine take-up rate by pregnant women and non-pregnant women for each province. Ontario has the highest vaccination rate of pregnant and non-pregnant women among all the provinces with Nova Scotia following closely behind. Most provinces witness a higher vaccination rate of non-pregnant women than pregnant women except Newfoundland and Labrador and Manitoba.

Table 2 reports the average vaccine take-up rate for pregnant and non-pregnant women by each program and each covariate considered in the regression.[9] Aligning with the trends shown in Figure 1, non-pregnant women have a higher vaccination rate than pregnant women in every group defined by the health and socio-demographic dummy variables. Among the four programs, the full-coverage program appears to achieve the best outcome of encouraging pregnant women to get vaccinated. The average vaccine take-up rate among pregnant women under the full-coverage program is 32%, which is 18.5 percentage points higher than the no-coverage program, 11.6 percentage points higher than the partial coverage program and 7.4 percentage points higher than UIIC. For non-pregnant women, however, UIIC seems to be the most encouraging program with full-coverage, partial-coverage and no-coverage programs ranking in descending order.

Most of the covariates exhibit the patterns suggested by previous studies. Women with chronic conditions and low self-rated health have a considerably higher propensity to take the vaccine. Smoking appears to be a negative factor, with the lowest vaccination rate among the smokers and the highest vaccination rate among the people who never smoked. Labour market status, however, shows no clear pattern. For non-pregnant women, there is little difference between part-time and not-in-the-labour-force groups while having a full-time job appears to be a discouraging factor. For pregnant women, the not-in-the-labour-force group has the lowest take-up rate while the full-time and part-time groups have similar rates. Both pregnant women and non-pregnant women's take-up rates increase with income. Nonetheless, education shows a nonlinear pattern. For non-pregnant women, the vaccination rate remains at the same level for the first three education groups and experiences a jump for the post-secondary education group. While

[9] The administration-fees-only program is regrouped into no-coverage program to protect the confidentiality of the respondents according to the disclosure rule set by Statistics Canada.

pregnant women with post-secondary education also have the highest propensity to get vaccinated, the secondary and some post-secondary education groups have even lower take-up rates than the less-than-secondary education group. Having a partner, living with children of aged 5 and below and living in an urban area are all associated with a higher vaccination rate for both non-pregnant and pregnant women with the exception of living with young children having no significant effect on non-pregnant women. The summary statistics show some evidence of the impact of the programs and covariates on the vaccination behaviour. Better estimates of the program effects can be obtained using proper econometric methods.

Chapter 5

Empirical Strategy

First I start with a baseline regression with individual determinants only to provide comparison estimates for the regression with immunization programs. The dependent variable Y_{ipt} is a binary outcome indicating if the individual i in province p and flu season t is actively vaccinated. X includes all the health and socio-demographics covariates as defined above: self-rated health, chronic conditions, smoking status with non-smoker as the default group, age, labour market status with full time as the default group, education level with the secondary education as the default group, natural log of adjusted equivalent household income, urban residence, marital status, presence of young children. Provincial fixed effects and time trends are used in equation (5.1).[10] In equation (5.2), I use flu-season fixed effects instead of a time trend to test the sensitivity of the specification and it also serves as a comparable baseline regression for the NACI recommendation effect model introduced below.

$$(5.1)\quad Y_{ipt} = \beta_0 + \beta_1\, Pregnancy_{ipt} + \beta_2\, X_{ipt} + \beta_3\, Prov_p + \alpha * t + u_{ipt}$$

$$(5.2)\quad Y_{ipt} = \beta_0 + \beta_1\, Pregnancy_{ipt} + \beta_2\, X_{ipt} + \beta_3\, Prov_p + \beta_4\, FluSeason_t + u_{ipt}$$

To analyze how well the public react to the NACI recommendations and how strongly the updated health information affects public vaccination, I choose three provinces Ontario, Prince Edward Island and Newfoundland and Labrador, and four flu seasons 2004/05, 2006/07, 2007/08, 2008/09 during which the three provinces experienced the NACI recommendations' change while keeping their own provincial immunization programs constant. During the flu seasons 2004/05-2008/09, Ontario implements UIIC, Prince Edward Island charges administration fees and Newfoundland and Labrador sticks to no-coverage program. The NACI extends the influenza vaccine recommended recipients to include all pregnant women in 2007 (NACI 2007). Therefore, I create the NACI recommendation indicator, taking the value of 1 for the flu season

[10] Regressions with a linear time trend and with a quadratic time trend produce similar results. Here only the regression with a linear time trend is reported.

2007/08 and after, and add it to the baseline regression model with provincial fixed effects and a time trend in equation (5.3).[11]

(5.3) $Y_{ipt} = \beta_0 + \beta_1 Pregnancy_{ipt} + \beta_2 NACI_t + \beta_3 Pregnancy_{ipt} * NACI_t + \beta_4 X_{ipt} + \beta_5 Prov_p + \beta_6 Pregnancy_{ipt} * Prov_p + \alpha * t + u_{ipt}$

To make sure the coefficients of the NACI indicator and the interaction term in the above regression truly capture the causal effect of the NACI recommendations, a pseudo policy should be set up to do a falsification test. The purpose of this analysis is to rule out the possibility that the relationship between the NACI recommendations and the increased vaccine take-up of pregnant women, if observed, is not confounded by unobserved factors. I thus create a pseudo policy dummy variable indicating a counterfactual recommendation change in 2006 instead of 2007. The pseudo policy should have no significant impact on vaccine take-up of pregnant women. Equation (5.4) shows the falsification test regression with pseudo policy variable and its interaction with pregnancy status.

(5.4) $Y_{ipt} = \beta_0 + \beta_1 Pregnancy_{ipt} + \beta_2 PseudoPolicy_t + \beta_3 Pregnancy_{ipt} * PseudoPolicy_t + \beta_4 X_{ipt} + \beta_5 Prov_p + \alpha * t + u_{ipt}$

Finally, to quantify the impact of provincial immunization programs, the provincial immunization program variables enter the regression in equation (5.5), with no-coverage program as the default group. As 2009/2010 is also in the sample, I use flu-season fixed effects instead of a time trend to control for the possible structural break from the 2009 H1N1 pandemic. Since the administration-fee program was only implemented by one province, Prince Edward Island, from 2004-2008, I also try the same regression with the exception of PEI, focusing on the analysis of the other three programs, UIIC, full-coverage and partial-coverage programs.

[11] Flu-season fixed effects cannot be used in the regression because it is perfectly correlated with the NACI recommendation indicator. And judging from the baseline regression results shown in the next chapter, the choice between time trend and flu-season fixed effects has little influence in the regression results.

(5.5) $Y_{ipt} = \beta_0 + \beta_1 Pregnancy_{ipt} + \beta_2 Program_{pt} + \beta_3 Pregancy_{ipt} * Program_{pt} + \beta_4 X_{ipt} + \beta_5 Prov_p + \beta_6 Season_t + u_{ipt}$

Chapter 6

Results

6.1 The Baseline Results

Table 3 reports estimates of the linear probability model in equation (5.1) and (5.2). Its purpose is to identify the important health and socio-demographics factors influencing vaccination. The first column reports the baseline regression with all health and socio-demographics covariates; the second column includes the provincial fixed effects; the third and fourth columns further consider the time effect, and use a time trend and flu-season fixed effects respectively. Although provincial fixed effects cause little change in coefficients of the covariates, all the coefficients are significant at the 1% level. Therefore, there are systematic differences of vaccine take-up between different provinces that are not captured by the first regression. Aligning with the figure 1, the flu-season-fixed effect in column (4) shows the non-linear trend of vaccine take-up across flu seasons.[12] The time trend specification restricts vaccine take-up to follow a certain pattern while flu-season fixed effects allow for structural break.[13] Hence, the baseline regression in column (4) is the most appropriate and will be used to analyze the effect of all covariates.

Pregnancy appears to be a statistically significant predictor effect of vaccination. Pregnant women are 3.85% less likely to take vaccine compared to non-pregnant women of childbearing age, *ceteris paribus*. One possible explanation is that pregnant women are more concerned with vaccine side effects and thus their perceived costs of vaccination are higher than non-pregnant women's. The rest of the covariates demonstrate the expected patterns that are aligned with the descriptive data. Among all the health related factors, presence of a chronic condition is the primary driving force of vaccination. Women with one or more chronic conditions are 13.1% more likely to take the influenza vaccine. Women with poor or fair self-perceived health are 7.1% more inclined to get vaccinated compared to people rating their health good or better. Smoking status, a proxy

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[12] The coefficients of flu-season fixed effects are omitted from the Table 3 and can be provided upon request.

[13] Even though the quadratic form of time trend allows more flexibility, it still establishes certain patterns and is not the most appropriate way to account for the much lower vaccine take-up rate in 2009/10 than other flu seasons.

for health attitude towards respiratory health issues, suggests a clear impact on vaccination. The possibilities of vaccination for current and former smokers are both lower than non-smokers, 4.2% and 1.7% to be specific. Age has have a non-linear effect on vaccination behaviour. With age increasing, the probability of getting vaccinated decreases at a decreasing rate with age reaching the lowest point at age 45. All these estimators are significant at the 1% level except age and the age squared coefficients, which are significant at the 10% and 5% level.

The results for socio-demographic factors also show no surprises. Education, a proxy for health literacy, has a positive effect on encouraging women to immunize. There are 4.5% more women from the post-secondary education group taking flu shots than women from some post-secondary education group. This coefficient is significant at the 1% level. However, there are minor differences of vaccine take-up rates between the lower three education groups and the coefficients are not statistically significant. Despite the mixed effects of labour market status discussed above, the regression results produce a clear and statistically significant coefficient for women who are not in the labour force. They are 4.3% less likely to take the vaccine compared to full-time workers. However, the coefficient of part-time workers is not statistically significant, which means no difference is captured between part-time and full-time workers. These findings match Zhdanava (2013)'s results. A plausible explanation is that female workers are concerned about the foregone income if they are sick with influenza so that their propensity to get vaccinated is higher than for women who are not in the labour force. Income, marital status, presence of young children and urban residency appear to play an insignificant role in vaccination behaviour in the population of women aged 15-49.

6.2 The NACI Regression Results

To test if pregnant women react to newly updated health information about pregnancy during the flu season, i.e. the change of the NACI recommendations, the linear probability model of the NACI regression model in equation (5.3) as well as the falsification test in equation (5.4) are conducted. Only four flu seasons, 2004/05, 2006/07, 2007/08 and 2008/09 and three provinces, Ontario, Newfoundland and Labrador and Prince Edward Island enter the regression. Results are reported in Table 4. The first and second columns report regression results for equation (5.3) with and without two interaction terms respectively, one with pregnancy and the NACI recommendation indicator and the other with pregnancy and three provinces, Ontario Newfoundland and Labrador, Prince Edward Island. The third column reports the falsification test results.

Since the time trend is used instead of flu-season fixed effects in the NACI model to circumvent the multicollinearity problem, the baseline regression with the time trend will be used as the comparison estimators. The estimators of the NACI regression show a similar pattern to the baseline regression except for labour market status. Women who are not in the labour force are reported to be 15% more likely to get vaccinated than in the full-time group in the NACI regression as opposed to 6% less likely to get vaccinated in the baseline regression. Moreover, the estimator of the part-time group changes from statistically insignificant and small in magnitude to -2.3% and significant at the 10% level. One plausible explanation is that the estimator of the NACI regression captures the effect of some factors discouraging full-time workers to get vaccinated, which are specific to the three studied provinces. This calls out for more studies on this topic, isolating the two opposite effects of the labour market status on the vaccination behaviour and identifying the dominant one, to get a better understanding of vaccination behaviour.

Other estimators only change slightly. Pregnancy status appears to have a much smaller effect on vaccination behaviour in the NACI regression model. The estimator is now negligibly small. Self-rated health, presence of a chronic condition, smoker status and age continue to be contributing and statistically significant factors. The secondary education group continues to be less likely to get vaccinated compared to the default education group (some post secondary education group). The coefficient is more statistically significant in the NACI regression than the baseline regression. Income and marital status remain small and insignificant while the estimators of presence of young children and urban residency are significant at the 10% level. However, their magnitudes are negligible.

The estimator of the NACI indicator represents the average effect of the NACI recommendations' change in flu season 2007/08 and thereafter on women aged 15-49. As the new recommendations target pregnant women and encourage them to get vaccinated, a slightly positive estimator is expected. However, the results show that the NACI recommendations appear to be a discouraging effect. Women on average are 5.5% less likely to get vaccinated after the change in the NACI recommendations in 2007. The estimator is significant at the 5% level. What the estimator captures here might be the average take-up differences before and after 2007 that are not captured by the time trend in the model. The baseline regression with flu-season fixed effects shows that flu seasons 2004/05, 2006/07 have higher average take-up rates than flu seasons 2007/08, 2008/09 after controlling for the health and socio-demographics factors. With the time trend failing to capture the non-linear trend pattern in the NACI regression, the NACI indicator picks up this pattern and hence produces a significantly negative estimator.

The second column reports the NACI regression with the interaction terms. The results reveal similar patterns as seen in the baseline regression and the first NACI regression. The key variable of interest is the Difference-in-Difference estimator of the interaction between pregnancy and the NACI indicator. This captures the differential effect of the NACI recommendations, if any, on pregnant women relative to the non-pregnant women of childbearing age. The result shows that the NACI recommendations targeting pregnant women did indeed encourage pregnant women to get vaccinated. The vaccine take-up rate of pregnant women group is 2.0% higher than non-pregnant women cohort after the new NACI recommendations are in place. However, the estimator is only significant at 10% level and it fails to compensate for the negative effect of pregnancy. Therefore, the new NACI recommendations do not generate enough incentive for pregnant women to overcome the obstacles that pregnancy poses.

To ensure this interaction term is not picking up the existing trend in the vaccine take-up of pregnant women, a falsification test is conducted using a counterfactual policy indicator assuming the change happened in 2006. Results are reported in the third column of table 4. As expected, the estimators of health and socio-demographics factors are unaffected by the change. Again the pseudo policy indicator is picking up the difference between the first flu season and the other three flu seasons. The estimator is 0.5% at the 10% significant level, which implies that the first flu season 2004/05 has 0.5% higher take-up ratio than the other three flu seasons. This result matches the baseline results of the flu-season fixed effects. The important point is that the interaction between pseudo policy and pregnancy is very small and statistically insignificant. This result does not refute the idea that the results from the second column indeed capture the casual link between the NACI recommendations' change and the change in the vaccination behaviour of pregnant women.

6.3 The Program Regression Results

Table 5 reports the results for equation (5.5), studying the influence of four types of provincial immunization programs on vaccination behaviour of pregnant women. Since multicollinearity is no longer a problem in the final regression, I go back to using flu-season fixed effects and the baseline regression with flu-season fixed effects as a comparison. The estimators of health and socio-demographics covariates experience even change even less than the NACI regression compared to the baseline regression. The plausible reason is that the program regression and the baseline regression are using the same observations while the NACI regression uses a sub-sample. The estimators undergo no change in significance or sign and only negligible change in magnitude compared to the baseline regression.

The major focus of the study, the four types of programs, appear to have a significant effect on women's vaccination behaviour. Compared to women who reside in the provinces that do not provide any coverage for pregnant women in the flu seasons, the probability of them getting vaccinated in that same flu season is significantly higher, 24.3% more for UIIC, 11.5% for full-coverage programs, 6.9% for partial-coverage programs, and 2.9% for administration-fees-only programs. The difference between the programs can be explained as follows: although the UIIC and full-coverage programs offer free vaccine to pregnant women, the full-coverage program does not cover non-pregnant women. Therefore, the female vaccine take-up rate on average should be lower under the full-coverage program than the UIIC program. As the partial-coverage program only offers free vaccine to pregnant women in the third trimester, the average take-up rate should be even lower. The coefficient of the administration-fees-only program implies that the women's reaction to the monetary costs of vaccine is non-linear. Around one-third reduction in vaccination costs offered by the administration-fees-only program is only associated with a 2.9% increase in vaccine take-up while the elimination of vaccination costs results in a 24.3% increase among women.[14] This suggests that women are much more sensitive to whether they need to pay for the vaccine or not than how much they have to pay for vaccine.

To investigate if pregnant-women-targeted programs play a more important role in encouraging pregnant women specifically to getting vaccinated than UIIC programs, and to capture the potential heterogeneous reactions of pregnant women to different types of programs, the interaction terms of different programs and pregnancy status are included in column (2). The comparison of the results in column (1) and column (2) in Table 5 reveals little change in the common covariates. The estimators of programs now represent the effect on non-pregnant women while the estimators of the interactions represent the additional influence the programs exert on pregnant women. The effect of programs on non-pregnant women possesses the same pattern as in the first program regression, without the interaction. UIIC is still the most encouraging program with full-coverage, partial-coverage and administration-fees-only programs ranking in descending order.

However, the interaction terms depict a different picture. UIIC discourages pregnant women to get vaccinated relative to their non-pregnant cohort by 2.7%. The estimator is only significant at the 10% level and hence this effect is not precisely estimated. The full-coverage program, as expected, have a huge impact on the vaccination behaviour of pregnant women. It increases the vaccine take-up rate of pregnant women 10.4% more than non-pregnant women. The estimator is large in magnitude and significant at the 5% level. The coefficient for the partial-coverage program, however, does not present a clear differential influence on pregnant women. The estimator for the interaction term is only 3.0% and statistically insignificant. However, this does not imply that partial-coverage program is not effective in encouraging vaccination among pregnant women in their third trimester. Firstly, the differential effect that the coefficient captures is averaged across all pregnant women and thus the effect is dampened. Secondly, the pregnancy status is likely to be different

[14] The administration-fees-only program in Prince Edward Island charges around $10 for the influenza vaccine ($10 is suggested by the Medical Society of Prince Edward Island while it is up to doctors how much they want to charge) while the influenza vaccine used to cost $15 for the residences in Prince Edward Island before 2004 (CBC News 2004).

between the flu season when the program is in effect and the interview date when the pregnancy status is recorded. This problem is more prominent for the partial-coverage program than other programs as the trimester status is even more likely to change. The coefficient of the interaction between partial-coverage program and pregnancy status here also captures the program effect on some pregnant women in their first/second trimesters or even some non-pregnant women, which leads to the regression results that are statistically insignificant and small in magnitude.

For future study, variables recording the pregnancy and trimester statuses should be used to more accurately capture the effect of partial-coverage program on pregnant women in the third trimester. With pregnancy associated with a 3.6% lower probability of vaccination, UIIC, full-coverage and partial-coverage programs, compared to no-coverage program, not only offset the negative impact of pregnancy status, but also lead to a higher vaccine take-up rate among pregnant women than non-pregnant women. Overall, compared to no-coverage programs, UIIC enhances the vaccine take-up rate of pregnant women by 21.3%; full-coverage program increases it by 21.5%; partial-coverage program increases it by 7.0%.

Curiously, administration-fees-only program, a universal program also, discourages pregnant women to get vaccinated by 13.4% and the effect is significant at the 1% level. This abnormality might be attributed to the limited sample of the administration-fees-only program. Since the program is only adopted by PEI during 2004-2008, I dropped the observations of PEI and conduct the same regression in column (3) as a robustness check. The results show that the regression is not sensitive to this change. The estimators of programs, interaction term and other covariates have the same sign, magnitude and significance level.

To sum up, UIIC and full-coverage program achieve a great success in promoting vaccination behaviour among pregnant women. Both enhance the vaccine take-up rate of pregnant women by over 21%. Full-coverage program brings the influenza vaccine take-up rate of pregnant women from 3.6% lower to 6.8% higher than the take-up rate of non-pregnant women.

6.4 Limitations of the Study

Due to data limitations, there are significant measurement errors related to the key factor, "pregnancy", that cannot be circumvented. The CCHS survey functions as a camera shot recording the information in one particular frame. The data-collection method of an on-going interview throughout the year causes little problem when the study only uses the factors that are less time-variant. Unfortunately, the pregnancy status used in this study is quite sensitive to the date when the survey is taken. Every year for a considerable part of respondents, there will be up to nine to twelve months' gap between the time when the vaccine and the interview are taken, during which the pregnancy status may change. This jeopardizes the validity and accuracy of the results. Moreover, failing to collect the data of the trimester status makes capturing the effect of the partial-coverage program accurately impossible as the partial-coverage program only targets pregnant women in their third trimester.

There are also some parts of the regression models that future studies can improve on. First of all, this paper focuses on the demand side of vaccination while it has been pointed out that supply side factors, like physician's quality, are also important factors (Maurer 2009). Future studies can attempt to approach this issue from both demand and supply sides and distinguish the supply and demand effect of immunization programs. Secondly, the program regression model might be capturing the effect of the NACI recommendations at the same time. More analysis should be done to isolate the program effect from the NACI recommendation effect and identify the magnitude of the effect of health information and economic incentives. As the information regarding how provinces disseminate the NACI recommendations is unavailable, the issue of the channel through which the newly-updated health information influences public's vaccination behaviour remains unsolved. Finally, the partial-coverage program that targets pregnant women in their second/third trimesters should be investigated with the more up-to-date data of recent flu seasons.

Chapter 7

Conclusions

The paper uses three regressions to analyze the vaccination behaviour of pregnant women in 10 provinces of Canada from 2000-2010. The baseline regression is to identify the important health and socio-economic factors influencing the probability of vaccination for all women; the NACI regression is to capture the effect of the NACI recommendations on vaccination behaviour of pregnant women; the program regression is to quantify and compare the effect of different types of provincial immunization programs on vaccination behaviour of pregnant women.

Baseline results show that pregnant women are 3.8% less likely to get vaccinated compared to their non-pregnant counterparts. This implies pregnant women are facing more intangible barriers. It could be that pregnant women are overly concerned about vaccine safety and worried that it will do harm to their unborn child. The results of the other covariates align with the literature. Presence of a chronic condition is the most influential factor of vaccination behaviour of women in general. Self-rated health, smoking status and age also significantly affect their propensity to get immunized. Among the socio-economic factors, education and labour market status help explain the vaccination behaviour while income, martial status, presence of young children and residence locations have little impact on propensity of immunization for women.

The NACI regression shows that the new NACI recommendations targeting pregnant women have some minor effect. The probability of immunization for pregnant women is 2.1% higher after the new NACI recommendations are in place. However, the effect is not strong enough to help pregnant women overcome the invisible barriers of vaccination they are facing, and to reach or even surpass the vaccination rate of the non-pregnant group. Therefore, the new NACI recommendations do not create enough incentive for pregnant women to overcome the fear of vaccine side effects. However, this does not imply that pregnant women are insensitive to the high risks they are exposed to during the influenza season. It is highly possible that many pregnant women are unaware of the change in the NACI recommendations. Unfortunately, this hypothesis cannot be verified as the information about whether pregnant women are aware of the changes and how the NACI recommendations reach the public in each province are unavailable.

The regression of the impact of provincial immunization programs on the probability of vaccination shows a clear and substantial effect of various programs on the vaccine take-up of pregnant women. Among UIIC, full-coverage program and partial-coverage program, the full-coverage program is the most successful one to encourage pregnant women to get vaccinated. Compared to no-coverage program, both UIIC and full-coverage programs raise the vaccine take-up rate of pregnant women by over 21% in total. However, the result shows a different picture of the differential effects that these two programs have on pregnant women and non-pregnant women. While UIIC does not present a differential effect on the full-coverage program raises the vaccination rate among pregnant women by 10.6% compared to non-pregnant women. The probability of vaccination among non-pregnant women under the full-coverage program only increases by 11.2% compared to the no-coverage program. As healthy non-pregnant women do not belong to the priority group for vaccination, the full-coverage program is more cost-effective than UIIC in the issue of encouraging vaccination of pregnant women. The partial-coverage program, targeting pregnant women in the third trimester, is associated with a 6.8% increase in vaccination rate for all women compared to no-coverage program. It does not produce any significant differential effect on pregnant women. This might be attributed to the fact that the survey records the pregnancy status at the interview date instead of during the flu season. Pregnant women who are in their third trimester at the interview date are mostly likely in their first/second trimesters during the flu seasons and thus unaffected by the program.

To more accurately estimating the effect of publicly funded immunization programs, future study should control for pregnancy status and trimester status during the flu season. A new program covering pregnant women in second/third trimesters is in place in some provinces and requires evaluation. After capturing the effect of programs on the vaccination rate of pregnant women, more research needs to be conduct to evaluate the short-term and long-term health outcomes of maternal immunization on infants, which, according to the fetus origins hypothesis, should be quite significant. This will provide a much deeper understanding of the importance of vaccination of pregnant women.

References

Almond, Douglas. 2006. "Is the 1918 Influenza Pandemic Over? Long-Term Effects of In Utero Influenza Exposure in the Post-1940 U.S. Population." *Journal of Political Economy* 114 (4): 672-712.

Almond, Douglas, and Currie Janet. 2011. "Killing Me Softly: the Fetal Origin Hypothesis." *Journal of Economic Perspectives* 25 (3): 153-172.

Benowitz, Isaac, Daina B. Esposito, Kristina D. Gracey, Eugene D. Shaprio, and Marietta Vázquez. 2010. "Influenza Vaccine Given to Pregnant Women Reduces Hospitalization Due to Influenza in Their Infants." *Clinical Infectious Diseases* 51 (12): 1355-61.

British Columbia Ministry of Health. 2014. "Inactivate influenza (flu) vaccine." September 2014. Vancouver: Government of British Columbia. Accessed May 28, 2015. http://www.healthlinkbc.ca/healthfiles/hfile12d.stm

Dodds, Linda A., Shelly A. McNeil, Deshayne B. Fell, Victoria M. Allen, Ann Coombs, Jeffrey Scott, and Noni MacDonald. 2007. "Impact of Influenza Exposure on Rates of Hospital Admissions and Physician Visits Because of Respiratory Illness among Pregnant Women." *CMAJ* 176 (4): 463–68.

Eick, Angelia A., Timothy M. Uyeki, Alexander Klimov, Henrietta Hall, Raymond Reid, Mathuram Santosham, and Katherine L. O'Brien. 2010. "Maternal Influenza Vaccination and Effect on Influenza Virus Infection in Young Infants." *Arch Pediatr Adolesc Med* 165 (2): 104-11.

Harris, John W. 1919. "Influenza Occurring in Pregnant Women: A Statistical Study of Thirteen Hundred and Fifty Cases." *JAMA* 72 (14): 978-80.

France, Eric K., Renae Smith-Ray, David McClure, Simon Hambidge, Stanley Xu, Kristi Yamasaki, David Shay, Eric Weintraub, Alicia M. Fry, Steve B. Black, Henry R. Shinefield, John P. Mullooly, and Lisa A. Jackson. 2006. "Impact of Maternal Influenza Vaccination during Pregnancy on the Incidence of Acute Respiratory Illness Visits among Infants." *Arch Pediatr Adolesc Med* 160 (12): 1277-83.

Fraser Health. 2007. Influenza vaccine news. October 04, 2007. BC: Accessed May 28, 2015. http://www.fraserhealth.ca/your-health/mhoupdates/archive/2007-archive/influenza-vaccine-news

"'Free' flu shots may cost $10 or more." *CBC.ca.* September 16, 2004. http://www.cbc.ca/news/canada/prince-edward-island/free-flu-shots-may-cost-10-or-more-1.479743

Freeman, Donald W., and Barno Alex. 1959. "Deaths from Asian Influenza Associated with Pregnancy." *Am J Obstet Gynecol* 78: 1172-5.

Institut National de Santé Publique du Québec. 2009. *Enquête québécoise sur la vaccination contre la grippe A(H1N1), la grippe saisonnière et le pneumocoque.* Québec: Institut National de Santé Publique du Québec. Montreal: Institut National de Santé Publique du Québec. Accessed May 10, 2015. https://www.inspq.qc.ca/pdf/publications/1309_EnqueteVaccinGrippeAH1N1SaisonPneumocoque.pdf

Johansen, Helen, Kathy Nguyen, Luling Mao, Richard Marcoux, Ru-Nie Gao, and Cyril Nair. 2004. "Influenza Vaccination*."* Health Reports (Statistics Canada, Catalogue 82-003) 15 (2): 33-43.

Lindsay, Lisa, Lisa A. Jackson, David A. Savitz, David J. Weber, Gary G. Koch, Lan Kong, and Harry A. Guess. 2006. "Community Influenza Activity and Risk of Acute Influenza-like Illness Episodes Among Healthy Unvaccinated Pregnant and Postpartum Women." *Am J Epidemiol* 163 (9): 838–48.

Mak, Tippi K., Punam Mangtani, Jane Leese, John M. Watson, and Dina Pfeifer. 2008. "Influenza Vaccination in Pregnancy: Current Evidence and Selected National Policies." *The lancet Infectious Disease* 8 (1): 44-52.

Maurer, Jürgen. 2009. "Who Has a Clue to Preventing the Flu? Unravelling Supply and Demand Effects on the Take-up of Influenza Vaccinations." *Journal of Health Economics* 28 (3): 704-717.

McNeil, Shelly A., Beth Halperin, and Noni MacDonald. 2009. "Influenza in Pregnancy: the Case for Prevention." *Adv Exp Med Biol* 634: 161-83.

McNeil, Shelly A., Linda A. Dodds, Deshayne B. Fell, Victoria M. Allen, Beth A. Halperin, Mark C Steinhoff, and Noni E. MacDonald. 2011. "Effect of respiratory hospitalization during pregnancy on infant outcomes." *AJOG* 204 (Supplement 6): S54-57.

Mullahy, John. 1999. "It'll Only Hurt a Second? Microeconomic Determinants of Who Gets Flu Shots." *Health Economics* 8 (1): 9-24.

Mullooly, John P., William H. Barker, and Timothy F. Nolan Jr. 1986. "Risk of Acute Respiratory Disease among Pregnant Women During Influenza A Epidemics." *Public Health Rep* 101: 205–11.

National Advisory Committee on Immunization (NACI). 2006. *Statement On Influenza Vaccination For the 2006-2007 Season*. Canadian Communicable Disease Report 32 (ACS-7). Ottawa, June.

National Advisory Committee on Immunization (NACI). 2007. *Statement On Influenza Vaccination For the 2007-2008 Season*. Canadian Communicable Disease Report 33 (ACS-7). Ottawa, July.

National Advisory Committee on Immunization (NACI). 2014. "Statement On Influenza Vaccination For 2014-2015." Ottawa. http://www.phac-aspc.gc.ca/naci-ccni/flu-grippe-eng.php.

Newfoundland and Labrador Health and Community Services. 2009. "Seasonal Influenza Vaccination Program to Begin in October." St. John's: Newfoundland and Labrador Health and Community Services. Accessed May 1, 2015. http://www.releases.gov.nl.ca/releases/2009/health/0925n08.htm

Newfoundland and Labrador Health and Community Services. 2010. "Residents Encouraged to Receive Seasonal Influenza Vaccination." St. John's: Newfoundland and Labrador Health and Community Services. Accessed May 1, 2015. http://www.releases.gov.nl.ca/releases/2010/health/1019n03.htm

Newfoundland and Labrador Health and Community Services. 2013. "Residents Encouraged to Receive the Flu Shot." St. John's: Newfoundland and Labrador Health and Community Services. Accessed May 1, 2015. http://www.releases.gov.nl.ca/releases/2013/health/1119n04.htm

Newfoundland and Labrador Health and Community Services. 2014. "Promoting Healthy Communities Through Prevention." St. John's: Newfoundland and Labrador Health and Community Services. Accessed May 1, 2015. http://www.releases.gov.nl.ca/releases/2014/health/1219n05.aspx

Pierce, Matthis, Jennifer J. Kurinczuk, Patsy Spark, Peter Brocklehurst, and Marian Knight. 2011. "Perinatal Outcomes after Maternal 2009/H1N1 Infection: National Cohort Study." *BMJ* 342: d3214.

Poehling, Katherine A., Kathryn M. Edwards, Geoffrey A. Weinberg, Peter Szilagyi, Mary Allen Staat, Marika K. Iwane, Carolyn B. Bridges, Carlos G. Grijalva, Yuwei Zhu, David I. Bernstein, Guillermo Herrera, Dean Erdman, Caroline B. Hall, Ranee Seither, and Marie R. Griffin. 2006. "The underrecognized burden of influenza in young children." *N Engl J Med* 355: 31–40.

Poehling, Katherine A., Peter G. Szilagyi, Mary A. Staat, Beverly M. Snively, Daniel C. Payne, Carolyn B. Bridges, Susan Y. Chu, Laney S. Light, Mila M. Prill, Lyn Finelli, Marie R. Griffin, and Kathryn M. Edwards. 2011. "Impact of maternal immunization on influenza hospitalizations in infants." *Obstet Gynecol* 204 (Supplement 6): S141-8.

Public Health Agency of Canada (PHAC). 2012. Vaccine coverage amongst adult Canadians: Results from the 2012 adult National Immunization Coverage (aNIC) survey. Ottawa: PHAC. Accessed June 3, 2015. http://www.phac-aspc.gc.ca/im/nics-enva/vcac-cvac-eng.php

Public Health Agency of Canada (PHAC). 2015. "Public Funding for Influenza Vaccination by Provincy/Territory (as of March, 2015)." Ottawa: PHAC. Accessed April 28, 2015. http://www.phac-aspc.gc.ca/im/ptimprog-progimpt/fluvacc-eng.php

Rasmussen, Sonja A., Denise J. Jamieson, and Joseph S. Bresee. 2008. "Pandemic influenza and pregnant women." *Emerg Infect Dis* 14 (1): 95-100.

Santé et Services Sociaux Québec. 2010. "Avoid complications from the seasonal flu. Get vaccinated!" Montreal: Santé et Services Sociaux Québec. Accessed June 5, 2015. http://publications.msss.gouv.qc.ca/acrobat/f/documentation/2010/10-007-02A.pdf

Saskatchewan Ministry of Health. 2012. "Saskatchewan Immunization Manual." Regina: Saskatchewan Ministry of Health. Accessed May 10, 2015. http://www.ehealthsask.ca/services/manuals/Documents/sim-chapter1.pdf

Schanzer, Dena L, Joanne M. Langley, and Theresa W.S. Tam. 2007. "Influenza-attributed hospitalization rates among pregnant women in Canada 1994–2000." *JOGC* 29 (8): 622–629.

Siston Alicia M., Sonja A. Rasmussen, Margaret A. Honein, Alicia M. Fry, Katherine Seib, William M. Callaghan, Janice Louie, Timothy J. Doyle, Molly Crockett, Ruth Lynfield, Zack Moore, Caleb Wiedeman, Madhu Anand, Laura Tabony, Carrie F. Nielsen, Kirsten Waller, Shannon Page, Jeannie M. Thompson, Catherine Avery, Chasisity Brown Springs, Timothy Jones, Jennifer L. Williams, Kim Newsome, Lyn Finelli, and Denise J. Jamieson. 2010. "Pandemic 2009 Influenza A(H1N1) Virus Illness Among Pregnant Women in the United States." *JAMA* 303 (15): 1517-1525.

Statistics Canada. 2000–2010. "Canadian Community Health Survey (CCHS) Cycle 1.1, 2.1, 3.1, 2007, 2008, 2009, 2010: master files." Statistics Canada Health Statistics Division. Ottawa.

Steinhoff, Mark C., Saad B. Omer, Eliza Roy, Shams El Arifeen, Rubhana Raqib, Caitlin Dodd, Robert F. Breiman, and K. Zaman. 2012. "Neonatal outcomes after influenza immunization during pregnancy: a randomized controlled trial." *Candian Medical Association Journal* 184 (6): 645-653.

Tamma, Pranita D., Kevin A. Ault, Carlos del Rio, Mark C. Steinhoff, Neal A. Halsey, and Saad B. Omer. 2009. "Safety of influenza vaccination during pregnancy." *American Journal of Obstetrics and Gynecology* 201 (6): 547-552.

Tong, Agnes, Anne Biringer, Marianna Ofner-Agostini, Ross Upshur, and Allison McGeer. 2008. "A Cross-sectional Study of Maternity Care Providers' and Women's Knowledge." *Journal of Obstet Gynaecol Can* 30 (5): 404-410.

Ward, Courtney J. 2014. "Influenza Vaccination Campaigns: Is an Ounce of Prevention Worth a Pound of Cure?" *American Economic Journal: Applied Economics* 6 (1): 38-72.

World Health Organization (WHO). 2012. "Vaccines against influenza. WHO position paper." *Weekly Epidemiological Record* 87 (47): 461-476.

Zaman K., Eliza Roy, Shames E. Arifeen, Mahbubur Rahman, Rubhana Raqib, Emily Wilson, Saad B. Omer, Nigar S. Shahid, Robert F. Breiman, and Mark C. Steinhoff. 2008. "Effectiveness of maternal influenza immunization in mothers and infants." *N Engl J Med* 359 (15): 1555-64.

Zhdanava, Maryia. 2013. "Correlates of Seasonal Flu Vaccination in Canada: Demographics, Epidemics, and Vaccination Program Design." MA thesis, Dalhousie University.

Appendix A

Tables and Figures

Table 1: Summary of Provincial Influenza Immunization Programs 2004/05-2014/15

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
ON	UIIC	UIIC	UIIC	UIIC	UIIC	UIIC	UIIC	UIIC	UIIC	UIIC	UIIC
PEI	Admin fee	Admin fee	Admin fee	Admin fee	Admin fee	Targeted	Targeted	Targeted	Targeted	Targeted	Targeted
AB			3rd only	Targeted	Targeted	UIIC	UIIC	UIIC	UIIC	UIIC	UIIC
MB NS SK				Targeted	Targeted	Targeted	UIIC	UIIC	UIIC	UIIC	UIIC
NB				Targeted	Targeted	Targeted	Targeted	Targeted	Targeted	Targeted	Targeted
NL							Targeted	Targeted	Targeted	Targeted	UIIC
QB							2nd/3rd	2nd/3rd	2nd/3rd	2nd/3rd	2nd/3rd
BC				3rd only	3rd only	3rd only	3rd only	3rd only	3rd only	3rd only	Targeted

Note: Except Ontario, there is no coverage over pregnant women in other provinces before 2004

UIIC: Universal Influenza Immunization Campaign

Targeted: The immunization programs that offer free vaccine to all pregnant women

2nd/3rd: The immunization programs that offer free vaccine to pregnant women in their second/third trimesters

3rd: The immunization programs that offer free vaccine to pregnant women in the third trimester

Admin fee: PEI started to charge residents administration fees for vaccine. It was removed in 2009 for pregnant women

Table 2: Influenza Take-up by Programs and Health and Socio-demographics, Average Across All Flu Seasons and All Provinces (Table continues on the next page)

	Non-pregnant women	Pregnant women
No-coverage program	0.175	0.135
	(0.002)	(0.008)
Partial-coverage program	0.209	0.204
	(0.004)	(0.021)
Full-coverage program	0.279	0.320
	(0.005)	(0.027)
UIIC	0.320	0.246
	(0.002)	(0.012)
Chronic condition	0.369	0.246
	(0.004)	(0.023)
No chronic condition	0.235	0.204
	(0.002)	(0.008)
SRH: poor or fair	0.320	0.273
	(0.005)	(0.038)
SRH: excellent, very good, good	0.241	0.198
	(0.001)	(0.007)
Never smoked	0.265	0.216
	(0.002)	(0.011)
Former smoker	0.247	0.189
	(0.002)	(0.010)
Smoker	0.212	0.182
	(0.002)	(0.016)
Works full-time	0.234	0.204
	(0.003)	(0.017)
Works part-time	0.255	0.206
	(0.002)	(0.009)
Not in the labour force	0.251	0.196
	(0.003)	(0.015)
Income < 30K	0.224	0.153
	(0.002)	(0.011)
30K < Income < 50K	0.261	0.230
	(0.003)	(0.014)
Income > 50K	0.287	0.243
	(0.004)	(0.016)
Less then secondary	0.212	0.186
	(0.003)	(0.020)
Secondary	0.216	0.161
	(0.004)	(0.016)
Some postsecondary	0.212	0.154
	(0.004)	(0.023)
Postsecondary graduation	0.269	0.213
	(0.002)	(0.008)
Has a partner	0.259	0.205
	(0.002)	(0.007)
No partner	0.231	0.170
	(0.002)	(0.015)
Lives with children <5 years	0.247	0.221
	(0.003)	(0.010)
No children <5 years in household	0.246	0.183
	(0.002)	(0.009)

Table 2: Continued. Influenza Take-up by Programs and Health and Socio-demographics, Average Across All Flu Seasons and All Provinces

	Non-pregnant women	Pregnant women
Urban residence	0.251	0.203
	(0.002)	(0.008)
Rural residence	0.225	0.189
	(0.003)	(0.013)
Full sample obs.	60,426	2,171

Notes: Statistics are calculated using the master files of the CCHS Cycles 1.1, 2.1, 3.1, 2007, 2008, 2009, and 2010. Results are weighted using normalized survey weights. Standard errors are presented in parenthesis. The administration-fees-only program is regrouped into no-coverage program to protect the confidentiality of the respondents according to the disclosure rule set by Statistics Canada.

Table 3: The Baseline Linear Probability Estimates of Vaccination Probability on Pregnant Status and Individual Health and Socio-demographics Variables (Table continues on the next page)

VARIABLES	(1) With all covariates	(2) With provincial fixed-effect	(3) With provincial fixed-effect and time trend	(4) With seasonal fixed-effect and time trend
Pregnancy	-0.0385***	-0.0380***	-0.0389***	-0.0385***
	[0.00927]	[0.00903]	[0.00831]	[0.00756]
SRH	-0.0828***	-0.0719***	-0.0715***	-0.0710***
	[0.00951]	[0.00904]	[0.00872]	[0.00891]
Chronic conditions	0.132***	0.130***	0.131***	0.131***
	[0.00735]	[0.00666]	[0.00663]	[0.00685]
Current smoker	-0.0575***	-0.0447***	-0.0423***	-0.0419***
	[0.00544]	[0.00288]	[0.00282]	[0.00275]
Former smoker	-0.0312***	-0.0184***	-0.0168***	-0.0173***
	[0.00281]	[0.00224]	[0.00236]	[0.00236]
Age	-0.00786*	-0.00855**	-0.00835*	-0.00767*
	[0.00419]	[0.00346]	[0.00370]	[0.00387]
Age^2	0.000173**	0.000181***	0.000179**	0.000172**
	[6.29e-05]	[5.26e-05]	[5.54e-05]	[5.72e-05]
Less than secondary	-0.0145*	-0.0101	-0.0117	-0.0123
	[0.00778]	[0.00823]	[0.00898]	[0.00916]
Secondary	-0.00967	-0.0153*	-0.0147	-0.0126
	[0.00892]	[0.00819]	[0.00896]	[0.00835]
Post-secondary	0.0394***	0.0417***	0.0430***	0.0454***
	[0.00391]	[0.00315]	[0.00392]	[0.00359]
Not in the labour force	-0.0751***	-0.0689***	-0.0596***	-0.0426***
	[0.00820]	[0.00940]	[0.00755]	[0.00994]
Part time	-0.00446	-0.00807	-0.00612	-0.00463
	[0.00897]	[0.00669]	[0.00694]	[0.00669]
Natural log of income	0.0230**	0.0159	0.0150	0.0151
	[0.00927]	[0.00919]	[0.00838]	[0.00847]
Have a partner	-0.000192	0.00167	0.00242	0.00198
	[0.00480]	[0.00501]	[0.00471]	[0.00487]
Have a young child	0.0316*	0.0273	0.0267	0.0269
	[0.0170]	[0.0171]	[0.0164]	[0.0164]
Urban residence	0.0229**	0.0119	0.0118	0.0127
	[0.00894]	[0.00884]	[0.00871]	[0.00863]
Time trend			0.00484	
			[0.00370]	
Flu-season fixed effects	No	No	No	Yes
Provincial fixed effects	No	Yes	Yes	Yes
Constant	0.212	0.151	0.131	0.102
	[0.139]	[0.0958]	[0.110]	[0.110]

Table 3: Continued. The Baseline Linear Probability Estimates of Vaccination Probability on Pregnant Status and Individual Health and Socio-demographics Variables

	(1)	(2)	(3)	(4)
VARIABLES	With all covariates	With provincial fixed-effect	With provincial fixed-effect and time trend	With seasonal fixed-effect and time trend
Observations	62,597	62,597	62,597	62,597
R-squared	0.031	0.053	0.054	0.057

Notes: Dependent variable is Flu Vaccination Status. The table reports coefficients from a linear probability model. Statistics are calculated using the master files of the CCHS Cycles 1.1, 2.1, 3.1, 2007, 2008, 2009, and 2010. Results are weighted using normalized survey weights. Clustered standard errors are presented in parenthesis.

***Significant at the 1% level.

**Significant at the 5% level.

*Significant at the 10% level.

Table 4: The Linear Probability Estimates of Vaccination Probability on Pregnant Status, NACI Recommendations and Individual Health and Socio-demographics Variables

(Table continues on the next page)

	(1)	(2)	(3)
VARIABLES	NACI recommendation	NACI with interaction	Pseudo policy with interaction
Pregnancy	-0.0201	-0.0364***	-0.0235**
	[0.00760]	[0.00186]	[0.00355]
NACI indicator	-0.0550**	-0.0555**	
	[0.00692]	[0.00716]	
Pregnancy*NACI indicator		0.0202*	
		[0.00581]	
Pseudo policy indicator			-0.00469*
			[0.00138]
Pregnancy*pseudo policy			-0.00634
			[0.00217]
SRH	-0.0690***	-0.0689***	-0.0687***
	[0.00241]	[0.00247]	[0.00245]
Chronic conditions	0.119***	0.119***	0.119***
	[0.00140]	[0.00132]	[0.00128]
Current smoker	-0.0381***	-0.0382***	-0.0377***
	[0.00191]	[0.00201]	[0.00192]
Former smoker	-0.0376**	-0.0377**	-0.0375**
	[0.00525]	[0.00510]	[0.00506]
Age	-0.0141***	-0.0142***	-0.0143***
	[0.000629]	[0.000534]	[0.000542]
Age^2	0.000267***	0.000268***	0.000270***
	[1.60e-05]	[1.44e-05]	[1.46e-05]
Less than secondary	0.00950	0.00941	0.00909
	[0.00657]	[0.00667]	[0.00675]
Secondary	-0.0383*	-0.0384*	-0.0378*
	[0.0108]	[0.0109]	[0.0107]
Post-secondary	0.0534**	0.0535**	0.0543**
	[0.00652]	[0.00679]	[0.00649]
Not in the labour force	0.150***	0.149***	0.149***
	[0.00993]	[0.00965]	[0.00961]
Part time	-0.0228*	-0.0227*	-0.0226*
	[0.00538]	[0.00539]	[0.00535]
Natural log of Income	-0.00657	-0.00654	-0.00645
	[0.00242]	[0.00239]	[0.00243]
Have a partner	0.0108	0.0108	0.0114
	[0.00414]	[0.00424]	[0.00418]

Table 4: Continued. The Linear Probability Estimates of Vaccination Probability on Pregnant Status, NACI Recommendations and Individual Health and Socio-demographics Variables

	(1)	(2)	(3)
VARIABLES	NACI recommendation	NACI with interaction	Pseudo policy with interaction
Have a young child	0.00425*	0.00457*	0.00445*
	[0.00145]	[0.00118]	[0.00114]
Urban residence	0.00578*	0.00556**	0.00532*
	[0.00135]	[0.00122]	[0.00140]
NL	-0.153***	-0.160***	-0.160***
	[0.000747]	[0.000804]	[0.000942]
PEI	-0.128***	-0.123***	-0.122***
	[0.000574]	[0.000497]	[0.000528]
Pregnancy*NL		0.180***	0.183***
		[0.000934]	[0.00129]
Pregnancy*PEI		-0.119***	-0.127***
		[0.000841]	[0.00200]
Time trend	-0.00108	-0.00121	-0.0149**
	[0.00180]	[0.00174]	[0.00303]
Constant	0.591***	0.593***	0.648***
	[0.0385]	[0.0365]	[0.0422]
Observations	12,895	12,895	12,895
R-squared	0.033	0.034	0.033

Notes: Dependent variable is Flu Vaccination Status. The table reports coefficients from a linear probability model. Statistics are calculated using the master files of the CCHS Cycles 1.1, 2.1, 3.1, 2007, 2008, 2009, and 2010. Results are weighted using normalized survey weights. Clustered standard errors are presented in parenthesis.

***Significant at the 1% level.
**Significant at the 5% level.
*Significant at the 10% level.

Table 5: The Linear Probability Estimates of Vaccination Probability on Pregnant Status, Provincial Immunization Programs and Individual Health and Socio-demographics Variables (Table continues on the next page)

VARIABLES	(1) Basic program effect	(2) Program effect with interaction	(3) Program effect with interaction (Exclude PEI)
Pregnancy	-0.0382***	-0.0364**	-0.0359*
	[0.00752]	[0.0161]	[0.0161]
UIIC	0.243***	0.244***	0.244***
	[0.0398]	[0.0396]	[0.0397]
Full-coverage program	0.115***	0.111***	0.112***
	[0.0154]	[0.0146]	[0.0147]
Partial-coverage program	0.0686***	0.0674***	0.0678***
	[0.0155]	[0.0147]	[0.0145]
Admin-fees-only program	0.0285***	0.0351***	
	[0.00707]	[0.00743]	
Pregnancy*UIIC		-0.0266*	-0.0268*
		[0.0130]	[0.0130]
Pregnancy*Full coverage		0.104**	0.106**
		[0.0423]	[0.0439]
Pregnancy*Partial coverage		0.0299	0.0298
		[0.0306]	[0.0309]
Pregnancy*Admin-fees-only		-0.134***	
		[0.0163]	
SRH	-0.0688***	-0.0688***	-0.0696***
	[0.00906]	[0.00907]	[0.00906]
Chronic conditions	0.131***	0.131***	0.131***
	[0.00674]	[0.00679]	[0.00671]
Current smoker	-0.0430***	-0.0430***	-0.0426***
	[0.00292]	[0.00290]	[0.00279]
Former smoker	-0.0180***	-0.0181***	-0.0175***
	[0.00232]	[0.00231]	[0.00218]
Age	-0.00756*	-0.00757*	-0.00756*
	[0.00385]	[0.00383]	[0.00380]
Age^2	0.000171**	0.000171**	0.000171**
	[5.69e-05]	[5.67e-05]	[5.63e-05]
Less than secondary	-0.0127	-0.0127	-0.0131
	[0.00997]	[0.00994]	[0.00994]
Secondary	-0.0126	-0.0127	-0.0123
	[0.00826]	[0.00823]	[0.00835]
Post-secondary	0.0446***	0.0446***	0.0440***
	[0.00380]	[0.00377]	[0.00391]
Not in the labour force	-0.0433***	-0.0434***	-0.0432***
	[0.0100]	[0.0101]	[0.0102]

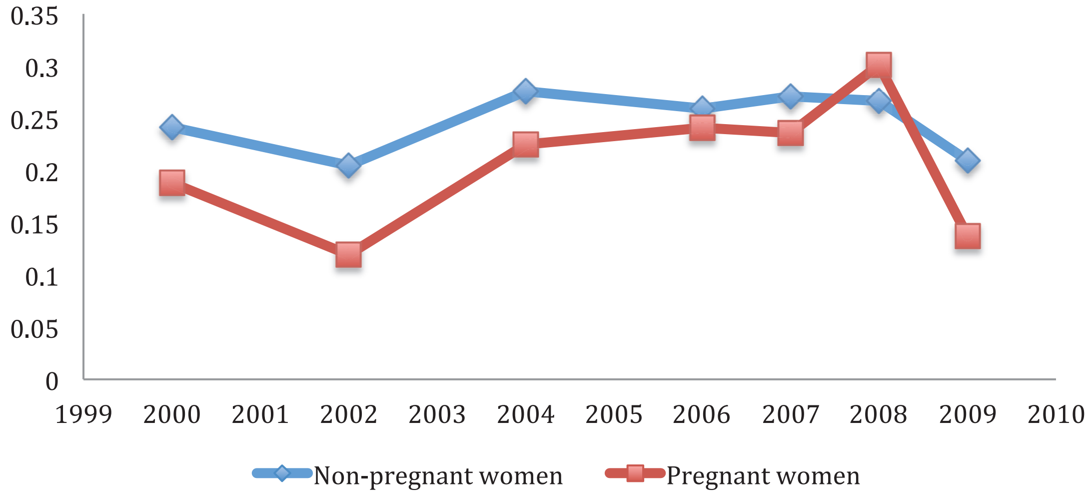
Table 5: Continued. The Linear Probability Estimates of Vaccination Probability on Pregnant Status, Provincial Immunization Programs and Individual Health and Socio-demographics Variables

VARIABLES	(1) Basic program effect	(2) Program effect with interaction	(3) Program effect with interaction (Exclude PEI)
Part time	-0.00404	-0.00416	-0.00327
	[0.00673]	[0.00666]	[0.00669]
Natural log of income	0.0139	0.0139	0.0140
	[0.00869]	[0.00869]	[0.00862]
Have a partner	0.00156	0.00161	0.00162
	[0.00478]	[0.00482]	[0.00480]
Have a young child	0.0267	0.0267	0.0258
	[0.0167]	[0.0168]	[0.0167]
Urban residence	0.0121	0.0122	0.0125
	[0.00863]	[0.00860]	[0.00866]
Flu-season fixed effects	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes
Constant	0.116	0.116	0.114
	[0.106]	[0.105]	[0.105]
Observations	62,597	62,597	61,310
R-squared	0.060	0.060	0.061

Notes: Dependent variable is Flu Vaccination Status. The table reports coefficients from a linear probability model. Statistics are calculated using the master files of the CCHS Cycles 1.1, 2.1, 3.1, 2007, 2008, 2009, and 2010. Results are weighted using normalized survey weights. Clustered standard errors are in parenthesis.

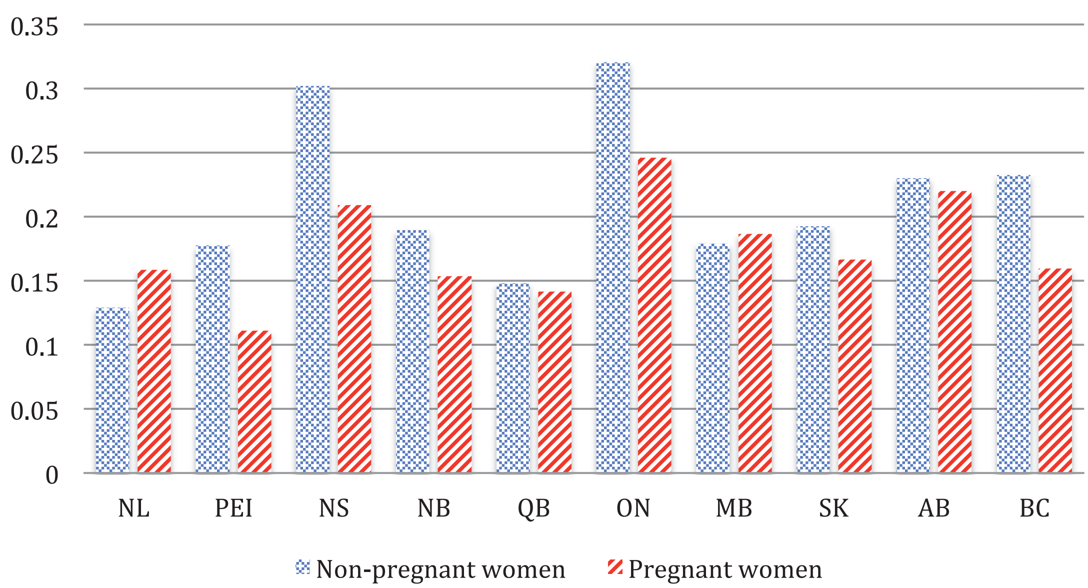
***Significant at the 1% level.
**Significant at the 5% level.
*Significant at the 10% level.

Figure 1: Influenza Take-up Rate of Pregnant and Non-pregnant Women, by Flu Seasons



Notes: Y-axis plots the proportion of respondents in pregnant and non-pregnant groups who were actively vaccinated in different flu seasons based on the master files of the CCHS Cycles 1.1, 2.1, 3.1, 2007, 2008, 2009 and 2010. Normalized survey weights are adopted.

Figure 2: Influenza Take-up Rate of Pregnant and Non-pregnant Women, by Province



Notes: Y-axis plots the proportion of respondents in pregnant and non-pregnant groups who were actively vaccinated in different provinces based on the master files of the CCHS Cycles 1.1, 2.1, 3.1, 2007, 2008, 2009 and 2010. Normalized survey weights are adopted.