

# Influenza-Attributed Hospitalization Rates Among Pregnant Women in Canada 1994–2000

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## Abstract

**Background:** Although it is recommended that pregnant women at risk for influenza complications receive influenza vaccine, it is not clear if healthy pregnant women are at increased risk for adverse outcomes. We aimed to estimate the rate of hospitalization attributable to influenza for healthy pregnant women and for those with known co-morbidities.

**Methods:** Hospital admission records of women admitted from 1994 to 2000 with a respiratory condition during pregnancy were extracted from the hospitalization database (Canadian Institute of Health Information). Admissions for childbirth were excluded. Weekly admissions, stratified by the presence of co-morbid conditions, were modelled as a function of viral activity, seasonality, trend, and holiday effects using Poisson regression with proxies for influenza and other viral activity developed previously for similar age-specific models of influenza-attributed hospital admissions.

**Results:** Approximately 300 hospitalizations of pregnant women per year were attributed to influenza, of which 140 were in women with co-morbidities. This hospitalization rate corresponds to 150 (95% CI 140–170) hospitalizations per 100 000 pregnant women per year. An estimated 1 in 1000 healthy pregnant women were hospitalized due to influenza per year. Asthma was the most important risk factor, accounting for an estimated 450 (95% CI 300–600) admissions per 100 000 pregnant women. Admission rates in pregnant women were relatively constant across multiple influenza seasons of varying severity among older adults. During the four weeks of peak influenza activity, 60% of respiratory-related admissions of otherwise healthy pregnant women could be attributed to influenza.

**Conclusion:** Healthy pregnant Canadian women have consistently higher rates of hospital admission attributable to influenza infection than their non-pregnant peers. The admission rate for healthy pregnant women corresponds to the rate for men and women aged 65 to 69 years, which suggests that this population may benefit from annual influenza immunization.

**Key Words:** Influenza, hospitalization, pregnancy, respiratory infection, immunization

Competing Interests: None declared.

Received on February 7, 2007

Accepted on April 12, 2007

## Résumé

**Contexte :** Bien qu'il soit recommandé aux femmes enceintes courant des risques de complications associées à l'influenza de chercher à obtenir une vaccination contre l'influenza, nous ne savons pas si cette vaccination entraîne une hausse du risque d'issues indésirables chez les femmes enceintes en santé. Nous avons pour but d'estimer le taux d'hospitalisation attribuable à l'influenza chez les femmes enceintes en santé et chez celles qui présentaient des comorbidités connues.

**Méthodes :** Les dossiers d'hospitalisation des femmes hospitalisées entre 1994 et 2000 en raison d'une pathologie respiratoire au cours de la grossesse ont été extraits de la base de données sur l'hospitalisation (Institut canadien d'information sur la santé). Les hospitalisations étant motivées par l'accouchement ont été écartées. Les hospitalisations hebdomadaires, stratifiées en fonction de la présence de pathologies comorbides, ont été modélisées sous forme de fonction des effets de l'activité virale, de la saisonnalité, de la tendance et des jours fériés au moyen d'une régression de Poisson, laquelle faisait appel à des valeurs substitutives pour l'influenza et les autres activités virales ayant déjà été élaborées pour des modèles par âge semblables en ce qui concerne les hospitalisations attribuables à l'influenza.

**Résultats :** Près de 300 hospitalisations de femmes enceintes par année ont été attribuées à l'influenza; la présence de comorbidités a été constatée chez 140 de ces hospitalisations. Ce taux d'hospitalisation correspond à 150 (IC à 95 %, 140–170) hospitalisations par 100 000 femmes enceintes par année. On estime qu'une femme enceinte en santé sur 1 000 a été hospitalisée en raison de l'influenza par année. L'asthme constituait le facteur de risque le plus important, étant à l'origine de près de 450 (IC à 95 %, 300–600) hospitalisations par 100 000 femmes enceintes. Les taux d'hospitalisation chez les femmes enceintes ont été relativement constants au fil de multiples saisons d'influenza de gravité variable chez les personnes âgées. Au cours des quatre semaines d'activité maximale de l'influenza, 60 % des hospitalisations de femmes enceintes autrement en bonne santé étant associées à des problèmes respiratoires pouvaient être attribuées à l'influenza.

**Conclusion :** Les Canadiennes enceintes en santé présentent invariablement des taux plus élevés d'hospitalisation attribuable à une infection à l'influenza que leurs homologues n'étant pas enceintes. Le taux d'hospitalisation des femmes enceintes en santé correspond à celui des hommes et des femmes dont l'âge se situe entre 65 et 69 ans, ce qui laisse entendre que cette population pourrait tirer avantage d'une immunisation annuelle contre l'influenza.

J Obstet Gynaecol Can 2007;29(8):622–629

## INTRODUCTION

Pregnancy leads to physiological changes in respiratory function resulting from progesterone-induced hypoventilation, altered chest size, edematous respiratory mucosa, and a physiological anemia.<sup>1</sup> Although increased maternal morbidity and mortality have been observed in influenza pandemics,<sup>2</sup> the burden associated with seasonal influenza in healthy pregnant women is less clear.<sup>3,4</sup> The National Advisory Committee on Immunization in Canada recommends immunization for pregnant women who have conditions that increase the risk of complications and for those who will be caregivers of infants under 24 months of age during the influenza season, but only encourages immunization of pregnant women who are healthy.<sup>5</sup> By contrast, the Advisory Committee on Immunization Practices in the United States recommends universal influenza vaccination for women who will be pregnant during the influenza season.<sup>6,7</sup> One US study estimates the influenza-attributable hospitalization rate in the third trimester of pregnancy at 250 per 100 000 healthy women,<sup>8</sup> a rate similar to that estimated for adults aged 75 to 79 years in Canada.<sup>9</sup>

We sought to estimate the number of influenza-attributed hospital admissions in pregnant Canadian women with and without comorbidities that increase the risk of influenza-related complications on the basis of discharge records from our national hospital morbidity database (Canadian Institute of Health Information) and adapting models used in previous work.<sup>9–11</sup>

## METHODS

### Sources of Data

Records of all patients discharged from hospital in Canada since April of 1994 are maintained in the CIHI patient-specific Hospital Morbidity Database.<sup>12</sup> Each discharge record identifies the primary diagnosis and up to 15

additional diagnostic fields, which were coded to ICD-9-CM<sup>13</sup> over the study period.

Hospital discharge records with a primary respiratory diagnosis (ICD-9 460–519) during pregnancy, or a pregnancy-related code with a secondary respiratory diagnosis, were extracted from the HMDB for the period September 1994 to August 2000, corresponding to six full influenza seasons for which admissions were exclusively coded to ICD-9 (regardless of age). Pregnancy was defined to include any diagnosis of ICD-9 codes 640–648 (pregnancy complication) or V22–23 (normal or high-risk pregnancy). Admissions with any ICD-9 code indicating birth or other termination of pregnancy (V27, 630–639, 650–669) were excluded. Records were aggregated to a weekly level and stratified by presence of comorbidities as follows: none (acute respiratory only); any mention of asthma (ICD-9 493); any other chronic respiratory condition (490–492, 494–496, 500–519); any chronic heart disease (393–398, 412–414, 416, 427, 428); diabetes (250); kidney or other metabolic conditions (240–279, 580–629), and any other diagnosed condition. Women with co-diagnosis of an infectious disease (1–139) other than HIV and viral hepatitis were considered to be otherwise healthy.

Admission records of non-pregnant women aged 20 to 34 with a primary respiratory diagnosis were also extracted in order to compare admission rates of pregnant and non-pregnant women and to control for age. This age group accounts for 80% of all deliveries. An extract of delivery admissions records for women aged 20 to 34 from the HMDB provided one estimate of the prevalence of co-morbidities in pregnant women.

Records of influenza-certified deaths were obtained from the Canadian Vital Statistics Death Database<sup>14</sup> and used as one measure of influenza activity. Records for respiratory virus identifications were obtained from the Respiratory Virus Detection Surveillance System, Public Health Agency of Canada, which collects weekly data from selected laboratories on numbers of tests performed and numbers positive for influenza, respiratory syncytial virus, para-influenza virus, and adenovirus. Weekly influenza admission records for women aged 20 to 34 were extracted from the HMDB for use as a third measure of influenza activity.

Rates were calculated by dividing the estimated number of influenza-attributed admissions by the specific population estimate. The population of women aged 20 to 34 was obtained from Statistics Canada census and inter-census estimates.<sup>15</sup> The population of pregnant women was estimated from Vital Statistics records of live births and stillbirths.<sup>16</sup> These databases indicate the gestational age at birth as well as the number of births and cover the study period. Prevalence estimates of co-morbidities at the time of

## ABBREVIATIONS

CI	confidence interval
CIHI	Canadian Institute of Health Information
COPD	chronic obstructive pulmonary disease
HIV	human immunodeficiency virus
HMDB	Hospital Morbidity Database
ICD-9-CM	International Classification of Disease, Ninth Revision, Clinical Modification
ILI	influenza-like illnesses
MBCI	model-based confidence interval
PIV	para-influenza virus
RSV	respiratory syncytial virus

**Figure 1. General form of the Poisson regression model used to model admissions for a variety of cause-specific and age-specific groups.**

$$\hat{H}_w = \sum_{m=1}^{12} \beta_{1,m} \times Mon_{w,m} \quad \text{general seasonality}$$

$$+ \sum_{y=1995}^{2000} \beta_{2,y} \times FY_{w,y} \quad \text{general trend}$$

$$+ \beta_3 \times Holiday_w \quad \text{general effect of a statutory holiday}$$

$$+ \beta_4 \times Pre\_Xmas_w \quad \text{pre-Christmas slowdown}$$

$$+ \beta_5 \times Xmas_w \quad \text{Christmas week Dec25-Jan1}$$

$$+ \beta_6 \times Janww1_w \quad \text{return to work week (week includes Jan 5)}$$

$$+ \beta_7 \times Sept1_w \quad \text{indicator variable to account for asthma spike in mid Sept.}$$

$$+ \beta_8 \times Inflbase_w \quad \text{influenza-attributed}$$

$$+ \beta_9 \times RSVbase_w \quad \text{RSV-attributed}$$

$$+ \beta_{10} \times PIV_w \quad \text{Para-influenza-attributed}$$

$$+ \beta_{11} \times Adeno_w \quad \text{Adeno virus -attributed}$$

$$+ \beta_{12} \times OtherILL_w \quad \text{Attributed to other ILI}$$

Where  $\hat{H}_w$  is the predicted number of hospital admissions for week  $w$  (by age group or cause);  $Mon_{w,m} = 1$  if month  $m$  corresponds to week  $w$ , 0 otherwise;  $FY_{w,y}$  an indicator variable if week  $w$  corresponds to flu year  $y$  (September to August);  $Pre\_Xmas_w$  accounts for the general reduction in admissions in the days leading up to December 25;  $Xmas_w$  accounts for the Christmas holidays and semi-holidays between December 25 and January 1;  $Janww1_w$  identifies the return to work week, algorithmically identified as the week containing January 5th;  $Sept1_w$  is an indicator variable for the first week of September, to account for the surge in asthma admissions usually starting in the second week of September;  $Inflbase_w$  is the weekly proxy variable for influenza activity;  $RSVbase_w$  is the weekly proxy variable for RSV activity;  $PIV_w$  is the the number of weekly laboratory confirmations for para-influenza;  $Adeno_w$  is the number of weekly laboratory confirmations for adenovirus; and  $OtherILL_w$  is a proxy variable for other influenza-like illness (ILI).

delivery were compared with other published estimates to provide denominators to calculate rates by health status.

### Statistical Analysis

Weekly admissions categorized by comorbidities present at the time of admission were modelled using the Poisson regression-model framework developed to estimate influenza-attributable hospitalization among children.<sup>11</sup> The general form of the model is seen in Figure 1. A regression-model approach facilitated the simultaneous estimation of the effects of influenza and other respiratory viruses (RSV, PIV, and other viral activity) on weekly respiratory admissions and controlled for other factors affecting admissions, such as seasonality, holidays, the extended three-week Christmas period, population growth, and the

trend towards generally reduced admission rates. The influenza year was defined as running from September to August. Influenza-attributed admissions were calculated as the difference between admissions predicted by the model and the admissions predicted by the model under the hypothetical absence of influenza (influenza activity variable set to zero). To assist in calculating rates, it was assumed either that women admitted during the first two months of pregnancy would likely not know that they were pregnant, or that the pregnancy would not be identified in the hospital record at that time. The positive predictive value of a respiratory admission for influenza was calculated for the four weeks of peak viral activity for each year as the number of influenza-attributable admissions divided by the total number of admissions.

**Table 1. Average annual influenza-attributable hospital admissions among pregnant women, Canada 1994/95–1999/2000**

	Annual respiratory admissions	Influenza-Attributed	% of all Influenza-attributed	PPV during peak* influenza activity (%)	Rate / 100 000 population pregnant women	(95% MBCI)
Total	1948	323	100	46	150	(140–170)
By presence of comorbid conditions						
None (healthy)	632	185	57	59	100	(90–110)
493 Asthma	833	57	18	29	450	(300–600)
Other chronic respiratory (490-492, 494-496, 500-519)	246	32	10	39	1500	(1000–2000)
Metabolic, kidney, chronic heart disease†	102	32	10	57	620	(470–770)
Any other comorbidity‡	134	20	6	46	140	(80–200)
By primary respiratory diagnosis§						
460–464, 466–478 Other Acute, incl Bronchitis	250	47	15	45		
465 Multiple or unspecified ARI	251	79	24	63		
480–486 Pneumonia	279	36	11	34		
487 Influenza	177	84	26	71		
490–492, 494–519 COPD, other resp diseases	232	25	8	35		
493 Asthma	759	44	14	26		

\*4 weeks of peak influenza activity

†ICD-9 categories: 240–279, 580–629, 412–414, 416, 427, 428, 393–398, 412–414

‡ Any other comorbid diagnoses excluding acute respiratory, pregnancy related, or infectious diseases

§ Either MRD or primary respiratory diagnosis for admissions with a pregnancy-related MRD

Proxy variables similar to those used in the pediatric<sup>11</sup> and age-specific adult models were developed for viral activity. These proxy variables were primarily based on the viral identifications, normalized to agree with selected hospital admissions. While weekly laboratory confirmations for influenza closely predicted influenza admissions, the relationship between the number of laboratory confirmations and influenza admissions varied slightly with each influenza season. Hence the proxy variables for influenza and RSV were normalized to reflect annual influenza and bronchiolitis admissions respectively. To assess the potential for bias due to omitted confounders, proxies for RSV, PIV, and adenovirus activity, as well as a surrogate for other influenza-like illnesses, were included in the model. The results were compared with results from alternative models without these additional proxies. The proxy for other ILI was constructed by correcting the weekly number of negative identifications for the estimated number of false negative results.

Where calculated, 95% confidence intervals are model-based. As a reminder that any bias or uncertainty due in part to potentially omitted confounders or poor proxy variables for viral activity is not captured in these

calculations, the designation 95% model-based confidence intervals (95% MBCI) is used. Other uncertainties, such as uncertainties for the prevalence of co-morbidities among pregnant women, were not included in the MBCI. SAS PROC GENMOD (SAS Institute Inc. Cary, NC; 2002) was used for all model estimation. A linear link function was chosen to maintain a linear relationship between viral activity and attributed hospitalizations. Rate ratios were calculated assuming similar prevalence of risk conditions for pregnant and non-pregnant women.

## RESULTS

During the study period, an average of 1948 pregnant women were admitted to hospital for a respiratory illness each year; 323 admissions per year (16%) were attributed to influenza, or 150 admissions per 100 000 pregnant women per influenza season (95% MBCI 140–170). Admission rates for pregnant women with conditions considered high risk for influenza-related complications were considerably higher than for healthy pregnant women (Table 1), and this elevated risk persisted for all plausible prevalence estimates. While an estimated 100 admissions per 100 000 (95% MBCI 90–110) occurred in healthy pregnant women, rates

**Table 2. Estimated annual influenza-attributable hospitalization rates for pregnant and non-pregnant women aged 20–34 years, Canada 1994/95–1999/2000**

	Annual respiratory admissions	Influenza-attributed	%	PPV during peak influenza activity (%)	Rate* / 100 000	95% MBCI	Rate ratio† pregnant / non-pregnant
All women aged 20–34 years							
Not-pregnant	10 708	514	66	21	17	14,19	
Pregnant	1495	264	34	47	156	140,170	9
Healthy women							
Not-pregnant	4756	152	51	14	6	4,8	
Pregnant	495	148	49	59	104	91,116	18
Diagnosed asthma							
Not-pregnant	3111	211	83	28	110	90,130‡	
Pregnant	625	42	17	28	410	240,580‡	4
Other chronic respiratory							
Not-pregnant	1343	50	66	18	160	80,240‡	
Pregnant	186	26	34	42	1,500	900,2100‡	10
Metabolic, kidney, chronic heart disease							
Not-pregnant	530	59	69	38	80	60,100‡	
Pregnant	82	27	31	59	700	500,900‡	8
Other conditions							
Not-pregnant	969	39	68	19	20	10,30	
Pregnant	107	18	32	47	200	130,270	10

\*Rates calculated based on estimated prevalences of chronic conditions.

†Assuming similar prevalence of risk conditions for pregnant and non-pregnant women

‡Rates most sensitive to uncertainties in prevalence of health status.

associated with asthma were estimated at 450 per 100 000 (95% MBCI 300–600) and with other chronic respiratory conditions at 1500 per 100 000 (95% MBCI 1000–2000).

Pregnant women in all states of health were found to be at an increased risk for influenza-attributable hospital admission compared with non-pregnant women of similar age and health status (Table 2); the level of estimated increase in risk ranged from fourfold to 18-fold. Healthy pregnant women aged 20 to 34 were estimated to be 18 times as likely to be admitted for influenza-attributed illness as their non-pregnant peers. Influenza-attributed admission rates for women with other conditions not usually considered risk conditions for influenza complications were found to be somewhat higher than those of their healthy peers. (Rates were estimated to be 2–3 times higher, Table 2.)

During the four-week peak influenza season a “respiratory admission” of a pregnant woman had a positive predictive value of 46% for being due to influenza. The strong effect of influenza on weekly respiratory admissions of pregnant women is shown in Figure 2, in which weekly admissions are plotted along with the model prediction and baseline. The most notable pattern in the baseline is the sharp

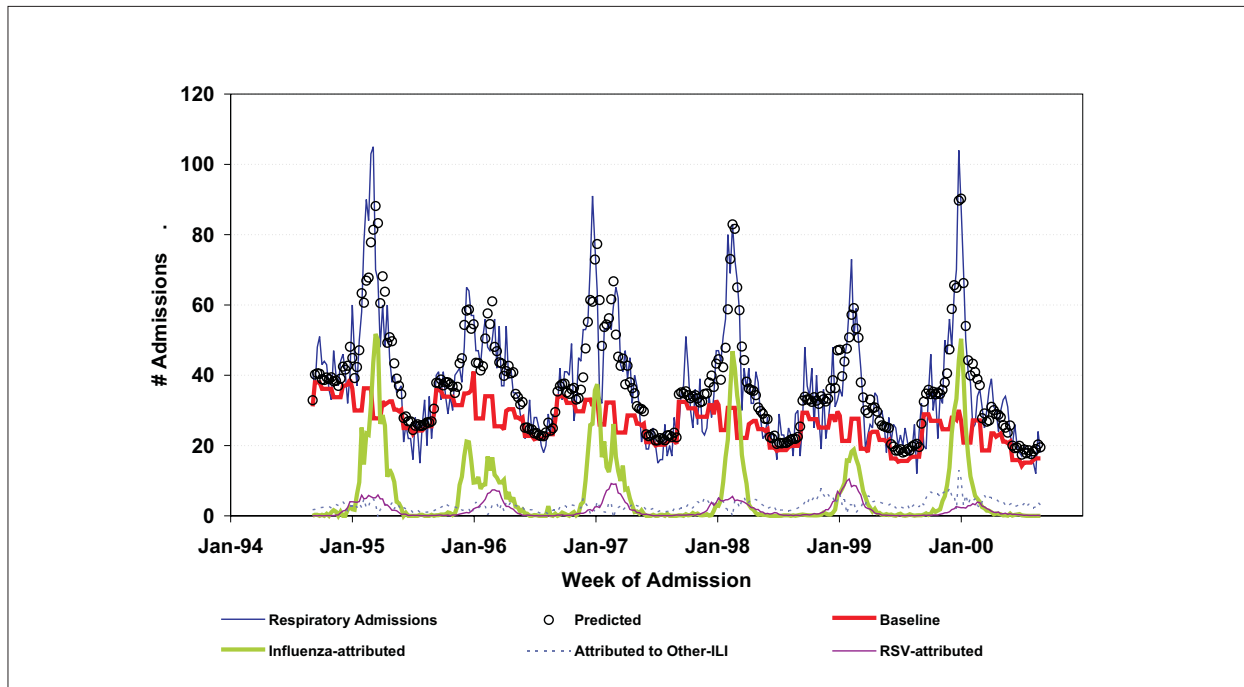
increase in admissions in mid-September and subsequent decline over the November to April influenza season. This baseline pattern is consistent with the seasonality of asthma admissions.

No appreciable season-to-season variation in admission rates of pregnant women was observed. RSV accounted for an additional 100 admissions per year (95% MBCI 20–180), and other ILI another 150 per year (95% MBCI 20–280) (corresponding  $P > 0.02$ ). For more than half the admissions attributed to influenza (194/323, or 60%), the primary diagnosis was assigned a complication of pregnancy code (ICD-9 chapter XI) rather than a respiratory code.

## DISCUSSION

Our study confirms that pregnancy is associated with an increased incidence of influenza-associated hospitalization in both healthy women and those with conditions that otherwise increase the risk of complications related to influenza. The rate of influenza-attributed admissions for healthy pregnant women is similar to that estimated for all adults aged 65 to 69 in Canada.<sup>9</sup> Over 50% of influenza-attributed admissions occurred in otherwise healthy

**Figure 2. Weekly respiratory admissions of pregnant women and admissions attributed to influenza, RSV and other ILI, Canada 1994/95–1999/2000**



pregnant women. Overall, we identified an admission rate of one hospitalization per 1000 healthy pregnant women per season. Assuming a clinical attack rate of 5%, this rate means that for every 50 healthy pregnant women who became clinically ill with influenza virus one was admitted to hospital. Since hospitalization is seen as a manifestation of complicated or severe illness by advisory bodies, this suggests that annual influenza immunization should be recommended for healthy pregnant women.

We found a nine-fold increase in hospital admission rates attributable to influenza during pregnancy, which is similar in magnitude to that identified in the study by Neuzil et al. of a Tennessee Medicaid population.<sup>8</sup> Because modelling allows the estimation of influenza-attributable admissions rather than identifying only those with a confirmed diagnosis, our rates of admissions in pregnant women are higher than some studies based on cases of laboratory-confirmed influenza. Also, studies that used ILI admissions as a proxy for influenza admissions<sup>17,18</sup> tend to underestimate the full impact of influenza. As our estimated seasonal baseline for respiratory admissions declines from September to July (see baseline in Figure 1), it is possible that Neuzil's use of a periseasonal baseline did not adequately control for seasonality.

While several studies have documented increasing risk of influenza complications later in gestation,<sup>17,19,20</sup> we were unable to differentiate between trimesters of pregnancies in this analysis, as the HMDB does not record this information. If we assumed that most influenza-related admissions occurred during the third trimester, our average rates would double to 200 per 100 000 for healthy third-trimester women, giving a rate similar to that estimated by Neuzil.<sup>8</sup> Because we found influenza-attributable admission rates in pregnant women to be relatively constant across multiple influenza seasons of varying severity for seniors, our estimated rates should be similar to studies covering other influenza seasons.

While we were able to detect some burden due to RSV and other viruses at the aggregate level of all pregnant women, we were unable to partition this to any of the subgroups. This is likely due to the limited size of the population of hospitalized pregnant women. The seasonal pattern of influenza was distinct from RSV and other viruses, so ignoring the level of other viral activity did not modify our estimates of influenza-attributed admissions.

The main limitation of our study is the lack of precise prevalence estimates for the co-morbid conditions. The prevalence of risk conditions varies by disease severity, and

**Table 3. Prevalence of comorbidity at time of delivery**

Level of co-morbidity present	Average annual deliveries*	Prevalence† (%)	Adjusted prevalence (%)
None (healthy)	348 000	90	84
Asthma	2000	0.6	6
Other chronic resp	500	0.1	1.0
Metabolic, kidney, chronic heart	9000	2.4	2.4
Diabetes	1000	0.2	0.2
Other conditions	25 400	7	6.6

\*Average annual deliveries, all ages

†Prevalence, as identified in hospital discharge record. Prevalences for deliveries of women aged 20–34 only (not shown) were similar.

conditions are often undiagnosed.<sup>21–23</sup> These factors complicate the selection of a prevalence estimate. We attempted to select a population prevalence estimate that would correspond to the population at risk who were likely to have their comorbid condition noted on the discharge record of a respiratory admission. Our estimates of influenza-attributed admissions for pregnant women by health state would also be affected by how completely these conditions were recorded as a secondary diagnosis on the hospital record. By using hospital records from the time of delivery to estimate the prevalence among the population of pregnant women, we hoped to arrive at consistent definitions of “healthy” and “risk conditions” (see Table 3). For diabetes, we found close agreement between the prevalence of primarily juvenile diabetes among women giving birth (0.2%), and published rates for 12 to 34-year-old Canadians (0.5%).<sup>24</sup> Asthma and COPD, however, were significantly under-represented in the hospital delivery discharge records. These conditions may not have been considered a complication during the delivery. Prevalence estimates of asthma range from 4% to 8%,<sup>25</sup> and we chose 6% for our calculations, in keeping with prevalences in other studies.<sup>26,27</sup> It has been noted that exacerbations of asthma peak in weeks 20 to 24 of pregnancy and tend to improve in the third trimester<sup>26</sup>; this could explain the lower rate ratio (pregnant to non-pregnant) in asthmatics compared with healthy women (Table 2). Severity-related variation was also seen in the prevalence of COPD among young adults.<sup>23</sup> Because we assumed no difference in the general health status of pregnant and non-pregnant women, we may have overestimated the population of healthy non-pregnant women. However, even with adjustments for a healthier pregnant population (not shown), the rate ratio (pregnant to non-pregnant) for healthy women still exceeds the population average of nine. Rates most sensitive to uncertainties in prevalence of health status are shown with ‡ in Table 2.

Influenza-attributable hospitalization rates specific to pregnant women over 35 were not assessed.

Is the burden of illness associated with healthy pregnant women sufficient to make them a priority group for annual influenza immunization? Although pregnancy itself appears to be a risk factor for influenza-attributable admission, the efficacy of influenza vaccines in preventing influenza-related admissions in this population has not been evaluated in randomized controlled trials, and observational studies are unlikely to detect a reduction in admission rates given the small size of the population and the relatively low event rate.<sup>28</sup> Our estimated event rate implies that from 750 to 900 pregnant women would need to be vaccinated with an 80% effective vaccine to prevent one hospital admission. It is reasonable, however, to expect immunization to be effective in healthy pregnant women, and no study has documented increased risk of maternal complications or adverse fetal effects associated with maternal immunization using inactivated influenza vaccine.<sup>29,30</sup>

As lack of adequate information about the risks and benefits of vaccination has been identified as a barrier to influenza vaccine programs for pregnant women,<sup>29</sup> expanding the recommendation for influenza immunization to healthy pregnant women may also increase vaccine uptake in high-risk pregnant women. At present, less than 10% of the pregnant population in multiple studies receives influenza immunization.<sup>6,17,18,28–30</sup> Increased coverage among people who understood their risks of complications due to influenza has been documented.<sup>31</sup>

It is not known if hospital utilization is higher for pregnant women because care providers have a lower threshold for admission in this population, or if admission rates truly reflect serious illness requiring institutional care. Regardless, these consistently elevated estimates of resource utilization over multiple years suggest that this is a high-risk population.

## ACKNOWLEDGEMENTS

Vital statistics data were provided to the Public Health Agency of Canada from the Canadian Vital Statistics databases at Statistics Canada with the knowledge and consent of the provincial and territorial vital statistics registries, which supply the data to Statistics Canada. Parts of this material are based on data and information provided by the Canadian Institute for Health Information. However, the analyses, conclusions, opinions, and statements expressed herein are those of the authors, and not necessarily those of the Canadian Institute for Health Information. The authors gratefully acknowledge the support of the National *FluWatch* Network and the Data Coordination and Access Program of the Public Health Agency of Canada, and all those involved in the collection and compiling of these data.

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