Asthma health services utilisation before, during and after pregnancy: a population-based cohort study

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ABSTRACT During pregnancy, females with asthma may be at higher risk of exacerbation. The objective of this study was to determine whether females with asthma in Ontario, Canada have increased health services utilisation (HSU) during pregnancy.

Rates of asthma-specific, asthma-related and non-pregnancy-related HSU were calculated in a population-based cohort of pregnant females with asthma. Poisson regression with repeated measures was used to determine adjusted rate ratios and 95% confidence intervals of HSU during and 1 year after pregnancy, compared to the year before pregnancy.

The cohort consisted of 103 976 pregnant females with asthma. Compared to the year prior to pregnancy, hospitalisation rates per 100 person-months during pregnancy increased 30% for asthma (from 0.016 to 0.020), 24% for asthma-related conditions (from 0.012 to 0.015) and decreased 37% for non-pregnancy-related conditions (from 0.24 to 0.15). Emergency department visits for asthma and asthma-related conditions did not increase significantly during pregnancy. During pregnancy, physician office visits decreased 19% for asthma (from 2.20 to 1.79), 10% for asthma-related conditions (from 9.44 to 8.47) and increased 74% for non-pregnancy-related conditions (from 56.4 to 98.2).

Hospitalisations for asthma and asthma-related conditions increased during pregnancy, demonstrating that the overall increase in non-pregnancy-related physician office visits may not meet the primary care needs of pregnant females with asthma.

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Introduction

Several prospective studies of pregnant females with asthma have demonstrated that, during pregnancy, asthma tends to improve in one-third of females, stays the same in one-third and worsens in one-third [1, 2].

The prognosis of asthma during pregnancy has been shown to be affected by provider and patient factors. An Australian survey demonstrated that many general practitioners involved in the primary care of pregnant females decreased patients' asthma medications during pregnancy even when asthma was well-controlled by current therapy, despite reporting a good knowledge of asthma [3]. Healthcare providers in North America have been shown to delay or reduce prescription of systemic corticosteroids to pregnant females during asthma exacerbations treated in acute care settings, compared to non-pregnant females [4–7]. Many pregnant females themselves have been reported to reduce or discontinue asthma controller medications during pregnancy, due to concern about the effect of asthma medications on the fetus [8, 9]. Other factors that may affect the prognosis of asthma during pregnancy include pre-pregnancy severity of asthma, viral infections, allergic rhinitis and smoking [2, 10–13].

Deviation from asthma guidelines during pregnancy may place pregnant females at higher risk of asthma exacerbations, thus leading to avoidable maternal and possibly fetal morbidity, and an increased burden on the healthcare system. A systematic review of 33 published studies did not find any conclusive links between preventive asthma medications and adverse pregnancy outcomes [14]. The authors of the study recommended that healthcare providers follow asthma guidelines produced by professional organisations such as the Global Initiative for Asthma (GINA), which emphasises the importance of actively treating asthma during pregnancy and not stepping down medications even if asthma is well-controlled [15]. Furthermore, it has been demonstrated that the use of asthma medications below levels recommended by GINA is associated with more severe asthma during pregnancy [13].

In order to understand the unique healthcare needs of pregnant females with asthma and the impact that these needs have on the healthcare system, it is important to describe the patterns and risk factors of healthcare utilisation of this vulnerable population. The objective of this study was to determine whether females with asthma in Ontario, Canada have increased health services utilisation (HSU) during pregnancy, compared to before and after pregnancy, and to identify individual as well as community level risk factors for increased HSU.

Methods

Study design

In this population-based cohort study, pregnant females with asthma living in Ontario, Canada were followed using health administrative databases to determine HSU for asthma, asthma-related conditions and non-pregnancy-related conditions. HSU was evaluated at three time points: in the year before pregnancy, during pregnancy and in the first year post-delivery.

Approval to conduct this study was obtained from the Institute for Clinical Evaluative Sciences (ICES) and the research ethics board at the Hospital for Sick Children (Toronto, Canada).

Study population

The study population consisted of pregnant females with pre-existing asthma aged ⩾19 years living in Ontario, Canada. Females with asthma were identified from the Ontario Asthma Surveillance Information System (OASIS; http://lab.research.sickkids.ca/oasis/), which includes all individuals covered by Ontario's universal healthcare system who meet the following definition of asthma: one or more hospitalisations for asthma or two or more outpatient claims for asthma in two consecutive years [16]. Females were included if they delivered between April 1, 2005 and March 31, 2015 and if their pregnancy had gestational age between 37 and 42 weeks (inclusive) and did not result in termination, stillbirth or multiple births. Females were further excluded if, during the study period (*i.e.* within the year prior to and first year post-delivery), they had another delivery or had incomplete health insurance coverage or data. Fewer than six females had congestive heart failure; in order to protect individual identities, they were removed during the initial screening process.

If females had more than one delivery during the study period, only the first delivery that met inclusion/exclusion criteria was used in this study.

Data sources

All study data were captured in six large, population-based health administrative databases housed at ICES (online supplementary eTable 1). Individuals in the study cohort were linked across these databases using their encrypted, unique health card number, given to every Ontario resident covered by Ontario's universal healthcare system.

Exposure and outcome measures

Exposure

The three exposure times investigated were the year prior to pregnancy, during pregnancy and the first year post-delivery. These dates are calculated using the mother's gestation weeks at delivery and the newborn's date of birth, as recorded in health administrative databases.

Outcomes

Asthma

HSU was captured using the diagnostic code 493 (International Classification of Diseases (ICD)-9) or J45/J46 (ICD-10) (online supplementary eTable 2).

Asthma-related conditions

HSU was captured using diagnostic codes for acute respiratory infections, pneumonia, influenza, chronic obstructive pulmonary disease (COPD), atopic dermatitis, gastro-oesophageal reflux disorder, heartburn and allergic contact dermatitis (online supplementary eTable 2).

Non-pregnancy-related conditions

HSU was captured using any diagnostic code except for the following ICD chapter headings: complications of pregnancy, childbirth and the puerperium and certain conditions originating in the perinatal period (online supplementary eTable 2). Therefore, non-pregnancy-related conditions included asthma and asthma-related conditions.

Three forms of HSU were captured for each group of conditions: hospitalisations, emergency department visits and physician office visits. For hospitalisations and emergency department visits, only primary diagnostic codes were considered. For physician office visits, only one diagnosis code is available and is used per patient visit.

Statistical analysis

Counts of HSU were tabulated for the three time periods of the study, and rates per 100 person-months were calculated. This approach ensures that rates can be compared between the three time periods, which vary in duration from approximately nine to 12 months.

Poisson regression with repeated measures using generalised estimating equations was used to generate rate ratios (RR) and 95% confidence intervals for the effect of each period of pregnancy on HSU (reference period: the year prior to pregnancy). Separate models were run for the three groups of conditions (asthma, asthma-related conditions and non-pregnancy-related conditions) and each type of HSU. HSU was modelled as rates, using the number of days in each time period as an offset. To examine if HSU differed by maternal age at delivery, duration of maternal asthma, material deprivation, rural/urban residence and the presence of certain comorbidities, these variables were included as covariates in multivariable regressions. The duration of maternal asthma was calculated as the number of years since each woman was first included in OASIS. Material deprivation, a measure of socioeconomic status (SES), was measured using the Ontario Marginalization Index [17]. The following comorbidities were considered at each of the three exposure periods: diabetes, cardiovascular disease, COPD and cancer (defined in online supplementary eTable 3).

Results

Descriptive data

The study cohort consisted of 103 976 pregnant females with asthma with one singleton delivery each (figure 1). Pregnant females with asthma were aged mean±SD 28.9±5.5 years at delivery (table 1). They were first included in OASIS at an average age of 16.4±8.2 years and had an average duration of asthma of 12.5±5.5 years. 22.8% of the females were in the highest quintile of material deprivation (most deprived), whereas 23.0% were in the lowest quintile, and 11.2% lived in rural areas. The most common comorbidity was cardiovascular disease (8.7% in the year prior to pregnancy) followed by diabetes (1.7%).

Rates of HSU

Compared to the year prior to pregnancy, hospitalisations for asthma and asthma-related conditions increased during pregnancy, after which they dropped markedly in the first year post-delivery (figure 2). Emergency department visits for asthma and asthma-related conditions were stable during pregnancy, after which they dropped markedly in the first year post-delivery. In contrast, acute care visits (hospitalisations and emergency department visits) decreased during pregnancy for non-pregnancy-related conditions, after which hospitalisations rebounded to pre-pregnancy levels and emergency department visits continued to decrease. Physician office visits for asthma and asthma-related conditions decreased during pregnancy and

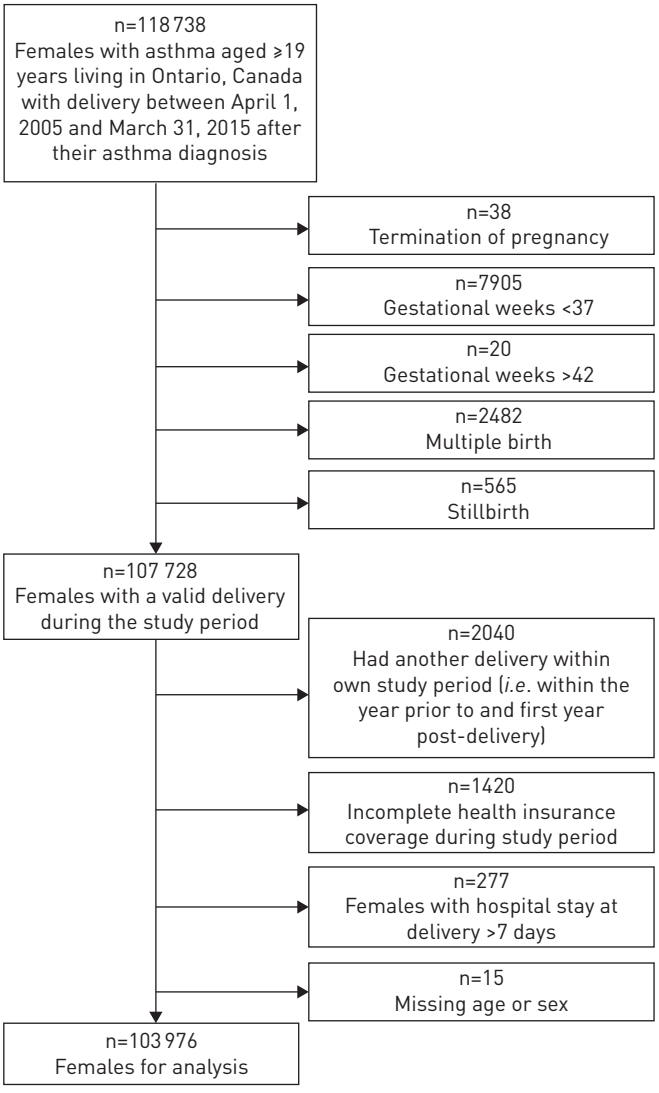

FIGURE 1 Flow diagram of the assembly of the study cohort.

in the first year post-delivery, whereas they increased during pregnancy for non-pregnancy-related conditions (figure 2).

Rates further broken down by trimester of pregnancy are shown in online supplementary eFigure 1. While hospitalisations increased steadily across all trimesters of pregnancy for asthma, they were only increased in the second and third trimesters for asthma-related conditions. Emergency department visits for asthma and asthma-related conditions were highest in the second trimester, and emergency department visits for non-pregnancy-related conditions peaked in the first trimester. The increase in physician office visits for non-pregnancy-related conditions during pregnancy was most pronounced in the third trimester.

Multivariable analysis

Figure 3 displays RR (95% CI) for HSU during pregnancy and in the first year post-delivery (reference period: the year prior to pregnancy). In addition, covariate effects are displayed.

Hospitalisations

Multiple regression analyses could not be conducted for asthma or asthma-related hospitalisations, due to too few outcomes occurring for these conditions. Compared to the year prior to pregnancy, hospitalisations for non-pregnancy-related conditions decreased 37% during pregnancy (0.63, 0.59–0.68), rebounding to baseline levels in the first year post-delivery (0.99, 0.94–1.05).

Emergency department visits

Compared to the year prior to pregnancy, emergency department visits increased 6% for asthma and remained the same for asthma-related conditions during pregnancy (1.06, 1.00–1.12 and 0.99, 0.96–1.03,

TABLE 1 Characteristics of pregnant females with asthma who delivered between April 1, 2005 and March 31, 2015

Subjects	103 976
Mother's age at discharge of the delivery	28.9±5.5
Duration of asthma years	12.5±5.5
Mother's age when first captured in provincial asthma surveillance system	16.4±8.2
Gestation at delivery weeks	39.2±1.2
Deaths	241 (0.2)
Deprivation quintile	
1 (least deprived)	23 611 (23.0)
2	18 552 (18.1)
3	18 609 (18.1)
4	18 428 (18.0)
5 (most deprived)	23 392 (22.8)
Rurality	
Urban	92 274 (88.8)
Rural	11 674 (11.2)
Comorbidities[#]	
Cardiovascular disease	
Year prior to pregnancy	9021 (8.7)
During pregnancy	9709 (9.3)
Year post-delivery	10 508 (10.1)
Diabetes	
Year prior to pregnancy	1778 (1.7)
During pregnancy	2032 (2.0)
Year post-delivery	2331 (2.2)
Cancer	
Year prior to pregnancy	540 (0.5)
During pregnancy	595 (0.6)
Year post-delivery	621 (0.6)
COPD	
Year prior to pregnancy	206 (0.2)
During pregnancy	308 (0.3)
Year post-delivery	373 (0.4)

Data are presented as n, mean±SD or n (%). Percentages are adjusted for missingness. COPD: chronic obstructive pulmonary disease. [#]: comorbidities were tabulated at the beginning of each time period of pregnancy. Categories are not mutually exclusive.

respectively) then decreased by ~40% in the first year post-delivery (0.53, 0.49–0.57 and 0.67, 0.65–0.70, respectively). Emergency department visits for non-pregnancy-related conditions decreased 8% during pregnancy and 27% in the first year post-delivery (0.92, 0.91–0.94 and 0.74, 0.72–0.74, respectively).

Physician office visits

Compared to the year prior to pregnancy, physician office visits decreased 19% for asthma and 10% for asthma-related conditions during pregnancy (0.81, 0.79–0.83 and 0.90, 0.88–0.91, respectively) and 28% and 11% in the first year post-delivery (0.72, 0.71–0.74 and 0.89, 0.88–0.90, respectively). Physician office visits for non-pregnancy-related conditions increased 74% during pregnancy (1.74, 1.72–1.75) and nearly returned to baseline levels in the first year post-delivery (1.02, 1.01–1.03).

Covariate effects

Increased material deprivation was generally associated with increased HSU. Compared to being in the lowest (least deprived) quintile of material deprivation, being in the highest quintile was associated with double the emergency department visits and 22% more physician office visits for asthma (1.95, 1.74–2.20 and 1.22, 1.16–1.29, respectively). Similarly, being in the highest quintile of material deprivation was associated with a 41% higher hospitalisation rate and a 73% higher emergency department visit rate for non-pregnancy-related conditions (1.41, 1.28–1.55 and 1.73, 1.67–1.80, respectively), but was not as strongly associated with physician office visits (1.02, 1.00–1.03).

Females in rural areas experienced a higher rate of hospitalisations and emergency department visits and a lower rate of physician office visits, compared to females in urban areas. For example, females in rural

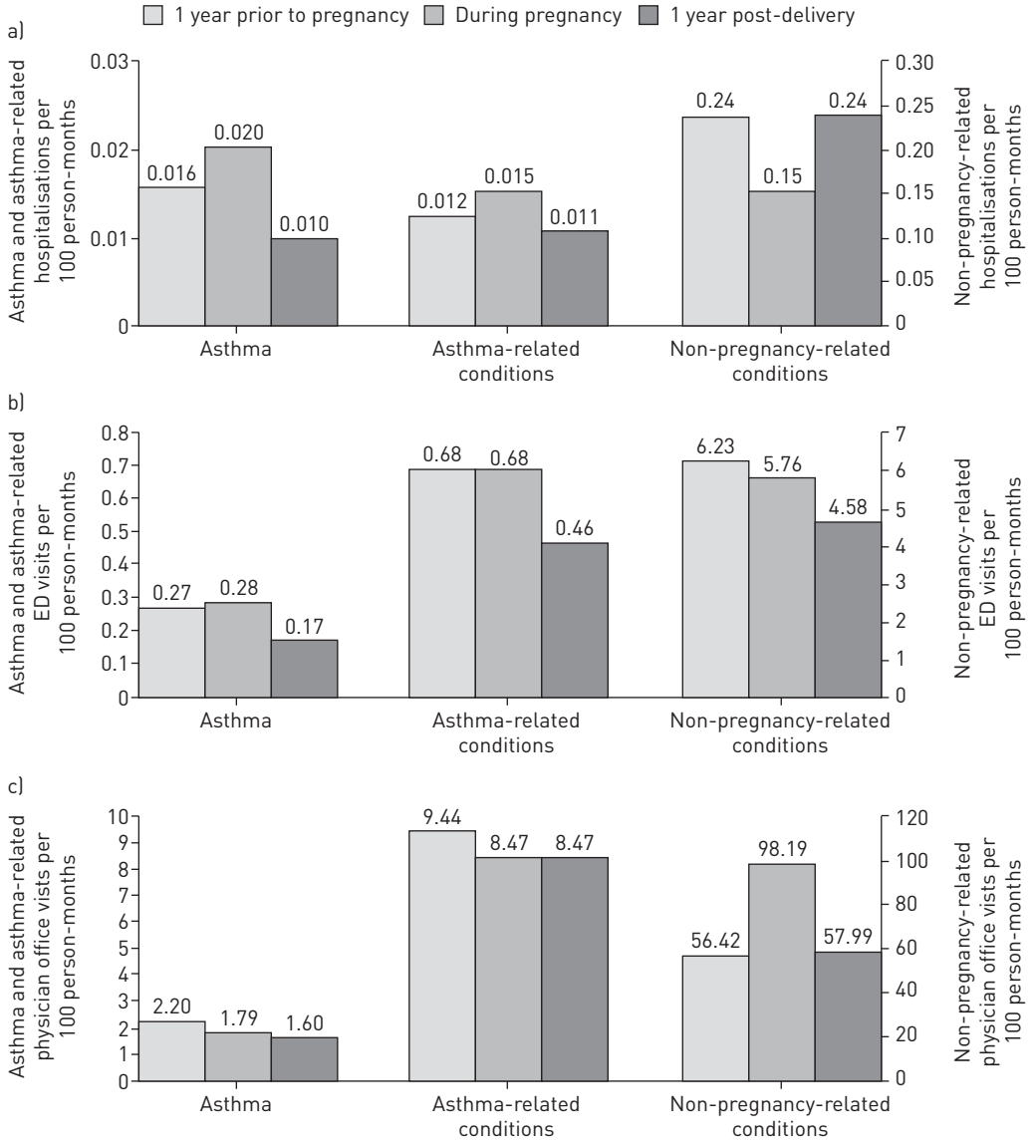

FIGURE 2 Rates per 100 person-months of follow-up for a) hospitalisations, b) emergency department (ED) visits and c) physician office visits for asthma, asthma-related conditions and non-pregnancy-related conditions during the three time periods in this study.

areas experienced an 85% higher emergency department visit rate and 32% lower physician office visit rate for asthma (1.85, 1.68–2.04 and 0.68, 0.64–0.73, respectively).

Comorbidities were generally associated with increased HSU. COPD was the comorbidity associated with some of the greatest increases in HSU, including emergency department visits for asthma, asthma-related conditions and non-pregnancy-related conditions (3.87, 2.08–7.17; 2.39, 1.51–3.76; and 2.05, 1.63–2.57, respectively). Diabetes was associated with the greatest increases in physician office visits for non-pregnancy-related conditions (1.50, 1.46–1.54).

Discussion

Our study used a population-based cohort of pregnant females with asthma to compare patterns of HSU before, during and after pregnancy. We reported a significant increase in hospitalisations during pregnancy for asthma and asthma-related conditions. In addition, we found that physician office visits for non-pregnancy-related conditions were increased during pregnancy, whereas physician office visits for asthma and asthma-related conditions decreased. Higher levels of material deprivation, rural residence and the presence of comorbidities were associated with higher rates of HSU among pregnant females with

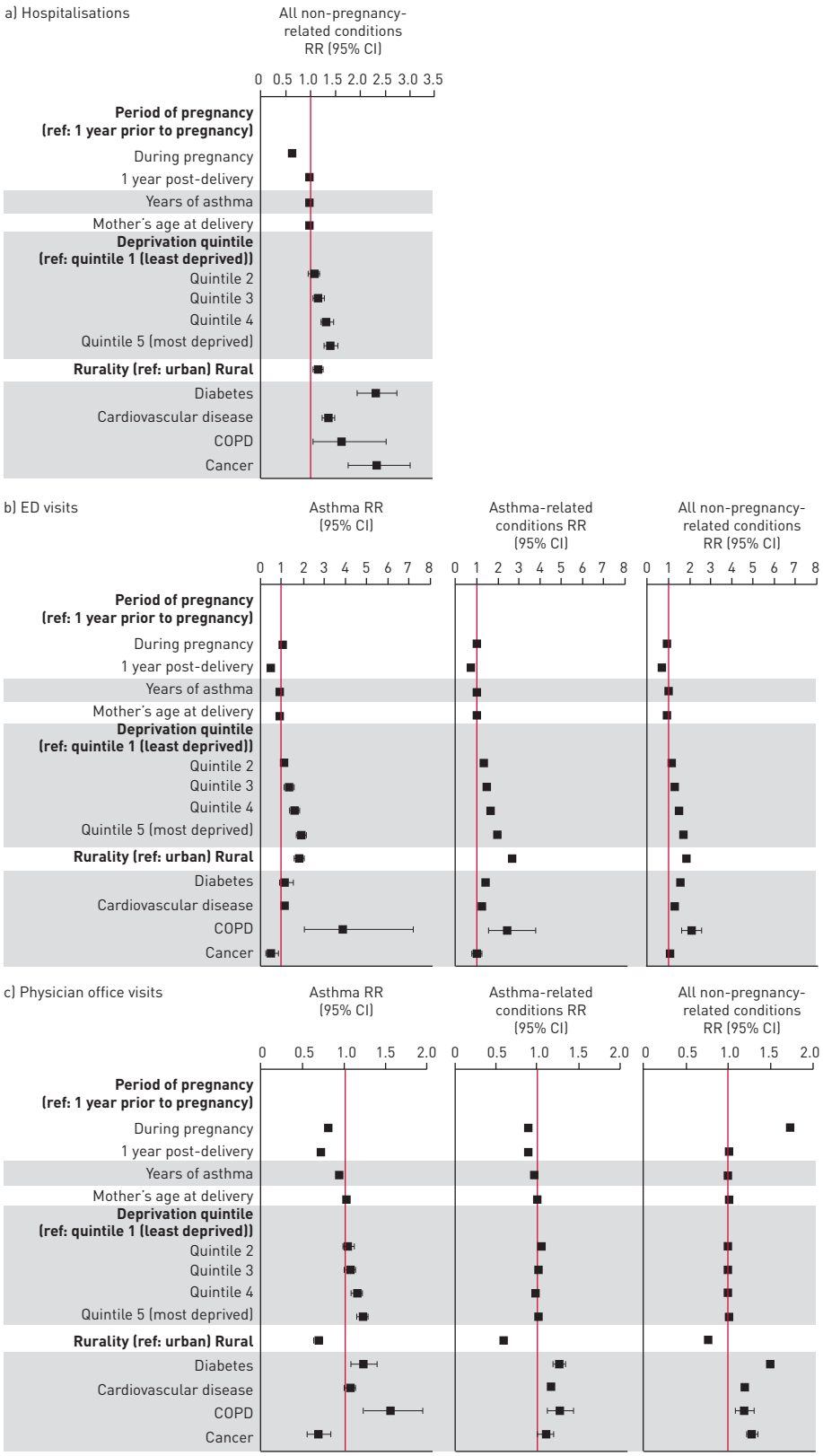

FIGURE 3 Rate ratios (RR) and 95% confidence intervals from Poisson regression with repeated measures describing exposure and covariate effects on a) hospitalisations, b) emergency department (ED) visits and c) physician office visits for asthma, asthma-related conditions and non-pregnancy-related conditions. Multiple regression analyses could not be conducted for asthma or asthma-related hospitalisations, due to too few outcomes occurring for these conditions. COPD: chronic obstructive pulmonary disease.

asthma. The increase in hospitalisations for asthma and asthma-related conditions during pregnancy suggests a role for asthma-focused primary care during pregnancy.

Interpretation of findings in broader context of existing literature

Kim *et al.* [18] examined asthma HSU in 3357 pregnant and 50 355 non-pregnant females using the Korean National Health Insurance claim database. They examined patterns of HSU in the year prior to pregnancy, during pregnancy and in the first and second years after delivery. Crude rates of asthma HSU were higher in the study by Kim *et al.* than in our study, probably because their inclusion criteria included prior asthma HSU and asthma-related medications or tests during the study period; therefore, their cohort would have been more likely to have "active" disease than the females in our study. However, the overall patterns of HSU were very similar to our study. As in our study, they showed that hospitalisations for asthma increased during pregnancy, whereas outpatient visits were significantly lower. In contrast to our findings, Kim *et al.* showed that emergency department visits declined during pregnancy and in the first year post-delivery. However, increases in hospitalisations and decreases in the number of emergency department visits for asthma during pregnancy were not statistically significant in their study, in which only a small number of acute care visits were seen.

The observed peak in emergency department visits for asthma during the second trimester of pregnancy is consistent with prospective cohort studies that have found asthma exacerbations to be most frequent between gestational weeks 17 and 24 [19, 20]. In our study, hospitalisations for asthma, which accounted for a minority (~10%) of acute care visits for asthma, peaked in the third trimester of pregnancy. This is consistent with the study by Kim *et al.* [18] and may reflect an increased tendency toward hospitalisation among pregnant females with asthma presenting to the emergency department in the third trimester with respiratory complaints.

The association between material deprivation and HSU observed in our study is consistent with both Canadian and international literature. In Canada, low SES has previously been reported to be associated with increased healthcare utilisation for asthma and other chronic health conditions, as well as generally higher healthcare utilisation [21–26]. Some of this association may be explained by differing health needs across levels of SES [27]. International studies have also supported an association between lower SES and increased asthma HSU [28, 29].

In Ontario, Canada, there is a low availability of primary care physician services in some rural areas, particularly in northern areas of the province; this is probably the reason that physician office visits are generally lower for females with rural residence, while hospitalisations and emergency department visits are higher [30].

The increase in hospitalisations for asthma and asthma-related conditions during pregnancy could be explained by a well-documented decrease in adherence to asthma medications during pregnancy. Enriquez *et al.* [9] analysed prescriptions filled by >8000 pregnant females with asthma who were enrolled in Tennessee Medicaid between 1995 and 2001. Although their use of health administrative data did not allow them to comment on reasons for the patterns they observed, Enriquez *et al.* demonstrated that pregnant females filled 22.9% fewer prescriptions for inhaled corticosteroids (ICS), 13.2% fewer prescriptions for short-acting β-agonists and 54.3% fewer prescriptions for rescue oral corticosteroids from 5 to 13 weeks after the last menstrual period. Using health administrative databases to analyse 4920 pregnancies among females with asthma in Québec, Canada, Blais *et al.* [31] found that 48.5% of pregnancies were in females who discontinued or reduced their ICS use during pregnancy. Interestingly, Blais *et al.* found that females who discontinued ICS experienced fewer asthma exacerbations, while females who increased their use of ICS experienced more, probably reflecting residual confounding by asthma severity.

Strengths and limitations

Strengths of this study include the use of large, population-based databases covering the entire province of Ontario. The linkage of these large, population-based databases allowed us to assemble a longitudinal cohort to observe HSU before, during and after pregnancy for >10 years. The use of prospectively collected, population-based data reduces the risk of recall and selection bias and increases the generalisability of our results.

Limitations of this study include a lack of clinical variables, making it impossible for us to control for or stratify analyses by pre-pregnancy asthma severity. However, in our cohort study, females assessed for outcomes during pregnancy were the same females assessed for outcomes during the pre-pregnancy period. Therefore, the increase in acute care visits for asthma and asthma-related conditions seen during pregnancy cannot be due to a greater proportion of people with severe asthma being present in the study

during this time period. The inclusion of live, singleton births at 37–42 weeks gestation resulted in the exclusion of preterm births, which are associated with asthma exacerbation [32]. Therefore, the magnitude of the association between pregnancy and acute asthma HSU is probably greater than that reported in our study. The use of health administrative data does not allow us to determine whether patterns of HSU changed due to disease worsening, or due to a change in health behaviours such as greater concern for the health of pregnant females. However, we observed a decrease in acute care visits for non-pregnancy-related conditions, suggesting that the increase in hospitalisations we observed for asthma and asthma-related conditions was not merely a signal of overall changed health behaviours. Lastly, the lack of prescription data for those in Ontario aged <65 years makes us unable to examine medication prescriptions as potential mechanisms underlying the association between periods of pregnancy and HSU.

Conclusions

We conducted a population-based study of pregnant females with asthma and found an increase in hospitalisations and a decrease in physician office visits during pregnancy for asthma and asthma-related conditions, suggesting less preventative and more reactive treatment. The observed increase in physician office visits for non-pregnancy-related conditions during pregnancy does not appear to meet the need for asthma-focused primary care during pregnancy. Since avoidance of hospitalisations for asthma is highly important during pregnancy, these findings point to a possible need for more preventive, focused physician office visits to ensure asthma is under control.

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Conflict of interest: None declared.

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